CHAPTER 3
AFFECTED ENVIRONMENT

This chapter provides an overview of the baseline physical, biological, social, and economic conditions that occur within the region of influence (ROI) for the actions proposed under No Action and Alternatives 1, 2, 3, and 4. The potentially affected environmental and socioeconomic resources include land use and recreation, airspace, visual resources, air quality, noise, traffic and transportation, water resources, geology and soils, biological resources, cultural resources, hazardous materials and wastes, socioeconomics and environmental justice, public services and utilities, and wildfires. Only those environmental and socioeconomic conditions relevant to the impact analysis for the proposed project are presented.

This chapter is organized into sections for each resource area. As applicable, each section contains an introduction to the resource, a definition of the ROI, and background on how the resource is related to the proposed project activities. In addition, resource discussions review existing Army programs, where applicable. The remainder of each resource section is a discussion of the existing condition of the resource within the ROI.

As described in Chapters 1 and 2, the use of Mākua Valley by the Army dates back to the 1920s. The site has been used for many decades to train our troops as they fight by conducting ground maneuvers, nonlive-fire exercises and live-fire exercises, and air exercises. Training activities have included squad, section, platoon, and company level live-fire training, ground maneuvers, aviation assault training, demolitions training, and sniper training.

From 1988 to September 1998, the Army used the CCAAC extensively before suspending training. During past annual training, the Army used ammunitions and medium-heavy artillery, such as 40mm, 60mm, 81mm, and 105mm mortar live-fire. The actual number of training days over the 10-year period ranged from 153 to 259 days per year, with a 10-year annual average of 210 days. The number of live-fire days ranged from 37 to 100, with a 10-year annual average of 72 days. Prior to the voluntary suspension of training at MMR in September 1998, the 25th ID conducted 15 CALFEXs in fiscal year 1997 and 18 company live-fire exercises in fiscal year 1998.

With the suspension of training in 1998, the 25th ID tried to meet its live-fire training requirements using other military installations. Consequently, the Army did not perform CALFEXs at MMR during 1999, 2000, and 2001. In fiscal year 2002, 13 CALFEXs were conducted at MMR, and in fiscal year 2003 eight CALFEXs were conducted at MMR, pursuant to the Settlement Agreement; no CALFEXs were conducted at MMR in fiscal year 2004. These past and current training activities have contributed to the existing conditions described in Chapter 3, Affected Environment.

PTA was established as a multi-functional training facility in 1956 for the US Army Western Command and other Pacific Command units. The installation encompasses approximately 132,000 acres (53,419 hectares), with a central impact area of approximately 51,000 acres (20,638 hectares). Total acreage includes the recently acquired Keʻāmuku Maneuver Area, or Keʻāmuku Parcel. The primary mission of PTA is to operate and maintain a safe, modernized, major training area for USARHAW, US Army, Pacific, and other US Pacific Command military units. PTA assets are geared towards maneuver unit live-fire, maneuver training, and artillery live-fire. The largest live-fire range and training complex belonging to USARHAW is located on PTA.

The CALFEX/Twin Puʻu location was found to be the only operationally feasible PTA Alternative for consideration as a replacement range for the MMR. Although there are very challenging issues to overcome with respect to terrain, construction, and operation of a range in this area, the Twin Puʻu alternative has the least significant operational challenges. A comprehensive environmental analysis of the Twin Puʻu location is carried forwarded throughout the remainder of this the EIS.

Field Investigations

The Army has conducted the following site-specific environmental and cultural resource studies as a result of conditions stipulated in the MMR settlement agreements, and to address the major public concerns and

issues expressed during the EIS scoping process (Section 1.7, Public Involvement):

- Air sampling during a prescribed burn and two CALFEXs;
- Terrestrial noise monitoring during three CALFEXs;
- Hydrophonic noise study and noise modeling;
- Hydrogeologic investigation;
- *Muliwai* sediment sampling;
- Marine resources study;
- Nearshore dive survey; and
- Cultural resources studies that include
  - A traditional cultural places survey,
  - Surface and subsurface archeological surveys of all areas within the CCAAC training area circumscribed by the south firebreak road,
  - Surface archaeological surveys of some portions of the SDZ areas, except for those areas outside the firebreak road, and
  - Subsurface archaeological surveys.

Data available for incorporation into the EIS from the above Army studies is discussed in the related resource sections listed in Table 3.0-1.

Table 3.0-1
Summary of Sections Providing Discussions Pertaining to Army Field Investigations

Field Investigations	Discussion of the Results of the Investigations	Discussion of the Associated Impacts
Air studies	Section 3.4	Section 4.4
Noise studies*	Sections 3.5 and 4.9	Sections 4.5 and 4.9
Water studies	Section 3.7	Section 4.7
Soil studies	Section 3.8	Section 4.8
Muliwai sediment studies	Sections 3.7 and 3.11	Section 4.7
Marine resources study	Section 3.7	Section 4.7
Near shore dive survey	Section 3.11	Section 4.11
Cultural resources surveys	Section 3.10	Section 4.10

*Study

With past and current use of MMR for military training with live ammunition, a variety of ordnance and ammunition have been deposited

throughout MMR. Chemical compounds from these munitions may have entered the environment through a number of processes, such as emission of particles and gases into the air, percolation into the groundwater, runoff into surface water, runoff and erosion of contaminated solid particles into surface water, and transport to nearby *muliwai* by the intermittent streams that flow from MMR. Possible compounds released by these munitions include metals, explosives, and byproducts of explosives.

One site known to be a likely source of chemical contamination is the open burn/open detonation (OB/OD) area (Figure 2-6), an inactive RCRA treatment facility that is in delayed closure status from the Hawai‘i Department of Health (HDOH), Solid and Hazardous Waste Branch. The area is approximately 4 acres (1.6 hectares) and lies downslope of the access road. Army, Air Force, Navy, and Marine Corps personnel used this area to burn and detonate a variety of materials from the 1960s into the 1990s. The quantities of ordnance detonated at the OB/OD area per year are discussed in the ammunition subsection of Section 3.11, Hazardous Materials and Waste, of this EIS.

An overview of the field investigations is provided below. Sampling protocols reflect many of the public comments and concerns attained during the public scoping period.

Air Sampling

Prescribed burn operations and military training exercises have the general potential to release air pollutants to the atmosphere. Materials released into the air during prescribed burns, ordnance and explosives (OE) firing, or detonation represent the primary source of particulate-borne and gaseous emissions at MMR. The primary objectives of the air sampling and monitoring program at MMR included the following (USACE 2002b):

- Survey the range for air quality effects that occur during both a prescribed burn operation and a typical CALFEX;
- Identify the presence or absence of airborne pollutants of interest at representative potential on-site and off-site exposure locations, including upwind and downwind locations;
- Evaluate any airborne pollutants relative to applicable regulatory standards, including federal, state, and local air quality goals and objectives; and
- Estimate the impacts of prescribed burn operations and of conducting military training activities on human health and the environment.

Air pollutants consist of particulate-borne and gaseous emissions, so the principal strategy of the air sampling and monitoring proposed for MMR was to assess the following activity-specific emission parameters:

- The potential for air pollutants to be generated during controlled or prescribed burns;
- The potential for air pollutants to be generated from firing or detonating ordnance and explosives (both complete and incomplete combustion) during a CALFEX;
- The potential for air pollutants to be generated during logistical support activities (e.g., helicopter transport) during a CALFEX;
- The potential for on-site and off-site migration of air pollutants resulting from ordnance and explosives firing or detonation or logistical support activities during a CALFEX; and
- The potential for adverse human health impacts from these air pollutants, if detected, during a CALFEX.

The air sampling program at MMR is complete and results are summarized in Section 3.4, Air Quality. A copy of the sampling report is included in Appendix G-6.

Noise Monitoring

The Army monitored and recorded noise levels at three MMR locations (on-site, beach site, and Silva Ranch) during CALFEXs on May 22, 2002, January 31, 2003, and April 10, 2003. Background noise data was collected on April 8, 2003. The highest noise levels (L_{eq}, peak noise, and L_{max}) were recorded at the on-range site, followed by the beach site, and the lowest levels were recorded at Silva Ranch, the closest residence to MMR. High background levels (L_{eq} and L_{min}) were observed at the beach site due to the surf and at Silva Ranch due to the highway traffic. Low background levels (L_{min}) were recorded at the on-range site on January 29, 2003, as compared to January 31, 2003, because of less helicopter activity and taxiing during the periods of rain on January 29, 2003. The highest noise sources (peak and L_{max}) were recorded at the beach site due to low altitude helicopter passes. Additional details of this monitoring are discussed in Section 3.5, Noise. A copy of the noise monitoring report is included in Appendix G-4.

Hydrophonic Noise Study and Noise Modeling

The Oceanwide Science Institute (Dr. Marc Lammers and Dr. Whitlow Au) will conduct a hydrophonic noise study to measure surface and underwater noise during future live-fire training. This study will record the impulse noise generated by training activities occurring during that

exercise. Noise levels will be collected at one terrestrial location on Mākua Beach, as well as at two representative off-shore marine locations. For the marine locations, sound will be measured above and below the water surface using calibrated hydrophones within the spinner dolphin habitat off Mākua Beach (see Figure 3.9-1).

Noise data will be collected at the following locations:

- **Terrestrial Location 1:** Off-range on Mākua Beach across Farrington Highway and just west of MMR;
- **Marine Location 1:** The Oceanwide Science Institute will select this off-shore location as the best estimate of where spinner dolphins approach closest to the beach head near Mākua Valley. Previous spinner dolphin research performed at Mākua Beach also will be considered in selecting this location (Lammers 2003a; Lammers et al. 2000); and
- **Marine Location 2:** This off-shore location will be at the approximate outer edge of the typical dolphin swimming area near Mākua Valley.

To provide a preliminary estimate of the anticipated noise levels at the three monitoring locations, the Army has conducted noise modeling. A copy of the noise modeling report is included in Appendix G-5 of this document.

Hydrogeologic Investigation (Soil, Surface Water, and Groundwater)
The Army's current hydrogeologic (soil, surface water, groundwater) investigation and environmental sampling program at MMR has evaluated the potential for contaminants to migrate beyond the boundaries of MMR.

The potential for contamination from past training exercises and from the OB/OD area to migrate from the surface water to the groundwater pathway was considered in the 1994 Halliburton NUS study (Halliburton NUS Corporation 1994). Groundwater samples collected from monitoring well SP-7 were analyzed for energetics, semivolatile organic compounds, nitrates, nitrites, and total metals. None of the samples had detectable concentrations of energetics or semivolatile organic compounds. The nitrate and nitrite concentrations in the samples were below risk-based health criteria and drinking water standards. Detectable levels of barium, chromium, lead, mercury, and nickel were also below risk-based health criteria and drinking water standards (Halliburton NUS Corporation 1994). The study concluded that the basal aquifer at MMR was not contaminated.

To confirm this conclusion, the Army has conducted a more detailed investigation with the following objectives:

- Assess potential sources, types, and degree of potential contamination within the OB/OD area and other areas of MMR, including the CCAAC;
- Evaluate whether contamination from the OB/OD area or the range complex has migrated, is currently migrating, or has the potential to migrate off-site;
- Acquire data to be used to evaluate potential pathways of exposure;
- Refine the hydrogeological model for MMR; and
- Evaluate the potential for soil erosion and subsequent discharge of soil particles during heavy rains from the MMR site.

The investigation involved the following components:

- Collect four sets of soil samples from the streambeds at varying depths;
- Collect two sets of soil samples at varying depths from the OB/OD area and one set from the junk car pit. Collect unsaturated pore water samples from boreholes in the OB/OD area and junk car pit;
- Rehabilitate the monitoring well SP-7, installed for the 1994 investigation, and collect groundwater samples;
- Install and collect groundwater samples from nine wells in Mākua Valley;
- Collect 123 shallow soil samples from throughout Mākua Valley;
- Collect background soil samples from six off-site locations and 10 soil samples for background metals concentrations; and
- Collect six rounds of groundwater samples from 10 monitoring wells.

Samples were analyzed for semivolatile organic compounds, metals, cyanide, sulfides, energetics, nitrates, and nitrites. Discussion of the preliminary results of water samples can be found in Section 3.7, Water Resources, and the soil sampling results are discussed in Section 3.8, Geology and Soils. A copy of the sampling report can be found in Appendix G-1.

Muliwai Sediment Sampling

Muliwai are brackish water pools near the mouths of streams created by seasonal barriers of sand or sediment. Because metals and explosives contaminants in the surface soil and surface water may be carried by surface water runoff to the *muliwai* west of Farrington Highway, the Army sampled the ponds' sediment to determine if the ponds have been affected by migration of contaminants from the reservation. The primary objectives of the *muliwai* sediment sampling program at MMR included the following:

- Determine if explosives, metals, benzene, chlorinated pesticides, nitroglycerine, dioxins, cyanide, semi-volatile organics, or chlorinated herbicides are present in subaqueous sediments; and
- Evaluate whether contamination from the OB/OD area or the range complex has migrated or is currently migrating off-site.

Discussion of the sediment sampling results can be found in Sections 3.7, Water Resources, and 3.11, Hazardous Materials and Waste. A copy of the *muliwai* sediment sampling report is included in Appendix G-3 of this document.

Marine Resources Study

The Army conducted a marine resources study in 2007, and supplemented in 2008, to determine whether marine resources near Mākua Beach and in the Mākua *muliwai* are contaminated with constituents primarily associated with proposed training activities at MMR. This study also evaluated the potential that activities at MMR contribute to any contamination detected in the marine resources, and evaluated whether the proposed training activities at MMR pose a human health risk to area residents that rely on marine resources for subsistence.

The objectives of the marine resources sampling program were as follows:

- To evaluate whether fish, shellfish, limu (marine algae/seaweed), and other marine resources near Mākua Beach or *muliwai* (estuaries or stream mouths), which area residents rely on for subsistence are contaminated by substances associated with proposed military training at Mākua;
- To evaluate whether the potential that activities at Mākua Military Reservation (MMR) have contributed or will contribute to contamination in fish, shellfish, limu and other marine resources; and

- To evaluate whether the proposed training activities pose a human health risk to area residents who rely on marine resources for subsistence.

A copy of the Marine Resources Study report, as well as responses to 2009 comments, is included in Appendix G-8 of the Final EIS. The original Marine Resources Study is found at Appendix G of the Supplemental Draft EIS published in 2008.

Near Shore Dive Survey

The Army's 7th Dive Detachment conducted and videotaped a 12-diver, 3-day-long near shore dive survey off of Mākua Beach that included all locations where metal globules were suspected to be on the ocean floor. The planned dive followed a 4,921-foot (1,500-meter) transect that ran parallel to the beach at a distance of 492 feet (150 meters) off shore, and five 984-foot (300-meter) transects that were spaced equidistant along the 4,921-foot (1,500-meter) transect and were oriented perpendicular to Mākua Beach. The survey results are discussed in Section 3.11, Hazardous Materials and Waste.

Cultural Resources Studies

Cultural resource studies include conducting surveys to identify culturally important places following the State of Hawai'i Office of Environmental Quality Control's Guidance for Assessing Cultural Impacts (November 19, 1977). In addition, studies include (1) surface and subsurface archeological surveys of all areas within the CCAAC training area circumscribed by the south firebreak road; and (2) surface archaeological surveys of all the SDZ areas identified in the SEA, and limited areas located outside the firebreak road. There will be no archaeological surveys of areas suspected of containing Improved Conventional Munitions without the appropriate waiver from Headquarters, Department of the Army (HQDA). The results of the cultural studies are discussed in Section 3.10, Cultural Resources.

Prescribed Burn

To conduct UXO clearance necessary to support cultural resources surveys addressing areas that had not been adequately cleared during prescribed burns at MMR in October and November 2002, the Army conducted a prescribed burn on July 22, 2003, during which, changes in wind speed and direction caused the fire to spread out of control. Approximately 2,100 acres (850 hectares) in the northern portion of MMR were burned, in addition to an estimated 15 to 20 acres (6 to 8 hectares) of the state's Kuaokalā Forest Reserve and 10 acres (4 hectares) of state-owned property in the vicinity of Mākua Beach. The fire was under control by July 24. (The fire boundary is shown on Figure 2-1) Following

the fire, biological and cultural resource assessments were conducted to assess the damage to these resources (see Sections 4.9, Biological Resources, and 4.10, Cultural Resources).

3.1 LAND USE AND RECREATION

3.1.1 Introduction/Region of Influence Mākua Military Reservation

This section describes land and recreational uses on and around MMR. The ROI for land and recreational uses includes all lands within and adjacent to MMR, as well as any recreational facilities directly or indirectly linked to the area, such as trails and coastal waters.

The State of Hawai‘i Land Use law under Hawai‘i Revised Statutes, Section 205, places all land under one of four land use districts: urban, agricultural, conservation, and rural. The State Land Use Commission administers the land use law, and the Hawai‘i DLNR administers the law in regard to land placed in the conservation districts. Specific land use planning and land use designations are done by county and city governments; on O‘ahu, planning is carried out by the City and County of Honolulu.

O‘ahu is divided into eight planning areas, each of which has a development plan that is administered by the Department of Planning and Permitting and is adopted by city council ordinance. MMR falls under the Wai‘anae Sustainable Communities Plan of the General Plan for the City and County of Honolulu (City and County of Honolulu 2000b). The General Plan is, by design, a very general document and one of its purposes is to establish a coherent set of broad guidelines that can be used in developing plans, programs, and legislation for guiding O‘ahu’s future. Development Plans, according to the City Charter, are relatively detailed guidelines for the physical development of the island. They are intermediate means of implementing the objectives and policies of the General Plan in the various parts of the island. The development plans provide for land use and public facilities planning and indicate the sequence in which development will occur. They must implement and accomplish the objectives and policies of the General Plan. Appendix A (Section A.2) contains more information regarding land use policies of the State of Hawai‘i and the City and County of Honolulu.

Although it does not provide parcel-specific detail, the conceptual Wai‘anae Sustainable Communities Plan is intended to guide population and land use growth in conjunction with the general plan over a 20-year planning period. It is one of eight community-oriented development plans intended to help guide public policy, investment, and decision-making through the 2020 planning horizon. Each of these plans addresses one of eight geographic planning regions on O‘ahu and responds to specific conditions and community values of each region.

The Waiʻanae Sustainable Communities Plan identifies long-range use policy, which includes preserving MMR as agriculture/open space and preservation. Nevertheless, the plan recognizes the importance of MMR to the overall military mission and economy of the region; therefore, it recognizes the continued military use of these lands for the foreseeable future.

Although the proposed federal activities are not required to conform to state plans and policies, related land use documents as they are used in the impact analysis are included in Appendix A. Federal regulations and plans that may be applicable to land use are also included in this appendix. Federal agencies are required by the CZMA of 1972 (16 USC 1451 et seq.) to conduct their planning, management, development, and regulatory activities in a manner consistent with the state coastal management programs. The State of Hawaiʻi manages coastal resources under the authority of the Coastal Zone Management (CZM) law (Chapter 205A, Hawaiʻi Revised Statutes), which establishes objectives and policies with regard to recreation, historic resources, scenic and open space, coastal ecosystems, economic uses, coastal hazards, and development.

The Hawaiʻi Coastal Zone Management Program (HCZMP) is the state's policy guide for the use, protection, and development of land and ocean resources within Hawaiʻi's coastal zone. The HCZMP incorporates objectives and policies of the CZM and other state regulations, plans, and review processes for activities within the coastal zone. A general discussion of the compatibility of the Proposed Action with the objectives and policies of the CZM is presented in this section; however, the Army has coordinated separately with the State of Hawaiʻi to meet CZM consistency requirements. The Army separately submitted a CZM consistency determination to the State Department of Business, Economic Development, and Tourism (DBEDT). The completed CZM determination is found in Appendix H-7..

Comments received during the scoping process by the public regarding land use issues included the following:

- Land maintenance;
- Recognizing and respecting Hawaiians' private property;
- Fair designation and establishment of training boundaries; and
- Traditional native and cultural use of the land.

Pōhakuloa Training Area

PTA is in the north-central portion of the Island of Hawai‘i, just to the west of the plateau formed by Mauna Loa and Mauna Kea volcanoes. Access to PTA is from Saddle Road, which connects the towns of Hilo to the east and Waimea to the north. Land uses at PTA include the cantonment area, BAAF, maneuver training areas, drop zones, live-fire training ranges, artillery firing points, an ordnance impact area, and areas unsuitable for maneuver. The cantonment area consists of 566 acres (229 hectares) with 154 buildings, mostly Quonset huts. BAAF has a 3,969-foot (1,210-meter) runway and offers helicopter access and, until recently, limited C–130 access. Land suitable for field maneuvers consists of approximately 79,661 acres (22,930 hectares), and the ordnance impact area is approximately 51,000 acres (20,639 hectares).

3.1.2 Land Use and Ownership

Mākua Military Reservation

MMR, located in northwestern O‘ahu, is approximately 38 miles (61 kilometers) from Honolulu, in the Mākua and Kahanahāiki valleys (see Figures 1-1 and 2-1). It is bordered to the west by the Pacific Ocean and to the north, east, and south by the Wai‘anae Mountains. Most of MMR’s 4,190 acres (1,696 hectares) is ceded land owned by the federal government (3,236 acres [1,310 hectares]) and land leased by the State of Hawai‘i to the Army (782 acres [317 hectares]) (State of Hawai‘i 1964). The Army also owns 170 acres (69 hectares) in fee simple and holds 1.64 acres (0.66 hectares) by license (Figure 3.1-1).

Ceded lands are those that were originally controlled by the Kingdom of Hawai‘i and that were transferred to the US in 1898 when the Republic of Hawai‘i was annexed as a territory. When Hawai‘i became a state in 1959, the US retained ownership of the ceded lands it needed for military and public purposes and conveyed the remaining ceded lands to the State of Hawai‘i. More than 70 percent of the Army’s real estate in Hawai‘i consists of ceded land. Included in lands the state leases to the Army, is land at Mākua Beach (discussed below in Section 3.1.3).

MMR has 1,034 acres (459.7 hectares) of maneuver and training land, which includes SDZs and the 457-acre (185-hectare) CCAAC. MMR offers the largest combined-arms maneuver live-fire training range available in the state (Nakata Planning Group, LLC 2002a).

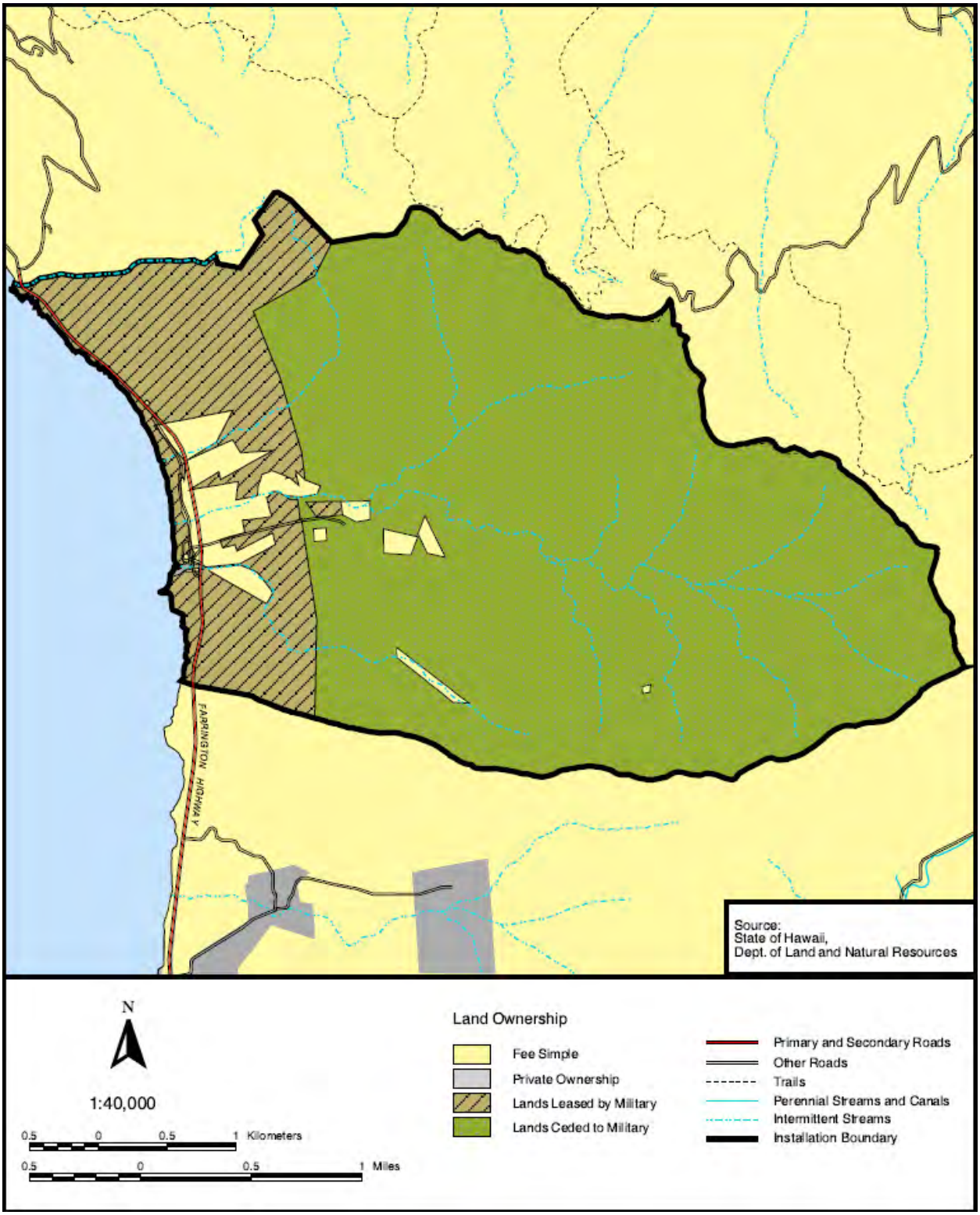


Figure 3.1-1 Land Ownership, MMR

SDZs are designed for each military range and training event, in accordance with DA PAM 385-64, *Ammunition and Explosives Safety Standards.* SDZs ensure proper buffer zones to the range and ordnance impact area and help prevent accidental injury or external exposure to live-fire training. In addition, prior to training, specific firing points are designated for the firing of most munitions, including claymore mines and artillery. Mortars are fired from changing locations, so prior to each training event, the company provides the range office with the training scenario in accordance with AR 210-6 and the MMR SOPs. The MMR Range Office builds an SDZ to fit the training scenario and gives the unit a safety card. The safety card specifies the right and left firing limits for mortars and the minimum and maximum range for firing to ensure that the mortar falls within the ordnance impact area.

MMR facilities include an administration and classroom building, a battery shop, an observation tower, a 60,000-gallon (227,125-liter) elevated water tank, a chlorinator shed, and two 300,000-gallon (1,135,624-liter) dip tanks for firefighting (Nakata Planning Group, LLC 2002b). Training land uses are described in Chapter 2. Most training on MMR is designed to take place on the CCAAC within the firebreak road. The CCAAC supports most small arms weapon systems integral to the 25th ID, including limited air-to-ground helicopter gunnery; no ground-to-air gunnery is permitted. Mock objectives within the firebreak road are used for maneuver exercises. High-explosive ammunition is aimed to land within the confines of firebreak roads.

State Land Use District designations are Urban, Agriculture, Conservation, or Rural (Hawai‘i Administrative Rules, Title 13, Chapter 5). Conservation District subzone designations, regulated by the DLNR, are Protective, Limited, Resource, General, and Special. DLNR manages land uses and activities based on the environmental sensitivity of these subzones. MMR is within the Limited, Resource, and Protective Subzones (Figure 3.1-2). Land use in the Wai‘anae Mountains along a portion of the north, south, and eastern boundary of MMR is in the Conservation District Resource subzone. Land use immediately within and adjacent to MMR’s eastern boundary is within the Conservation District Protective subzone. Conservation District subzone objectives are described in Table 3.1-1.

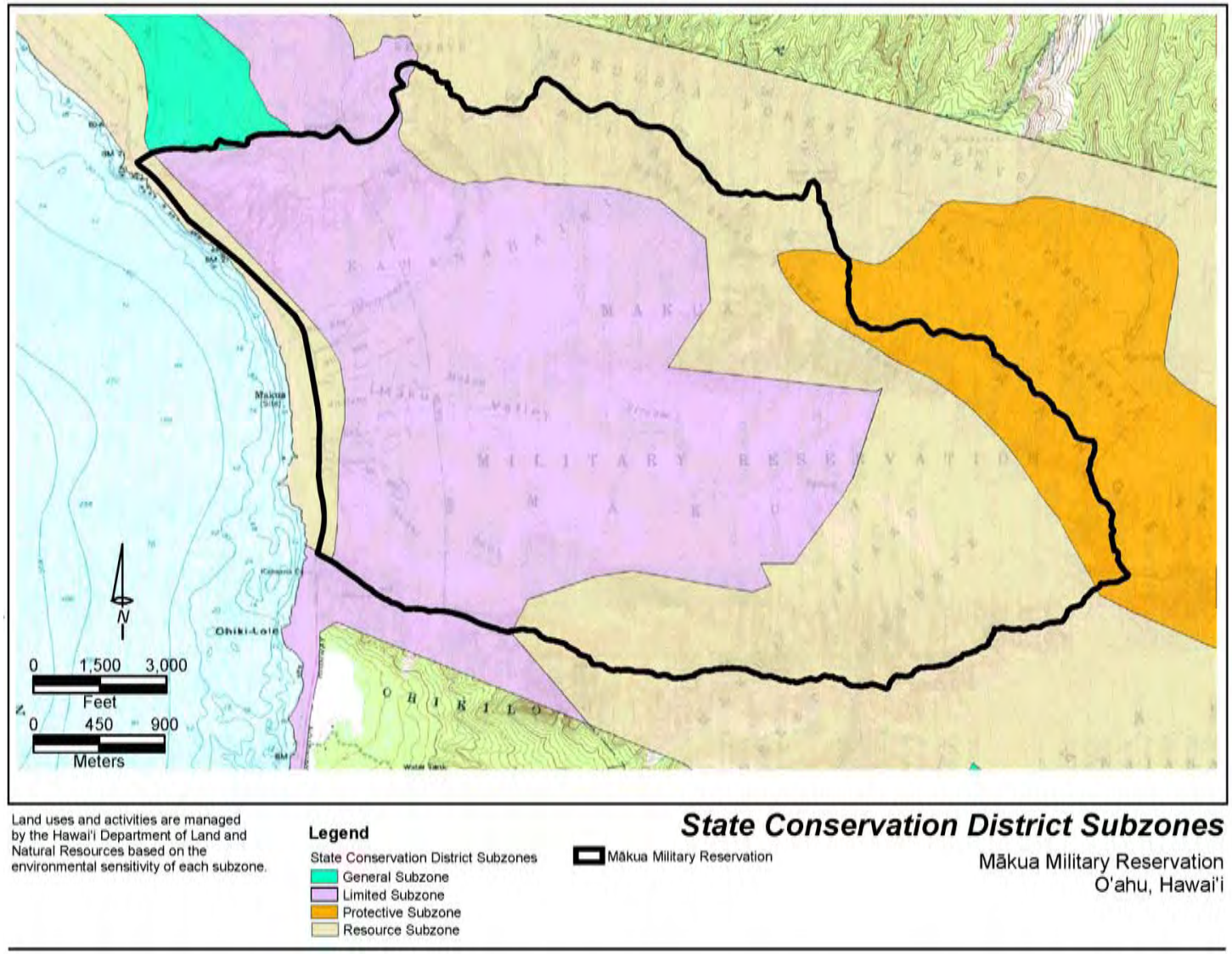


Figure 3.1-2 State Conservation District Subzones, MMR

Table 3.1-1
Conservation District Subzones

Area of MMR	Conservation District Subzone	Subzone Objective
Central valley area	Limited	Limit uses where natural conditions suggest constraints on human activities.
Shoreline and upper elevation areas	Resource	Develop, with proper management, areas to ensure sustained use of the area's natural resources.
Ridge area	Protective	Protect valuable resources in designated areas, such as restricted watersheds, marine, plant, and wildlife sanctuaries, significant historic, archaeological, geological, and volcanological features and sites, and other unique areas.

Source: Hawai‘i Administrative Rules, Title 13, Chapter 5

The Wai‘anae Sustainable Communities Plan land use map designates MMR as preservation (City and County of Honolulu 2000b). Section 3.12.2 of the Wai‘anae Sustainable Communities Plan includes the following General Policies Pertaining to Military Lands:

- 3.1.2.1. Long-Range Use Policy: Preservation. "The City's overall long-range land use policy for the military lands at Lualualei and at Mākua Valley is that these lands should be preserved as agricultural/open space and mountain preservation areas" (City and County of Honolulu 2000a).
- 3.1.2.2. Recognition of Military Use. "The importance of US military uses of lands at Lualualei and Mākua Valley is recognized both in terms of the overall mission of the military and the importance of the military to the economy to the State of Hawai‘i and the City and County of Honolulu. The current Wai‘anae Sustainable Communities Plan, which looks ahead to the Year 2020, therefore, recognizes the continued use of these lands for military purposes for the foreseeable future."
- 3.1.2.3. Cooperative Programs. The City is committed to working with the Army and Navy to organize and implement programs for the protection and preservation of important cultural and natural resources found on the military lands of the Wai‘anae District.

The Special Management Area (SMA) includes the western portion of MMR that abuts the shoreline (Figure 3.1-3). The SMA designation indicates a designated area that is regulated by the County of Honolulu for more intensive management. At MMR, the SMA boundary varies from

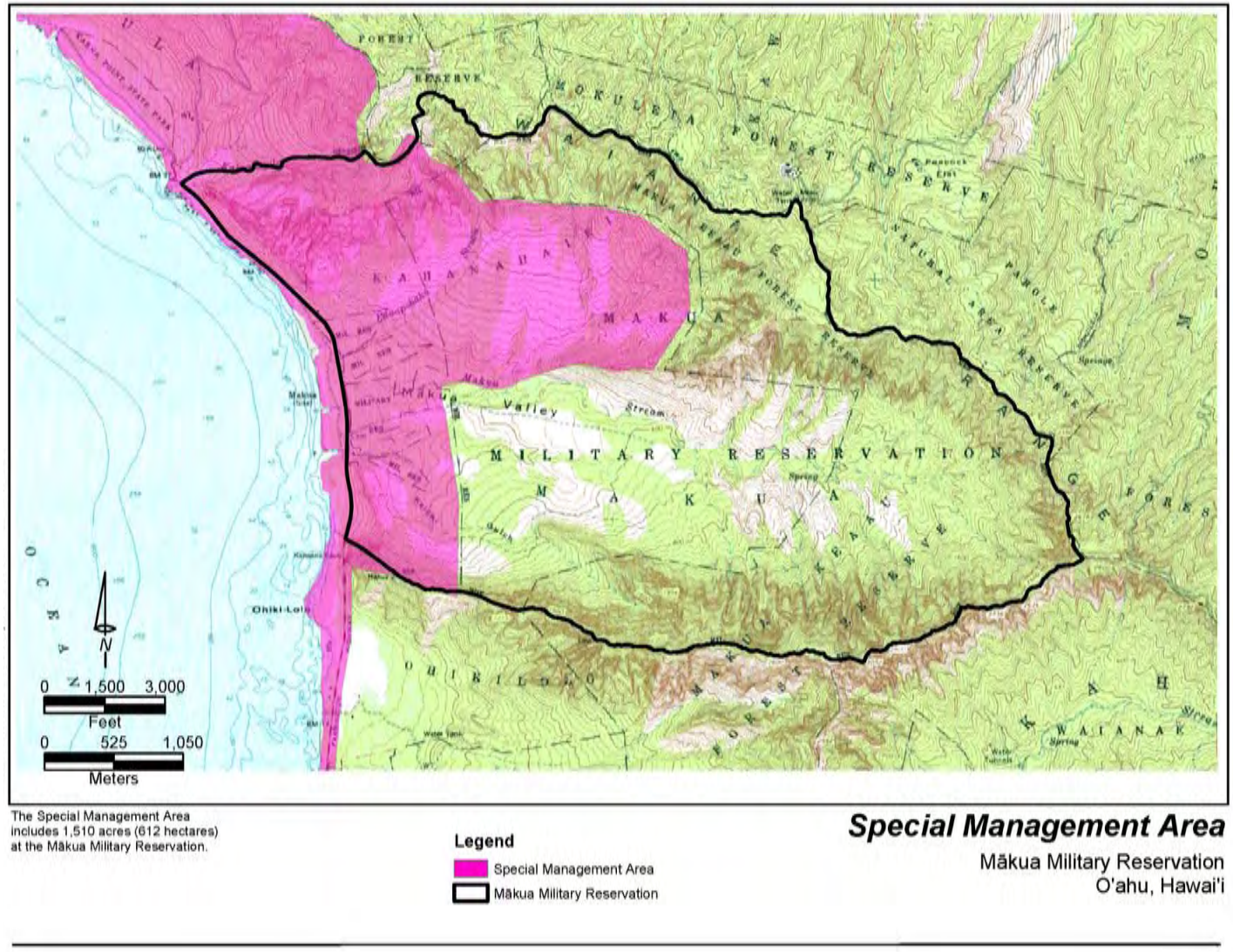


Figure 3.1-3 Special Management Area, MMR

about 3,500 to 10,000 feet (1,067 to 3,048 meters) from the shoreline (Figure 3.1-3) (Hawai‘i Administrative Rules, Title 13, Chapter 5). The coastline of MMR is within the 40-foot (12-meter) shoreline setback. Chapter 25 of the Honolulu Revised Ordinances requires permits for activities in the SMAs. As a federal agency, the US Army and its use of MMR are not governed by state and local government policies and regulations, such as State Land Use District designations and SMA designations. However, most, if not all, projects are planned to be compatible with local plans and ordinances.

Pōhakuloa Training Area

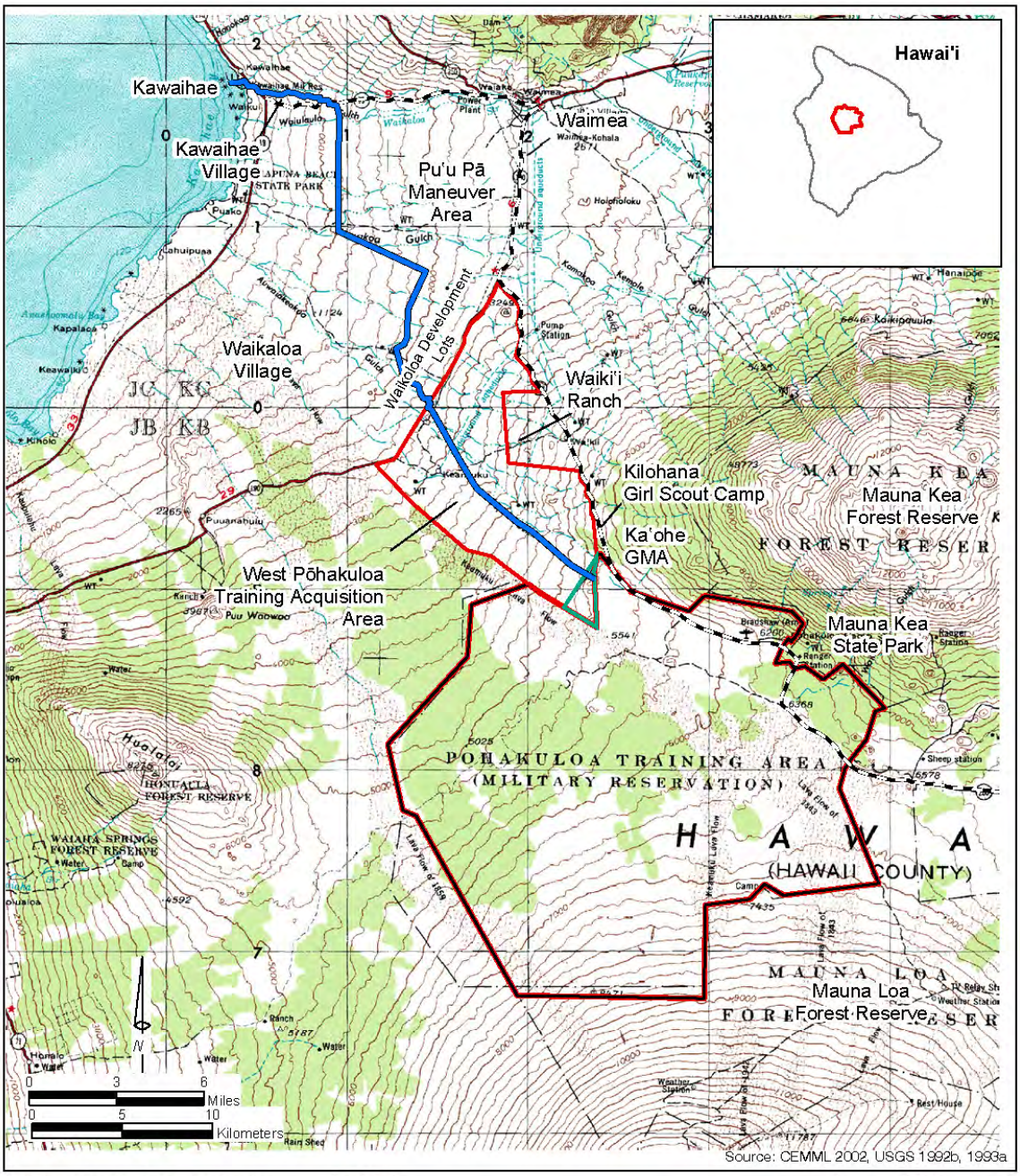
PTA’s designated land use is that of a military training installation and it is the largest live-fire range and training complex in Hawai‘i. Land uses at PTA (Figure 3.1-4) include the cantonment area, BAAF, maneuver training areas, drop zones, live-fire training ranges, artillery firing points, an impact area, and areas unsuitable for maneuver.

The cantonment area consists of 566 acres (229 hectares) with 154 buildings. The structures are mostly Quonset huts and include 11 dining facilities, two motor pools, rations warehouses, a bulk fuel facility, a chapel, a theater, a recreation club, and a medical facility.

BAAF has a 3,696-foot (1,127-meter) runway and offers helicopter access and limited C-130 access. Safety zones associated with BAAF extend 15,000 feet (4,572 meters) beyond each end of the runway and 1,500 feet (457 meters) to either side of the runway’s center line.

Land suitable for field maneuvers consists of approximately 79,661 acres (22,930 hectares). This total acreage does not include the MPRC, which has been temporarily closed for training. The impact area is approximately 51,000 acres (20,639 hectares). Two exceptions to the impact area are two M16 ranges oriented to the east and three small “dudded areas” (where UXO accumulates) east of Redleg Road.

Recreation at PTA includes archery, biking, motor sports, and hunting on designated training areas, which the Army coordinates with the state. Table 3.1-2 displays land ownership for PTA.



Pōhakuloa Training Area is bordered on the north, east, and south by Mauna Kea and Mauna Loa Forest Reserves and on the west by privately owned grazing land. Pōhakuloa Training Area is 32 miles from Hilo (pop. 41,000) on the eastern coast of the island and 27 miles from Waimea (pop. 6,000) on the western plain.

Legend

- Pōhakuloa Training Area Boundary
- 1010 Land Acquisition Area
- P7 West Pōhakuloa Training Acquisition Area
- P3/P4 Pōhakuloa to Kawaihae Trail
- Main Road

Land Use at Pōhakuloa Training Area

Island of Hawai'i, Hawai'i

Figure 3.1-4 Land Use, PTA

Table 3.1-2
Land Ownership for Pōhakuloa Training Area, Hawai‘i

Unit Ownership	Reference	Expiration Date	Size* acres	Size* hectares
Ceded to Army	Governor’s Executive Order No. 1719		758	307
Ceded to Army	Presidential Executive Order No. 11167		84,057	34,017
State of Hawai‘i	Lease No. DA-94-626-ENG-80	16 Aug 2029	22,988	9,303
Parker Ranch	Acquired by purchase		24,988	409
Other	Acquired by purchase		16	7
Other	Acquired by donation		6	3
Other	Used under license		1	<1
Total Land			**132,791**	**44,045**

Sources: USARPAC and USARHAW real property offices.
*Size rounded to nearest acre or hectare.

3.1.3 Surrounding Land Use and Ownership Mākua Military Reservation

Land uses surrounding MMR include the Kuaokalā Forest Reserve, Mokulē‘ia Forest Reserve, Wai‘anae Kai Forest Preserve, Pāhole Natural Area Reserve, and the Mākua Kea‘au Forest Reserve (see Figure 2-2). State hunting areas are located along the MMR borders to the north, east, and south; conditions for hunting near MMR are presented in Table 3.1-3. Figure 3.1-3 illustrates the Special Management Area.

Table 3.1-3
Hunting Near Mākua Military Reservation

	Game Mammals	Game Birds
Game to be taken	Wild pigs and wild goats	Ring-neck pheasant, green pheasant, California valley quail, Japanese quail, Gambel’s quail, Erckel’s francolin, gray francolin, black francolin, chukar partridge, barred dove (small dove), and spotted dove (large dove)
Permitted hunting methods	Rifles, shotguns, handguns, knives (Units B and E only), spears, and bows and arrows. Dogs permitted but must be kept under physical restraint and control except when actually hunting	Shotguns and bows and arrows

Table 3.1-3
Hunting Near Mākua Military Reservation

	Game Mammals	Game Birds
Open-hunting periods	Hunting Units A and E: February through April, archery only; May through July, firearms; August through October, use of dogs Hunting Unit B: year-round	First Saturday in November through Martin Luther King, Jr., Day or the third Sunday in January, whichever occurs later. There are additional special bird seasons for increased takes for the barred dove and spotted dove
Open-hunting days	Daily	Saturdays, Sundays, and state holidays
Special conditions and restrictions	Access through military lands, subject to military activities	Hunting on private lands requires permission of the landowner. The special dove seasons are limited to private lands
Hunters	Persons who have the appropriate hunting license, tags, permits, or permit tags on their person and who have signed in at a hunter checking station	

Source: DLNR 1999a, 1999b

The western boundary of MMR is adjacent to Mākua Beach, which is the southern portion of Ka‘ena Point State Park. The Army owns approximately 11 acres (4.4 hectares) of shoreline along Mākua Beach that it has leased back to the state for management in the beach park (Lanctot 2003). Mākua Beach is a long, curving sandy beach used for diving, pole fishing, limited body surfing, and swimming (Clark 1977). Facilities at Mākua Beach are limited to portable toilets.

The Mākua Beach Park access gates are closed to the public during the week and open to the public during the weekends from 3:00 PM Friday to 6:00 AM Monday (Quinn 2003). Roadside parking for Mākua Beach at the north and south ends of the beach, and beach patrons walk onto and use the beach on weekdays. Use of Mākua Beach during the week (i.e., at times other than when the access gates are open) is considered authorized use of the beach by the State of Hawai‘i (Quinn 2003).

Other than helicopter approaches over Mākua Beach to MMR, the Army does not use the beach to conduct training. As called for in lease agreements between the Army and the State of Hawai‘i, the Army provides beach access to leased and state-owned lands for DLNR employees and members of the public.

Ka‘ena Point State Park covers 778.6 acres (315 hectares), and park facilities include coastline with picnicking opportunities and shore fishing

(DLNR 2004b). Much of the fishing is done in the northern part of the park, near Ka‘ena Point itself. There is a large sandy beach at Keawa‘ula Bay (also known as Yokohama Bay) in the southern half of the main section of the park with board surfing and bodysurfing and swimming during calm conditions in the summer. This beach is at the end of Farrington Highway and is adjacent to the northwest point of MMR. The park is approximately one mile north of Mākua Beach and one and a half miles northwest of the MMR training area.

Hiking near MMR is limited to the Kuaokalā Trail and the Mokulē‘ia Fire Break Road, which are on DLNR land. The Kuaokalā Trail can be accessed from Ka‘ena Point and traverses the northern ridges of MMR above Mākua Valley. In the past, the Army has applied for permits to access this trail via the Ka‘ena Point Satellite Tracking Station Road. The permit is issued by the State DLNR.

Access to the Mokulē‘ia Firebreak Road is possible from the Keālia Trail and the Peacock Flats Trail. These trails, accessed from Farrington Highway on the North Shore, are used mainly by mountain bikers and some hikers traveling up Mokulē‘ia Road to the Mākua Valley Lookout. Mountain bikers use the trails extensively; from three to ten dozen riders use the trail on weekends and up to half a dozen use the trail on weekdays. The Mokulē‘ia Firebreak Road is also accessed from Ka‘ena Point, and allows four-wheel drive or bicycle access to Peacock Flats campground, hunting areas, and Keālia and Mokulē‘ia Trails. Hikers must obtain permits from the State DLNR and check in with the permit at the Ka‘ena Point Tracking Station security guard station. This access point is not commonly used. The Mokulē‘ia Firebreak Road follows the Mākua Rim above the Mākua Valley, along the east. Forest reserve and natural area reserve trails in the areas adjacent to MMR have been closed in the past due to wildfires, including those caused by prescribed burns that escaped control. An example is the extended closure in September 2003 of the forest and natural reserves in the northwest area of O‘ahu due to wildfires in July and August; an MMR prescribed burn that escaped control on July 22, 2003, contributed to these wildfires. The Hawai‘i DLNR closed all state forest reserves and public hunting areas, including those at Wai‘anae Kai, Kuaokalā, Mokulē‘ia, Wai‘anae Kai Forest Reserves (DLNR 2003).

The Kuaokalā Access Road and Trail proposed for troop marches extends south from DMR, along agricultural fields, and up the paved road to a point on the ridge crest along the northern ridgeline of MMR. A bicycle lane is planned along the highway corridor (City and County of Honolulu 2000b). There is a cemetery and a memorial to the late Israel Kamakawiwo‘ole west of Farrington Highway. Forest reserve lands north, east, and south of MMR are owned by the state. Other lands south of

MMR are owned by the City and County of Honolulu, and Alpha Kai Corporation.

Pōhakuloa Training Area

Lands surrounding PTA are generally within the state-designated Conservation District (US Army and USACE 2004). Land uses in the areas include cattle grazing, game management, forest reserves, and undeveloped land. Land to the northwest of PTA is agricultural, primarily for cattle grazing, and also provides limited hunting opportunities for big game species and game birds. Land to the north of PTA includes the Kaohe Game Management Area, Mauna Kea State Park, Mauna Kea Forest Reserve, and the Mauna Kea National Natural Landmark. Land to the east and south is included in the Mauna Loa Forest Reserve.

PTA Trail would include approximately 132 acres (53.4 hectares) of land northwest and west of PTA to Kawaihae Harbor. Land uses within the proposed military vehicle trail corridor include cattle grazing, agriculture, periodic military training, open space, utility easements, a portion of a former military vehicle trail, and Kawaihae Harbor. PTA Trail land is mostly agriculture, with urban areas at and near Kawaihae Harbor. The southern portion of the proposed military vehicle trail is designated as Other Agricultural Land (State of Hawai‘i 2002a). The trail alignment near Kawaihae Harbor is included in the SMA (County of Hawai‘i 2001). There is also a shoreline setback along the harbor property. The southern portion of the PTA Trail crosses the Parker Ranch-managed hunting area, which is located within the Ke‘āmuku Parcel.

Land uses surrounding the proposed military vehicle trail include cattle grazing, residential (Waikoloa Village and Kawaihae Village), Pu‘ukoholā Heiau National Historic Site, agriculture, agricultural subdivision, open space, and periodic military training.

The Ke‘āmuku Parcel (*West PTA Acquisition Area*) was acquired in July 2006, lies at the western foot of Mauna Kea, consists of approximately 23,000 acres. It was previously leased four to six times a year by the Army or other military entities for maneuver training (US Army and USACE 2004). The Māmalahoa Highway forms the northwestern boundary, and Saddle Road forms most of the eastern boundary. Saddle Road Junction, where these roads connect, forms the northern boundary.

Land uses surrounding the Ke‘āmuku Parcel include cattle grazing, military training, agriculture, residential lots, and open space. PTA is to the south-southeast of the area, and the Pu‘u Pā Military Maneuver Area is adjacent to the northern tip, west of Māmalahoa Highway. The remaining

surrounding lands are used for recreation and ranching or are undeveloped.

UXO hazards along the Saddle Road corridor (extending approximately 164 feet [50 meters] from the road) need to be cleared to a safe depth to support the heaviest track and wheeled vehicle that will use the area. According to the USACE, the overall ordnance and explosives hazard level for the Ke‘āmuku Parcel is low (Earth Tech 2002). The institutional controls for these low-risk areas include community awareness outreach programs, educational media, and pre-coordinated construction support.

3.2 AIRSPACE

3.2.1 Introduction/Region of Influence

Airspace, which lies above a nation and comes under its jurisdiction, is generally viewed as being unlimited. However, for aviation purposes, it is a finite resource that can be defined vertically and horizontally, as well as chronologically. The scheduling, or time dimension, is a very important factor in airspace management and air traffic control.

The following list identifies comments received during the scoping process and the sections where these are addressed in the EIS:

- Frequency of helicopter use (Chapter 2, Description of the Proposed Action and Alternatives);
- Length of flights and preferred flight patterns (Chapter 2);
- Whether or not there would be helicopter flights over heavily populated areas, including homes and Mākaha Elementary School (Chapter 2);
- Whether the community would be provided with flight schedules in advance (Chapter 2);
- Risks to the community from the use of helicopters (Section 3.2, Airspace);
- Aviation safety (Section 3.2);
- Requests for accident reports and descriptive maps (Chapter 2 and Section 3.2);
- Avoidance of bird-helicopter interactions (Section 3.9, Biological Resources); and Mitigations to nesting birds (Section 3.9).

The ROI is defined as the area that could be affected by implementing the live-fire training activities at MMR on O‘ahu, or PTA on Hawai‘i.

Mākua Military Reservation

The ROI for MMR is that airspace in the northwest part of O‘ahu over and surrounding MMR itself, along with SBMR, WAAF, and DMR. Helicopters participating in the training activities at MMR are based at and fly out of WAAF and land at SBMR and DMR for rearming and refueling. The affected airspace environment is described below in terms of its principal attributes, namely controlled and uncontrolled airspace, special use airspace, military training routes, en route airways, airports and airfields, and air traffic control/aviation safety. Jet routes are not included in the ROI because they are above 18,000 feet (5,486 meters) mean sea level (msl) and well above the proposed training activities.

Pōhakuloa Training Area

The ROI for PTA is that airspace over and surrounding PTA on the Island of Hawai‘i, along with the en route airways between SBMR, WAAF and PTA. Helicopters participating in the training activities at PTA are based out of WAAF and will utilize BAAF for staging, refueling and rearming.

3.2.2 Airspace Overview

The Federal Aviation Administration (FAA) regulates military operations in the National Airspace System by implementing FAA Handbook 7400.2E, *Procedures for Handling Airspace Matters,* and FAA Handbook 7610.4J, *Special Military Operations.* The latter was jointly developed by the DoD and FAA to establish policy, criteria, and specific procedures for air traffic control planning, coordination, and services during defense activities and special military operations.

There are two categories of airspace or airspace areas, as follows:

- Restricted, prohibited, and regulatory areas (the last consisting of controlled airspace [Class A, B, C, D, and E airspace areas, in descending order of restrictive operating rules]); and
- Nonregulatory, consisting of military operations areas, warning areas, alert areas, and controlled firing areas.

The following four types of airspace exist within these two categories:

- Controlled;
- Uncontrolled;
- Special use; and
- Other airspace.

The categories and types of airspace are dictated by the complexity or density of aircraft movements, the nature of the operations conducted within the airspace, the level of safety required, and the national and public interest. (Appendix D provides a full definition of the different classes of airspace and an explanatory diagram.)

Issues related to airspace and noise are addressed in Section 3.5, Noise.

3.2.3 Controlled/Uncontrolled Airspace

Most of the airspace above northwest O‘ahu is controlled. The distinction between controlled and uncontrolled airspace is important. Within controlled airspace, air traffic control service is provided to aircraft in accordance with the airspace classification. Aircraft operators also are

subject to certain pilot qualification, operating rules, and equipment requirements. Whereas within uncontrolled airspace, no air traffic control service to aircraft is provided, other than possible traffic advisories when the air traffic control workload permits and radio communications can be established (Illman 1993).

Mākua Military Reservation

Helicopters participating in the training activities at MMR are based at and fly out of WAAF. The airspace over northwest O‘ahu is dominated by the Class D airspace over WAAF, with a ceiling of 3,300 feet (1,006 meters), and special use airspace, discussed separately below (Figure 3.2-1). The Class D airspace over WAAF has two control zone extensions, to the east and south outside the 4.3-nautical-mile (8-kilometer) radius of the airfield’s traffic area, that facilitate instrument flight rule (IFR) landings and departures. Elsewhere, the airspace below 18,000 feet (5,486 meters) not designated as Class D or E airspace is uncontrolled (Class G) airspace from the surface to a ceiling of either 700 or 1,200 feet (213 or 366 meters). Above this, the rest of the ROI is covered with Class E controlled airspace up to 18,000 feet (5,486 meters) msl.

The airspace above 18,000 feet (5,486 meters) msl is Class A airspace. There is no Class B (generally, that airspace surrounding the nation’s busiest airports) or Class C (where all aircraft are subject to air traffic control) airspace in the region of influence.

The airspace above DMR is composed of Class G (uncontrolled) airspace from the surface to a ceiling of 1,200 feet (365 meters) and Class E (controlled) airspace above 1,200 feet (365 meters).

Pōhakuloa Training Area

Most of the airspace above the northern half of the Island of Hawai‘i is controlled airspace of various classes. Class G (uncontrolled) airspace extends from the surface to 700 feet (213 meters), except around Kona and Hilo International Airports and BAAF, which are surrounded by Class D airspace.

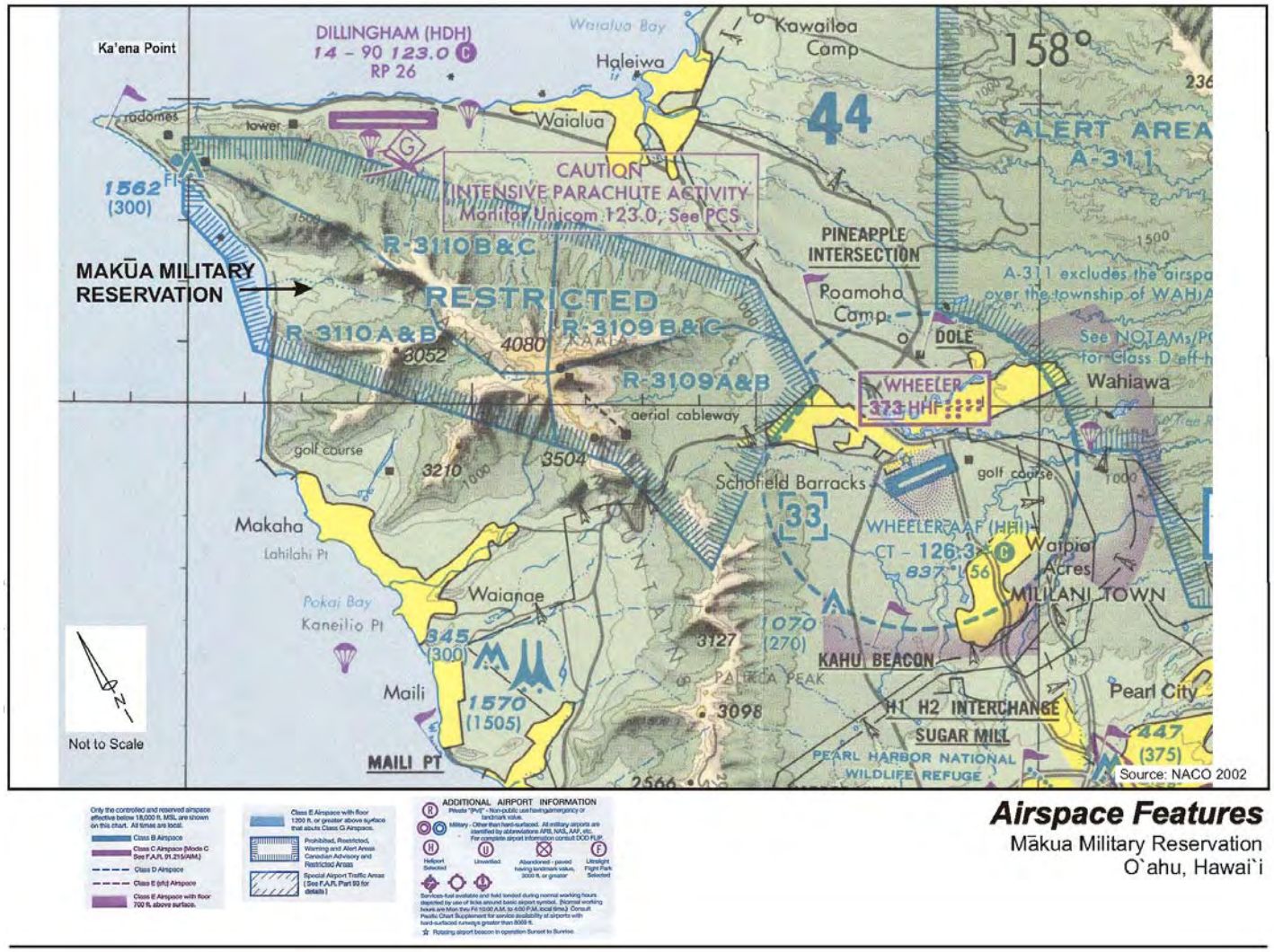


Figure 3.2-1 Airspace Features

3.2.4 Special Use Airspace

The effective altitudes, time of use, and controlling agencies are given in Table 3.2-1. During the published hours of use, the user agency is responsible for controlling all military activity within the restricted area and for determining that its perimeters are not violated. When the airspace is scheduled to be inactive, the user agency releases it back to the controlling agency or center, and, in effect, the airspace is no longer restricted.

Table 3.2-1
Special Use Airspace in the MMR Region of Influence

Number/ Name	Effective Altitude (feet/meters)	Time of Use	Controlling Agency
A-311	To 500 ft (152 m) AGL	7:00 AM to 10:00 PM	No A/G
R-3109A	To 9,000 ft (2,743 m)[1]	Intermittent[2]	Honolulu ATCT
R-3109B	9,000 to 19,000 ft (2,743 to 5,791 m)[1]	Intermittent[2]	Honolulu ATCT
R-3109C	To 9,000 ft (2,743 m)[1]	Intermittent[2]	Honolulu ATCT
R-3110A	To 9,000 ft (2,743 m)[1]	Intermittent[2]	Honolulu ATCT
R-3110B	9,000 to 19,000 ft (2,743 to 5,791 m)[1]	Intermittent[2]	Honolulu ATCT
R-3110C	To 9,000 ft (2,743 m) [1]	Intermittent[2]	Honolulu ATCT

Source: NACO 2002
Notes:
A = Alert Area; AGL = above ground level; ATCT = air traffic control tower;
No A/G = no air-to-ground communications; NOTAM = notice to airmen; R = restricted area
[1]To but not including the indicated altitude
[2]By NOTAM

Restricted areas contain airspace within which aircraft, while not wholly prohibited, are subject to restrictions. They denote the existence of unusual, often invisible, hazards to aircraft, such as artillery firing, aerial gunnery, or guided missiles. Alert areas are depicted on aeronautical charts to inform nonparticipating pilots of areas that may contain a high volume of pilot training or an unusual type of aerial activity.

Mākua Military Reservation

The MMR ROI has several special use airspace areas, including the R-3109 and R-3110 restricted area complex over MMR and the areas to the north and east, and the A-311 alert area northeast of WAAF. The alert area extends over the western side of the Koʻolau Mountain Range, from east of Mililani Town to almost Kahuku Point (Figure 3.2-1). There is no special use airspace above DMR. However, the R-3109/R-3110 restricted area complex lies immediately to the south of DMR.

Pōhakuloa Training Area

The northern part of the Island of Hawai‘i has just one special use airspace area, the R-3103 restricted area over PTA in the central part of the island. Its effective altitude is 30,000 feet (9,144 meters) and time of use is intermittent. The controlling agency is the Honolulu Combined Center Radar Approach Control (US Army and USACE. 2004).

3.2.5 Military Training Routes

Mākua Military Reservation

Although there are no formal, published military training routes in the MMR ROI, or indeed anywhere on O‘ahu, the A-311 Alert Area identified in Figure 3.2-1 is used for helicopter training, with an average of 3,500 aircraft movements per month. Movements are defined as arrivals, departures, or overflights. WAAF experiences an average of 6,500 movements per month, 90 percent of which involve helicopters. The movement statistics cover all DoD branches, including the Hawai‘i Air National Guard (Ahching 2002a, 2002b). No movement statistics are available for DMR.

Pōhakuloa Training Area

Although not a published military training route, the R-3103 restricted area is used for helicopter training exercises, with an average of 900 aircraft movements per month, 99 percent of which involve helicopters. These movement statistics cover all DoD branches, including the Hawai‘i Air National Guard (Ahching 2002a, 2002b). Typical training involves the use of 10 rotary winged aircraft at any one time.

3.2.6 En Route Airways

Mākua Military Reservation

There are no low-altitude en route airways that enter or transect the MMR ROI (Figure 3.2-1). The closest one, V-15, is approximately 9 nautical miles (17 kilometers) southwest of MMR, between O‘ahu and Kaua‘i.

General aviation, however, does use the airspace over northwestern O‘ahu. This includes all civil aviation operations, other than scheduled air services and unscheduled air transport operations for hire. For example, 97 percent of DMR’s average of 167 daily operations involve general aviation. WAAF is not open to general aviation aircraft.

For general aviation, the airspace over SBMR and WAAF is congested because it lies in the north-south corridor over O‘ahu, which is hemmed in by the R-3109 and R-3110 restricted area complex to the west and the

mountains to the east (Ahching 2003). However, there are procedures in place that, although not mandatory, allow general aviation to function satisfactorily. For example, general aviation pilots follow the convention of transiting north through the corridor over WAAF on the east side at 2,000 feet (610 meters) msl, and southbound traffic flies on the west side at 2,500 feet (762 meters) msl (Bruckner 2003).

The area around Dillingham Airfield, which is at DMR and situated east of Kaʻena Point on the north shore of Oʻahu is indicated on aeronautical charts as a glider operating and parachute jumping area. In addition, Dillingham Airfield is a center for skydiving and for ultralight and vintage airplane and aerobatic flights (AirNav.com 2002). The coastal area off Kāneʻīlio Point to the south of Mākaha is a parachute jumping area (NACO 2002).

Pōhakuloa Training Area

In addition to the commercial traffic that use the low altitude en route airways, general aviation aircraft use the airspace over the Island of Hawaiʻi. This includes all civil aviation operations, other than scheduled air services and unscheduled air transport operations for remuneration or hire. For example, 50 percent of Kona International Airport's 281 average daily operations; 28 percent of Hilo International Airport's 316 average daily operations; and 78 percent of ʻUpolu Airport's 27 average daily operations involve general aviation (US Army and USACE 2004).

3.2.7 Airports and Airfields

Mākua Military Reservation

The principal airports in the MMR ROI are WAAF and Dillingham Airfield. WAAF had an average of 207 operations per day in 2001 (Ahching 2002a), and Dillingham Airfield had a total of 222 operations per day in 2001, down four percent from 2000 (HI DOT 2002). There are no commercial heliports in the ROI (AirNav.com 2002).

Dillingham Airfield is a joint-use military/civil airfield, portions of which have been leased to the Hawaiʻi DOT. The lease limits civil operations from sunrise to sunset. Night operation is reserved for military operations. The Army can close the airfield for daytime military operations with prior notification to the Hawaiʻi DOT.

Pōhakuloa Training Area

The Island of Hawaiʻi is served primarily by three principal airports. Kona International Airport, just north of Keāhole Point, is on the west coast, Hilo International Airport is on the east coast, and Waimea-Kohala

Airport is located on the northern part of the island. Other airports/airfields in the ROI include BAAF, serving PTA; ‘Upolu at ‘Upolo Point at the northern tip of the island; and the Pu‘u Wa‘a Wa‘a private airfield off Highway 190, midway between Kona and Waimea. There is a private heliport, Ka‘ūpūlehu, on the west coast north of Makalawena, just north of Kona International Airport (US Army and USACE 2004).

3.2.8 Air Traffic Control—Aviation Safety

The Honolulu Air Traffic Control Center manages air traffic in the ROI within the 12-nautical-mile (22-kilometer) territorial waters limit of the US. All military aircraft fly in accordance with Federal Aviation Regulations (FAR) Part 91, Subchapter F (Air Traffic and General Operating Rules), which governs the following:

- Operating near other aircraft;
- Right-of-way rules;
- Aircraft speed; and
- Minimum safe altitudes when flying outside special use airspace.

AR 95-1 (Aviation Flight Regulations) covers Army aircraft operations, crew requirements, and flight rules. These regulations have precise requirements for the following:

- Use of airports, heliports, and other landing areas;
- Local flying rules; and
- Special use airspace.

For example, installation commanders having Army aircraft assigned, attached, or tenant to their command, must prepare and publish local flying rules. These rules include the use of tactical training and maintenance test flight areas, arrival and departure routes, and airspace restrictions as appropriate to help control air operations.

There are no formal or special flight plans or restrictions for the air transport of munitions used in the live-fire exercises. Traffic pattern altitudes at Army airfields for airplanes are set at 1,500 feet (457 meters) AGL. Helicopter traffic pattern altitudes are at least 700 feet (213 meters) AGL. Installation commanders may set different altitudes based on noise abatement, fly-neighborly policies, or other safety considerations. These are displayed in flight operations and published in flight information publications for all pilots.

The Army's aviation safety record on O'ahu has been excellent. In the last ten years, there have only been two serious mishaps. The first was the collision of two UH60 Blackhawks, the Army's tactical transport helicopter, in bad weather over the tactical training flight area at Kahuku Training Area; the second was the crash of an AH-1 Cobra, an attack helicopter, while landing at WAAF. These mishaps involved the fatalities of crew members. All other aircraft incidents have been limited to precautionary landings or too-fast descents during sling-load training, where concrete blocks are used to simulate the weight of vehicles or water that may be carried by helicopters during training. There have been no mishaps over MMR in the last ten years. There have been no mishaps or accidents between military aircraft and civilian aircraft anywhere over O'ahu in the last 20 years (Sawyer 2003; Akana 2003).

3.3 VISUAL RESOURCES

This section addresses the visual resources issues related to military training and activities at MMR and PTA by describing the visual character of the area, identifying potentially sensitive visual resources, and summarizing local policies relating to maintaining visual quality.

Visual resources are usually defined as the visual quality or character of an area, consisting of both the landscape features and the social environment from which they are viewed. The landscape features that define an area of high visual quality may be natural (e.g., mountain views) or manmade (e.g., city skyline). In order to assess the quality of visual resources in the action area, this section describes the overall visual character and distinct visual features on or in the viewshed of each installation or training area, as well as any sensitive viewpoints within these viewsheds. The analysis of visual resources examines the impacts on visual resources from both the installations and at a distance from the installations. In general, features beyond 1 mile (1.6 kilometers) are so distant that only forms and outlines are discernable, and visual impacts are negligible. Visual resources also include places of cultural importance, which are addressed in Section 3.10, Cultural Resources.

The visual character of an area is defined in terms of four primary components, including water, landform, vegetation, and cultural modifications. These components are characterized or perceived in terms of the design elements form, line, color, texture, and scale. Visual components also may be described as being distinct (unique or special), average (common or not unique), or minimal (a liability) elements of the visual field and in terms of the degree to which they are visible to surrounding viewers (e.g., foreground, middle ground, and background).

The visual quality of an area is defined in terms of the visual character and the degree to which these features combine to create a landscape that has the following qualities: vividness (memorable quality), intactness (visual integrity of environment), and unity (compositional quality). An area of high visual quality usually possesses all three of these characteristics. Visual quality of an area is also defined in terms of the visual sensitivity within the viewshed of the Proposed Action. Locations of visual sensitivity are defined in general terms as areas where high concentrations of people may be present or areas that are readily accessible to large numbers of people. They are further defined in terms of several site-specific factors, including the following:

- Areas of high scenic quality (i.e., designated scenic corridors or locations);

- Recreation areas characterized by high numbers of users with sensitivity to visual quality (i.e., parks, preserves, and private recreation areas); and
- Important historic or archaeological locations.

3.3.1 Introduction/Region of Influence

MMR is within the City and County of Honolulu (hereafter also referred to as Honolulu County), covering the Island of O‘ahu. PTA is within the County of Hawai‘i, covering the Island of Hawai‘i. Although the counties do not have jurisdiction over the use of federal lands, the Army considers the guidance contained in the general plans in its decisions, to the greatest extent practicable, in order to avoid or minimize conflicts with surrounding nonfederal lands. The county general plans provide policies and objectives with respect to scenic resources.

Mākua Military Reservation

The ROI for MMR includes all areas within the line of sight of proposed training activities. Because high ridges surround most of MMR, the ROI is largely limited to views from the adjacent beach area, Farrington Highway, and areas of near-shore ocean. Very limited or intermittent views from adjacent publicly accessible trails or forest reserves are also considered to be part of the ROI.

General Plan for the City and County of Honolulu. As described above, the Army considers the guidance contained in general plans in its descion-making process. The General Plan for the City and County of Honolulu is a statement of the long-range social, economic, environmental, and design objectives for O‘ahu, as well as a statement of broad policies that facilitate attainment of the plan objectives (City and County of Honolulu 1992). Section III of the plan contains the objectives of the City and County of Honolulu with respect to scenic resources, including the following:

- Objective B: Preserve and enhance the natural monuments and scenic views of O‘ahu for the benefit of both residents and visitors.
- Policy 2: Protect O‘ahu’s scenic views, especially those seen from highly developed and heavily traveled areas.

O‘ahu is divided into eight planning areas, each of which has a development plan that implements the objectives and policies of the general plan and guides the long-range land use and infrastructure planning for the area.

MMR is within the geographic area represented by the Wai‘anae Sustainable Communities Plan of the General Plan for the City and

County of Honolulu. The Waiʻanae Sustainable Communities Plan states that scenic resources and the open space character of the area should be preserved and protected for the enjoyment of many generations to come, but does not provide any specific guidance for visual resource management in the area (City and County of Honolulu 2000b).

In this plan, the land within the boundaries of MMR is classified as agriculture land. This classification was to preserve agricultural lands that contribute to open space and the rural character of the Waiʻanae community. Preserving open space and scenic beauty is a high priority for any developments that may affect the coastal lands, valleys, and mountains of the Waiʻanae District. This plan, as currently adopted, acknowledges military use of the lands at MMR (City and County of Honolulu 2000b). Public comments received during the EIS scoping process regarding visual resources include the potential fragmentation of cultural sites and geographic features, cleanup methods, and assurance that the land will remain aesthetically pleasing and able to support crops.

Pōhakuloa Training Area

The following discussion of visual resources includes PTA, the Keʻāmuku Parcel (also referred to as the West PTA Acquisition Area - WPAA), and the PTA Trail.

General Plan for the County of Hawaiʻi. The General Plan for the County of Hawaiʻi is a statement of development objectives, standards, and principles with respect to the most desirable use of land within the county (County of Hawaiʻi 1989). The long-range goals with respect to the natural beauty of the Island of Hawaiʻi include the following:

- Protect, preserve, and enhance the quality of areas endowed with natural beauty, including the quality of coastal scenic resources;
- Protect scenic vistas and view planes from becoming obstructed; and
- Maximize opportunities for present and future generations to appreciate and enjoy natural and scenic beauty.

PTA, WPAA, and PTA Trail are within the planning area of the General Plan of Hawaiʻi. Specific standards provide guidelines for designating sites and vistas of extraordinary natural beauty that must be protected, including the following types of features:

- Distinctive and identifiable landforms distinguished as landmarks, such as Mauna Kea;

- Coastline areas of striking contrast;
- Vistas of distinctive features; and
- Natural or native vegetation, which makes a particular area attractive (County of Hawai‘i 1989).

3.3.2 Landscape Character
Mākua Military Reservation

The landscape of MMR is characterized by panoramic views of the Pacific Ocean to the west and by the gently sloping open Mākua Valley, Kahanahāiki Valley, and rugged ridges and gulches of the Wai‘anae Range to the east. The Pacific Ocean is a dominant visual feature for *makai* (oceanward) views at MMR, ranging from a background feature, with a simple even form and smooth texture when viewed from the upper reaches of the valley, to a distinct foreground feature, with varied irregular form and coarse texture when viewed from the lower part of the valley or beach area.

Mauka (upland) views are of the gently sloping Mākua Valley and Kahanahāiki Valley landform, which rises gradually to create a smooth curving line that draws the eye up toward the steep jagged ridges. The valley is dissected by prominent gullies with steeper slopes of the Wai‘anae Range that rise sharply and enclose the valley floor.

Human-made features of MMR include parking areas, roads, gates, operational support buildings, a six-story observation tower, and various training areas. Many of these features have only a moderate effect on the visual character of the area because they are low relief, screened, bermed, or otherwise visually indistinct. Most training and support facilities are in the lower half of Mākua Valley, which is generally more open and devoid of vegetation tall enough to screen training activities. The training area is divided by Mākua Valley Road and bounded by the firebreak road. Prominent features of the training area include Punapōhaku Stream to the north, Ko‘iahi Gulch (also known as Kaiahi Gulch) to the south, and Mākua Stream to the east. Punapōhaku Stream and Mākua Stream are intermittent. The ordnance impact area used for live-fire exercises is limited to the area south of Mākua Valley Road and north of the Ko‘iahi Gulch. The southern half of the training site contains the training objectives, a combination of surface and subsurface emplacements and entrenchments. A small demolition area is in the upper portion of the site.

Under normal conditions, vegetation in the valley consists largely of grasses and low shrubs that give the area a smooth even texture. The

landscape color ranges from pale green to deep rich green, with dark areas along the slopes created by vegetation, rock outcroppings, and shadows.

The ridges of the Wai‘anae Range are a dominant background feature in the Mākua area. They are very irregular and rugged, with a coarse texture due to outcroppings of rock and vegetation. Vegetation on the ridges consists of shrubs and grasses that are rich green. Lands around MMR are largely undeveloped. Cultural modifications include roads, beach parks, and agricultural features.

This area has a high visual quality due to the panoramic views, the lack of substantial modifications that break up the visual character of the landscape, and the integrated form of the natural features.

Photograph 3.3-1 depicts a view of Mākua Valley looking east from Mākua Valley Road. The view from this vantage point shows the general terrain of MMR; the upper portion of the southern training area is in the right middle ground of the view. The training objectives, which lie farther to the right, are not visible in this view. Photograph 3.3-2 depicts a view looking south across Mākua Valley from the northern perimeter road. The view from this vantage point shows landscape characteristics similar to Photograph 3.3-1. The southern training area is clearly discernable. The training objectives are seen in the middle of the view along the upper portions of the valley floor. The perimeter roads are more easily recognized. From this vantage point, the vegetation is low and does not provide any screening effect.

Photograph 3.3-1 View of Mākua Valley looking east past the Southern Training Area

Photograph 3.3-2 View looking south across Mākua Valley

Pōhakuloa Training Area

The landscape of PTA is characterized by panoramic views of the broad open area between Mauna Kea and Mauna Loa. The gently sloping form and smooth line of Mauna Kea to the north and Mauna Loa to the south are dominant background features of the visual landscape. Terrain in the PTA area is gently sloping and open, periodically interrupted by remnant volcanic cones (pu‘u). Lava flows create dark visually receding areas throughout PTA. Vegetation generally consists of grasses and shrubs that tend to be sparse and low in height.

Observatories are on Mauna Loa and Mauna Kea to the south and northeast of PTA. There are few human-made features in the area except roads and support facilities within the training area and structures, roads, and an airfield within the cantonment area of PTA. The cantonment area is a visually distinct element of the landscape. Visible cultural features include walls, platforms, and many rock shelters.

The extremely uniform vegetation and topography result in middle ground and background views of PTA that lack visual complexity but that are dramatic in their expansiveness. The panoramic views, the integrated visual space, and the unity of the natural features give this area a high overall visual quality, despite the uniformity of the landscape. Photograph 3.3.-3 shows the view south from Saddle Road toward Pu‘u Keekee and Photograph 3.3-4 shows the view from Saddle Road near the PTA eastern boundary, looking west.

Photograph 3.3-3 View south from Saddle Road toward Pu‘u KeeKee

Photograph 3.3-4 View from Saddle Road looking west near the PTA Eastern Boundary

The proposed CALFEX range at PTA would be in the Twin Puʻu area. Prominent features include the ʻaʻā lava flow (Keʻāmuku Lava Flow) about 0.25 mile (0.4 kilometer) to the north of the proposed range, Puʻu Leilani at the northern edge of the proposed range, and Puʻu Kulea and Puʻu Moana about 0.75 mile (1.2 kilometers) to the south of Puʻu Leilani. The terrain of the proposed range is relatively flat, consisting of pāhoehoe type lava flows and areas covered with grasses, primarily fountain grass. From an observational point along Saddle Road, about 3 miles (4.8 kilometers) to the north-northwest, the Twin Puʻu area would be viewed as part of the PTA middle ground and background. Photograph 3.3-5 shows the view south at Twin Puʻu Area.

Photograph 3.3-5 View south at Twin Puʻu Area

Ke‘āmuku Parcel (also referred to as the West PTA Acquisition Area). The WPAA is in the Waikoloa area at the western foot of Mauna Kea. The WPAA land steadily slopes away from Mauna Kea and toward the ocean. Māmalahoa Highway forms the northwestern boundary and Saddle Road forms most of the eastern boundary; Saddle Road Junction, where these roads connect, forms the northern boundary. Cattle grazing, limited hunting, quarrying, and occasional Army training are the primary activities in this area. The WPAA’s visual characteristics are similar to PTA because of its proximity. The ROI includes all areas within the line of sight of activities or changes proposed at PTA and its surroundings.

PTA Trail. The PTA Trail begins at Kawaihae Harbor (Photogarph 3.3-6) and runs inland from the harbor on public roadways, near the lands of Pu‘ukoholā Heiau National Historic Site. The trail travels up the gentle western slope of the island to PTA. The area through which the route passes is largely undeveloped except for the village of Waikoloa. The route is most visible where it parallels the Kawaihae Road and where it crosses the Hawai‘i Belt Road. Photograph 3.3-7 shows the view from Māmalahoa Highway looking north.

Photograph 3.3-6 View from Highway 19, looking northeast from Kawaihae Harbor

Photograph 3.3-7 View looking north from Mamalahoa Highway

Terrain along the PTA Trail is generally gently sloping with intermittent pu‘u. Lava flows that create dark, visually receding areas occur throughout the trail alignment. Vegetation generally consists of grasses and low shrubs, with only occasional sparse trees, resulting in a fine even texture to the landscape. The landscape through which the trail passes ranges from heavily modified areas near Kawaihae with low to moderate visual quality, to areas with little modification and panoramic views with high overall visual quality. The middle ground and background views along PTA Trail lack visual complexity but are dramatic in their expansiveness because of the dominant features of Mauna Kea, Mauna Loa, Mt. Hualalai, and a number of volcanic cones (pu‘u).

The PTA Trail ROI includes a corridor of land along the route, extending from Kawaihae to PTA. It includes views from coastal and nearshore areas, adjacent roadways (Kawaihae Road, Hawai‘i Belt Road, and Saddle Road), populated areas along the route, and adjacent preserve areas.

3.3.3 Wildfire Effects
Mākua Military Reservation Wildfire

Wildfires at MMR can temporarily alter the landscape character of the valley, but in time the grasses and shrubbery would reestablish themselves. The valley would once again become an area with a high

visual quality, with panoramic views and the integrated form of the natural features

For example, a wildfire at MMR in July 2003, left the valley blackened and charred, giving way to irregular forms and coarse textures. Where grasses and shrubs were once the dominant vegetative cover, in many places only ashes and the blackened trunks of small trees remained, while in other places patches of green grass still existed. The area with fire damage had a low visual quality due to the altered panoramic views, which break up the visual character of the landscape. Over time, the natural vegetation made substantial gains in reestablishing itself throughout MMR, aided by the 2004 rainy season.

The grasses and shrubbery in areas burnt in the fire have since reestablished themselves. The valley became once again an area with a high visual quality, with panoramic views and the integrated form of the natural features, which lack substantial modifications that break up the visual character of the landscape.

3.3.4 Sensitive Views
Mākua Military Reservation

The Wai‘anae Sustainable Communities Plan identifies a number of significant views, which include coastal views, mountain views and open space views (City and County of Honolulu 2000b). Mākua Beach, which is part of the Ka‘ena Point State Park, and Farrington Highway, at the western end of the Mākua Valley, are two locations where these sensitive coastal views occur.

Sensitive viewing locations are also found on trails adjacent to MMR. Hiking near MMR is limited to the Kuaokalā Trail and the Mokulē‘ia Fire Break Road, which are on DLNR land. Trail users are required to obtain permits from DLNR and check in with the permit at the Ka‘ena Point Tracking Station security guard station. The Mokulē‘ia Road follows the Mākua Rim above the Mākua Valley. Because the State of Hawai‘i requires users to obtain permits, these viewing locations are not frequently used (Photograph 3.3-8).

The ‘Ōhikilolo Trail on the southern ridge of MMR also provides several vantage points from which to observe training activities in Mākua Valley. However, the Army does not permit public use of this trail.

Photograph 3.3-8 View looking south across Mākua Valley from Mākua Rim Trail

Pōhakuloa Training Area

The General Plan of the County of Hawai‘i (County of Hawai‘i 1989) lists island locations as examples of natural beauty and includes the scenic countryside around Waiki‘i (TMK 6-7-01:003); the *mauka* and *makai* view plane from various locations along Queen Ka‘ahumanu Highway in South Kohala and North Kona; the Mauna Kea State Park area (TMK 4-4-16:003); and the Pu‘ukoholā Heiau National Historic Site.

Sensitive views may occur in areas of recreational or high public use. These include Mauna Kea State Recreation area adjacent to PTA; beach areas near Kawaihae; the Pu‘ukoholā Heiau National Historic Site; and adjacent roadways. The primary public viewing area on or near PTA is along the Saddle Road corridor. Saddle Road traverses PTA more or less along its northern boundary. Public traffic through the area is generally light, and travelers typically drive through without stopping. While the typical public view of the PTA area is from a vehicle traveling at normal speed, some hikers, photographers, and artists pause along Saddle Road to appreciate the views.

3.4 AIR QUALITY

3.4.1 Introduction/Region of Influence

The ROI for air quality issues depends on the pollutant and emission sources under consideration. The ROI for a regional secondary pollutant such as ozone (O_3) would generally be island-wide. The ROI for primary pollutants would be much more limited, depending on the physical size of the emission source, its height above ground, the type and rate of pollutant emissions, and the potential for meteorological conditions that limit pollutant dispersion. In most cases, the ROI for primary pollutants would be an area extending no more than a few miles from the emission source. The ROI for small emission sources with low emission rates may extend less than 1 mile (2 kilometers) from the source.

During the scoping process for this EIS, the public expressed general concerns regarding the potential for hazardous air pollutant emissions (primarily in connection with ordnance use) and fugitive dust from vehicle or helicopter activity.

3.4.2 Air Quality Overview

A background discussion of air pollution terminology and regulatory considerations are presented in Appendix E. The regulatory framework pertinent to MMR and PTA for potential impacts on existing air quality is discussed in the following subsection.

National Ambient Air Quality Standards

The Clean Air Act (CAA) provides the principal framework for national, state, and local efforts to protect air quality. Under the CAA, the Office of Air Quality Planning and Standards (OAQPS) of the EPA is responsible for setting standards, known as National Ambient Air Quality Standards (NAAQS), for pollutants considered harmful to humans and the environment. The pollutants that have NAAQS are ozone, nitrogen dioxide, carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide, and lead. These pollutants are referred to as “criteria pollutants.” OAQPS is also responsible for ensuring that these air quality standards are met, or “attained” (in cooperation with state, tribal, and local governments), through national standards and strategies to control pollutant emissions from automobiles, factories, and other sources (EPA 2002e).

Section 110 of the CAA requires each state to submit a State Implementation Plan (SIP), which provides for the “implementation, maintenance, and enforcement” of primary and secondary ambient air quality standards. Primary standards relate to the protection of public

human health, and secondary standards relate to the protection of welfare, such as effects on crops and animals. SIPs must include enforceable emissions' limitations, provide measures for monitoring, and prohibit emissions that will contribute to the nonattainment of a standard.

Table 3.4-1 shows NAAQS values for the six criteria pollutants. The CAA requires states to monitor ambient levels of these pollutants and to develop air quality management plans that ensure that NAAQS are achieved and maintained. No areas in the State of Hawai‘i are classified as nonattainment or maintenance areas. The State has an approved SIP to address the requirements of the CAA. Table 3.4-2 shows changes in ozone and particulate matter standard values.

Table 3.4-1
National Ambient Air Quality Standards (Primary)

Pollutant	Standard Value	Standard Type
Carbon Monoxide (CO)		
8-hour average	9 ppm	Primary
1-hour average	35 ppm	Primary
Nitrogen Dioxide (NO_2)		
Annual arithmetic mean	0.053 ppm	Primary and secondary
Ozone (O_3)		
1-hour average	0.12 ppm	Primary and secondary
Lead (Pb)		
Quarterly average	1.5 $\mu g/m^3$	Primary and secondary
Particulate Matter (PM_{10})		
Annual arithmetic mean	50 $\mu g/m^3$	Primary and secondary
24-hour average	150 $\mu g/m^3$	Primary and secondary
Sulfur Dioxide (SO_2)		
Annual arithmetic mean	0.03 ppm	Primary
24-hour average	0.14 ppm	Primary
3-hour average	0.50 ppm	Secondary

Source: EPA 2002e

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter

Table 3.4-2
Changes in Ozone and Particulate Matter Standard Values

Pollutant	Standard Value	Standard Type
Ozone (O_3)		
From: 1-hour average	0.12 ppm (235 µg/m^3)	Primary and secondary
To: 8-hour average	0.08 ppm (157 µg/m^3)	Primary and secondary
Particulate Matter (PM_{10})		
From: Annual arithmetic mean	50 µg/m^3	Primary and secondary
24-hour average	150 µg/m^3	Primary and secondary
To: Annual arithmetic mean	15 µg/m^3	Primary and secondary
24-hour average	65 µg/m^3	Primary and secondary

Source: EPA 2002f

Prevention of Significant Deterioration

The CAA also established the Prevention of Significant Deterioration (PSD) Program to prevent areas that are cleaner than the minimum standards set by the NAAQS from having their air quality degraded, while allowing room for growth. Every new, modified, or expanded major stationary source in an attainment or unclassifiable area is required to use the "best available control technology" for preventing significant degradation of air quality. The PSD Program also establishes maximum allowable increases that limit the overall increase in pollution levels over the baseline concentrations in clean air areas. States are required to abide by the PSD Program to ensure their state's air quality does not degrade.

Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) are any compounds designated as such under the CAA. Programs regulating hazardous air pollutants focus on substances that alter or damage genes and chromosomes in cells (mutagens); substances that affect cells in ways that can lead to uncontrolled cancerous cell growth (carcinogens); substances that can cause birth defects or other developmental abnormalities (teratogens); substances with serious acute toxicity effects; and substances that undergo radioactive decay processes, resulting in the release of ionizing radiation. Rather than setting ambient exposure standards federal air quality management programs for HAPs focus on setting emission limits for particular industrial processes. Some states have established ambient exposure guidelines for various HAPs and use those guidelines as part of the permit review process for industrial stationary emission sources.

The State of Hawai‘i has adopted ambient concentration guidelines for HAPs. These guidelines are used as part of the permit review process for

stationary emission sources that require state or federal air quality permits. The State's ambient exposure guidelines for HAPs are contained in the state Administrative Rules, Chapter 60.1 (HDOH 2001).

Clean Air Act General Conformity

Section 176(c) of the CAA requires federal agencies to ensure that actions undertaken in nonattainment or maintenance areas are consistent with the CAA and with federally enforceable air quality management plans. The EPA's general conformity rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds.

No areas in the State of Hawai‘i are classified as nonattainment or maintenance areas. Consequently, the CAA conformity analysis procedures do not apply to Army actions in the State. Although not applicable in a regulatory context, the conformity rule de minimis levels provide a widely used basis for judging the relative significance of emissions associated with a proposed federal agency action.

3.4.3 Existing Air Quality Conditions
Mākua Military Reservation

There are no air quality monitoring stations close to MMR. The closest air quality monitoring stations are in the Barbers Point area, approximately 16 miles (26 kilometers) south of MMR. As there are few permanent facilities at MMR, the primary sources of emissions are intermittent activities, such as vehicle traffic to and from the area used for periodic training activities, low altitude aircraft or helicopter flights, ordnance firing and detonations during live-fire training exercises, limited ordnance demolition activities following training exercises, engineer demolitions training, prescribed burns, and unplanned wildfires.

The Army operates the following three automated weather stations at MMR:

- Mākua Range Station near the office trailer area at the western end of the Mākua Valley;
- Mākua Valley Station in the central part of Mākua Valley at the eastern end of the OB/OD area; and
- Mākua Ridge Station along the northern ridgeline of the Mākua Valley.

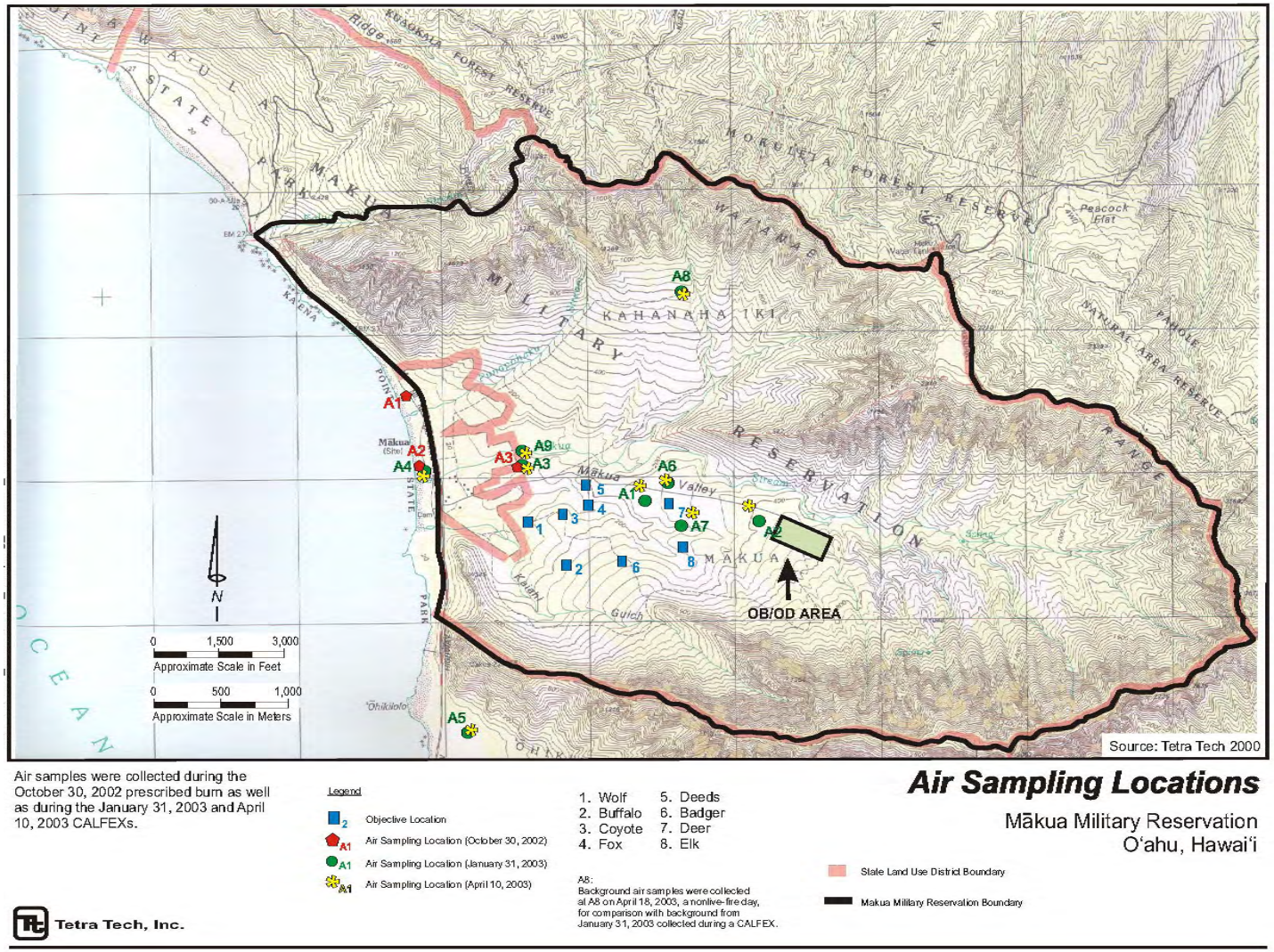
These weather stations are used for monitoring and predicting wildfire hazard conditions. Wind speed frequency distributions for these stations from the past three years of data are provided in Appendix E of this document. Maximum and average wind speeds measured at the station in the central part of Mākua Valley are lower than wind speeds measured near the coast at the Mākua Range Station or on the northern ridgeline at the station. Wind speeds exceeded the typical 15 miles (24 kilometers) per hour threshold for wind erosion about 5 percent of the time at the Mākua Range Station, about 0.2 percent of the time at the Mākua Valley Station, and about 9 percent of the time at the Mākua Ridge Station. High wind speeds cause fugitive dust and smoke generated during exercises to dissipate quickly, resulting in very minor visual, aesthetic, or respiratory localized problems. Meteorological data for MMR air sampling can be found in Appendix G-7.

The Army has conducted prescribed burns in portions of MMR, within the last decade to achieve the following goals:

- A reduction in vegetative fuel loads;
- Minimized risk of potential wildfires caused by military training activities; and
- Improved access for archaeological surveys.

The Army conducted air sampling during the October 30, 2002, prescribed burn. Ambient air samples were collected at two off-range monitoring stations at Mākua Beach (south beach and north beach) and at one on-range monitoring station near Objective Deer (Figure 3.4-1). Winds throughout the burn period generally blew down-valley toward the coast, with periodic directional shifts within the general axis of the valley. Analytical methodology and validated results from this air sampling episode are summarized in Appendix E.

All of the monitoring stations appeared to be qualitatively affected by smoke plumes during some portion of the prescribed burn operation. Data from all three air monitoring stations show that the south beach and on-range monitoring stations received the greatest amount of smoke. However, none of the criteria pollutants were observed at concentration levels above federal and state ambient air quality standards. Thus, these levels complied with human health criteria and hazardous air pollutant criteria. In addition, many of the tested pollutant categories were not detected at any of the air monitoring stations and thus do not appear to represent emission concerns relevant to prescribed burn operations at MMR.



Air samples were collected during the October 30, 2002 prescribed burn as well as during the January 31, 2003 and April 10, 2003 CALFEXs.

Legend

- Objective Location
- Air Sampling Location (October 30, 2002)
- Air Sampling Location (January 31, 2003)
- Air Sampling Location (April 10, 2003)

1. Wolf
2. Buffalo
3. Coyote
4. Fox
5. Deeds
6. Badger
7. Deer
8. Elk

A8:
Background air samples were collected at A8 on April 18, 2003, a nonlive-fire day, for comparison with background from January 31, 2003 collected during a CALFEX.

Air Sampling Locations

Mākua Military Reservation
O'ahu, Hawai'i

State Land Use District Boundary

Makua Military Reservation Boundary

Tetra Tech, Inc.

Figure 3.4-1 Air Sampling Locations

The Army conducted air sampling during CALFEXs on January 31, 2003, and April 10, 2003 (Figure 3.4-1). Ambient air samples were collected at the following locations:

- Two off-range monitoring stations at Mākua Beach and Silva Ranch; and
- Nine on-range monitoring stations, located at the North Firebreak Road, near Objectives Deer and Elk, near the OB/OD area, and near the bivouac area.

Similar to the prescribed burn, winds throughout each of the CALFEXs generally blew down-valley toward the coast, with periodic directional shifts within the general axis of the valley. Analytical methodology and validated results from these CALFEX air sampling episodes are summarized in Appendix E.

None of the criteria pollutants were observed at concentration levels above state and federal ambient air quality standards and thus comply with human health criteria and hazardous air pollutant criteria. In addition, many of the tested pollutant categories were not detected at any of the air monitoring stations and thus do not appear to represent emission concerns relevant to CALFEX operations at MMR.

Pōhakuloa Training Area

There are no permanent air quality monitoring stations close to PTA. The closest permanent air quality monitoring stations are in Hilo and Kona. Both stations are approximately 30 miles (48.2 kilometers) from PTA. The monitoring station in Hilo collects data on sulfur dioxide and PM_{10} levels. The Kona monitoring station in Kealakekua currently collects data on sulfur dioxide levels; PM_{10} monitoring at this station was discontinued in June 2000. Military vehicles, aircraft flight operations (mostly helicopters), and ordnance use represent the major Army emission sources at PTA (US Army and USACE 2004). A package rock crushing facility from SBMR is moved to PTA when needed. There is a full time rock crushing operation at PTA at the quarry in TA 13 that is producing large quantities of aggregate for Saddle Road Realignment Construction.

A rain gauge at BAAF records precipitation data. Annual precipitation averages 16.9 inches (42.9 centimeters) per year, ranging from 1.6 inches (4.1 centimeters) in June to 4.4 inches (11.2 centimeters) in March (WeatherDisc Associates 1990). The Army operates four automated weather stations at PTA, one each in the eastern, southern, north-central, and western portions of PTA. Data from these stations are used in a real-

time context for fire management purposes. Consequently, comprehensive data summaries from these stations are not available. Wind speed data from these stations have been evaluated to assist in evaluation of potential wind erosion conditions. Data from the eastern and western stations are most representative of conditions in areas where troop and vehicle maneuver activity occurs. Three years of data from the eastern station show an average hourly wind speed of 13 miles (20.9 kilometers) per hour and a maximum hourly average wind speed of 33 miles (53.1 kilometers) per hour. Hourly average wind speeds at the eastern station exceeded 8.2 miles (13.2 kilometers) per hour 75 percent of the time and exceeded the 15 miles (24.1 kilometers) per hour threshold commonly associated with wind erosion processes about 35 percent of the time. Three years of data from the western station show an average hourly wind speed of 8.4 miles (13.5 kilometers) per hour and a maximum hourly average wind speed of 44 miles (70.8 kilometers) per hour. Hourly average wind speeds at the western station exceeded 4.7 miles (7.6 kilometers) per hour 75 percent of the time. The low-density silty soils common at PTA are subject to wind erosion at lower wind speeds than most soils. Wind speeds on the western side of PTA exceed the likely wind erosion threshold of 12 miles (19.3 kilometers) per hour about 15 percent of the time (US Army and USACE 2004).

Although the State is in a PM_{10} attainment area under the CAA, the Island of Hawai‘i and the surrounding land at PTA have experienced discrete events in which dust impacts have had adverse effects. PM_{10} emissions are important because they are easily airborne and are small enough to be inhaled deep into the lungs, creating potential adverse health effects. Because of the extremely small particle size of the soils found on Ke‘āmuku Parcel, the particles easily become airborne during high-wind events and other disturbances once vegetation has been removed. In July 1999, a severe dust storm resulted from wind blowing over areas denuded of vegetation by a recent fire. The result was fugitive dust emissions at high enough levels to require temporary evacuation of residences at Waiki‘i Ranch (US Army and USACE 2004).

In January 2006, the Army installed seven air-monitoring stations around PTA (Morrow 2007). The purpose of the monitors was to monitor concentrations of total suspended particulates (TSP) and PM_{10}. TSP was included because it is more representative of fugitive dust than the finer, inhalable PM_{10}.The monitors were installed as close to PTA’s boundaries as access and safety would allow. Between January 29, 2006 and June 30, 2007, the monitors sampled particulate matter following the EPA’s schedule of once every six days.

Analysis of the data collected during the sample period indicates that concentrations of particulate matter at PTA under current activity levels are well within federal and state air quality standards (Morrow 2007). The 24-hour PM_{10} concentrations at the seven sites ranged from 0 to 72 $\mu g/m^3$ with a mean value of 7.2 $\mu g/m^3$ (2.22 parts per billion [ppb]) for all sites. The federal and state standards for PM_{10} are 150 $\mu g/m^3$ (46.15 ppb) (24-hour) and 50 $\mu g/m^3$ (15.39 ppb) (annual average). The 24-hour TSP levels ranged from 1.4 to 132 $\mu g/m^3$ (0.43 to 40.62 ppb) for all sites with an annual mean of 14.4 $\mu g/m^3$ (4.43 ppb) (US Army and USACE 2004). Although there are no longer federal or state standards for TSP, the former standards were the same as the PM_{10} standards cited above.

Sampling PM occurred during training of the 2/25th SBCT in 2007. This training included both maneuver and live fire training (small arms training, and mortars). All 24-hour PM_{10} concentrations from the sampling events were below the federal and state standards for PM_{10} of 150 $\mu g/m^3$ (46.15 ppb) (24-hour) (US Army and USACE 2004).

3.5 NOISE

3.5.1 Introduction/Region of Influence

The ROI for noise depends on the intensity of noise generation. For most common noise sources, the ROI is limited to areas within 0.5 mile (1 kilometer) of the noise source. High intensity noise sources, such as ordnance detonations, may have an ROI extending several miles from the noise source.

During the scoping process for this EIS, the public expressed general concerns regarding noise from ordnance use, helicopter flight operations, and vehicle traffic.

3.5.2 Noise Overview

Noise and sound are often used interchangeably. The sensation of sound is produced when pressure variations having a certain range of characteristics reach a responsive ear. Sound is the term describing pressure variations that are pleasant or useful for communication. Noise is generally defined as unwanted sound, often made up of different frequency components.

Noise is among the most pervasive pollutants today. Unwanted sounds from road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes, lawn mowers, leaf blowers, and chain saws, to name a few sources, are among the noises routinely broadcast into the air. Noise negatively affects the health and well being of both humans and wildlife in many ways (NPC 2001). Responses to noise vary, depending on the type and characteristics of the noise, expected level of noise, distance between the noise source and the receptor, the receptor's sensitivity, and the time of day. The most conspicuous problems related to noise are hearing loss and hearing impairment. Other health impacts include stress and exacerbation of mental health problems; high blood pressure and restricted blood flow; sleep loss, distraction, and loss of productivity; and a general reduction in the quality of life and opportunities for tranquility. Noise can provoke annoyance responses and changes in social behavior. The effects of noise can be immediate or latent as a result of long-term exposure (Plog 1993; EPA 1974; Berglund et al. 1995).

Sources of noise that have the potential to affect wildlife include aircraft overflights; recreational activities, such as motor boating; domestic sources such as leaf blowers, lawnmowers, and chainsaws; automobile traffic; and heavy machinery and equipment. Responses vary among species of wildlife, as well as among individuals of a particular species

(Busnel and Fletcher, 1978, cited in Radle, no date), although the problems are similar to those found in humans. Increased noise levels mask sounds used by wildlife for communication; for example, they mask mating calls and the sounds that parents use to locate their young (Dooling, no date; Schubert and Smith 2000). Disturbed mammals sometimes trot short distances; birds might walk around flapping their wings. Panic and escape behavior results from more severe disturbances. Behavioral and physiological responses have a potential to cause injury, energy loss due to movement away from the noise source, decreased food intake, habitat avoidance and abandonment, and reproductive losses (National Park Services 1994; Nature Sounds Society 2001). All species, wildlife and humans, initially respond to an impulse noise with some form of startle response which diminishes with each subsequent exposure. There is a strong tendency for species to acclimate or habituate to a repetitive noise disturbance.

One common response to noise is annoyance. A person's expectation of a sound level associated with an activity has a direct bearing on the level of annoyance. For example, noise is tolerated at a bowling alley, but it is not tolerated at a library. The annoyance might be personal or experienced as a group. The five factors identified as indicators for estimating community complaint reaction to noise are the following:

- Type of noise;
- Amount of repetition;
- Type of neighborhood;
- Time of day; and
- Amount of previous exposure.

Sound levels, reported in decibels (dB), are used to summarize how people hear sound and to determine the impact of noise on public health and welfare. Table 3.5-1 presents a range of sound levels by various sources of noise. The following are six different noise-weighting descriptors, used to equate noise impacts on the human ear:

- L_{eq} (equivalent sound level) is used to describe a time varying noise energy as a steady noise level;
- L_{max} (maximum sound level) is used to measure the highest decibel level during a noise event;

- SEL (sound exposure level) is used to measure the cumulative sound exposure of a particular event integrated into a 1-second time frame;

Table 3.5-1
A-Weighted Decibel Values for Example Noise Sources

Characterization	dBA	Example Noise Source or Condition	Other Noise Examples
Threshold of pain	130	Surface detonation, 30 pounds (13.6 kilograms) of TNT at 1,000 feet (305 meters)	Jackhammer and power drill at one foot
Possible building damage	120	Mach 1.1 sonic boom under aircraft at 12,000 feet (3,658 meters)	Air raid siren at 50 feet (15 meters); B-1 flyover at 200 feet (61 meters)
	115	F/A-18 aircraft takeoff with afterburner at 1,600 feet (488 meters)	Commercial fireworks (5-pound [2.3-kilogram] charge) at 1,500 feet (457 meters)
	110	Peak crowd noise, pro football game, open stadium	Peak noise at firing position of rifle range
	100	F/A-18 aircraft departure climbout at 2,400 feet (732 meters)	Jackhammer at 10 feet (3 meters); B-52 flyover at 1,000 feet (305 meters)
Extremely noisy	95	Locomotive horn at 100 feet (30 meters); 2-mile (3-kilometer) range foghorn at 100 feet (30 meters)	Wood chipper processing tree branches at 30 feet (9.1 meters)
8-hour OSHA limit	90	Heavy truck, 35 mph (56 kmph) at 20 feet (6 meters); leaf blower at 5 feet (1.5 meters)	Person yelling at 5 feet (1.5 meters); dog barking at 5 feet (1.5 meters)
Very noisy	85	Power lawn mower at 5 feet (1.5 meters); city bus at 30 feet (9.1 meters)	Pneumatic wrench at 50 feet (15 meters); jet ski at 20 feet (6 meters)
Noisy	75	Street sweeper at 30 feet (9.1 meters); idling locomotive at 50 feet (15 meters)	Beach with medium wind and surf
	70	Auto, 35 mph (56 kmph) at 20 feet (six meters); 300 feet (91 meters) from busy six-lane freeway	Stream bank 10 feet (3 meters) from small/medium waterfall
Moderately noisy	65	Typical daytime busy downtown area conditions	Beach with light wind and surf; tree branches, light wind. Air conditioner at 15 feet (4.5 meters). Sewing machine.
	55	Typical daytime urban residential area away from major streets	Leaves, tall grass rustling in light/moderate wind
	50	Typical daytime suburban conditions	Light traffic. Normal conversation. Quiet office. Open field, summer night, insects
Quiet	45	Typical rural area daytime conditions	
	40	Quiet suburban area at night	Living room, refrigerator
Very quiet	30	Quiet rural area, winter night, no wind	Library; quiet bedroom at night, no air conditioner
	20	Empty recording studio	Barren area, no wind, water, insects, or animals
Barely audible	10	Audiometric testing booth	
Threshold of hearing	0		

Source: Data compiled by Tetra Tech staff from various published sources, noise monitoring studies, and noise modeling analyses.
Indicated noise levels are average A-weighted decibel (dBA) levels for stationary noise sources or peak dBA levels for brief noise events and noise sources moving past a fixed point.
Average and peak dBA levels are not time-weighted 24-hour day-night average sound level (DNL) values.
Decibel scales are not linear. Apparent loudness doubles for every 10 dBA increase in noise level, regardless of the dBA values.

- ADNL or L_{dn} (A-weighted day-night average sound level) is used to evaluate human response or annoyance to noise, typically aircraft and ground transportation;
- CDNL (C-weighted day-night average sound level) is used to evaluate human response or annoyance to blasts, commonly associated with large-caliber ammunition and explosives; and
- dBP (linear decibel) is used to evaluate human response to a sudden sharp noise.

Additional general information on noise is presented in Appendix F of the EIS.

3.5.3 Federal and State Noise Standards and Guidelines

Federal Guidelines

Several laws require the federal government to set and enforce uniform noise control standards for aircraft and airports, interstate motor carriers and railroads, workplace activities, medium- and heavy-duty trucks, motorcycles, and portable air compressors and for federally assisted housing projects located in noise-exposed areas. Among these laws are the Noise Control Act of 1972 (Public Law 92-574), Aviation Safety and Noise Abatement Act of 1979, the Control and Abatement of Aircraft Noise and Sonic Boom Act of 1968. According to the Federal Aviation Administration 's 2000 Aviation Noise Abatement Policy, "noise relief continues to be a shared responsibility…. The FAA and the aviation industry have the primary responsibility to address aircraft source noise…. Airport proprietors, state and local governments and citizens have the primary responsibility to address airport noise compatibility planning and local land use planning and zone."

The EPA, the federal agency charged with enforcing the Noise Control Act, recommends the use of the day-night sound level for environmental noise to quantify the intrusiveness of nighttime noise. The day-night sound level is the A-weighted equivalent sound level for a 24-hour period, with an additional 10-dB weighting imposed on the equivalent sound level occurring during the nighttime hours (10:00 PM to 7:00 AM). These sound levels represent an annual average exposure, where on any given day the level may be greater. Table 3.5-2 presents examples of outdoor DNLs in decibels measured at various locations.

The Federal Interagency Committee on Urban Noise (FICUN) has developed land use guidelines for areas on or near noise-producing activities, such as highways, airports, and firing ranges. The Installation

Table 3.5-2
Examples of Outdoor Day-Night Average Sound Levels

Outdoor Location	Sound Level (DNL) in dB
Apartment next to freeway	88
0.75 mile (1.2 kilometers) from touchdown location at major airport	86
Urban high-density apartment	83
Old urban residential area	59
Wood residential	51
Agricultural cropland; Beach area (ambient)	45
Rural residential	40
Wilderness background noise	35

Source: EPA 1974

Compatible Use Zone (ICUZ) program designates noise zones for land use planning. The program considers land areas with noise-sensitive land uses that are exposed to generally unacceptable noise levels. Noise-sensitive land uses include, but are not limited to, residences, schools, medical facilities, and churches.

The DoD began developing noise evaluation programs in the early 1970s. Initial program development involved the Air Installation Compatible Use Zone (AICUZ) program for military airfields. Early application of the AICUZ program emphasized Air Force and Navy airfields. The Army implemented the ICUZ program by addressing both airfield noise issues and other major noise sources, such as weapons testing programs and firing ranges. Joint Air Force, Army, and Navy planning guidelines use annual average DNL values to categorize noise exposure conditions on military installations.

The Army uses three noise zones described in AR 200-1 (US Army 1997a) and DA PAM 200-1 (US Army 2002c), referred to as LUPZ. Chapter 7 of DA PAM 200-1, the Army Environmental Noise Management Plan (ENMP), outlines procedures to meet the objectives of minimizing the impact of environmental noise on the public without impairing the mission of the installation. The Army's three noise zones are as follows:

- Zone I—compatible with noise-sensitive land use;
- Zone II—normally incompatible with noise-sensitive land use; and
- Zone III—incompatible with noise-sensitive land use.

These noise zones serve as guidance for land use planning and may be used as tools for both noise abatement planning and noise complaint management as seen in Table 3.5-3.

Table 3.5-3
Land Use Planning Guidelines

Noise Zone	Percent Population Highly Annoyed	Transportation/Small Arms Noise ADNL in A-weighted dB	Impulsive Noise CDNL in C-weighted dB
Zone I	<15	<65	<62
Zone II	>15	65–75	62–70
Zone III	>39	>75	>70

Source: US Army 2002c

Notes:
Noise levels from all sources should be evaluated in terms of annual averages of the identified noise metric.
Noise from transportation sources (aircraft and vehicles) and common industrial sources should be evaluated using A-weighted DNL values.
Noise from impulsive sources (such as armor, artillery, and demolition activities) should be evaluated using C-weighted DNL values.
Noise from small arms ranges should be evaluated using peak unweighted dB values until the Z-weighting standard is adopted, at which time peak A-weighted decibel values should be used.
Noise-sensitive land uses include housing, schools, and medical facilities.
Compatibility determinations for existing conditions and proposed actions should be supplemented by descriptions of projected noise increases and potential public reactions where:
(1) the noise environment is determined by a few infrequent but very high level noise sources (such as blast events over 110 dBC SEL);
(2) single event noise levels from the proposed action are 10 dB or more greater than existing levels;
(3) where the A-weighted DNL is between 60 and 65 dBA and the proposed action would increase the DNL by 3 dB or more; and
(4) where the A-weighted DNL is above 65 dBA and the proposed action would increase the DNL by 1.5 dB or more.

The historical expected annoyance complaints within each zone are identified as follows (US Army 2001):

- Zone I is defined by the noise exposure that would be expected to result in less than 15 percent of the population described as "highly annoyed";
- Zone II is defined by the noise exposure that would be expected to result in more than 15 percent of the population described as "highly annoyed"; and
- Zone III is defined by the exposure resulting in more than 39 percent of the population describing themselves as "highly annoyed."

According to the Army's Environmental Noise Management handbook (US Army 2001), many of the complaints received by installations are from people living in Zone I. The document further states, "These are people who are living in quiet areas but who are disturbed by infrequent events such as helicopter flyovers, or a single large detonation of explosives" (US Army 2001).

The Army has recently supplemented these guidelines to develop a more comprehensive ENMP, as described in DA PAM 200-1. The ENMP program incorporates ICUZ evaluations. Other components of the ENMP include programs for handling noise complaints and undertaking supplemental noise evaluations when warranted by the nature of discrete noise events.

Criteria for evaluation of noise levels has been expanded beyond the normal A-weighted DNL descriptor. Criteria include the use of C-weighted DNL values to characterize major blast noise sources and the use of A-weighted decibel values to characterize small arms firing (Table 3.5-3). These levels are in agreement with the planning use guidelines and percent of population annoyed, published by the Department of Housing and Urban Development (HUD), the WHO, and other numerous studies performed over the past two decades.

The US Army Center for Health Promotion and Preventive Medicine (US Army CHPPM) assists Army installations in developing environmental noise management plans. US Army CHPPM also undertakes special noise studies to evaluate noise problems associated with various types of noise sources. When investigating noise conditions related to weapons firing or ordnance detonations, US Army CHPPM typically measures peak unweighted decibel levels and/or C-weighted SEL levels and develops noise contours using a computer model (BNOISE2) for land use guidelines. Table 3.5-4 indicates compatible land uses for the identified zones.

Table 3.5-4
Compatible Land Use Guidelines

Noise Zone	Residential	Schools and Hospitals	Recreational	Industry
Zone I	Yes	Yes	Yes	Yes
Zone II	Not recommended	Not recommended	Yes	Yes
Zone III	Not compatible	Not compatible	Not compatible	NLR = 30

Source: US Army 2002c
NLR = Noise Level Reduction Factor

Several studies have been performed at MMR on accepted "dose-response" relationship annoyance due to aircraft, impulse, and overall noise. Other studies have shown that, although annoyed by the noise levels, people become more tolerant over time and accept the noise exposure levels.

State Regulations

The Army has stated that "In light of this (Noise Control Act), we think the correct Army policy with respect to the Noise Control Act is that all Army activities should endeavor to comply with all federal, state and local requirements respecting the control of noise as stated in Section 4(b) of the Act, unless to do so would conflict with the Army's mission. The obligation to comply arises out of the Army's policy of cooperation on environmental matters generally" (US Army 2002c).

The State of Hawai'i has adopted statewide noise standards that apply to fixed stationary noise sources, agricultural equipment and construction equipment. The alternatives under this project do not involve introduction of or modifications to stationary sources, and thus Title 11 of Chapter 46 of the Hawai'i Administrative Rules does not apply to any of the alternatives.

3.5.4 Existing Noise Conditions Mākua Military Reservation

The ambient noise level at Mākua Beach is estimated to be 40 to 50 dBA during quiet time, with peaks greater than 70 dBA during periods of high tide and afternoon winds; typically, noise levels range from 55 to 70 dBA. Beach areas closer to Farrington Highway will have typical background noise levels of 45 to 55 dBA. Noise level contributions resulting from MMR activities vary greatly, depending on whether or not live-fire training exercises are in progress. When there are no training exercises in progress at MMR, noise conditions are dominated by wind, bird songs, and insects. Under such conditions, noise levels typically vary between about 25 dBA and 45 dBA, depending on wind conditions and proximity to bird or insect noises. Noise levels during live-fire training exercises include periods of vehicle activity, helicopter activity, weapons firing, and ordnance detonation superimposed on background noise conditions.

Live-fire training at MMR during a company-level CALFEX typically lasts about four hours, so DNL values are not very useful in characterizing the peak noise levels associated with these events. Noise monitoring was conducted at MMR during three CALFEX events between May 2002 and January 2003 (Figure 3.5-1).

While differences among these three CALFEXs (for example, use of weapons and sequence of events) required different instrument placements within MMR, a Mākua Beach location, routinely used for public recreation and picnicking, was used for all three exercises. One noise meter was placed on Mākua Beach opposite the observation tower area of MMR. A second meter was placed either on the north side of the administrative trailers at MMR or at the eastern end of the helicopter landing pad area east of the administrative trailers. During the May 2002 CALFEX, the third meter was located at Objective Coyote, which was used as a forward exercise viewing point. During the two January 2003 CALFEX exercises, the third meter was located on Silva Ranch property, the nearest residence, immediately south of MMR (Figure 3.5-1).

Table 3.5-5 lists the weapons used for a typical daytime CALFEX conducted between 2001 and 2003. No nighttime CALFEXs were conducted during that period. Night rounds in the table represent those rounds fired before 6:59 AM. Noise monitoring was conducted during one CALFEX in 2002 and three CALFEXs in 2003. As an example of the data collected during those exercises, Table 3.5-6 summarizes noise monitoring data from the January 31, 2003, CALFEX. Data for both the Mākua Beach and Lower Mākua Valley sites included significant contributions from helicopter activity. Noise levels at Silva Ranch were influenced by traffic on Farrington Highway.

Table 3.5-5
Existing Weapons Used at MMR for One CALFEX

Type of Artillery	Day	Night
60mm mortar inert	27	19
60mm mortar HE	22	15
81mm mortar HE	29	20
105mm howitzer HE	71	50
Bangalore	2	1
Claymore (M18A1)	5	4
C4, 2 lbs.	2	1
Grenades	20	14
Smoke	7	5
Javelin and AT-4 antitank rockets	4	1
Small arms ammunitions	24,264	10,399

Note: Small arm ammunitions include M24, M249, M16A2, M4, M240, M2, MK19 and .50-caliber machine gun. Inert artillery does not create detonation noise upon target impact (noise is only from firing of projectile).

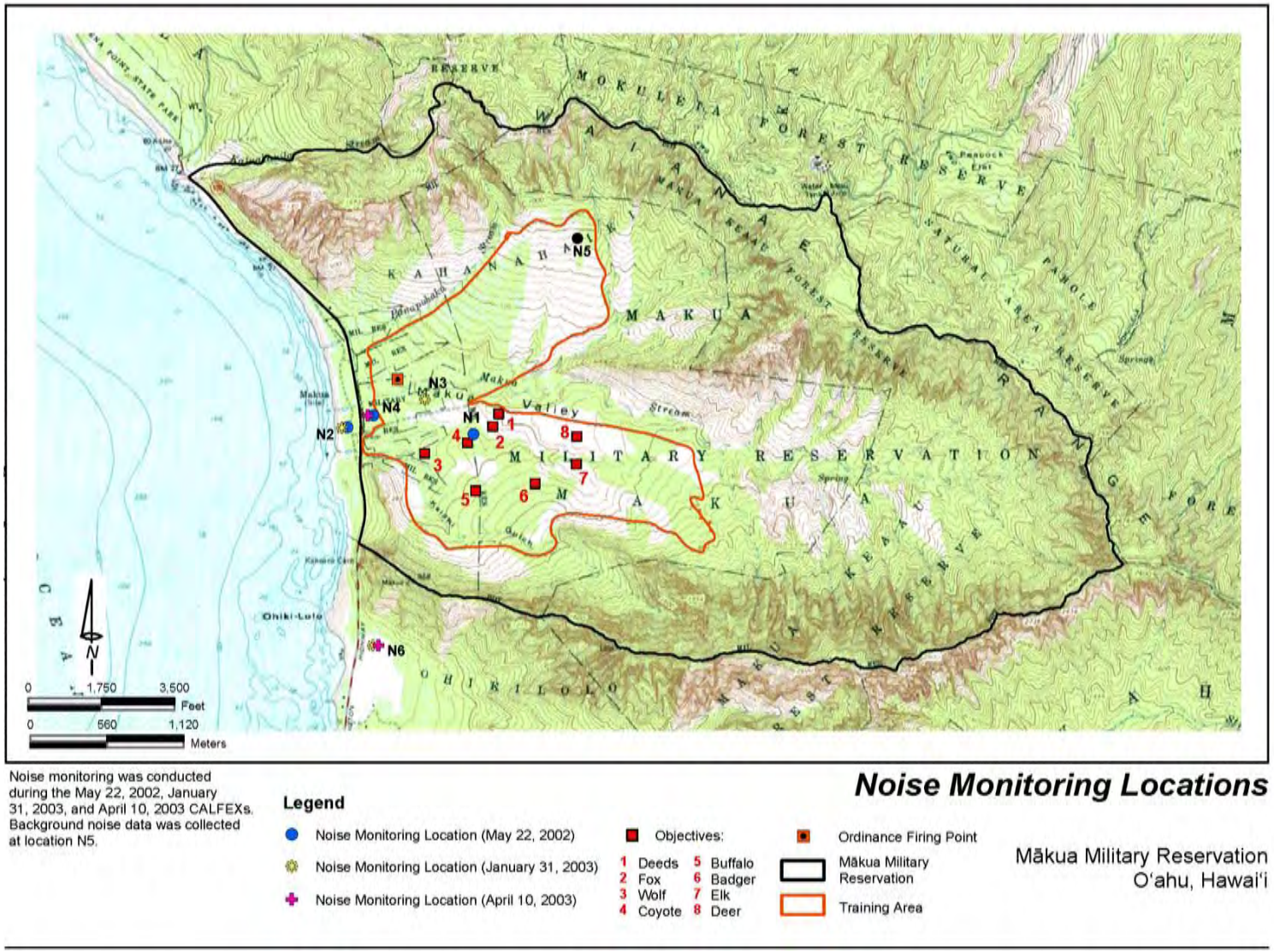


Figure 3.5-1 Noise Monitoring Locations, MMR

Table 3.5-6
Summary of Noise Data From 31 January 2003 CALFEX

Parameter	Units	Mākua Beach	Lower Mākua Valley	Silva Ranch
Meter Model		Larson Davis 824	Larson Davis 824	Larson Davis 824
Start Time		7:38:16 AM	7:26:33 AM	7:48:46 AM
Duration	Hours:min:sec	6:23:15	5:02:12	4:59:52
L_{eq}	DBA, fast	62.7	69.2	56.3
	DBC, fast	76.7	81.3	67.1
	DBF, fast	79.6	83.1	69.2
L_{max}	DBA, fast	96.8	97.6	92.7
	DBC, fast	115.2	116.7	107.2
	DBF, fast	120.5	121.9	110.7
L_{min}	DBA, fast	41.1	51.9	48.7
	DBC, fast	51.6	55.6	53.9
	DBF, fast	53.3	56.3	54.6
L_{pk}	DBA, fast	122.3	125.5	115.7
	DBC, fast	124.6	126.1	125.2
	DBF, fast	129.6	130.4	125.5
L_{max}	DBA, slow	89.4	93.8	83.9
	DBC, slow	107.4	109.0	100.2
	DBF, slow	112.5	113.8	104.8
L_{min}	DBA, slow	42.1	52.4	49.4
	DBC, slow	53.0	56.4	55.0
	DBF, slow	55.8	57.4	55.9
L_{05}	DBA, fast	66.5	74.0	61.0
L_{10}	DBA, fast	63.9	68.2	57.7
L_{33}	DBA, fast	57.3	61.3	52.5
L_{50}	DBA, fast	52.7	55.9	51.6
L_{90}	DBA, fast	47.5	52.9	50.2
L_{95}	DBA, fast	46.5	52.8	50.0

Source: site-specific data collected at MMR by Tetra Tech

Notes:
dBA, fast = fast response setting (32 samples per second, 1/8 second integration), A-weighted readings
dBC, fast = fast response setting (32 samples per second, 1/8 second integration), C-weighted readings
dBF, fast = fast response setting (32 samples per second, 1/8 second integration), unweighted readings
dBA, slow = slow response setting (8 samples per second, one-second integration), A-weighted readings
dBC, slow = slow response setting (8 samples per second, one-second integration), C-weighted readings
dBF, slow = slow response setting (8 samples per second, one-second integration), unweighted readings

Noise measurements were taken at various locations during four CALFEX (Appendix G-4 of the EIS). The instruments used to monitor noise levels during three CALFEXs in 2003 included an impulse event detector, in addition to the conventional detector used to measure fast and slow response data. Minimum and maximum impulse detector readings were

slightly higher than the comparable fast response readings. For all three events, the impulse noise is comparable. The peak noise is a short duration event occurring only a few times during each CALFEX week. There are no schools, day-care centers, hospitals, or nursing homes within two miles of MMR.

To evaluate the complaint potential from impulsive noise, a set of guidelines were developed by the Naval Surface Warfare Center, Dahlgren, Virginia (Pater 1976). These guidelines for delaying tests at the Dahlgren installation are based on over 10 years of experience using meteorological forecasts. The guidelines are shown in Table 3.5-7. These levels resulted from the best compromise among cost, efficiency of range operations, and good community relations.

Table 3.5-7
Noise Complaint Guidelines

Predicted Sound Level (dBP)	Risk of Complaints
<115	Low risk of noise complaints
115-130	Moderate risk of noise complaints
130-140	High risk of noise complaints, possibility of damage
>140	Threshold for permanent physiological damage to unprotected human ears; high risk of structural damage claims

Source: Pater 1976

For 90 percent of the time during a three- to six-hour exercise per week, the noise level is below 65 dB. It is estimated that for 60 percent of the time, the noise level over the beach would be less than 55 dB. A DNL for each event can be calculated using the SEL fly-over noise level (A-weighted decibel [dBA] compressed into one second) of the louder Chinook, 99.9 dB at 100 feet (30 meters) or 87 dB at 400 feet (122 meters) for one minute, and then correcting for the 86,400 seconds in a day. This calculation gives the ADNL over the beach area to be 50.5 dB. This ADNL will increase by approximately 3 dB for each doubling of overflights. It is estimated that all the combined intermittent Chinook helicopter activity during the six hours per week (16 overflights per week) would result in an ADNL of 59.5 dB at the beach area (each doubling of helicopter operations results in a 3 dB increase to the ADNL). Weather conditions have an effect on sound levels. Noise becomes louder during overcast high humid periods.

The Army uses UH-60 Blackhawk, OH-58D Kiowa Warrior, and CH-47D Chinook helicopters to support the infantry training at MMR. The UH-60 is used primarily for standby in case of a wildfire. The OH-58D Kiowa is primarily used for exercise observation and assault support during a CALFEX. The Chinook CH-47 is used for transporting troops and equipment from SBMR to MMR. Noise levels for Army helicopters are

shown in Table 3.5-8. The Chinook helicopter has a louder slant angle noise than the Blackhawk or the Kiowa, but the Chinook is used much less of the time.

Table 3.5-8
Measured Levels of Aircraft Noise (Maximum dBA)

Slant Distance (feet [meters])	CH-47D Chinook	OH-58D Kiowa	UH-60 Black Hawk
200 (61)	97.5	89.0	91.0
500 (152)	89.3	80.5	82.5
1,000 (305)	83.0	73.8	75.9
2,000 (610)	76.5	66.7	68.7
5,000 (1,524)	67.1	56.1	57.8
10,000 (3,048)	59.1	47.1	48.0

Source: US Army CHPPM 1999; NTIS 1988

The typical uses of these helicopters during a CALFEX exercise are as follows:

- Two UH-60s fly from DMR to MMR via Ka‘ena Point. These two helicopters cross Mākua Beach at approximately 400 feet (122 meters) AGL and set down inside the MMR installation prepared for wildfire fighting. The UH-60s would perform one approach to and one departure from MMR on two days during each CALFEX. This activity would result in eight beach overflights per CALFEX, exposing beach receptors for one minute of noise per overflight. This results in a single event SEL of 88 dBA to the beach receptors for a total of four minutes per week per CALFEX. The calculated ADNL resulting from this noise exposure would be 47.6 dBA.
- Two OH-58D Kiowa helicopters and one UH-60 participate in air assault support during CALFEX exercises, flying over the beach at 100 to 200 feet (30 to 60 meters). Typically these aircraft would make a combined total of four to five practice approaches during the rehearsal phase of the CALFEX and another four to five approaches during the actual exercise day of the CALFEX week. This results in an average total of eight to 10 beach overflights per CALFEX week. Each beach overflight would result in a single event SEL of 89 dBA for a period of one minute and an ADNL of 58.5 dBA. Beach receptors would experience this SEL level eight to ten times for one minute on two days of each CALFEX week. Occasionally, one of these helicopters would hover inside the MMR over the ridge from the beach area. This activity would result in an SEL at the beach of 82.5 dBA for two to three 20-minute periods during the two assault days of each CALFEX. The resultant ADNL from this activity would be 39.1 dBA.

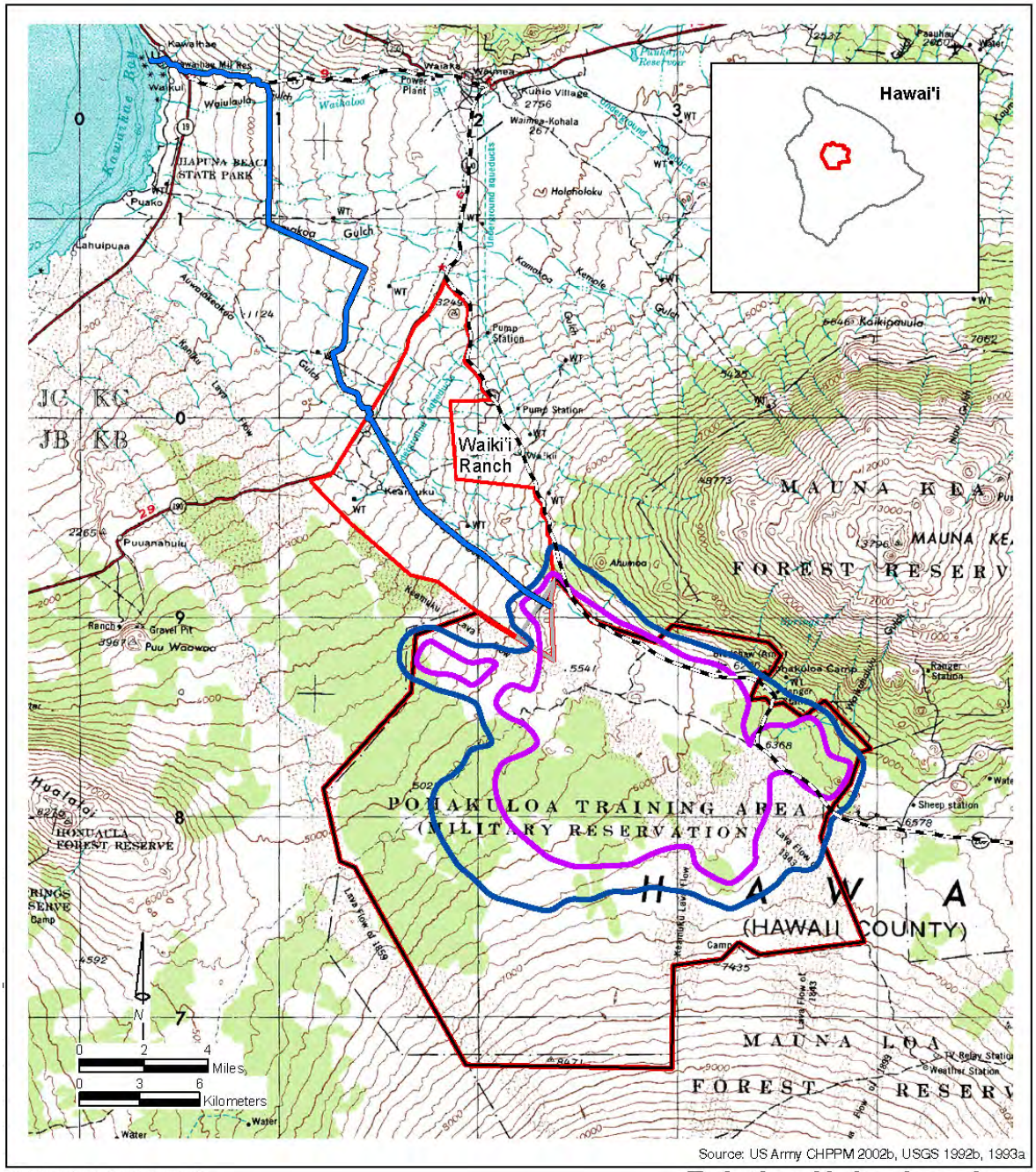
- The CH-47 Chinook is louder than the other helicopters used at MMR. However, it is used less frequently and mainly for transporting troops and equipment from SBMR to MMR during exercises. The CH-47 would approach the MMR by flying over the beach area at 400 to 500 feet (122 to 152 meters) AGL, set down inside the MMR and depart over the beach after unloading its cargo. It is estimated that two CH-47s would make a total of four to five beach overflights per CALFEX week. Although the CH-47 is louder than the UH-60 and the UH-58, its approach to and departure from MMR would be at a higher altitude. The calculated beach overflight noise level for each CH-47 flying at 400 feet (122 meters) would be 87 dBA for one minute. The resultant ADNL from this activity would be 50.4 dBA.

In summary, the existing noise conditions resulting from aircraft activity from one CALFEX per week would be short periods of time (one minute duration) 85 to 87 dBA for a total of 22 minutes per week and an ADNL of 54.6 dBA. Most of this noise would be early morning hours of the weekdays (Wednesday and Thursday) when the number of beachgoers is small. In general, the Army does not train at MMR during weekends when beaches are typically more crowded.

Troops and equipment would be transported by military vehicles from SBMR to MMR during each week of a CALFEX. Table 4.6-1 in Section 4.6, Traffic and Transportation, details the type of vehicles and time of transport for a typical CALFEX. The noise generated from these vehicles on Mākua Valley Road and Farrington Highway would result in very short periods of localized noise as the convoys pass by.

Pōhakuloa Training Area

Noise conditions on PTA vary depending on location and time of day. Main sources of noises are explosive detonations, aircraft, and vehicles. Because of the unpopulated nature of the area and the relatively low volume of traffic on Saddle Road, ambient noise levels within the PTA are generally low. Figure 3.5-2 illustrates estimated annual average noise contours from heavy weapons firing at PTA. Zone III noise conditions are contained within the present boundaries of PTA. Zone II noise conditions affect BAAF and the western portion of the cantonment area. Zone II noise conditions extend beyond the boundaries of PTA from BAAF westward to the northwest corner of the post. Except for the cantonment area, no noise-sensitive land uses are affected by existing Zone II noise conditions (US Army and USACE 2004). No troops are permanently based at PTA. All troop housing is used for troops who are visiting PTA to participate in training exercises.



An illustration estimating annual average noise contours from heavy weapons firing at Pōhakuloa Training Area

Legend

- Pōhakuloa Training Area Boundary
- 1010 Land Acquisition Area
- P3/P4 Pōhakuloa to Kawaihae Trail
- P7 West Pohakuloa Training Area Land Acquisition Area
- Main Road
- Zone II (62-70 dBC)
- Zone III (>70 dBC)

Existing Noise Levels at Pōhakuloa Training Area

Island of Hawai'i, Hawai'i

Figure 3.5-2 Existing Noise Levels, PTA

3.6 TRAFFIC AND TRANSPORTATION

3.6.1 Introduction/Region of Influence

This section describes roads and traffic, defines traffic terms, and describes the regional transportation agencies and applicable standards.

Traffic and circulation refers to the movement of vehicles and pedestrians along and adjacent to roads. Freeways and major roads are under the jurisdiction of the State through the Hawai‘i DOT; other streets and roads are under the jurisdiction of the counties. Roadways consist of multilane road networks with asphalt surfaces to unpaved plantation roads. Traffic conditions in Hawai‘i vary depending on location but are typically over capacity during peak hours, resulting in significant traffic delays. These traffic delays occur in urban areas with multilane roads as well as less developed areas with only two-lane roads.

Mākua Military Reservation

The MMR ROI for this traffic study is Farrington Highway, specifically those portions adjacent to MMR and within the Wai‘anae town area. While the Army transports troops and equipment using Interstate Highways H-1 and H-2 and local roadways, this impact analysis excludes those freeways because vehicles traveling to and from MMR account for only a small proportion of the volumes on Interstate Highways H-1 and H-2, and the multiple lanes on the freeways allow faster vehicles to pass the slower military convoys. Additionally, there were some objections in the public scoping comments about transporting ammunitions through Wai‘anae, especially when school children are traveling to and from school. The public asked for information about the number and types of vehicles in military convoys, as well as travel times and travel routes.

Pōhakuloa Training Area

The PTA ROI for traffic and transportation resources is the travel corridor between Kawaihae Harbor and PTA, which generally follows Saddle Road, Māmalahoa Highway, and Queen Ka‘ahumanu Highway. This corridor is approximately 26 miles (42 kilometers) long.

The major urban areas on the Island of Hawai‘i are Hilo, which is on the eastern side of the Island, and Kailua-Kona, which is on the western side. Air service to these centers is provided by Hilo International Airport and Kona International Airport, respectively. Generally, state highways around the island link the major population centers. The only roadway across the central part of the Island is Saddle Road. With minor exceptions within the urban areas, the major roads are two-lane roadways. The major roadways

on the Island are Queen Kaʻahumanu Highway, Māmalahoa Highway, Hawaiʻi Belt Road, Volcano Highway, Kawaihae Road, and Waikoloa Road.

3.6.2 Traffic Terms

Traffic and circulation refers to the movement of vehicles on local and regional street networks. The roadway network is a hierarchy of roads and streets classified by function. For example, arterial streets are typically four or more lanes that provide the connection from limited access highways to local collector streets, which collect traffic from local neighborhood-serving streets.

Level of Service

Level of service (LOS) denotes traffic operating conditions that may occur on a given lane, roadway, or intersection when it is subjected to specific traffic volumes, geometric conditions, and traffic controls. LOS is a qualitative measure of the effect of a number of factors, including speed, travel time, traffic interruptions, freedom to maneuver, safety, driving comfort, and convenience.

There are six LOSs (A through F) that relate to the driving conditions from best to worst. In general, LOS A represents free-flow conditions with no congestion, and LOS F represents severe congestion with stop-and-go conditions. LOS E is typically considered the highest acceptable LOS for peak-hour conditions in urban areas.

Corresponding to each LOS is a volume/capacity ratio. This is the ratio of either existing or projected traffic volumes to the capacity of the intersection. Capacity is defined as the maximum number of vehicles that can be accommodated by the roadway during a specified period. The capacity of a particular roadway is dependent upon its physical characteristics, such as the number of lanes, the operational characteristics of the roadway (e.g., one-way, two-way, turn prohibitions, bus stops), the type of traffic using the roadway (e.g., trucks, buses), and turning movements.

Unsignalized Intersections

The operating conditions at unsignalized intersections (which are controlled by stop or yield signs) can be classified by LOS A to F. The methodology for determining LOS for these intersections is based on the acceptance of gaps in traffic on the major street by motorists crossing or turning through that traffic stream. Specifically, the capacity of the controlled legs of an intersection is based on two factors: the distribution of gaps in the major street traffic stream and driver judgment in selecting gaps through which to execute a desired maneuver. Therefore, the criteria

for LOS at an intersection without signals is based on delay of each turning movement. Table 3.6-1 summarizes the definitions for LOS and the corresponding delay for such intersections.

Table 3.6-1
LOS Definitions for Unsignalized Intersections

Level of Service	Average Control Delay (seconds per vehicle)
A	<10.0
B	10.1 to 15.0
C	15.1 to 25.0
D	25.1 to 35.0
E	35.1 to 50.0
F	>50.1

Source: Transportation Research Board 2000
Note: When demand volume exceeds the capacity of the lane, extreme delays are encountered with queuing, which may cause severe congestion, affecting other traffic movements in the intersection. This condition usually indicates improvements may be needed at the intersection.

Signalized Intersections

The operating conditions at signalized intersections (which are controlled by traffic signal controls) can be classified by LOS A to F. The methodology for determining LOS for signalized intersections assesses control delay, which is an indicator of driver discomfort frustration, fuel consumption, and increased travel time. A traffic control signal allocates time to conflicting movements at an intersection, and the analytical methodology estimates the delay caused by the traffic signal operations. Table 3.6-2 summarizes the LOS and the corresponding delay for signalized intersections.

Table 3.6-2
LOS Definitions for Signalized Intersections

Level of Service	Control Delay(Seconds per Vehicle)
A	<10.0
B	10.1 to 20.0
C	20.1 to 35.0
D	35.1 to 55.0
E	55.1 to 80.0
F	See note

Source: Transportation Research Board 2000

Note: When demand volume exceeds the capacity of the lane, extreme delays are encountered with queuing, which may cause severe congestion, affecting other traffic movements in the intersection. This condition usually indicates improvements may be needed at the intersection.

3.6.3 Roads

Mākua Military Reservation

Farrington Highway

Farrington Highway is a state-owned and state-maintained roadway that has two lanes between Ka‘ena Point State Park and Mākaha and four travel lanes between Mākaha and Kapolei, with left turn lanes at many of the intersections. In general, the travel lanes are 11 and 12 feet (3.5 to 4 meters) wide, and the shoulder width varies between 0 and 10 feet (0 and 3 meters).

Near MMR, Farrington Highway is a rural two-lane roadway. It provides access to farms and recreational facilities in the area, as well as to the Air Force satellite tracking station north of MMR. The highway ends about 2 miles (3 kilometers) north of MMR at Ka‘ena Point State Park.

Mākua Valley Road

Mākua Valley Road is an unimproved roadway that meanders through the valley for approximately 1.3 miles (2 kilometers).

Mākaha Valley Road

Mākaha Valley Road provides access to the town of Mākaha, approximately 3 miles (5 kilometers) south of MMR, and to the Mākaha Valley Country Club, which is approximately one mile east of Farrington Highway. The intersection of Mākaha Valley Road and Farrington Highway is approximately five miles south of the installation.

Pōhakuloa Training Area

Saddle Road

Saddle Road (SR 200) is a two-lane, two-way roadway that connects PTA with Māmalahoa Highway. The posted speed limit is 45 miles (72 kilometers) per hour; however, a more practical speed limit is 30 to 35 miles (48 to 56 kilometers) per hour because of the deteriorated pavement conditions, constrained alignment, and several one-lane bridges. Advisory speed limits are as low as 25 miles (40 kilometers) per hour. The average daily traffic (ADT) is approximately 400 vehicles per day.

Māmalahoa Highway

Māmalahoa Highway (SR 190) is a two-lane undivided state highway connecting Kailua-Kona with Waimea. The posted speed limit is 55 miles (89 kilometers) per hour between Waikoloa Road and approximately 1 mile (1.6 kilometers) south of Waimea; the remaining section is 35 miles (56 kilometers) per hour. The ADT between Waikoloa Road and south of

Waimea is 5,200 vehicles per day; within Waimea, the ADT is approximately 7,000 vehicles per day.

Waikoloa Road

Waikoloa Road runs between Queen Kaʻahumanu Highway on the west and Māmalahoa Highway on the east. It is a two-lane undivided roadway, except for a short section midway that is a four-lane divided roadway. This section is posted for a 35–mile- (56–kilometer-) per-hour speed limit; west of this section, the speed limit is 45 miles (72 kilometers) per hour. The speed limit to the east is 55 miles (89 kilometers) per hour. No traffic volume data were available for Waikoloa Road.

Queen Kaʻahumanu Highway

Queen Kaʻahumanu Highway (SR 19) is a two-lane state roadway connecting Kailua-Kona with Kawaihae. The posted speed limit is 55 miles (89 kilometers) per hour. The ADT between Waikoloa Road and Kawaihae Road is 10,400 vehicles per day.

Kawaihae Road

Kawaihae Road runs east-west between Waimea and Kawaihae. East of Waimea, the speed limit varies between 35 and 55 miles (56 and 89 kilometers) per hour with speed limits reduced to 25 miles (40 kilometers) per hour near schools and at the intersection of Kawaihae Road at SR 250, which is a congested area. The ADT varies from approximately 17,000 vehicles per day in Waimea to 8,000 vehicles per day just east of Queen Kaʻahumanu Highway.

3.6.4 Transportation Agencies

Three transportation agencies have authority in the MMR and PTA ROI: the Hawaiʻi DOT, City and County of Honolulu Department of Transportation Services, and County of Hawaiʻi Department of Public Works. None of these agencies have specific guidelines or criteria for traffic impact studies; rather, they defer to national standards. Guidelines established by the Institute of Transportation Engineers (ITE) have been used to evaluate traffic conditions.

Adopted transportation goals and policies that guide Oʻahu's and Hawaiʻi's transportation development are contained in the *Transportation for Oʻahu Plan 2025* (TOP 2025) and *Hawaiʻi Long Range Land Transportation Plan* (LRLTP).

3.6.5 Existing Traffic Conditions

Following in this and subsequent sections is a comprehensive description of the existing traffic conditions in the MMR ROI, along Farrington

Highway. Also detailed are the transportation requirements for Army units that would train at MMR.

A greater discussion of the traffic conditions in the PTA ROI is presented in the traffic and transportation section (4.6). Studies and analysis were not as rigorous for the PTA ROI.

In this section and subsequent sections is a comprehensive description of the existing traffic conditions in the MMR ROI, along Farrington Highway. Also detailed are the transportation requirements for Army units that would train at MMR. Studies and analysis were rigorous for the MMR ROI. A greater discussion of the traffic conditions in the PTA ROI is presented in the traffic and transportation section in Chapter 4.

Field observations showed that the following types of vehicles operate at MMR, accessing it from Farrington Highway:

- HMMWVs;
- 5-ton (4.5 metric ton) light medium tactical vehicle (LMTV) (cargo truck);
- 10-ton (9 metric ton) palletized loading system (PLS), also known as family of medium tactical vehicles (FMTV);
- 20-foot (6-meter) trailer;
- HMMWV-type vehicles (most standard, but two equipped for fire support with hoses, pump, and small water tank);
- Flatbed truck;
- Septic tank truck (maintenance contractor vehicle);
- Tractor;
- Bobcat (small loader);
- 8-passenger vans;
- 44-passenger buses;
- Forklift;
- Fire trucks and HMMWV equipped as small fire trucks; and
- Privately owned vehicles (POV).

Larger vehicles are transported by aircraft, and Blackhawk helicopters travel under their own power to the site. Some vehicles, such as the bobcat and the two HMMWVs equipped as small fire trucks, are assigned to the MMR and remain on-site at all times.

Convoy Policies and Instructions

The Division Transportation Office (DTO) recently issued revised instructions for convoy operations (25th ID[L] PAM 55-1). Based on those instructions, convoy clearances are required from DTO for the following:

- Any group of six or more vehicles temporarily organized to operate together, with or without an escort, proceeding together under a single commander;
- Ten or more vehicles an hour dispatched to the same destination over the same route; or
- Any vehicle, with or without escort, that requires a special hauling permit. Convoys and vehicles requiring special hauling permits are prohibited on local highways from 6:00 AM to 8:30 AM and from 3:00 PM to 6:00 PM, Monday through Friday.

Convoys are organized into serials, which are further divided into march units. A convoy is limited to four serials and a serial is limited to four march units. A march unit is the smallest element in a convoy and is limited to 25 vehicles. Recommended spacing between march units is 15 minutes and between serials is 30 minutes (25th ID[L] PAM 55-1). Buses also may be used to transport military personnel; Hawai‘i DOT has confirmed that the buses are considered civilian vehicles and do not have to adhere to the banned travel times for convoys.

Hawai‘i DOT policy regarding convoys states that vehicles traveling under permit authority requiring escort vehicles (i.e., convoys containing oversize or overweight vehicles) shall not be allowed to travel in convoys on two-lane highways, and a separate escort shall be provided for each vehicle or vehicles and load moved under escort (Section 19-104-26[a], Hawai‘i Administrative Rules). Vehicles are considered oversize if their dimensions are greater than the following: 9 feet (3 meters) wide; 13 feet 6 inches (4 meters) tall; 40 feet (12 meters) (single vehicle), 58 feet (18 meters) (truck and semi trailer), or 65 feet (20 meters) (truck and full trailer) long (Section 19-104-14, Hawai‘i Administrative Rules). Vehicles are considered overweight if they exceed the limit calculated based on the distance between their axles (Section 19-104-21[a], Hawai‘i Administrative Rules). Such vehicles shall also be spaced about 15 minutes apart along the route (Section 19-104-26[a], Hawai‘i Administrative Rules). The Hawai‘i DOT policy regarding convoys on multilane highways is that the district engineer may permit oversize or overweight vehicles to travel by pairs under escort. The foregoing spacing requirement of 15 minutes shall also apply between pairs of vehicles (Section 19-104-26[b], Hawai‘i Administrative Rules).

CALFEX Training—Types and Number of Vehicles

The actual number and types of vehicles vary for each CALFEX exercise as the battalion commander has the discretion to use vehicles as appropriate for the planned activities. The following listing of number and types of vehicles represents the baseline conditions for the various activities that usually occur during a CALFEX:

- 17 HMMWVs;
- 7 HMMWVs with trailers;
- 2 5-ton LMTVs;
- 1 10-ton PLS;
- 6 buses or 12 LMTVs to transport infantry; and
- 2 fire trucks.

In addition, senior battalion officers can visit and observe the CALFEX at any time and may travel in military automobiles or POVs.

CALFEX Training—Mākua Military Reservation Transport Schedule and Travel Route

The following describes a typical schedule of transport activities that occur during a five-day CALFEX :

- Day 1 (Monday). Tactical Operations Center staff begin setting up at MMR in the afternoon.
- Day 2 (Tuesday). The rest of the participants are transported to MMR in military vehicles or buses in the morning. Food and water are scheduled for delivery twice a day, once in the morning and afternoon. The afternoon delivery includes a hot evening meal and the next day's breakfast.
- Days 3 and 4 (Wednesday and Thursday). Two Lualualei fire trucks and one SBMR HMMWV arrive in the morning and remain on-site during training. They return to their respective bases in the afternoon. Cleanup usually begins on Thursday afternoon.
- Day 5 (Friday). Personnel with equipment depart on Friday after cleanup is complete.

The approximate travel times and number of vehicles in the convoys are identified in Section 4.6, Traffic and Transportation. The convoys primarily travel between SBMR and MMR via Interstate Highway H-2, Interstate Highway H-1, and Farrington Highway.

Intersection Turning Movement Traffic Counts

Manual traffic counts were conducted at the two MMR driveways off Farrington Highway (shown on Figure 2-2) and at the intersection of Farrington Highway and Mākaha Valley Road on April 22 and 23, 2003. These were the first two travel days of a CALFEX. The MMR south driveway serves as the primary access to the MMR administrative office, maintenance buildings, and paved parking lots. The MMR north driveway is located at the bivouac area. Mākaha Valley Road at Farrington Highway is the location of the first signalized intersection when traveling southbound from MMR; Farrington Highway also transitions from two to four lanes in the vicinity of this intersection. Figure 3.6-1 shows the traffic volumes at these intersections for an early morning peak hour (6:00 AM to 7:00 AM) and a mid-morning peak hour (10:00 AM to 11:00 AM).

At Mākaha Valley Road, there is one northbound through lane and a separate right turn lane on Farrington Highway. The southbound approach widens to allow two through lanes and a separate left turn lane at this intersection. For the Mākaha Valley Road approach, there are double left turn lanes; the north lane is shared with the right turn movement.

Unsignalized Intersection Analysis Results

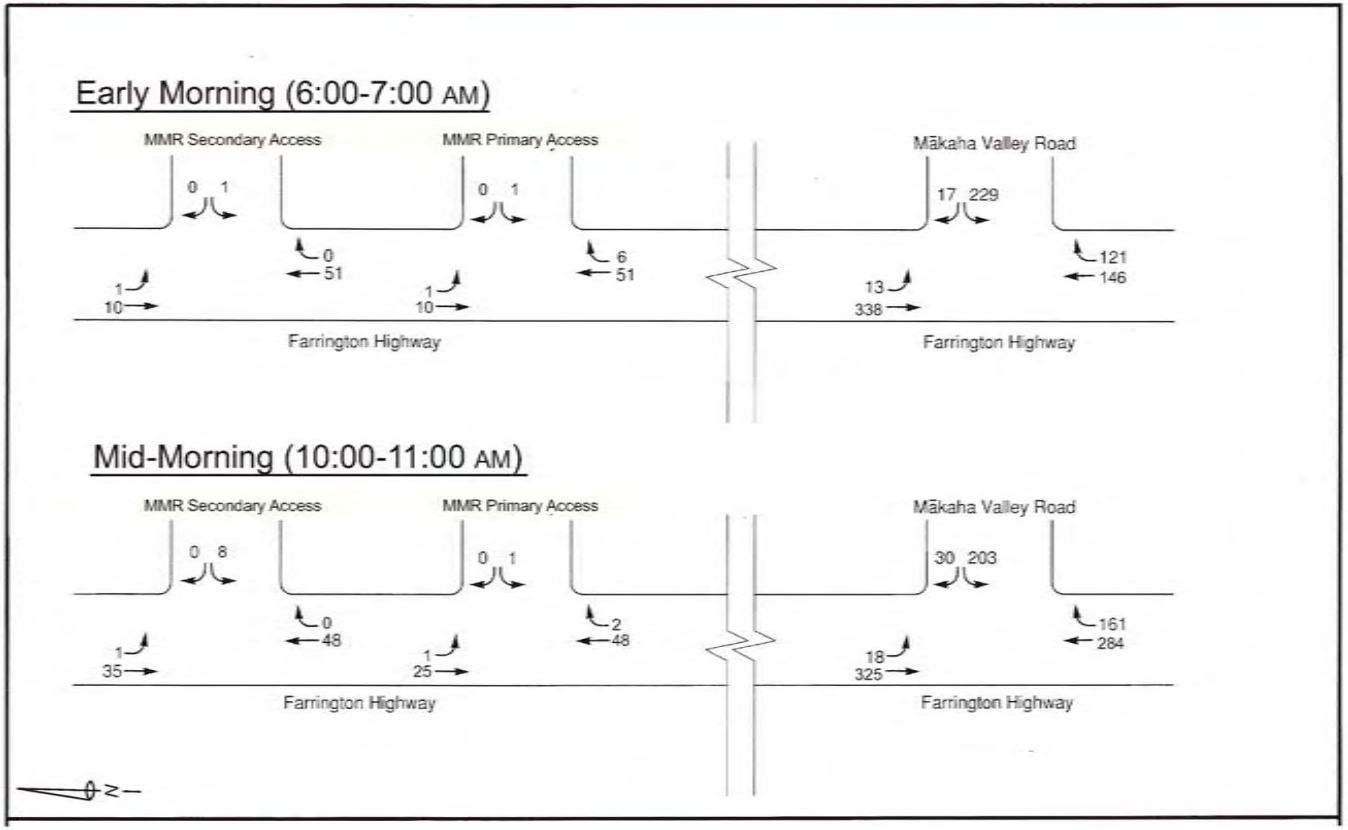
The MMR primary and secondary driveway connections to Farrington Highway are analyzed according to the 2000 Highway Capacity Manual (HCM, Transportation Safety Board 2000) unsignalized intersection methodology. The analysis results are given in Table 3.6-3 for the Primary MMR South Access Road and in Table 3.6-4 for the Secondary MMR North Access Road.

Table 3.6-3
Farrington Highway at Primary MMR South Access Road
Unsignalized Intersection Analysis Results

	Early Morning		Mid-Morning	
	Delay (seconds)	**LOS**	**Delay (seconds)**	**LOS**
Southbound Left Turn	7.3	A	7.3	A
Primary MMR Access Road	8.8	A	8.9	A

Table 3.6-4
Farrington Highway at Secondary MMR North Access Road
Unsignalized Intersection Analysis Results

	Early Morning		Mid-Morning	
	Delay (seconds)	**LOS**	**Delay (seconds)**	**LOS**
Southbound Left Turn	7.3	A	7.3	A
Secondary MMR Access Road	8.8	A	8.9	A



Traffic counts were conducted at two intersections near MMR.

Existing Traffic Volumes

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.6-1 Existing Traffic Volumes, MMR

With the low volumes on Farrington Highway and at the two MMR driveways, the motorists turning into or out of these driveways experience LOS A conditions. While no motorists were observed making the southbound left turn from Farrington Highway into either the primary MMR South Access Road or the secondary MMR North Access Road, the delays shown in Tables 3.6-3 and 3.6-4 for this movement represent the average delay if a motorist were to make such a move. Similarly, for the delay at Farrington Highway at primary MMR South Access Road, where the existing count was zero, Table 3.6-3 represents a delay if a motorist were to make a left or right turn onto Farrington Highway.

Signalized Intersection Analysis Results

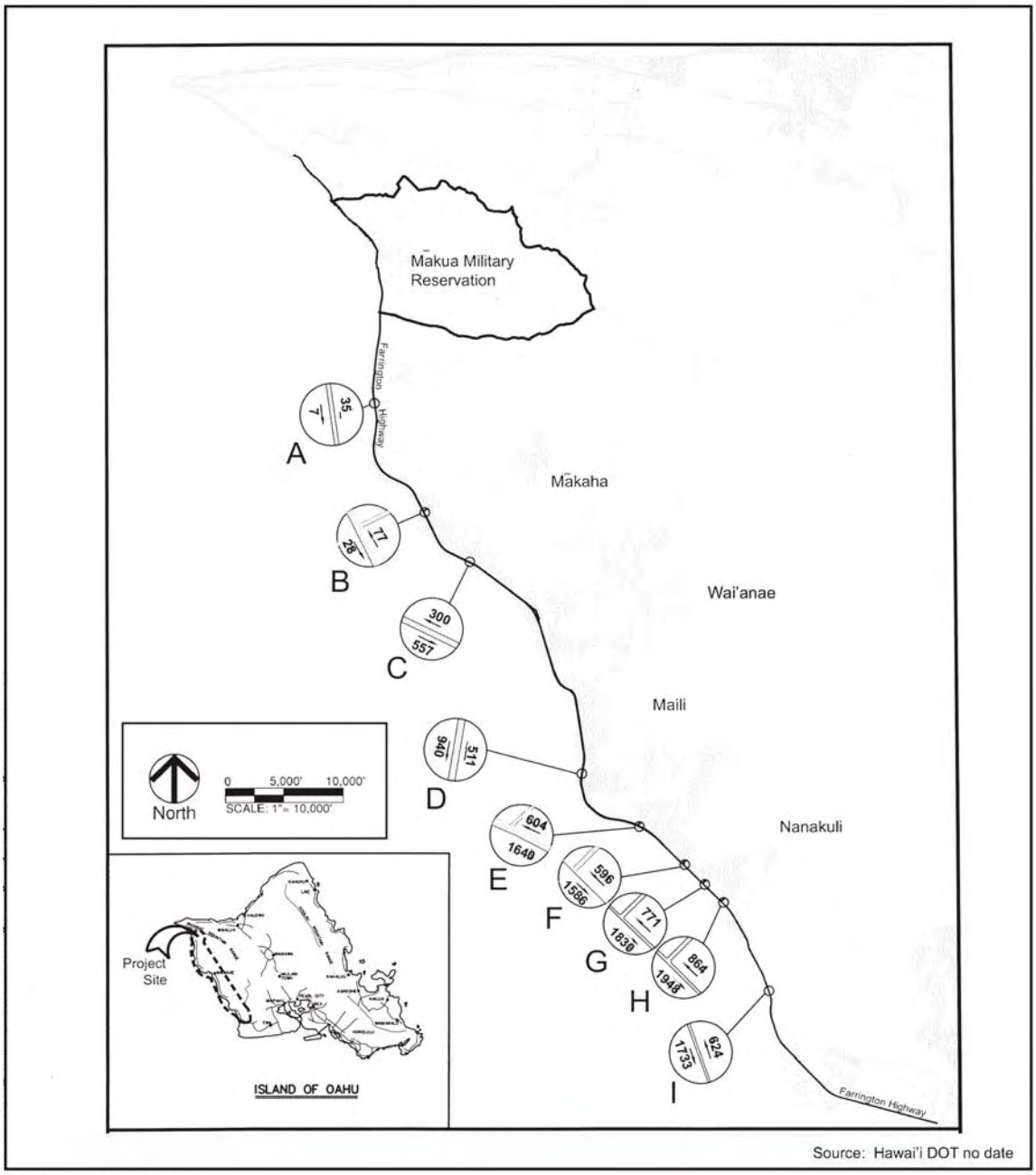
The HCM 2000 signalized intersection methodology is used to analyze the intersection of Farrington Highway and Mākaha Valley Road, and the results are given in Table 3.6-5. The Mākaha Valley Road approach experiences LOS C conditions during the early AM peak hour and the mid-morning AM peak hour. The Farrington Highway southbound left turn is at LOS D in the early AM peak hour and at LOS C in the mid-morning AM peak hour. The northbound and southbound approaches are at LOS A, respectively, while the overall intersection operations are at LOS B.

Table 3.6-5
Farrington Highway and Mākaha Valley Road
Signalized Intersection Analysis Results

	Early Morning		Mid-Morning	
	Delay (seconds)	LOS	Delay (seconds)	LOS
Northbound approach	9.3	A	9.3	A
Southbound approach	6.4	A	6.8	A
Left turn	36.0	D	31.5	C
Through movement	5.3	A	5.5	A
Mākaha Valley Road approach	32.4	C	26.1	C
Overall intersection	14.6	B	12.3	B

Farrington Highway Two-Way Traffic Counts

The Farrington Highway two-way traffic counts collected by Hawai‘i DOT are shown in Figure 3.6-2 for the early morning peak hour and in Figure 3.6-3 for the mid-morning peak hour. The most recent traffic count data available from Hawai‘i DOT is for 2002. The list of stations in Table 3.6-6 is arranged according to count station proximity to the MMR, with the closest station at the top of the list. In general, the Farrington Highway traffic volumes are lowest nearest MMR and increase as the stations become closer to Kapolei.

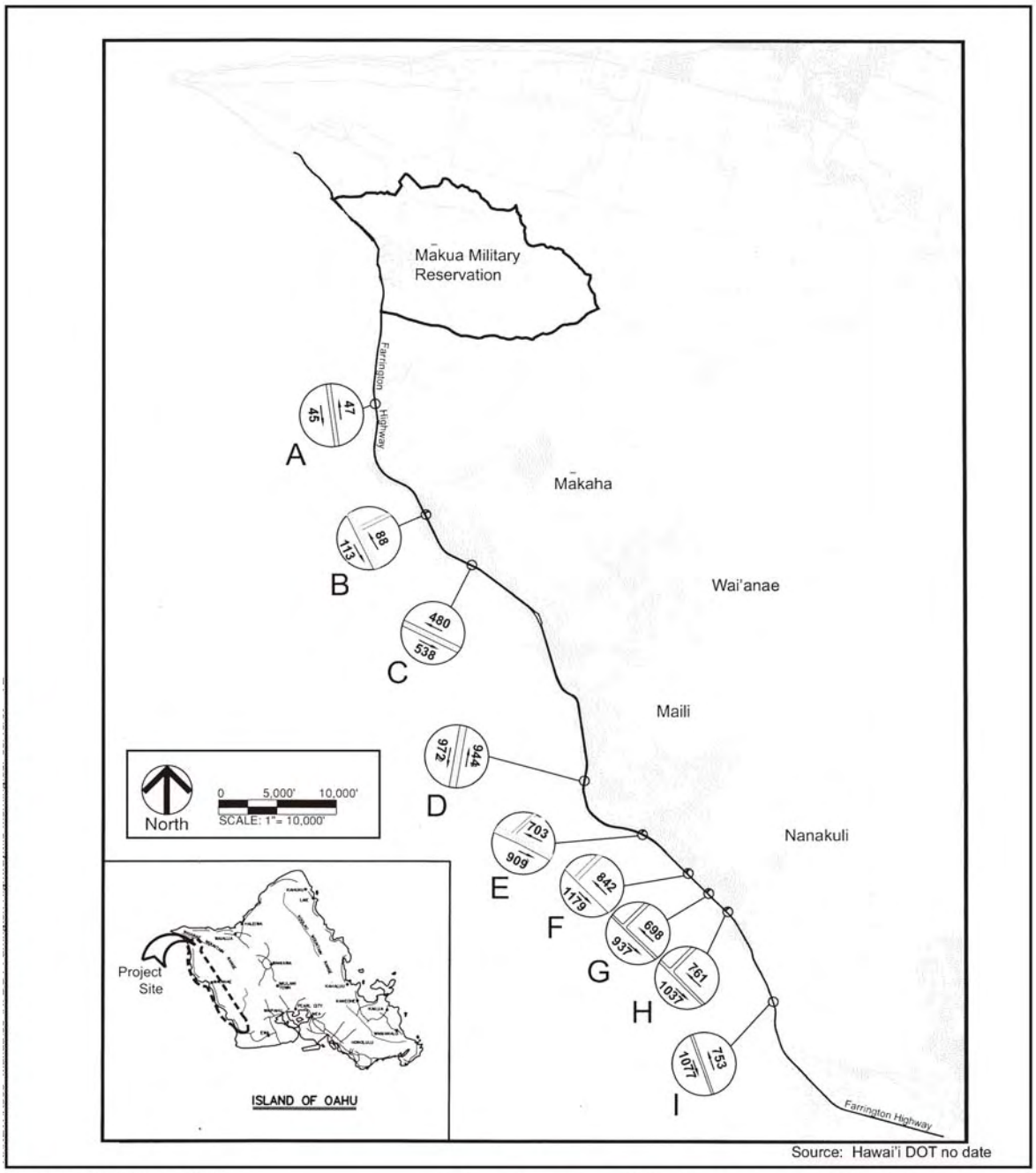


The Hawai'i DOT collected traffic counts at several locations along Farrington Highway.

Farrington Highway Traffic Volumes
Early Morning (6:00-7:00 AM) Peak Hour

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.6-2 Farrington Highway Traffic Volumes, Early Morning (6:00-7:00 AM) Peak Hour, MMR



In general, the Farrington Highway traffic volumes are lowest near MMR.

Farrington Highway Traffic Volumes
Mid-Morning (10:00-11:00 AM) Peak Hour

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.6-3 Farrington Highway Traffic Volumes, Mid-Morning (10:00-11:00 AM) Peak Hour, MMR

Table 3.6-6
Hawai‘i DOT Farrington Highway Count Stations

Station	Location
A	Mākaha Bridge #5A, ‘Ōhikilolo Stream Bridge
B	South of Water Street
C	Approximately 420 feet (128 meters) northwest of Māi‘u‘u Road
D	Maili‘ili‘i Stream E south of Hakimo Road
F	South of Lualualei Naval Road
G	South of Haleakalā Avenue
H	South of Nānākuli Avenue
I	Keananoio Bridge

Farrington Highway Vehicle Type Classification Counts

The Hawai‘i DOT also conducts vehicle type classification (VTC) counts, and the VTC counts for 2000 along Farrington Highway are provided in Table 3.6-7. At the ‘Ōhikilolo Stream Bridge, where traffic volumes are low, buses and trucks range between 1.5 percent and 10.9 percent of the total vehicles on Farrington Highway. In the vicinity of Maili‘ili‘i Stream Bridge and Keananoio Bridge, where traffic volumes are higher, the buses and trucks range between 1.8 percent and 5.4 percent of the Farrington Highway traffic volumes.

Wai‘anae Coast Emergency Access Road

In the past, accidents along the Wai‘anae Coast have caused Farrington Highway to be closed and have resulted in extensive delays to motorists while emergency services and the police respond to the situations. The city DTS is developing the Wai‘anae Coast Emergency Access Road in response to the community’s request for an alternative road to Farrington Highway in such incidents; a portion of the planned emergency road is under design. Also, although the Wai‘anae Coast Emergency Access Road roadway is not contiguous throughout the Wai‘anae Coast, it does offer an alternative route in selected areas if Farrington Highway is closed for any reason.

Mākua Military Reservation Ammunition Routes

The Army’s first priority is to transport ammunition to MMR by helicopter, thereby avoiding travel on Farrington Highway where there are several schools adjacent to the highway. This policy would be followed by other military units using MMR for training, such as the US Marine Corps

Table 3.6-7
Farrington Highway Vehicle Type Classification Counts

Location	Date	AM Peak Hour			PM Peak Hour			24-Hour Total		
		Northbound	Southbound	Total	Northbound	Southbound	Total	Northbound	Southbound	Total
Mākaha Bridge #5A										
(ʻŌhikilolo Stream Bridge)	January 17-18, 2002	11:00 AM - 12:00 PM			2:45 PM - 3:45 PM			1:00 PM - 1:00 PM		
Passenger vehicles		55	41	96	56	75	131	607	604	1,211
Buses		0	0	0	0	0	0	1	3	4
Trucks		1	5	6	0	2	2	3	35	38
Total		56	46	102	56	77	133	611	642	1,253
Subtotal buses and trucks		1	5	6	0	2	2	4	38	42
Percent buses and trucks		1.8%	10.9%	5.9%	0.0%	2.6%	1.5%	0.7%	5.9%	3.4%
Mailiʻiliʻi Stream Bridge	January 17-18, 2002	7:15 AM - 8:15 AM			3:30 PM - 4:30 PM			12:00 PM - 12:00 PM		
Passenger vehicles		1,044	989	2,033	1,303	992	2,295	16,243	15,370	31,613
Buses		1	0	1	2	1	3	11	9	20
Trucks		34	56	90	39	17	56	419	590	1,009
Total		1,079	1,045	2,124	1,344	1,010	2,354	16,673	15,969	32,642
Subtotal buses and trucks		35	56	91	41	18	59	430	599	1,029
Percent buses and trucks		3.2%	5.4%	4.3%	3.1%	1.8%	2.5%	2.6%	3.8%	3.2%
Keananoio Bridge	January 17-18, 2002	6:30 AM - 7:30 AM			3:15 PM - 4:15 PM			11:00 AM - 11:00 AM		
Passenger vehicles		876	1,535	2,411	1,785	1,112	2,897	17,704	18,102	35,806
Buses		2	8	10	11	4	15	100	108	208
Trucks		24	27	51	28	20	48	433	544	977
Total		902	1,570	2,472	1,824	1,136	2,960	18,237	18,754	36,991
Subtotal buses and trucks		26	35	61	39	24	63	533	652	1,185
Percent buses and trucks		2.9%	2.2%	2.5%	2.1%	2.1%	2.1%	2.9%	3.5%	3.2%

Source: HI DOT no date
Note: Peak hours determined by Hawai ʻi DOT.

If ammunition must be transported on the ground, it is done with a front and back escort at a maximum speed of 45 miles (72 kilometers) per hour. Transport is conducted in accordance with all Hawai‘i DOT rules and regulations for transporting explosive materials (Husemann 2003c).

For Army transportation of ammunition:

- Operators transporting explosives, grenades, mines, artillery rounds, anti-tank rounds, and mortar rounds avoid using the Farrington Highway from 5:00 AM to 7:00 PM; and
- Operators transporting other munitions and ordnance on Farrington Highway avoid using the highway during peak traffic hours and at times when children are traveling to and from school (5:30 AM to 8:30 AM and 12:30 PM to 6:30 PM).

These restrictions combine to substantially reduce the risk of accidents involving ammunition transport vehicles and public exposure to potential accidental explosion of munitions should an accident occur.

The Wai‘anae community has expressed concerns about transporting ammunition when children are traveling to and from school. In general, Wai‘anae public schools begin the school day between 7:45 AM and 8:00 AM. The ending time varies by school and day of week, but most public schools end the school day between 1:10 PM and 2:10 PM; hence, the morning school transport period is between 7:00 AM and 8:30 AM, and the afternoon school transport period is slightly longer, approximately 12:30 PM to 3:00 PM. Many children are transported to and from school in automobiles. In addition, field observations showed that many students of various ages walk along Farrington Highway or wait at bus stops for city buses.

As presented above, the Army’s ammunition transport times avoid use of Farrington Highway during those times when schoolchildren are likely to be present.

Ammunition is stored at three separate locations: WAAF, Lualualei Naval Magazine, and West Loch Naval Magazine. For WAAF, the primary route is Interstate Highways H-2 and H-1 and Farrington Highway. Vehicle trips begin at WAAF’s Aerodrome Road, exit at the Kunia Gate, then head east on Kunia Road, turning onto Wilikina Drive to reach Interstate Highway H-2, southbound. At the Wahiawa Interchange, the vehicles travel west onto Interstate Highway H-1. If a secondary route is required, then vehicles travel southbound on Kunia Road, between the Kunia Gate and the Kunia interchange with Interstate Highway H-1, then proceed westbound on Interstate H-1. In the vicinity of Kapolei, Interstate

Highway H-1 becomes Farrington Highway. Vehicles remain on Farrington Highway to access MMR.

For the Lualualei Naval Magazine, the travel route begins at Lualualei Naval Road (southwest bound), then turns onto Farrington Highway northbound to reach MMR. This is the only travel route between Lualualei Naval Magazine and MMR.

For the West Loch Naval Magazine, the primary travel route is Interstate Highway H-1 and Farrington Highway. The trip begins at Iroquois Point Road (westbound), then turns onto Fort Weaver Road northbound and accesses Interstate Highway H-1 (westbound) at the Kunia Interchange, then onto Farrington Highway (westbound) to MMR. A secondary travel route begins on Iroquois Point Road (westbound) and travels straight onto Geiger Road, then onto Roosevelt Avenue (westbound), through the former Barbers Point Naval Air Station, then onto Fort Barrette Road (northbound) and Farrington Highway to MMR.

If ammunition must be transported through the Interstate Highway H-3 tunnels (for example, for use of MMR by other military units, such as the US Marine Corps), the revised DTO convoy instructions require the units to contact the Interstate Highway H-3 Tunnel Control Center and to call 911 to inform the Honolulu Police Department, Fire Department, and Emergency Services.

The Army's DTO instructions do not meet the requirements of the Hawai‘i Statewide Traffic Code for transporting explosives on any public roadway. The code requires that the police department and fire department in the affected county be provided with written 48-hour minimum advance notice that indicates quantity and type of explosive to be shipped, date and time of shipment, and description of travel route (Section 286-226, Hawai‘i Revised Statutes). The military is exempted from this state requirement when the President or the Governor proclaims a civil defense emergency.

3.7 WATER RESOURCES

The range alternatives are located on two Hawaiian Islands, O‘ahu and Hawai‘i. Rainfall in the Hawaiian Islands is very unevenly distributed and is highly dependent on elevation as well as location. The maximum rainfall occurs at elevations between 2,000 to 3,000 feet (610 to 914 meters) above mean sea level (amsl). Above this elevation, rainfall decreases rapidly so that the high elevations are relatively dry (US Army and USACE 2004).

Water resources include both surface water and groundwater resources, with discussions including:

- Water quality;
- Water quantity (rainfall and runoff, flooding potential, and groundwater yield); and
- Water movement (currents and waves, stream flow, and groundwater movement).

Public comments received during the Mākua EIS scoping process regarding water resource issues include the following:

- Aquatic resource contamination (aquifers, streams, springs, wells, and groundwater);
- Native Hawaiian use of water resources;
- Water preservation for crops;
- Contaminated soil runoff;
- Erosion;
- Frequency of water sampling; and
- Water quality testing.

3.7.1 Introduction/Region of Influence

The ROI for surface water is not necessarily the same as the ROI for groundwater. Because groundwater often crosses topographic watershed boundaries, the ROI for surface water is expanded to include the aquifers underlying these watersheds and any aquifers downgradient (in the direction of groundwater flow) from the training and deployment areas. The ROIs for both surface water and groundwater include the downstream and downgradient near-shore areas along the coast where surface water and groundwater, respectively, discharge to the sea.

The MMR ROI for groundwater resources includes the following:

- Upper portion of the freshwater aquifer underlying the watershed and extending offshore; and
- Any additional groundwater resources that may be identified as downgradient of past or present military activities in the Mākua Valley.

Mākua Military Reservation

The MMR ROI for surface water resources is the Mākua watershed on the Island of Oʻahu.

Pōhakuloa Training Area

The PTA ROI for surface water resources is the Northwest Mauna Loa and the West Mauna Kea watersheds on the Island of Hawaiʻi.

3.7.2 Hydrologic Setting
Mākua Military Reservation

Climate

MMR is on the leeward side of Oʻahu, about 4 miles (1 kilometer) south of Kaʻena Point. The prevailing northeasterly trade winds, which are present about 90 percent of the time during the summer and about 50 percent during the winter, lose most of their moisture as they blow across the Koʻolau and Waiʻanae Range s, leaving the Waiʻanae Coast relatively dry. The average annual precipitation at MMR ranges from greater than 50 inches (127 centimeters) on the high ridges to about 15 inches (38 centimeters) near the coast (Nakata Planning Group LLC 2002b).

Monthly average rainfall on the leeward coast ranges from 3 to 4 inches (8 to 10 centimeters) between December and March and less than 1 inch (2 centimeters) from May to September (Stearns and Vaksvik 1935). On the ridges of the Waiʻanae Range, the average monthly winter rainfall approaches 10 inches (25 centimeters) in December and January and decreases to about 4 to 5 inches (11 to 13 centimeters) during the summer. Heavy rainfall on the leeward side of the island is mainly the result of rare Kona storms, which occur mainly during the winter (US Navy, undated). Kona storms tend to originate from low pressure systems that develop west of the Hawaiian Islands. They are characterized by southerly winds, high humidity, and prolonged rainfall, accompanied by thunderstorms.

The 100-year peak 1-hour rainfall at Mākua is estimated to be between 3 and 4 inches (8 and 10 centimeters). The 100-year peak 24-hour rainfall is

estimated at between 12 and 14 inches (30 and 36 centimeters). The 24-hour probable maximum rainfall is approximately 50 inches (127 centimeters) (Wu 1967).

Data from three precipitation gauges installed by the Army in July 1999 at MMR, including one near Farrington Highway (the "portable" station), one at the upper end of the training area (the "range" station), and one on the north rim of the valley (the "ridge" station), indicate that rainfall follows a seasonal pattern, with the highest monthly precipitation occurring from October through April (USARHAW and 25th(L) 2004). However, the limited record shows great variability. Monthly totals from July 1999 to July 2004 ranged from trace to more than 16 inches (41 centimeters) at the lower elevation and from less than 0.5 inch to about 17 inches (1.3 to 43 centimeters) on the ridge. The highest monthly rainfall at the mid-elevation range station during this period was about 9 inches (23 centimeters). Although the total annual rainfall is higher on the ridge than at lower elevations in the valley, the rainfall record indicates that the most intense storms occur at the lower elevations. hourly rainfall exceeded 1 inch (2 centimeters) on seven days at the portable station, on five days at the range station, and on two days at the ridge station. The highest recorded hourly rainfall during the period was nearly 2.2 inches (5.6 centimeters), recorded at the range station.

Based on the approximately 30-year rainfall record from the US Air Force Satellite Tracking Station at Ka'ena Point, just north of MMR, rainfall during the past several years has been unusually low.

Surface Water Drainage

MMR is in the Mākua watershed (HDOH 1998b), which includes the Mākua Valley and a smaller adjacent Kahanahāiki valley (refer to Figure 3.7-1). The following streams drain the valleys:

- Mākua Stream, an intermittent stream, is the principal drainage and discharges to the west along the north side of Mākua Valley;
- Ko'iahi Gulch (also known as Kaiahi Gulch) drains the south side of Mākua Valley;
- Punapōhaku Stream drains Kahanahāiki Valley; and
- Kaluakauila Stream, along the northern boundary of MMR, drains the north side of the north ridge of Kahanahāiki Valley.

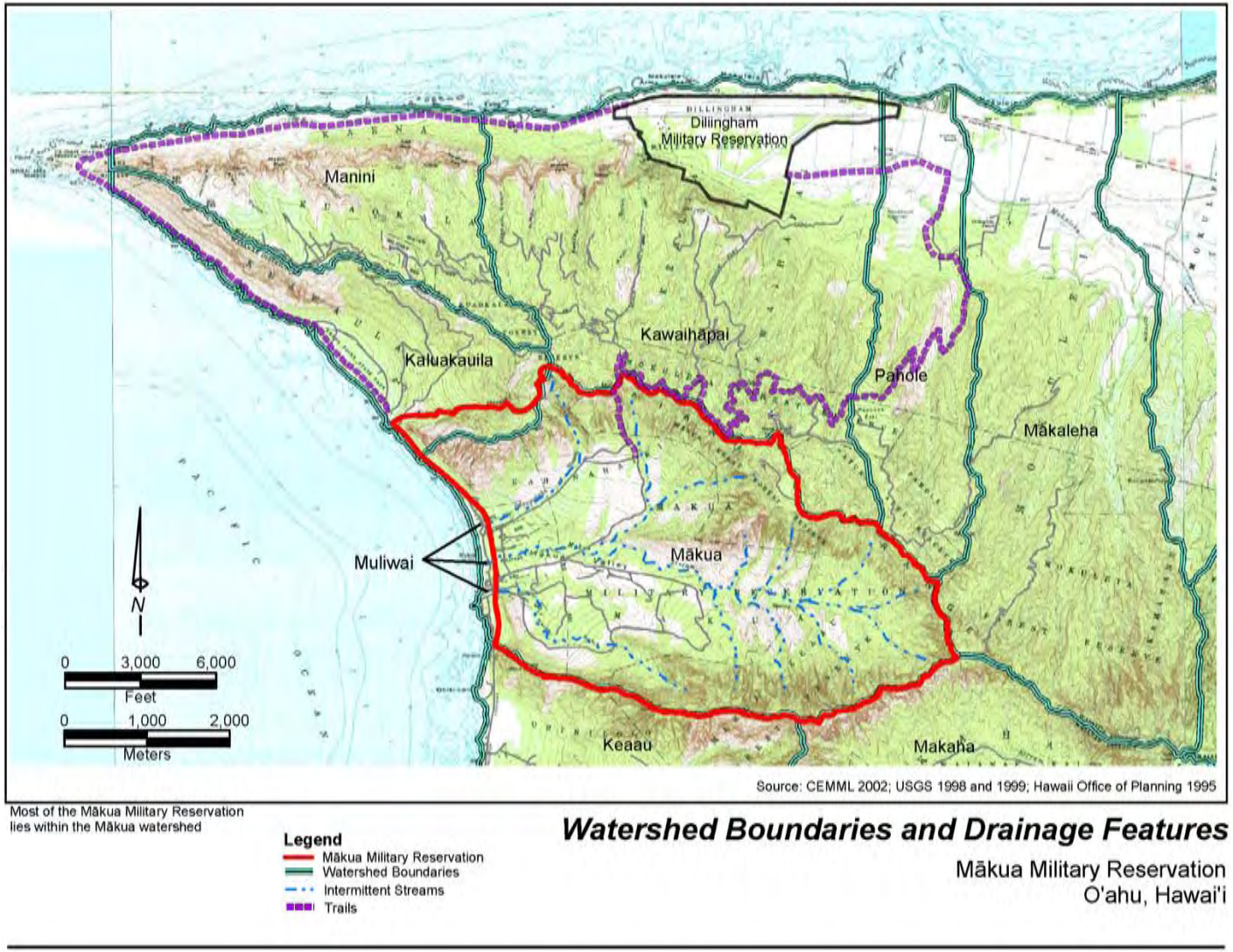


Figure 3.7-1 Watershed Boundaries and Drainage Features, MMR

The stream channels cross under Farrington Highway through concrete box culverts and terminate behind the long ridge of dune sand above the shoreline of Mākua Beach. Following a storm, the low areas behind the dunes fill with water to form temporary ponds (*muliwai,* the Hawaiian word for brackish water pools near the mouths of streams created by seasonal barriers of sand or sediment).

The presence of high-level dike-impounded groundwater in the upper portion of the watershed of the Mākua Valley is indicated by several springs in Mākua Valley. Springs occur at points where the groundwater discharges at the ground surface. Two springs are shown on Figure 3.7-2. One is at an elevation of about 800 feet (244 meters), near the course of Mākua Stream, and another is at an elevation of about 1,200 feet (366 meters) on the south side of the valley. Other springs reportedly appear intermittently, depending on rainfall.

Consistent with the low amount of measured rainfall that has prevailed during recent years, personnel at MMR have reported observing no flows in Mākua Valley streams for a number of years, until the storm of February 13 through 14, 2003. However, between February 2003 and March 4, 2004, five stream flow events were observed. As indicated in the Hydrogeologic Investigation Report (Appendix G-1), stream flows were reported in February and April of 2003 and in January, February, and March of 2004. A review of the rainfall record for this period shows that most of these events seem to have been associated with daily rainfall amounts greater than 3 inches (8 centimeters) at the ridge weather station. The first stream flow event, on February 13 through 14, 2003, was the result of higher than usual precipitation at the ridge station but not particularly unusual rainfall amounts at the lower elevations. The stream flows in early 2004, however, followed higher than normal rainfall at the lower elevations, accompanied by moderate rainfall on the ridge. In addition, total rainfall at all elevations was higher in the winter and spring of 2004 than in the preceding four years.

The Wai‘anae Sustainable Communities Plan (City and County of Honolulu 2000b) recommends that a stream conservation corridor be established for Mākua Stream. The plan states that these corridors should be used for natural resources conservation uses and programs, compatible recreational uses, such as walking and gathering native plants and stream animals, and controlled diversion of stream waters for agriculture. Due to existing safety and access restrictions, these plan recommendations are not being applied to MMR at this time. The results of the hydrogeologic investigation indicate that the impacts of past military training on water and sediment conditions in Mākua Stream have been negligible.

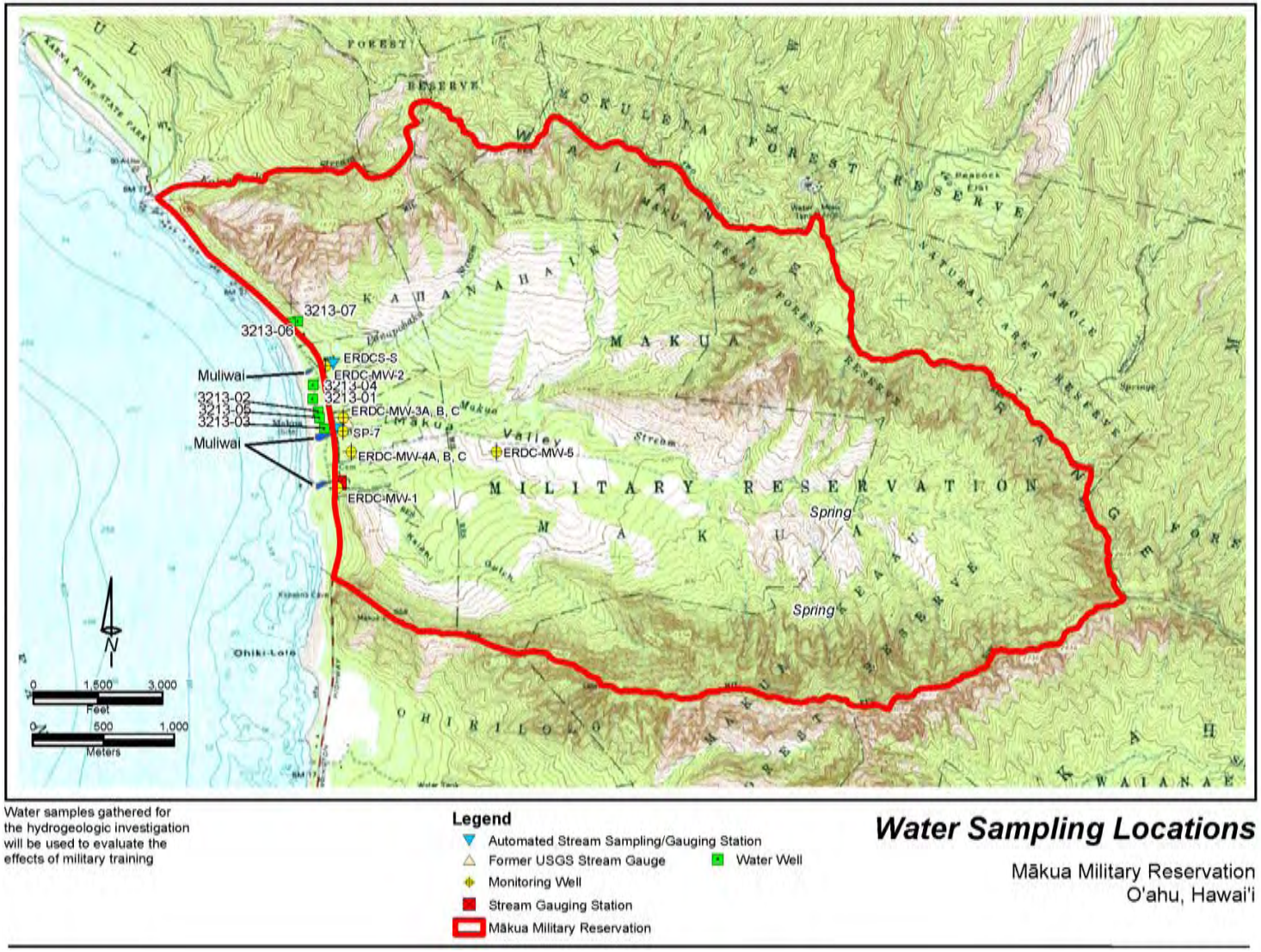


Figure 3.7-2 Water Sampling Locations, MMR

Wetlands

Wetlands are "areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 328.3[b]; 40 CFR 230.3[t]). Wetlands may be further classified by association with a particular hydrologic environment, such as coastal areas, streams or lakes, or swamps and bogs.

Several types of wetlands probably occur within the ROI of MMR, including estuarine wetlands (*muliwai* located adjacent to the ocean); palustrine wetlands, which are characterized by native trees, shrubs, or persistent emergent plants associated with seep areas; and riverine wetlands, adjacent to streams. No wetlands have been confirmed or delineated on MMR. Possible riverine wetlands and possible palustrine wetlands associated with Mākua Stream drainage are protected through restrictions on training (USARHAW and 25th ID[L] 2001b). The *muliwai* are on land west of Farrington Highway, which is managed by the State of Hawai'i DLNR.

Muliwai

Muliwai are brackish water pools near the mouths of streams created by seasonal barriers of sand or sediment (Wilcox et al. 1998). They are generally considered to be estuarine wetlands. *Muliwai* form at the mouths of each of the three streams that discharge from Mākua Valley, although the sizes and shapes of the *muliwai* may vary over time, and not all appear to contain water throughout the year. *Muliwai* have cultural and historical significance in the State of Hawai'i. In some areas, *muliwai* have been improved and maintained for aquiculture.

During a typical large storm runoff, the streams that drain the Mākua Valley discharge to the *muliwai* and the water level rises. Eventually the water spills over the sand dune, eroding a channel to the sea, and this quickly drains the ponds. As the flow in the streams decreases, normal wave action on the shore reestablishes the sand dune, again isolating the *muliwai* from the sea. If stream flows are not large enough to overtop the sand dune, the ponded water seeps through the dune sand to the sea. While this seepage is not perceptible, the fact that a small quantity of water has remained during recent years in the southernmost *muliwai*, located at the mouth of Kaiahi Gulch, despite no significant stream flow, suggests that the *muliwai* may be fed by groundwater seepage.

Muliwai Investigations A screening level study of the bottom sediment quality in the *muliwai* was performed by the EPA in 1999 to determine if there were downstream indications of contaminants from the OB/OD area

and if additional site investigation was warranted (Baylor 1999). Twenty sediment samples were collected from 18 locations in the three *muliwai* downgradient of MMR and in three "reference" *muliwai* (Waikomo, Mākaha, and Nānākuli) located south of MMR. Two additional sediment samples were collected from Kaluakauila Stream, which was identified as an off-site background location. The EPA concluded that it did "not appear that the metals in the *muliwai* presented a significant risk to ecoreceptors, or that additional investigation was warranted at that time" (Baylor 1999).

In May 2003, the Army conducted an additional investigation of *muliwai* sediment quality. Sediment samples were collected from the three *muliwai* downstream of MMR, and from two "reference" locations (adjacent upcoast and downcoast streams) that had been sampled previously in the EPA study. A total of 54 sediment samples were collected, and most were analyzed for a large range of compounds, similar to the range of compounds included in the current hydrogeologic investigation (USACE 2003). The results of the investigation are presented in Appendix G-3 of the EIS.

The study area was determined, in part, by plotting the area of standing water shown in a recent aerial photo of the *muliwai.* A storm on February 14, 2003, resulted in enough runoff that all three of the streams draining Mākua Valley broke through the sand dunes of the respective *muliwai* and drained directly to the ocean. As a result of this event, it is likely that some of the sediment deposited on the bottom or sides of the *muliwai* was eroded and carried to the ocean by the runoff from the February 14 storm event. Sediment samples were collected from depths accessible by manual excavation, as described in Appendix G-3. The results show that, of the explosives analyzed, only RDX was detected, in one of the 54 samples, from the *muliwai* of Punapōhaku Stream, at a concentration of 230 parts per billion.

Marine Resources Study

The Army conducted a marine resources study on fish and *limu* (seaweed) in 2007 and then supplemented the study in 2008 by testing shellfish. The purpose of the study, per the requirements of the 2007 Settlement Agreement (SA) between Mālama Mākua and the Army, was to; 1) Determine whether marine resources near Mākua Beach and in the Mākua *muliwai* are contaminated with constituents associated with proposed training activities at MMR; 2) Evaluate the potential that activities at MMR contribute to any contamination detected in the marine resources; and 3) Evaluate whether the proposed training activities at MMR pose a human health risk to area residents that rely on marine resources for subsistence. The study results are as follows:

1) Fish, shellfish, limu, [and the report assumes that other marine resources] near Mākua Beach and in the *muliwai*, on which area residents rely on for subsistence, are contaminated by substances that are known to be associated with the proposed training at Mākua. The study shows that there are potential chemical migration pathways between MMR and the *muliwai* and nearshore areas. It also confirms that several substances in the nearshore and *muliwai* marine resources are associated with military munitions.

2) There is a potential that activities at MMR have contributed or will contribute to contamination in fish, shellfish, limu and other marine resources. And;

3) There is a potential that the proposed training activities at MMR have the potential to contribute substances to the marine resources, and pose a possible human health risk to area residents who rely on marine resources for subsistence.

This third question posed by the Settlement Agreements calls for a definitive answer concerning whether future training at MMR will result in the release of substances that will, with certainty, contaminated marine resources consumed by local residents for subsistence. This question cannot be answered with certainty because it relies on predictions of the effects of future activities and assumptions based on the assessment of effects from past activities at MMR. Therefore, from a scientific standpoint, we must predict whether or not future training at MMR is likely to cause a human health risk from consumption of marine resources.

For this study, the Army collected samples of edible marine fish and shellfish from three *muliwai* and two nearshore open water sites and *limu* from only the nearshore waters of Mākua. Specimens of target species of fish were collected with nets and by hook and line fishing. *Limu* were collected by hand. Crabs, shrimp, sea urchins and other shellfish were collected by means of crab and lobster traps, and crab nets.

Whole specimens were preserved by freezing and the samples were analyzed by three laboratories to determine concentrations of dioxins/furans, organochlorine pesticides, volatile organic compounds, semi-volatile organic compounds, and metals. A human health risk assessment was performed to evaluate the threat to human health presented by the chemicals identified in the tissues of the organisms, assuming a range of consumption rates considered to approximate the rates of subsistence and recreational fishermen and their families over a 30 year period. The risk assessment compared the risks from consumption of

fish and shellfish collected from *muliwai* and nearshore locations adjacent to MMR to risks from consumption of fish and shellfish collected from "background" locations away from MMR.

The study identified a small increase in cancer risk to people who consume fish collected from *muliwai* or nearshore locations adjacent to MMR compared to background locations. The increased risk associated with consumption of fish collected by subsistence fisherman in the *muliwai* was estimated at seven additional occurrences of cancer per one million people. This is the sum of the risks contributed by all of the individual chemicals detected, most of which contributed very little, because the concentrations were very low compared to the level of cancer threat they present. Most of the cancer risk results from the concentrations of two pesticide compounds (beta and gamma benzene hexachloride (BHC)), and one compound that is a constituent of plastics (bis[2-ethylhexyl] phthalate). These compounds were not detected in fish collected in the background *muliwai*; however, the compounds may not be associated with military training activities at MMR.

The background risk associated with consumption by subsistence fishermen of fish collected in the nearshore waters was estimated at six occurrences of cancer per 100,000 people. Fish caught in the nearshore waters off Mākua Beach contained chemicals concentrations estimated to increase the risk by three occurrences of cancer per 100,000 people. This excess risk was primarily the result of concentrations of the plasticizer bis(2-ethylhexyl)phthalate and the pesticide alpha-BHC, which contributed the equivalent of about two occurrences of cancer per 100,000 people to the total cancer risk in excess of "background." Two additional compounds potentially associated with military activities at MMR (nitroglycerin and RDX) were detected in the Mākua Bay (nearshore waters off Mākua Beach) specimens but not in the background specimens. Concentrations of these two compounds, were detected in two fish specimens, and contributed the equivalent of about one occurrence of cancer per 200,000 people above the background cancer risk associated with eating fish from other waters. It is worth noting that the concentrations of nitroglycerine and RDX are considered uncertain because the levels were extremely low, at or near the laboratory detection limits.

Non-carcinogenic risks were found to be lower for consumption of fish from the *muliwai* adjacent to MMR, or from Mākua Bay, than in the background locations. The study concluded that non-carcinogenic risk levels in the two groups of samples were not significantly different. Concentrations of metals were higher in the background specimens than in the specimens collected near MMR. The single largest contributor to the

non-carcinogenic risk was manganese, a metal that is common in natural sediments and especially in Hawaiian volcanic rocks. The non-carcinogenic risks from manganese in background fish were about three times greater than in fish near MMR. The most significant contributors to the total non-cancer risk are naturally occurring metals (copper, aluminum, selenium, vanadium, and zinc, for example). The remaining chemicals associated with human activities tend to contribute very little to the non-cancer risk, with the exception of mercury. Mercury is widely distributed in fish and originates from a variety of sources. Military activities at MMR are not likely to be a significant source of mercury in the environment.

For shellfish, the risk and hazard estimates were based on the likely fish consumption rate for Hawai‘i (i.e., 100.6 g/day). This rate is higher than the shellfish consumption rate estimated for the US population in general, particularly the rate reported for prepared crab and shrimp (mean of approximately 2 g/day). Carcinogenic risk probabilities were calculated for current and future subsistence shellfish fishermen potentially exposed to the upperbound (maximum) concentrations of COPCs in shellfish harvested at the Mākua *muliwai*. The report found that the incremental carcinogenic risk of consuming shellfish within the Mākua area compared to background sites is approximately four additional occurrences of cancer per one million people. This incremental risk estimate is below the 1×10^{-5} risk level (one person in 100,000 people may develop cancer) used in assessing fish consumption (USEPA 2000). The data given is the sum of the risks contributed by all of the individual chemicals detected, most of which contributed very little, because the concentrations were very low compared to the level of cancer threat they present. The cancer risk associated with shellfish consumption in the *muliwai* results from the concentration of dioxin (tetrachlorodibenzo-*p*-dioxin (TCDD) equivalents). For the nearshore area, the carcinogenic risk probabilities were lower for the Mākua area than background sites. Therefore, there was no incremental risk for subsistence hunters consuming shellfish in the Mākua *muliwai* over background sites.

The non-carcinogenic risk was higher for subsistence fishers consuming shellfish in the MMR area *muliwai*. The overall hazard index was estimated at approximately 14 for the Mākua area *muliwai*, with a background contribution of 9. The incremental hazard (i.e., over background) from shellfish consumption for the *muliwai* was estimated at 5. The incremental hazard over background was largely due to assumed exposures to manganese and possibly cobalt. Other substances detected at greater concentrations within the Mākua area *muliwai* than background *muliwai* were barium, iron, mercury and vanadium. Concentrations of selenium, silver, and zinc were greater in background *muliwai*. It needs to

be reemphasized that there are numerous other natural and anthropogenic sources that contribute these substances to the Mākua and background areas. The incremental hazard (i.e., over background) from shellfish consumption for nearshore waters at Mākua Beach was estimated at 9. The incremental hazard over background was considered to be largely due to assumed exposure to cadmium and perchlorate. Notably, the maximum concentrations of cadmium and perchlorate were found in different types of shellfish in the Kona crab (cadmium) and the helmet urchin (perchlorate) at Mākua Beach.

For recreational fishers, the incremental risk associated with shellfish consumption in the *muliwai* over background locations was two additional occurrences of cancer for every 1 million people. Again, this is assuming the consumption of 100.6 g/day of shellfish from within the *muliwai* for a 30 year period. The increased risk is associated with the concentration of dioxin (tetrachlorodibenzo-*p*-dioxin (TCDD) equivalents). Within the nearshore area, the carcinogenic risk probabilities were lower for the Mākua nearshore than background sites. Therefore, there was no incremental risk for subsistence hunters consuming shellfish in the Mākua nearshore areas over background sites. This was due to a much higher concentration of dioxin in the background nearshore sites.

The non-carcinogenic risk for recreational fishers was greater for the Mākua *muliwai* and nearshore areas compared to background sites. The incremental risk for the *muliwai* was largely due to the assumed exposure to manganese. The nearshore area risk was assumed to be largely due to potential exposure to cadmium. Possible sources of these substances not specifically attributable to military activities are coal and oil combustion, refuse incineration, sewage, wastewater, naturally occurring in rocks and soil, and iron production, to name a few. Lastly, the differences in metals concentrations between the *muliwai* and nearshore and between Mākua and the background sites may be a function of the different species collected at each site rather than a function of location.

The carcinogenic (and the non-carcinogenic) risks from consumption of *limu* were found to be elevated in the local specimens as a result of the presence of arsenic. The risk assessment indicates that if the arsenic detected in *limu* is in the inorganic form, then consumption by subsistence fisherman of 18.2 grams per day (slightly more than one ounce per day) of *limu* from the *muliwai* near MMR would result in one occurrence of cancer per 100 people.

However, arsenic is well-known to concentrate in *limu* tissues as a result of normal processes unrelated to contamination. Studies of edible seaweed indicate that the arsenic concentrations found in the *limu* from the

nearshore adjacent to Mākua Beach are within the range typical of seaweed found elsewhere (FSA 2004). The concentrations of limu found in the study (4.56 to 109 mg/kg) were comparable to concentrations found in marine algae in pristine regions of Antarctica, ranging from 5.8 to 152 mg/kg (Farias et al. 2007). Furthermore, although one species of edible seaweed ("hijiki" found near Japan) has been identified as containing an inorganic form of arsenic that may be toxic to humans, the arsenic present in most edible seaweed species is an organic form that is not toxic to humans (COT 2004).

The marine resources study did not compare the local samples of *limu* against samples from background locations; the Army did not sample *limu* at locations other than Mākua. Without reference to a background site The Army is not aware if the risks at Makua are elevated above the risks at background locations. However, though it may have been preferable to collect limu from background locations, this lack of background for *limu* does not change the actual risk. By not having a background site the Army attributed all the risk to the Mākua area. The actual risks are likely much lower than reported due to the lack of speciation of arsenic. It is not certain whether the observed arsenic concentrations are normal for the type of *limu* collected in the study. As noted above, the observed concentrations were within the normal range for edible species of seaweed, generally.

It should be noted that *limu* species do not have roots as terrestrial plants do. *Limu* absorb nutrients and metals from the ambient water column, not from sediment. Arsenic is a natural constituent of seawater. The concentration and toxicity of arsenic in *limu* tissues is not related to the source of the arsenic or to its concentration in seawater, but to the way that a given species of *limu* processes the arsenic that it extracts from seawater. Due to normal water movement and mixing, it is highly unlikely that arsenic concentrations in the water column of Mākua Beach differ from arsenic concentrations elsewhere in Hawai‘i. Instead, *limu* remove the tiny amounts of arsenic that are naturally present in the ambient water column and concentrate it in their tissues (Eisler 1988). Review of readily available literature on the subject suggests that most species of seaweed that contain seemingly elevated concentrations of arsenic do not present a health hazard because the arsenic is in an organic form that is not toxic to humans and passes through the digestive system without being absorbed in the blood stream.

The Army was presented with responsible scientific opposition to both the methods and conclusions of the MRS. The EIS includes the MRS and responses to comments. The original MRS and comment responses are included in the 2008 Supplemental Draft EIS at Appendix G-8. The final

revised MRS and 2009 comments are included in the Final EIS at Appendix G-8.

Many commentors challenged the selection of background sites and demanded inclusion of a "pristine" background site. The MRS has been revised to contain a more complete discussion of the process and logic used to select the background sites. This shows that the MRS reasonably selected the background sites. It is important to note that chapter 4 of the MRS discloses the "absolute" risk of consuming the marine resources at Mākua without subtracting "background" contamination. The study also shows the "incremental risk," taking into account background contamination. Essentially, this means that a "pristine" source *was* effectively used as a comparison. The MRS does not use these background sites to eliminate MMR as a source for contaminants. Rather, it concludes that marine resources relied upon for subsistence are contaminated by substances associated with the proposed training at MMR. For purposes of the EIS, this information is important for the decisionmaker to take into account. The study also provides information to members of the public both about the proposed action in general and about the safety of food sources.

Another area of dispute was the alleged lack of statistical planning in the collection plan. The distribution of available biomass at Mākua made it impossible to conduct random statistical sampling and still collect sufficient biomass to complete the required analyses. The study did get a representative sample, nonetheless.

A related area of scientific opposition involved the location and quantity of samples collected. There were also comments that the samples could have been more closely tied to the marine resources most commonly eaten. Commentors also suggested that the water and sediments should have been tested. The Army has included responses to these comments. In the end, it is fair to say that the researchers could have collected many more samples and undertaken the survey for a longer period of time. The scope of the study was designed so that it could provide information in a timely way to allow completion of the MRS and the EIS. Despite this, the data were sufficient to support the conclusions. These purported gaps in data must be viewed in light of the fact that there will be a long-term monitoring program to look at the contamination.

Both Dr. Foran and Dr. Rensel comment about the arsenic found in fish and limu. The study did not differentiate between an inorganic form (resulting in elevated estimates of risk) and the less toxic organic form. The MRS assumed all the arsenic was of the more toxic type, leading to a possible overestimation of risk. In response to these comments, the Army

conceded that more information could have been gathered and that the actual risk of arsenic was probably much lower. In the end, there were other substances that drove the conclusions on risk and contamination associated with past and future military training at MMR. Even if all arsenic found were harmless or none found at all, the same conclusions regarding risk and contamination would have been reached. There are abundant references to the "over-conservative" nature of the arsenic findings. These were taken into account in the MRS and are available for the decisionmaker in the EIS.

Another area of scientific controversy is the ecological risk assessment. As with the health risk assessment, commentors point out that the "absolute" risk is missed because of problems with the background sites. Dr. Foran points out problems with bioaccumulation. He also points out why the water and sediments should have been tested as opposed to just the marine resources. Dr. Rensel states that additional trophic levels and seasonal variation should have been taken into account. There is also a question as to whether it was appropriate to do a "screening level risk assessment." As Dr. Rensel puts it, "I find no explanation in [the settlement agreement] to explain why the consultants thought that they were charged with performing a screening-level assessment." Part of the reason was that the Army is required to do more in an EIS than just look at the issues addressed in the settlement agreement; the EIS needs to address overall ecological impacts as well as human health impacts. The screening level assessment is certainly not an exhaustive study but it honestly considers the collected data and draws conclusions. Obviously, decisions made based on this aspect of the EIS will have to take into account all of the issues raised by the two experts, especially the overall problems associated with background site contamination. This portion of the MRS is still adequate, when the overall conclusions about MMR as a possible source for contamination are considered, to inform the public and the decisionmaker about the possible impact to the nearshore and muliwai environment near MMR.

Finally, there were several comments that said the Army was claiming "dilution is the solution" or was otherwise trying to downplay the results of the study. Much of the criticism is based on the fact that both chapter 4 and chapter 5 of the MRS show a measurement of risk that takes into account background levels of contamination. This is belied by the fact that the study clearly shows the estimated risk to human health without background adjustment. The Army frankly admits that there is the potential that substances associated with its training are potentially linked to the contamination in marine resources. Given this, there is certainly no deliberate attempt to conceal adverse information. More importantly, the MRS takes into account the data problems and the issues of background

location. It answers the questions posed in the settlement agreement squarely and serves as part of the hard look the EIS takes at the potential impacts of the proposed action.

Stream Flow and Flooding

The Flood Insurance Rate Map (FIRM) for the site identifies most of the area east of Farrington Highway as Flood Zone D, which includes areas in which flood hazards are undetermined but possible (FEMA 2004). Modeling described in the Hydrogeologic Investigation Report (Appendix G-1) suggests that the low-lying areas on the west side of the installation would be susceptible to flooding in a large storm. Some of these areas may also be subject to flooding from tsunamis. These are large sea waves generated by infrequent and unpredictable events such as earthquakes or submarine landslides, which may occur at great distances from the Hawaiian Islands. Tsunamis vary in height, just as earthquakes vary in magnitude, and the area inundated by a tsunami depends on the height of the wave and the nature of the shoreline. Tsunami evacuation maps have been developed to help people identify and avoid the areas that could be inundated in a large tsunami. The US Pacific Disaster Center's (PDC) Civil Defense Tsunami Evacuation Map indicates that the coastal area of Mākua Valley should be evacuated to a distance inland of at least 200 feet (61 meters) from Farrington Highway and to a distance of 800 feet (244 meters) inland in the lowest areas on both sides of Mākua Stream (PDC 2001). This evacuation area corresponds approximately with the lands within an elevation of about 40 feet (12 meters) above mean sea level (msl).

The Farrington Highway is constructed on an embankment or causeway that restricts the natural drainage from Mākua Valley. The highway is about 20 feet (6 meters) above msl and about 10 feet (3 meters) above the channels of the three streams draining Mākua Valley. The box culverts under Farrington Highway are able to accommodate large runoff events, but it is not known what size floods they can carry.

The largest measured flow event on Mākua Stream occurred in 1976, when the peak flow was estimated to be 3,220 cubic feet per second (cfs) (91 cubic meters per second). The US Geological Survey (USGS) has estimated this to be a 50-year flood event, meaning that based on the available streamflow record, a flow of this magnitude is expected to occur on average about once every 50 years. The USGS estimates the 100-year peak discharge on Mākua Stream to be 5,500 cfs (156 cubic meters per second) (Wong 1994). Extrapolation of the historical record of discharge and elevation reported for the gauge in use prior to 1976 suggests that, in a 100-year flood, the height of water in Mākua Stream would be more than 0.5 foot (about 15 centimeters) higher than the elevation recorded during

the 50-year flow event, which was reported to be approximately 13 feet (4 meters) above msl at that gauge. This is likely an underestimate of the flood elevation because it does not take into account the actual geometry of the channel or any limitations on the capacity of the channel or culverts, which could impede drainage during unusually high flows.

During the next largest recorded flow event, which occurred on November 14, 1996, the elevation of water at the USGS gauge on Mākua Stream was 16.74 feet (5.1 meters) msl. For comparison, this is approximately the ground elevation at monitoring well SP-7. Because the gauge has been moved several times in the past, the elevations cannot be directly compared; the equivalent elevation relative to the gauge that existed in 1976 is estimated to be about 11.6 feet (3 meters) amsl. The estimated recurrence period of the 1996 event is about seven years.

No information is available about flood damage that may have occurred during the 1976 event. In the 1996 event, water from Koʻiahi Gulch (also known as Kaiahi Gulch), the stream farthest south, located near the entrance gate, reportedly flooded the parking lot near the entrance gate. However, the culverts beneath the roadway reportedly accommodated the flow easily, and this flooding was apparently not the result of debris clogging the culverts. These anecdotal data suggest that minor flooding may occur relatively frequently at MMR over the long term, even though stream flows have been relatively small in recent years. Alternately, there may be some physical explanation, other than lack of rainfall, for the apparently low flows observed in recent years. One such factor may be the reported increase in the density of vegetation covering the slopes of the valley. An increase in vegetation could have the effect of slowing runoff and allowing more of the incidental rainfall to infiltrate instead of discharging directly to streams.

The February 14, 2003, storm and the subsequent storms that resulted in measurable stream flows are thought to have been associated with “Kona” storms—a relatively infrequent type of weather pattern typically generated in the Pacific Ocean west of the Hawaiian Islands and associated with higher than normal rainfalls (US Navy undated). Because Kona storms tend to move moisture on land from the west, the mountain ranges do not block the rainfall. The observation of higher rainfall at lower elevations in the valley, which occurred in several of the storms in 2004, is consistent with a westerly or southwesterly storm pattern.

The largest stream flow measured in Mākua Stream during the hydrogeologic investigation was approximately 400 cfs (about 11.5 cubic meters per second), on February 27, 2004. The flow measurement was made shortly after 11:00 AM, or about one to two hours after the peak

rainfall, based on data from the three rain gauges at MMR. The peak rainfall during this storm occurred between 9:00 and 10:00 AM. The rainfall record indicates that the intensity of the storm decreased with elevation. At the portable station, near Farrington Highway, more than 1.5 inches (3.8 centimeters) were recorded during this interval. At the range station, higher up the valley, about 0.9 inches (2.3 centimeters) were recorded, while at the ridge station, only about 0.45 inches (1.1 centimeters) were recorded (US Army 2004).

Finally, a significant shift in the weather pattern over the north Pacific resulted in wet conditions across most of the Hawaiian islands from December 10 through the remainder of 2008. An intense area of rain developed above the west slopes of the Waianae Range and moved northeast into central and northeast O'ahu with peak rain rates in excess of 4 inches per hour. By 8:00 AM HST, 6-hour rainfall accumulations at several sites such as Makaha Stream, Schofield Barracks, and South Fork Kaukonahua Stream exceeded 10 inches (NOAA December 2008 Precipitation Summary).

The December storms resulted in considerable erosion damage to the firebreak roads at MMR. The Army is currently planning repairs so that site access and regular installation maintenance can be resumed. In addition, water and soil sampling was conducted during this time at Koiahi Gulch Stream, Mākua Stream, and Punapohaku Stream. Groundwater samples were collected from the 10 monitoring wells located at MMR, and the Army collected soil samples from nine locations. A summary of the results of this sampling is found in the sub-heading, 2006 to 2008 Hydrogeologic Investigation. Data from these investigations is located in Appendix O.

Surface Water Quality

There are few historic data on surface water quality at MMR. In part, this may be due to the intermittent nature of stream flow at MMR, which makes collecting a representative sample of stream water difficult. Char (1977) collected water samples from the three *muliwai* on the Mākua Valley streams and from reference locations north and south of Mākua Valley. The samples were analyzed for selected metals and for nitrogen. None of the results exceeded regulatory standards at the time.

Surface water was sampled as part of the current hydrogeologic investigation of MMR during a storm on February 14, 2003 (see Appendix G-1). Samples were collected from the lower reaches of Ko'iahi Gulch (also known as Kaiahi Gulch), Mākua Stream, Punapōhaku Stream, and from Kaluakauila Stream near the points where the streams exit the installation boundary. Because no substantial runoff-producing storms are

thought to have occurred during the past three to five years, the runoff from the February 14 storm could have contained contaminants that were deposited on the soil surface throughout the entire period since the last major storm.

A total of 61 samples were collected. Forty samples were collected with an automated sample collection device installed in Mākua Stream, and twenty-one samples were collected manually from the four streams. The samples were analyzed for a variety of analytes, although not all samples were analyzed for the same suite of analytes. Sixty samples were analyzed for total suspended solids, and 57 were analyzed for metals and explosives. Selected samples were analyzed for the full suite of analytical parameters. One set of samples from each stream was analyzed for dioxins and furans. The samples analyzed for the full suite of parameters were selected mainly from among the samples collected early in the runoff event, the reasoning being that the initial stream flow would have the greatest likelihood of containing contaminants.

State of Hawai‘i water quality standards for inland waters are contained in the Hawai‘i Administrative Rules, Title 11, Chapter 54 (HAR 11-54-04). These include a list of numerical standards for specific toxic pollutants and “narrative” standards. Where applicable, the results of the surface water sampling in the hydrogeologic investigation have been compared against the numerical standards for acute toxicity in freshwater listed in the Hawai‘i Administrative Rules. Except for some metals, none of the samples had concentrations that exceeded the acute toxicity standards. The acute toxicity standards for aluminum, copper, nickel, and zinc were exceeded in some of the samples, and some samples contained combined (hexavalent and trivalent) chromium concentrations above the numerical acute toxicity standard for hexavalent chromium. Trivalent chromium is the dominant form in most natural waters with neutral pH. The toxicity of trivalent chromium is far lower than that of hexavalent chromium. HAR 11-54 standards for chronic toxicity, which refers to an average concentration not to be exceeded in any 24-hour period, were exceeded for selenium and heptachlor in some of the samples.

Note that many of the reported metals concentrations were “total” metals, from unfiltered samples; the acute and chronic toxicity standards apply only to dissolved metals. Also, both acute and chronic toxicity are measures that are usually applied to waters below point effluent discharges in order to regulate those discharges. Exceedances of acute toxicity standards for metals in the discharges from intermittent streams are not unexpected under natural conditions in the absence of human sources of contaminants, as a result of oxidation of naturally occurring minerals. This is especially true of those minerals that are abundant in the

soils of the area, such as aluminum, chromium, and nickel. The application of chronic toxicity standards to intermittent stream discharges is especially problematic. These standards are directed toward protecting human and environmental receptors from long-term exposures to low concentrations that may be significant over long periods of time. The opportunities for such exposures do not occur at MMR.

The regulatory standard for combined forms of dissolved inorganic nitrogen (nitrate + nitrite + nitrogen) was exceeded in some samples analyzed for nitrate only (nitrate is expected to be the dominant nitrogen species in waters exposed to atmospheric oxygen at neutral pH). The allowable standard for short duration during wet season flows is 0.30 mg/L, and several samples contained concentrations above 1.0 mg/L. Nitrate may be derived from plant and soil materials, and to a lesser extent from degradation of explosives. Since intermittent stream flows are expected to transport large loads of sediment and weathered organic material that has accumulated on the land surface during periods between significant rainfall events, it is not surprising to observe slightly elevated nitrate levels in natural intermittent stream flows for short periods of time.

Flows in the intermittent streams of Mākua Valley fit the state definition of Class 2 Inland Freshwaters. The objective for Class 2 waters is to "protect their use for recreational purposes, the support and propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation." The objectives provide guidance where numerical standards have not been defined. With regard to the intermittent streams at Mākua Valley, protection for support and propagation of aquatic life is assumed to imply protection of either marine aquatic life or aquatic life in the *muliwai*.

Stream water is not used for drinking, and drinking water standards, such as the EPA maximum contaminant limits (MCLs), are not considered applicable to the stream water in Mākua Valley. Nevertheless, water sample results have been compared to MCLs and EPA Region IX Preliminary Remediation Goals (PRGs) for tap water because they represent conservative health-based standards that would be protective of human health if the water were used for drinking. In general, the tap water PRGs are set at a more conservatively low level than MCLs. Also, PRGs have been established for more compounds than have MCLs.

In the sample collected from Ko‘iahi, or Kaiahi, Gulch at the beginning of the flow event in February 2003, four chlorinated pesticides were detected at concentrations above the EPA Region IX tap water PRGs. In four samples from Mākua Stream, benzene, thallium, and iron were detected at concentrations above the tap water PRGs. In one sample from Punapōhaku

Stream, two pesticides and thallium were detected at concentrations above the PRGs. Other chemicals were also detected, but the concentrations were generally below the PRGs.

In some samples, compounds were detected for which PRGs have not been established, including various isomers of dioxins and furans (isomers are molecules with the same chemical formula but different chemical structures). A tap water PRG has been established for the most toxic isomer of dioxin (2,3,7,8-TCDD), and the concentrations of other dioxin isomers can be expressed as equivalent concentrations to that isomer.

The equivalent concentrations of dioxins and furans detected in the stream water sample from Kaiahi Gulch exceeded the EPA Region IX tap water PRG for the 2,3,7,8-TCDD isomer, when the 1989 EPA toxicity equivalency factors were used to calculate the equivalent toxicity of the OCDD and OCDF dioxin and furan isomers, respectively. If the toxicity equivalency factors published in 1997 by the United Nations are used instead, the equivalent concentrations are lower than the tap water PRG. The tap water PRG is 0.5 picograms per liter, which is one millionth of one millionth of a gram per liter. The equivalent concentration in the sample from Koʻiahi, or Kaiahi, Gulch was about two times the standard. However, the concentration was within the human health risk range considered acceptable by EPA. Since dioxins and furans are present in background soils, and because the stream water samples contained suspended sediment that was analyzed along with the water, it is likely that the dioxins and furans in the stream water samples reflect sediment-borne concentrations of these chemicals.

As with dioxins, the chlorinated pesticides detected in the stream water samples are highly insoluble in water. These pesticides were likely bound to soil particles that were carried into the stream channel by surface runoff. The combined cancer risks represented by the pesticide concentrations detected in the sample from Koʻiahi, or Kaiahi, Gulch (assuming, as above, that the unfiltered stream water could be a source of drinking water), is 1.6×10^{-05}. This value is about 16 times the one per one million cancer risk threshold, but within the excess cancer risk range of 10^{-06} to 10^{-04} that is considered acceptable by EPA.

Of the metals, only iron and thallium, both noncarcinogens (chemicals that do not cause cancer), were detected above their respective tap water PRGs. As discussed further in Section 3.8, Geology and Soils, some metals, such as iron, are naturally present in Hawaiian soils at high concentrations. Thus, the presence of iron above the tap water PRG probably resulted from the iron contained in soil particles entrained in the unfiltered samples. Thallium exceeded the PRG in only two samples.

Of the compounds that were detected in the surface water samples at concentrations below their respective tap water PRGs, the most frequently detected were gasoline components, including benzene, toluene, ethylbenzene, and isomers of xylenes (the so-called BTEX compounds). Several other volatile organic compounds were also detected that may be associated with petroleum fuels. The low concentrations of gasoline or fuel constituents are not surprising because gasoline-powered grass-cutting equipment is routinely used at MMR.

Of 57 samples collected during the February 2003 event, only 3 had detectable concentrations of explosive compounds: perchlorate (detected in two samples) and 2,4-DNT (detected in one sample). Perchlorate was detected in two duplicate samples from Kaiahi Gulch at concentrations of up to 2.6 µg/L. This is less than the tap water PRG of 3.6 µg/L. Perchlorate is used as a propellant in some munitions and may be present in small quantities in the high explosive mixtures of munitions. It is highly soluble in water. 2,4-DNT (2,4-dinitrotoluene) is a high explosive similar to TNT (2,4,6-trinitrotoluene) and can either be present in munitions or can result from the chemical breakdown of TNT. Since TNT is more common in munitions than DNT and because so few explosives were detected, the more likely explanation for the presence of DNT is that it results from TNT degradation. The DNT was detected at concentrations of up to 3.1 µg/L in two samples from Mākua Stream. This is below the tap water PRG of 73 µg/L for 2,4-DNT.

The results from the samples collected in the later events in January and February 2004 showed similar results. RDX was detected in four samples from Mākua Stream, at concentrations of up to 1.7 µg/L, but was not detected in samples from the other streams. The drinking water PRG for RDX is 0.61 µg/L, and the detected concentration of RDX was below the PRG in two of the samples. No dioxins were detected in Ko‘iahi, or Kaiahi, Gulch samples from the 2004 events. Most of the dioxin detections in the 2004 flow events were in samples from Kaluakauila Stream.

As expected, total metals concentrations generally increased with sediment concentration. This is likely because the metals are a constituent of the minerals in the sediment. Lead and arsenic do not appear to follow this trend so closely, but neither compound was detected frequently. For example, lead was detected in only nine samples from three streams during the 2004 flow events, while arsenic was detected in only seven samples, all from Mākua Stream.

The Hydrogeologic Investigation Report also includes a comparison of the data to EPA Region V Ecological Data Quality Levels for Surface Water,

and to State of Hawai‘i Tier I action levels for rainfall less than 200 centimeters per year (the Hydrogeologic Investigation Report is included as Appendix G-1).

Coastal Water Quality

Coastal water quality and live coral may be affected by sediment discharged from streams and by nutrients or toxic chemicals carried in stream runoff. The HDOH maintained monitoring station 184 near the beach at the north end of Mākua Valley between July 1970 and October 1975, during which time it collected samples to measure physical, chemical, and microbiological parameters. Although this station was well north of Mākua Stream, Char (1977) noted that, based on one study of ocean currents in the area, the discharge from streams draining Mākua Valley would mix rapidly with the receiving ocean waters and that water quality should be similar everywhere along the beach.

Currently, all marine waters in Hawai‘i are classified as either Class A or Class AA, based on protection of water quality (HAR Chapter 54 11-54). Class A waters are considered to require less protection, and lower water quality standards apply to them.

Studies of coral reefs in many areas of the Hawaiian Islands have been undertaken or are ongoing, but there are no current studies of the corals adjacent to Mākua Valley (CRAMP 2003; Dollar 1999). Evidence of damage to corals offshore of Mākua Valley was from sedimentation following the flood in February 1976 (Chave, no date). Sediment can affect live coral in a number of ways, including covering the organisms, blocking light, and causing abrasion. The coral reportedly was showing evidence of recovery from the effects of sedimentation by September 1976 (Char 1977). At the time, erosion of roads in the OB/OD area was thought to be a major source of the high sediment loading observed during this storm, and the MMR roads were subsequently hardened with crushed coral to reduce erosion. Increased grass cover in Mākua Valley since this time may also have helped to reduce hill slope erosion rates.

Groundwater Occurrence and Flow

Mākua Valley is within the Kea‘au subunit, the most northerly of the five subunits that make up the Wai‘anae Hydrologic Unit. The Kea‘au subunit is bounded on the north by the Mokulē‘ia subunit, in which DMR is located, and the Mākaha subunit, which includes the Mākaha Valley. The Kea‘au subunit functions primarily as a groundwater management concept. The sustainable yield of the Kea‘au subunit is estimated at 4 million gallons (15 million liters) per day, based on general estimates of the proportion of the total rainfall that recharges groundwater (Takasaki and Mink 1985).

Groundwater in the upper portion of Mākua Valley is believed to occur primarily in dike-impounded conditions. Some of the rainwater that falls on the higher elevations in the Wai‘anae Range seeps into joints and fractures and along bedding in the volcanic deposits until it is blocked by vertical sheets of basalt that were intruded into the existing volcanic rock along fractures. The dike-impounded groundwater contained in the basalts that line the valley flows into the sedimentary deposits that fill the valley and is a primary source of recharge to the alluvial aquifer. These valley fill deposits consist of permeable sediments interbedded with less permeable sediments. These sediments were the result of cycles of deposition, followed by erosion, and further deposition over thousands of years. As the sea level receded relative to the land, some of the sediments that had been deposited on the sea bottom were eroded away. These changes in depositional conditions produced differences in permeability of the sediments that affect groundwater flow.

There were reportedly two tunnels in the southern part of upper Mākua Valley (Stearns and Vaksvik 1935), and Kelly and Quintal (1977) provide a map showing two tunnels near a parcel owned by Lincoln McCandless, a water engineer. The tunnels were reportedly at an elevation of about 1,100 feet (335 meters) and produced about 750 gallons (2,839 liters) per day, which was piped to the lower valley. There is reportedly no remaining evidence of the tunnels (Kelly and Quintal 1977). The tunnels may have been located near one of the five springs that reportedly were in Mākua Valley (Kelly and Quintal 1977). One of these five springs was recovered during field investigations following the July 2003 prescribed burn. USGS topographic maps indicate springs in the upper valley, at about 1,200 feet (366 meters) elevation on the south wall of the valley and at about 700 feet (213 meters) elevation near the head of Mākua Stream. Springs may indicate locations where dike-impounded groundwater spills to the surface; the elevations of the springs depend on the configurations of the dikes.

The USGS installed six shallow monitoring wells in 1962 near Farrington Highway, five near the mouth of Mākua Stream and one near the mouth of the Ko‘iahi Gulch (also known as Kaiahi Gulch) Stream. Most of the wells were drilled to a depth of 10 or 20 feet (3 or 6 meters), while one was drilled to a depth of 90 feet (27 meters) (USGS no date). Two additional wells, one for Ka‘ena State Park and one belonging to the Air Force, were installed near the north side of Kahanahāiki Valley, near Farrington Highway. The Air Force well was drilled to a depth of 50 feet (15 meters) from a land surface elevation of 26 feet (8 meters). The state park well was drilled to a depth of 80 feet (24 meters) from a land surface elevation of about 60 feet (18 meters).

During drilling, groundwater was first observed in the state park well at a depth of about 8 feet (2 meters). Subsequent monitoring indicates that the groundwater elevation ranges from about 6.5 to 7.5 feet (approximately 2 meters). Each of these wells appears to have intercepted groundwater at depths of less than 10 feet (3 meters). The groundwater was present in a layer of clinkers (loose volcanic material ejected from a volcano that resembles dense pumice) and fractured ʻaʻā lava within the Waiʻanae Volcanics formation. The yield of the state park well was tested at 100 gallons (379 liters) per minute (USGS no date).

2002-2003 Hydrogeologic Investigation

The Army began the hydrogeologic investigation of MMR to obtain additional data to evaluate existing conditions. The investigation included installing nine monitoring wells and rehabilitating an existing monitoring well that was installed as part of the 1994 Halliburton study (Halliburton NUS Corporation 1994). Representative groundwater samples were periodically collected from these ten wells to evaluate trends in water quality and groundwater elevation over time.

In addition to monitoring groundwater quality, the wells are intended to help with the following:

- Identification of groundwater depths at points throughout the floor of the valley;
- Identification of groundwater flow pathways; and
- Evaluation of the role that groundwater may play in the transport of contaminants in the subsurface at MMR.

The thickness of the sedimentary deposits that overlie the basalt bedrock has not been determined, but it likely extends to at least 300 feet below sea level near the shoreline. Within the depths that were explored during the current hydrogeologic investigation, the sedimentary deposits observed include alluvium and colluvium, reef deposits, and possible windblown sands. The hydrogeologic investigation focused on the freshwater in the uppermost portion of the aquifer, generally above an elevation of 100 to 150 feet (30 to 45 meters) below msl.

The direction of groundwater flow in the alluvial aquifer beneath Mākua Valley had not been determined prior to the current hydrogeologic investigation. The presumed direction of flow of this basal groundwater was toward the ocean, although local variations were expected to occur. The term basal aquifer refers to “a lens of freshwater that floats on saltwater within an aquifer, with the freshwater head in the aquifer near sea level” (Nichols, Shade, and Hunt 1996). Also, high-level groundwater

(impounded behind dikes) generally was expected to flow downward from recharge areas on mountain ridges toward the basal aquifer, through fractures and by overflowing the dikes. It has been theorized that there may be a tenuous hydraulic connection, through the volcanic dike system, between high-level groundwater in the Mākaha Valley and high-level groundwater in the Mākua Valley (WRRC 1992). The presumed direction of flow, toward the northwest, was described as "from Mākaha to Kea'au, and then into the ocean," possibly based on interpretation of the elevations of groundwater in wells in the Mākaha Valley. However, the nature and significance of this connection, if it exists, is unknown. Based upon existing hydrogeologic studies as outlined in Appendix G-1, groundwater flows mauka to makai (mountain to ocean) and is not expected to influence groundwater in adjacent valleys.

To further investigate groundwater flow conditions, nine new monitoring wells were installed at five locations, including one upland location (ERDC-MW-5) and four locations near the western boundary of the installation (ERDC-MW-1, ERDC-MW-2, ERDC-MW-3, and ERDC-MW-4).

Well ERDC-MW-5 was installed about 7,500 feet (2,300 meters) inland from the shoreline. A thick sequence of clayey alluvial and colluvial sediment was encountered from the surface to a depth of 220 feet (67 meters) below the ground surface (bgs). Within these deposits, there was no evidence of coarse sedimentary layers or perched groundwater. From 295 feet (90 meters) to 320 feet (97 meters) bgs, a deposit of fine-grained silty sand was encountered. Groundwater was not observed at this depth. Groundwater was first observed when a layer of gravel, in a silty matrix, was encountered at a depth of about 295 feet (90 meters). The boring was extended to a depth of about 360 feet (110 meters). The gravel, a well-rounded, poorly sorted stream gravel, increased in size with depth. Sediments above the gravel are of such low permeability for water that they effectively confine the water contained in the gravel layer and keep it under pressure. The low permeability of the alluvium would not only resist upward flow of groundwater but also downward flow.

Three of the well sites close to the western boundary of the installation (ERDC-MW-1, ERDC-MW-2, and ERDC-MW-3) are adjacent to the three streams that drain MMR. The fourth (ERDC-MW-4) is near the range control facility just north of the entrance gate. One existing well (SP-7), which is near Mākua Stream, was rehabilitated and was also included in the monitoring well network. ERDC-MW-3 and ERDC-MW-4 each consist of a cluster of three monitoring wells screened at different depths. The wells are identified as A, B, and C, from shallowest to deepest. The wells were installed to different depths in order to determine

if there are differences in groundwater quality associated with depth. Table 3.7-1 shows the location and screen interval for each monitoring well.

Table 3.7-1
Monitoring Well Screened Depths and Elevations

Well Number	Well Location	Screen Depth (feet, bgs)	Screen Elevation (feet, msl)
ERDC-MW-1	Near mouth of Kaiahi Gulch	6 to 36	+3 to –27
ERDC-MW-2	Near mouth of Punapōhaku Stream	6 to 36	+3.5 to –26.5
ERDC-MW-3A	Near Range Control Office, south of mouth of Mākua Stream	15 to 45	+3 to –27
ERDC-MW-3B	Same as MW-3A	44 to 69	-26 to –51
ERDC-MW-3C	Same as MW-3A	70 to 100	-52 to –82
ERDC-MW-4A	North of mouth of Mākua Stream	15 to 45	+3 to –27
ERDC-MW-4B	Same as MW-4A	45 to 70	-27 to –52
ERDC-MW-4C	Same as MW-4A	70 to 100	-52 to –82
ERDC-MW-5	Approximately one mile east of MW-4	215 to 320	+20.35 to –84.65
SP-7	Side of Mākua Stream, near mouth.	12 to 22	+5.39 to –4.61

Valley fill deposits probably extend to much greater depths than the depths to which the wells were drilled. Since the shoreline wells were completed to a maximum depth corresponding to an elevation of 82 feet below msl, and the inland well, ERDC-MW-5, was drilled to a depth corresponding to an elevation of about 225 feet (69 meters) below msl (143 feet [44 meters] lower in elevation than the deepest shoreline well), and because the bedrock basement of Mākua Valley probably slopes to the west, it seems that the bedrock basement is quite a bit deeper near the shoreline than the depths of the wells installed there.

Although no clear correlation between subsurface layers in different portions of the investigation area have been established, the elevation of the top of the gravel layer encountered at ERDC-MW-5 (62 feet [19 meters] below msl) and the elevation at which the basalt boulders were encountered in the shoreline wells (about 50 feet [15 meters] below msl) are similar enough to suggest that the gravels and the basalt boulders were deposited at about the same time. Therefore the gravels and basalt boulders may represent parts of the same laterally connected aquifer.

<u>2002-2003 Hydrogeologic Investigations of Groundwater Elevations</u>
Six rounds of groundwater sampling were completed for the hydrogeologic investigation (in December 2002, January/February 2003, April 2003, June/July 2003, September 2003, and December 2003/January 2004). The results are presented in detail in Appendix G-1 and are summarized here.

Groundwater depths and elevations in the monitoring wells are presented in Table 3.6-4 in the Draft Hydrogeologic Investigation Report (Appendix G-1 of the EIS). Groundwater depths were measured in the wells at the time of sampling.

Based on recorded data, the groundwater gradient appears to be in the general direction of the ocean from ERDC-MW-5, with a magnitude on the order of about 10.5 to 11.5 feet (3.2 to 3.5 meters) over a distance of about 7,500 feet (2,300 meters), or about 0.0015 foot per foot. The direction of the groundwater gradient and rate of groundwater flow is discussed further in the context of groundwater modeling below.

Two well clusters (ERDC-MW-3A, -3B, and -3C, and ERDC-MW-4A, -4B, and -4C) provide information about vertical hydraulic gradients in the aquifer at these locations from January 2003 to April 2003. Differences in the elevation of groundwater in wells screened at different depths in an aquifer suggest the possibility that there may be a vertical component of flow in the aquifer because groundwater tends to flow in the direction of the portion of the aquifer with the lowest groundwater elevation. Groundwater gradients are of interest because they help in understanding groundwater flow pathways and groundwater travel times. These results indicate that small changes in vertical flow patterns probably occur in the aquifer over time. However, the dominant pattern is the horizontal flow from points higher in the valley toward the ocean.

The elevation in ERDC-MW-5, which is inland of the other wells, was measured at 14.64 feet (4.46 meters) msl on January 24, 2003. The fact that the elevation of groundwater in ERDC-MW-5 is higher than the gravel and sand units and rises within the depth of the clayey silt deposits suggests that the groundwater may be under confining pressure. This observation and the presence of a thick sequence of fine sediments above the gravel unit, including clays and silts that are expected to have very low permeability, suggest that most of the recharge to this aquifer may come from another area of the valley. ERDC-MW-5 is on a topographic high point that separates the Mākua Stream drainage from the drainage of Ko‘iahi, or Kaiahi, Gulch. If the gravel unit is relatively horizontal and extends inland to the surrounding basalt bedrock walls of the valley, then the recharge to this aquifer unit may be primarily from deep infiltration through conduits in the bedrock the forms the sides of the valley.

<u>2002-2003 Hydrogeologic Investigations of Groundwater Quality</u>

The results of six rounds of groundwater sampling between December 2002 and January 2004 indicate that few compounds are present in the groundwater at concentrations that exceed either EPA primary drinking water standards or tap water PRGs.

In the first round of groundwater sampling, completed in December 2002, the explosive compound RDX was detected in only one well (ERDC-MW-4A; see Figure 3.7-2), at a concentration of 0.620 μg/L. This was just above the PRG of 0.610 μg/L. RDX was detected in the same well in the next sampling round at a concentration of 0.48 μg/L. Another explosive compound, 2,4,6-TNT, was detected in December and January from this well at 0.61 and 0.28 μg/L. These concentrations are well below the PRG of 2.2 μg/L.

Benzene was detected at a concentration of 0.92 μg/L in ERDC-MW-3B, slightly above the PRG of 0.35 μg/L but below the MCL of 5 μg/L. Benzene was detected again in this well in the second round of sampling in February 2003 at a similar concentration; benzene was not detected in the other two wells screened above and below this well at the same location. Other fuel constituents, including xylenes, ethylbenzene, and toluene, and 1,2,4-trimethybenzene, were detected at least once in all of the wells but at concentrations at least two orders of magnitude below the respective PRGs.

Heptachlor epoxide, an organochlorine pesticide, was detected in ERDC-MW-3C in the second round of sampling (but not in the first round) at a concentration of 0.039 μg/L, which is above the PRG of 0.007 μg/L but less than the MCL of 0.20 μg/L. Endosulfan I, another chlorinated pesticide, was also detected in this well in the second round of sampling, at a concentration of 0.45 μg/L, well below the PRG of 220 μg/L.

A number of dioxin isomers were detected in groundwater samples collected in December 2002 and February 2003. As described for the surface water samples, the dioxin results were converted to 2,3,7,8-TCDD equivalent values for comparison to the EPA tap water PRG for 2,3,7,8-TCDD. 2,3,7,8-TCDD equivalent concentrations for the combined dioxin and furan isomers were less than the tap water PRG in most of the samples except those from ERDC-MW-2 and ERDC-MW-5. In ERDC-MW-2, the sum of the 2,3,7,8-TCDD equivalent concentrations for all of the dioxin and furan isomers detected resulted in an equivalent concentration of 5.53×10^{-07} μg/L, which slightly exceeds the tap water PRG of 4.5×10^{-07} μg/L. In the sample from ERDC-MW-5, the sum of the equivalent concentrations was 6.84×10^{-06} μg/L, which is about 15 times the tap water PRG. These concentrations are within EPA's acceptable health risk range. Additionally, the samples were unfiltered and may reflect concentrations of dioxins and furans bound to entrained soil particles, which would normally be removed by filtration if the water were used for drinking. Note also that these particle-bound contaminants may have been introduced to the well during well construction.

Similar results for organic chemicals (other than dioxins and furans) were observed in groundwater samples from the April and June/July 2003 monitoring rounds. Benzene was detected below 1 μg/L in ERDC-MW-3B in April and June (the drinking water standard is 5 μg/L). The chlorinated pesticides alpha-, beta-, and delta-BHC were detected in ERDC-MW-3B in April 2003, at concentrations less than 1 μg/L and only slightly above their respective tap water PRGs. The chlorinated pesticide endosulfan I was detected in ERDC-MW-3C at less than 1 μg/L in April 2003 and far below the tap water PRG of 220 μg/L. Perchlorate, a highly soluble explosive compound, was detected at a concentration of 1.5 μg/L in ERDC-MW-4B in June 2003, which is less than half the tap water PRG of 3.6 μg/L. Perchlorate was not detected in groundwater prior to June 2003. Bis(2-thylhexyl)phthalate, a plasticizer, was detected at 14 μg/L in ERDC-MW-4C. However, the result was flagged as uncertain because the result was lower than the laboratory reporting limit. Toluene (a gasoline constituent) was detected sporadically in several wells in April and June 2003, at concentrations below or slightly above 1 μg/L, including in ERDC-MW-3C in April 2003, and in ERDC-MW-2 and ERDC-MW-4B in June 2003. Toluene was also detected in a rinsate sample, suggesting that the toluene may have been introduced from atmospheric contamination or some other source not associated with groundwater.

The metals arsenic and thallium were detected in some wells. Arsenic was reported at concentrations above tap water PRGs in samples from ERDC-MW-3C, ERDC-MW-4A, ERDC-MW-4C, and ERDC-MW-5 in the first sampling round, at concentrations ranging from 0.0027 mg/L to 0.0097 mg/L. The tap water PRG is 0.000045 mg/L, which is below the analytical method detection limit. However, none of the detected concentrations exceeded the MCL for arsenic, which is 0.010 mg/L, although the concentration in ERDC-MW-5 was nearly at the MCL. Interestingly, arsenic was not detected in any of the samples collected after the first round of sampling. This suggests that the arsenic may have been introduced during drilling and well construction.

Thallium was reported in the first round of sampling only in ERDC-MW-5, at 0.012 mg/L. It was reported only in ERDC-MW-5 again in the second round of sampling but at a much lower concentration of 0.00019 mg/L. It was not detected in ERDC-MW-5 in the subsequent rounds of sampling but was detected in ERDC-MW-4A and ERDC-MW-4B in the third round, at concentrations of 0.009 and 0.006 mg/L. In the fourth round, it was detected only in ERDC-MW-3B and only in one of two duplicate samples, at a concentration of 0.00034 mg/L. The tap water PRG for thallium is 0.0024 mg/L, and the MCL is 0.002 mg/L. Therefore, thallium exceeded the MCL only in the sample from ERDC-MW-5 in the first round of sampling.

Overall, the groundwater sampling data show that sporadic detections of trace levels of several groundwater contaminants have been observed, but the results suggest that the groundwater does not contain concentrations that present a significant risk to human health. The explosives RDX, TNT, and perchlorate were detected only in wells ERDC-MW-4A and ERDC-MW-4B. Benzene was detected in well ERDC-MW-3B, and the pesticides heptachlor epoxide and endosulfan I were detected only in well ERDC-MW-3C. Dioxins were detected above PRGs in two wells but were detected at lower concentrations in all wells, suggesting a ubiquitous source. The sources of some of the detected compounds, including pesticides and dioxins, is uncertain because they are likely to be chemically bound to sediment or soil particles and therefore may have been introduced during drilling or well construction, rather than being transported by groundwater. Further, long-term sampling has been proposed to help reduce the uncertainty associated with sporadic or anomalous detections and to confirm trends.

Vadose Zone Monitoring

The vadose, or unsaturated, zone is what lies between the ground surface and the water table (or a confined aquifer). In the vadose zone, the pores between the sediment particles are not saturated with water or are only temporarily saturated (as after a heavy rain). Also in the vadose zone, groundwater is either moving downward by gravity or is held in place by capillary forces.

In the hydrogeologic investigation at MMR, several borings were drilled to install water collection devices (lysimeters) in the vadose zone to test the quality of the water present within that zone.

Lysimeters were installed in two borings placed in the OB/OD area and in one boring placed near the junk car pit. These sites were selected for lysimeter sampling because they were considered to be more likely to provide an indication of the downward migration of contaminants over time. Soil samples were collected from the borings at 5-foot (1.5-meter) intervals, and then lysimeters were installed at selected depths in the borings. The borings were intended to be drilled to 50 feet (15 meters), but the actual depths of some of the borings were limited by materials encountered in the holes. For example, a large rock was encountered in one boring in the OB/OD area at a depth of 45 feet (14 meters), and another large rock was encountered at 25 feet (8 meters) in the other boring. The second boring was drilled through the rock, until gravel was encountered at 45 feet (14 meters). The boring at the junk car pit stopped at 20 feet (6 meters) due to the presence of gravel and rocks. Lysimeters were installed at depths of 30 feet (9 meters) (SB1A) and 45 feet (14 meters) (SB1B) below the surface in one boring and at depths of 30 feet (9

meters) (SB2A) and 42 feet (13 meters) (SB2B) in the other boring in the OB/OD area. One lysimeter was installed at a depth of 19 feet (6 meters) (SB3A) in the boring at the junk car pit.

Lysimeters allow the repeated collection of samples over time, as soil pore water continues to accumulate in the porous cup. Pore water samples were collected in April and July 2003. In both rounds of lysimeter sampling, some of the lysimeters were dry or contained insufficient water to enable analysis of all of the analytes intended (explosives, nitroglycerine, metals, and volatile organic compounds).

The results are presented in the Hydrogeologic Investigation Report. Only four chemicals (the chlorinated volatile organics carbon tetrachloride and chloroform and the explosives RDX and HMX) were detected at concentrations above the EPA Region IX tap water PRGs, which were used as a conservative reference for comparison. RDX was detected in one of the shallow lysimeters at the OB/OD area (SB1A), at concentrations of up to 4,800 µg/L, and in the other shallow lysimeter (SB2A) at a concentration of 27 µg/L. RDX was detected in the deeper lysimeter at the OB/OD area (SB1B) at a concentration of 2,900 µg/L. This sample also contained 2,700 µg/L of HMX. The deep lysimeter in the other boring at the OB/OD area contained 33 µg/L of RDX. HMX was detected in the other lysimeters at the OB/OD area, at concentrations ranging from 2.9 to 1,400 µg/L. Two other explosives, 2,4-DNT and tetryl, were detected at low concentrations in some samples from the OB/OD area. Of the explosives, only tetryl was detected in the lysimeter in the junk car pit, at a trace concentration.

These results indicate that RDX and several other contaminants have migrated to depths of at least 50 feet (15 meters) below the surface beneath the OB/OD area. The maximum depth of migration of RDX or other compounds was not determined, but given the low permeability of the sediments beneath the OB/OD area, which impedes the downward movement of groundwater, it is likely that the concentrations would decrease substantially with depth. Because the OB/OD area was used for disposing of large quantities of explosives, these results are not likely to be representative of the rest of the training area, and in fact the results from the junk car pit suggest that much lower concentrations of contaminants are present in the vadose zone there, even at shallow depths.

The soil samples from the boreholes in which the lysimeters were installed did not contain detectable concentrations of the explosives that were detected in the pore water samples from the lysimeters. The only explosive that was detected in the soil samples was perchlorate (which was not included in the analytical suite for the lysimeter samples). RDX,

HMX, 2,4-DNT, and tetryl were not detected in the soil samples. This suggests that only very small quantities of these compounds are carried downward, dissolved in percolating water, and that the concentrations in soils are low because the amount of water present in the soil is low.

This probably explains why RDX was not detected in the borehole samples. For example, suppose that the porosity of the sediments in the vadose zone is about 30 percent of the volume of the sediments and that the pores are only 25 percent saturated with water. For sediments with a density about two and a half times that of water, the soil moisture content under these conditions would be on the order of about one percent of the weight of the soil. The maximum concentration of RDX detected in the pore water samples was about 3,000 µg/L, which is about three parts per million by weight. One percent of this, which is the amount that would be present in an equivalent weight of soil, would be only 30 parts per billion in soil, which is well below the detection limit of RDX in soil. Under these conditions, if nearly all of the RDX were present in the pore water, then the RDX would not be detected in a soil sample containing this pore water.

RDX tends to bind to the surface of soil particles if the soil contains natural organic material. But most of the natural organic material in most soils is found in the surface layer of the soil. The amount of natural organic material tends to diminish greatly with depth below the root zone of plants. Therefore, if the RDX were deposited on the ground surface, most of it would be expected to bind with the natural soil organic matter in the top soil, and a relatively small percentage would dissolve in soil pore water and be carried downward through the soils. At depths of 30 to 50 feet (9 to 15 meters), the amount of RDX that binds with the sediment particles would be much less than in the surface soils, and a larger percentage of RDX would remain in the soil pore water. There is no indication that RDX has migrated to the depth of the groundwater aquifer beneath the OB/OD area; RDX was not detected in groundwater from MW-5, the well nearest to the OB/OD area.

Results of Numerical Modeling of Groundwater Flow

A numerical model of the Mākua Valley groundwater flow system was developed as part of the current hydrogeologic investigation and is described in Appendix G-1 of the EIS. The model represents the flow system in three dimensions, and covers an area of about 6.5 square miles (16.8 square kilometers) representing the entire Mākua Valley. The model was constructed with 12 layers, so that hydraulic parameters could be varied with depth. Based on estimates from available published studies, recharge (from rainfall) was assumed to equal four million gallons per day, and was assumed to originate from zones with three different rates of

recharge, resulting from different rainfall amounts controlled mainly by elevation.

Once the model was calibrated so that it gave a reasonably close representation of observed water levels, it was used to estimate flow rates along migration pathways within the valley. For example, based on the assumptions of the model, it was estimated that it would take about 66 years for groundwater to travel from a point in the aquifer beneath the OB/OD area to the shoreline.

Results of Numerical Modeling of Contaminant Transport

The numerical groundwater model was used to estimate the travel time and change in concentration of chemical contaminants injected into groundwater at a particular point in the valley. The estimate of travel time takes into account the chemical dispersion (mixing and spreading out) of the chemical in the water as it is carried along the groundwater flow path, and the model can also be used to account for the retardation (delay) of the chemical when it interacts chemically with sediment particles in the aquifer. RDX was selected to represent the worst-case scenario for chemical transport from the live-fire training area because it is not only the most prevalent explosive compound but it also has a relatively high toxicity, is not very interactive with sediments and soils (so travels at about the same rate as groundwater), and degrades relatively slowly in the environment. All other explosives compounds used in the proposed live-fire exercises are expected to have less of an impact on groundwater at the installation boundary than RDX.

The results of these simulations for indicated that if RDX continuously entered the water table beneath the entire 5-acre (2-hectare) OB/OD area at a concentration of 0.16 mg/L, assuming no retardation in the aquifer (worst case), the concentration at the shoreline would be 2 μg/L (slightly above the tap water PRG of 0.61 μg/L) after 50 years. The decrease in concentration in this scenario is entirely the result of dispersion. The model indicated that the plume would migrate much more slowly if a retardation factor were applied. Additional simulations were performed based on the assumption that up to 8 grams of RDX residue would be generated per year in the CCAAC from live-fire exercises. It was further assumed that 43 percent of this amount would reach the water table, resulting in a groundwater concentration beneath the CCAAC of 0.16 mg/L. The groundwater model indicated that, with no retardation, the concentration of RDX in groundwater at the installation boundary after 50 years would be 1.5 μg/L. With retardation taken into account, the plume would migrate much more slowly, and concentrations would not be measurable at the installation boundary after 50 years. In addition, modeling runs for density-dependent flow and transport are included in

Appendix H-2 of the Hydrogeologic Investigation Report, included as Appendix G-1. The estimates provided by these additional runs were similar to those described above.

The modeling results are based on a number of simplifying conservative assumptions that may result in an overestimate of the concentrations in groundwater over time. These include the assumption that there is a constant source of RDX entering groundwater and that there is no further degradation of the chemical after it reaches groundwater. Due to the relatively slow rate of groundwater flow and the effects of dispersion, the results suggest that the existing monitoring wells would likely show a very slowly increasing trend in concentrations (over many years) in monitoring wells located along the installation boundary if a plume were indeed migrating downgradient of a source of groundwater contamination. Although no such trend has been identified during the current hydrogeologic investigation, the model results suggest that it may be too soon to observe such a trend.

2006-2008 Hydrogeologic Investigation

To assist the Garrison in developing data on the munitions' constituent levels in groundwater, storm water, and sediment throughout the operational range assessment program (ORAP), administered by the U.S. Army Environmental Command (USAEC), a study is underway to evaluate off-site migration of these munitions constituents. Munitions constituents include metallic and explosive compounds. Since concern has been expressed over the possibility of munitions' constituent migration from training areas at MMR, this range was selected for sampling in 2006-2008 as part of this program. Results of this study, as summarized below, and are explained in ERDC 2009.

Surface water sampling included sampling on Koiahi Gulch Stream, Mākua Stream, and Punapohaku Stream during three (3) small storms and one very large rain-storm in Mākua Valley during the sampling period (January 2007 through December 2008). Groundwater samples were collected from the 10 monitoring wells at MMR. For soil samples, 9 locations were analyzed for metals, with four (4) of the locations analyzed for explosives.

For all the soil samples the metal, explosive, and perchlorate, concentrations are below industrial Preliminary Remediation Goals (PRGs). Out of 22 surface water samples for total and dissolved metals, one sample from a large flow in December 2008 contained cobalt at a concentration of 22.7 ug/l (above the PRG of 11 ug/l) and an iron concentration of 60,800 ug/l (above the PRG of 26,000 ug/l). One sample had an arsenic concentration of 1.7 ug/l above the PRG of 0.045 ug/l .

Arsenic concentrations from all samples were below drinking water PRGs of 10 ug/l. Out of 10 explosive surface water samples 3 samples had concentrations of RDX at low levels of 0.20 to 0.36 ug/l, all below the PRG of 0.61 ppb (Table 11). One surface-water sample had a 4-amino-2,6 dinitrotoluene concentration of 0.036 (compared to a PRG of 73 ug/l). Out of 12 perchlorate samples two samples contained values of 1.1 and 4.8 ug/l, with all values lower than the PRG of 28 ug/l. Trace levels of explosive concentrations were detected with all values below Region IX PRGs for both large and small stormwater events.

For the groundwater sampling results for both total and dissolved metals analysis for the three rounds of groundwater from the 10 monitoring wells at MMR only arsenic concentrations were above PRGs or MCLs. A total of 7 of the 10 monitoring wells, contained arsenic above the Region IX PRGs. The PRG for drinking water for arsenic is extremely low at 0.045 ug/l, which is a value below the laboratory detection limit for arsenic, so that any laboratory detection of arsenic in water will result in a value above the PRG. The arsenic levels in water, while above Region IX PRGs, are in line with concentrations found in sampling as part of the EIS (see Appendix G-1 of the EIS), and would result in similar evaluation of environmental impacts. Given that arsenic levels are so widespread across the entire valley there is likely naturally occurring arsenic in the groundwater.

For the explosive concentrations from the three rounds of groundwater, only one of the wells (MW-4A) from round 3 contained 2,4,6 Trinitrotoluene (TNT) at 0.07 ug/l and RDX at 0.11 ug/l, both values below PRGs and MCLs. Out of 36 samples for perchlorate 14 samples contained low levels of perchlorate at just above laboratory detection limits varying from 1.1 to 1.3 ug/l, with all concentrations below the Region IX PRG of 28 ug/l. It is apparent that the low levels of perchlorate are contained within the groundwater flow path extending from the portion of the valley containing the main impact area and the opening burning/open detonation area (OB/OD). The concentrations of perchlorate are just above laboratory detection limits, and are well below the PRG. There is no drinking water MCL for perchlorate that applies in Hawai'i.

A review of the results of the soil, surface-water, and groundwater sampling conducted during 2006-2008 (ERDC, 2009) showed similar levels of metal and explosive concentration as the sampling outlined as part of the EIS (Appendix G-1 of the EIS). For both evaluations, the levels of potential compounds of concern found in soil, surface-water, or groundwater are of insufficient magnitude to classify the military activities from MMR as contributing significantly to substances detected

off-site from MMR. This is because if there were significant contamination at MMR, many more of the samples would have contained higher levels of compounds related to military training. The Marine Resources Study (US Army 2009) concluded that the marine resources at the Mākua Beach nearshore and *muliwai* environments contain substances that are associated with military activities. Therefore, while the hydrogeologic data suggest there is no obvious pattern or pathway for substances to migrate off the installation, it is feasible that past activities at MMR contributed to the substances detected in marine resources there. The Army will conduct a long-term monitoring program to provide a clearer picture of the current contribution of substances that MMR may have to the Mākua Beach nearshore and *muliwai* environments, as well as identify the impact of proposed training at MMR.

Pōhakuloa Training Area Climate

The climate at PTA is classified as cool and tropical (upper montane to alpine). The 29-year average annual precipitation at BAAF on the northern portion of the installation is 14.7 in (37.3 centimeters), ranging from 10 to 16 inches (25 to 41 centimeters) across the installation. Most of PTA is above the thermal inversion layer and is not influenced by the trade wind-orographic rainfall regime. Moisture carried by the summer easterly trade winds is lost as precipitation with an increase in elevation and rarely reaches PTA (USARHAW and 25th ID[L] 2001c). The highest monthly precipitation generally occurs in winter in conjunction with Kona storms. Occasionally, moist air trapped below the inversion layer will rise into the Saddle Region in the later afternoon. Precipitation from condensation then can occur and may equal that from rainfall.

Surface Water Drainage

PTA lies within the Northwest Mauna Loa and the West Mauna Kea watersheds, which drain to the northern Hualālai and southern Kohala coasts, respectively (Mink and Lau 1993) (Figure 3.7-3). The WPAA and the PTA Trail are mainly within the West Mauna Kea watershed. The two watersheds are underlain by aquifer “sectors” of the same name.

There are no surface streams, lakes, or other bodies of water within PTA boundaries due to low rainfall, porous soils, and lava substrates. Intermittent stream channels quickly dry after rainfall stops. Rainfall, fog drip, and occasional frost are the main sources of water that sustain plants and animals in the dryland habitat of PTA and WPAA.

There are no perennial streams within 15 miles (24 kilometers) of PTA. However, there are at least seven intermittent streams that drain surface water off the southwestern flank of Mauna Kea and lie within the same drainage area as PTA. Popo’s Gulch is the closest stream to PTA boundaries. The stream converges with ‘Auwaiakeakua Gulch to drain

surface water toward the Waikoloa community to the west of PTA. There are three intermittent streams located within 2 miles (3.2 kilometers) of the cantonment area (Waikahalulu Gulch, Pōhakuloa Gulch, and an unnamed gulch) which collect runoff from the southern flank of Mauna Kea (US Army and USACE 2004).

Lake Waiau, near the summit of Mauna Kea, is the nearest known surface water body. There are also three freshwater springs, Hōkūpani Spring, Waihu Spring, and Liloe Spring, in Pōhakuloa Gulch on the slope of

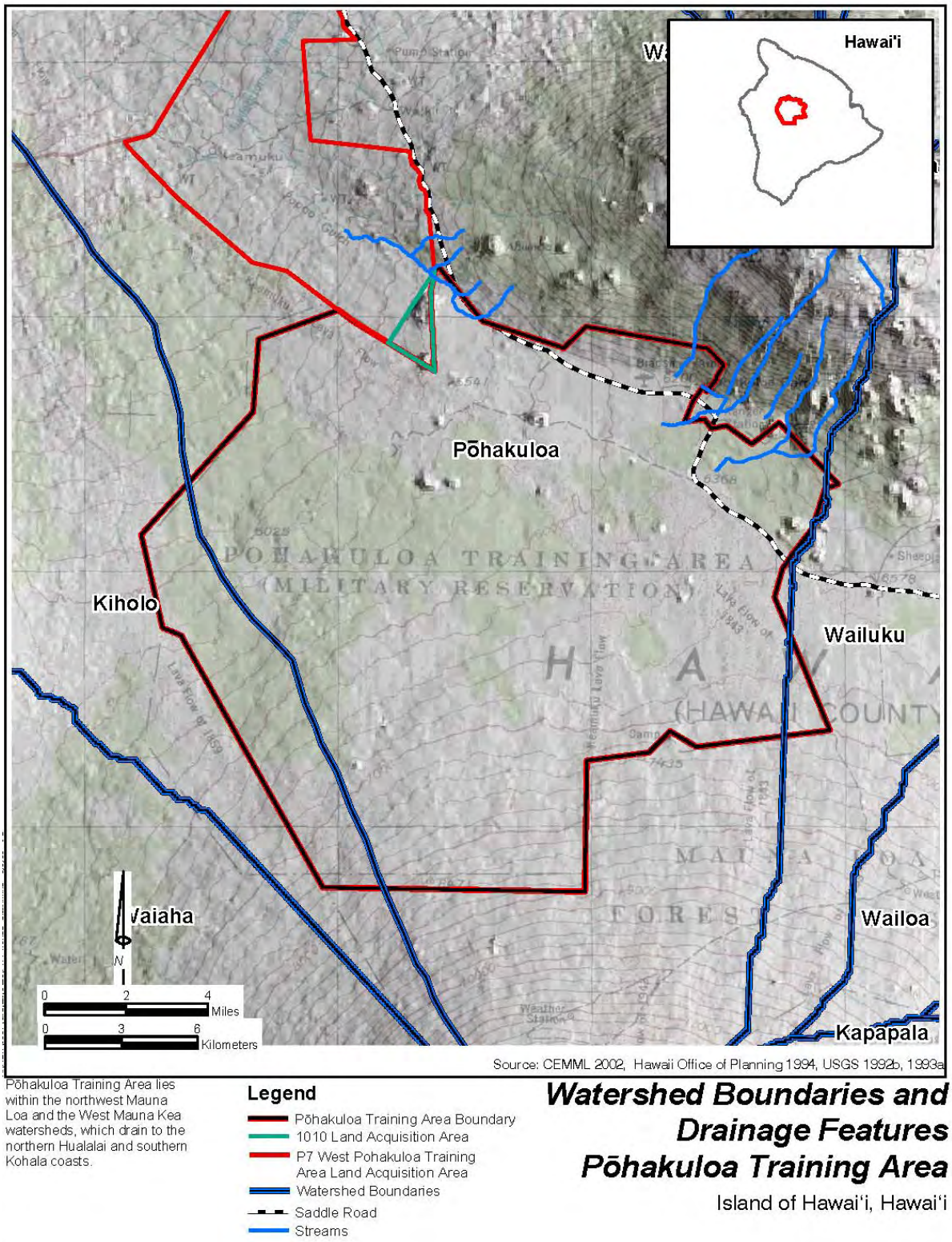


Figure 3.7-3 Watershed Boundaries and Drainage Features, PTA

Mauna Kea (USARHAW and 25th ID [L] 2001c, 1996). In the past, PTA used the springs as potable water sources under a nonexclusive rights agreement with the State of Hawai‘i. The springs are not currently used to meet the water needs of PTA. As discussed in Section 3.13.5, all water used at PTA is trucked in, thus no local PTA water resources are consumed at this time.

One perennial stream occurs downstream of the PTA. This is Waikoloa Stream, which begins in the Kohala Mountains, runs north parallel to State Highway 19, and discharges into Kawaihae Bay through the Wai‘ula‘ula Gulch (State of Hawai‘i 2002d). The proposed PTA Trail route crosses Waikoloa Stream near the rock wall south of Highway 19, in the upper reach of Wai‘ula‘ula Gulch.

Wetlands

Due to low rainfall, porous soils, and lava substrates, there are no surface streams, lakes, wetlands, or other bodies of water within PTA.

Stream Flow and Flooding

The cantonment and airfield areas of PTA, north of Saddle Road, are on land that slopes gently to the west. Under some circumstances, the runoff from the south slope of Mauna Kea could exceed the drainage capacity of the area and result in temporary flooding or localized ponding. However, the soils in the area are permeable, and the underlying lava flows contain sufficient secondary permeability (fractures and large openings related to cooling and emplacement of the lava) for rapid infiltration to the subsurface.

The civil defense tsunami evacuation map in the area of Kawaihae Harbor shows the evacuation area as extending inland beyond the Kawaihae-Mahukona Road (Highway 270) to an elevation of about 50 feet amsl (PDC 2001). The area west of the highway and north of the road to Spencer Beach Park, including the harbor, lies within the evacuation zone (US Army and USACE 2004).

Surface Water Quality

According to Hawai‘i’s 1998 305(b) report, most of the state’s water bodies have variable water quality that declines when stormwater runoff carries pollutants into surface waters. The most significant surface water pollution problems in Hawai‘i are siltation, turbidity, nutrients, organic enrichment, toxins, pathogens, and pH from nonpoint sources, including agriculture and urban runoff (EPA 1998c).

Few data on surface water quality are available for the PTA watersheds. There are no perennial streams within PTA. Waikoloa Stream flows across

Mauna Kea near the northern boundary of the West Mauna Kea watershed. According to the EPA 303(d) List of Impaired Waters in Hawai‘i prepared under the Clean Water Act, Waikoloa Stream water quality is impaired, although not threatened, due to the presence of nutrients (nitrogen- and phosphorous-containing compounds), pathogens (coliform bacteria), and turbidity (HDOH 2004).

Marine waters north of Wai‘ula‘ula Point are considered to be Class A waters rather than Class AA. The objective of Class A marine waters is to protect recreational and aesthetic uses. Pelekane Bay and Kawaihae Harbor are identified on the 303(d) list as impaired water bodies due to turbidity and were assigned low priority for development of total maximum daily loads (TMDLs) (HDOH 2004). Construction of the Kawaihae Harbor in 1995 had adverse effects on coral growth and water quality due to changes in sediment inputs in Pelekane Bay (Tissot 1998).

Coastal Water Quality

Marine waters north of Wai‘ula‘ula Point are considered to be Class A waters, rather than Class AA. Pelekane Bay is considered to be an impaired waterbody due to turbidity from erosion on overgrazed lands in the watershed above it. Construction of the Kawaihae Harbor in 1995 resulted in changes in coastal current patterns, increased sediment concentrations, and diverted stream channels that discharge to Kawaihae Bay (Makahuna and Makeāhua streams). Construction involved placing fill on the alluvial fan of the Makahuna Stream and disturbing offshore sediments. The breakwater was constructed in such a way as to make use of the existing coral reef, and the area inside the reef/breakwater was deepened by dredging. Studies performed afterward that focused on Pelekane Bay, just south of the new harbor facility, indicated that these activities had an adverse impact on coral growth and water quality, in part because of changes in sediment inputs (Tissot 1998).

Groundwater Occurrence and Flow

Groundwater occurrence on the Island of Hawai‘i is not well studied due to the younger age of the island, continuing volcanic activity, and the greater thickness of the volcanic deposits. Rainfall is the primary source of groundwater recharge on the Island of Hawai‘i. The geology of the island is characterized by highly permeable lavas from which little or no runoff occurs. Most of the precipitation percolates relatively quickly to the underlying groundwater body and then moves seaward, discharging into the coastal waters (Stearns and MacDonald 1946). The Island of Hawai‘i has the highest recharge rate among the Hawaiian Islands, with a rate of 246.4 cubic yards (188.4 cubic meters) per second (Lau 1983). Sustainable yields for each of the island’s aquifers are considerably less and are described below for each aquifer system underlying PTA (US Army and USACE 2004).

According to the classification scheme proposed by Mink and Lau (1993), PTA lies above two aquifer systems: the West Mauna Kea and the Northwest Mauna Loa aquifer sectors.

The northern portion of PTA and PTA Trail lie within the Waimea aquifer system of the West Mauna Kea aquifer sector. The Waimea aquifer system includes the entire West Mauna Kea aquifer sector, which has an area of 70 square miles (699.25 square kilometers). The southern boundary from Puakō Point to the Humuʻula Saddle is the trace of the Mauna Loa/Mauna Kea geologic contact. The northern boundary from Kawaihae to Waimea follows the Mauna Kea/Kohala contact. From Waimea the boundary strikes southeasterly along a weak rift zone to the summit of Mauna Kea (Mink and Lau 1993). The West Mauna Kea aquifer system is dry, but Waikoloa Stream, which rises in the Kohala Mountains, flows across Mauna Kea lavas near the northern boundary. A basal groundwater lens reaches to about 4 miles (6 kilometers) inland in the area. Beyond this point, the water becomes high-level groundwater, although the mode of occurrence is not understood. Wells at about 1,200 feet (366 meters) elevation develop freshwater. Near Waikiʻi and Waimea the groundwater level stands about 1,500 feet (457 meters) above sea level. Slightly thermal basal water is found along the Kawaihae to Waimea road below an elevation of 1,000 feet (305 meters). At the coast, basal springs discharge brackish water (Mink and Lau 1993). The Waimea aquifer system has an estimated sustainable yield of approximately 24 mgd (91 million liters per day (mld) (HDLNR 1995).

The majority of PTA lies within the Northwest Mauna Loa aquifer sector, which has an estimated sustainable yield of 30 mgd (114 mld) (HDLNR 1995). The Anaehoomalu aquifer system comprises the entire Northwest Mauna Loa aquifer sector and has a total area of 291 square miles (754 square kilometers). The sector boundaries reach from the 7-mile (11-kilometer) length of coast to the summit of Mauna Loa and the saddle between Mauna Loa and Mauna Kea. All rocks within the aquifer sector belong to Kaʻū Basalt. The total length of the sector is 37 miles (60 kilometers) from the coast to the saddle, the first 18 miles (29 kilometers) of which is a narrow corridor between the Hualālai and Mauna Kea volcanoes. The width of the corridor is about 5 miles (8 kilometers). High-level groundwater likely occurs at elevations greater than 1,200 feet (366 meters) amsl, although this has not been shown yet (Mink and Lau 1993). The basal lens, extending about 4 to 5 miles (6.4 to 8 kilometers) inland, is brackish except possibly near the inland periphery. Basal springs and anchialine ponds are common along the coast (Mink and Lau 1993).

Few data are available to evaluate groundwater conditions at PTA. Most of the USGS groundwater sampling and observation wells on the island

are located along the coast. Groundwater has not been found at levels lower than 1,000 feet (305 meters) below ground level on the Island of Hawai‘i (USARHAW and 25th ID[L] 2001c). The Island of Hawai‘i contains high water levels in the rift zones of Kilauēa and Kohala volcanoes.

High-level groundwater (perched groundwater) is groundwater that is held at levels above the basal water table by rocks that are relatively impermeable, including intrusive rocks, ash beds, dense lava flows, soil, alluvium, and ice. High water levels, possibly associated with a buried rift zone of Hualālai Volcano or fault scarps draped with lava flows, are present along the western coast of the Island of Hawai‘i. Areas of high water levels also are found along the northern and eastern flanks of the Mauna Kea and on the southern flank of Mauna Loa (USGS 2000a).

There is evidence of perched groundwater within the aquifer sectors underlying and adjacent to PTA (Stearns and McDonald 1946). The highest perched water in the Hawaiian Islands is Lake Waiau on Mauna Kea, at an elevation of 13,007 feet (3,965 meters) amsl. It is thought that the lake is perched on ground ice (Stearns and MacDonald 1946).

Based on regional hydrogeological information, it is believed that the groundwater beneath PTA occurs primarily as deep basal water within the older Pleistocene age basalts (US Army and USACE 2004). Exploratory well drilling was conducted in March 1965 by the DLNR near the PTA cantonment area. A test hole, (Pōhakuloa test hole T-20) located half a mile west of Mauna Kea State Park at an elevation of 6,375 feet (1,943 meters) msl, was drilled to a depth of 1,001 feet (305 meters) below ground surface (bgs). No groundwater was encountered in this test hole (US Army and USACE 2004).

There are limited data for groundwater quality for PTA due to the absence of a significant number of monitoring wells in the inland area of the island. In general, the quality of the natural fresh water in Hawai‘i’s basaltic aquifers is considered to be good (Lau 1983). Groundwater quality is threatened by saltwater encroachment and contamination from agricultural and other land uses.

Since August 1989, the HDOH has issued the “Groundwater Contamination Maps” for Hawai‘i. These maps identify locations where groundwater contaminants have been detected and confirmed. The maps identify the locations of current and historic contaminated wells and wellfields (an area where many wells in proximity share the same groundwater source) on each island. According to these maps, most of the well locations where contamination is detected on the Island of Hawai‘i are located along the eastern coast of the island. Groundwater quality on the island generally diminishes towards the coasts due to increased

saltwater intrusion. Detected contamination levels reported in the HDOH maps are below existing federal and state drinking water standards established for the protection of public health and do not pose a significant risk to humans (HDOH 1999b). Groundwater quality beneath PTA is likely of higher quality due to its distance inland from the coast.

3.8 GEOLOGY AND SOILS

Geologic resources include mineral resources, landforms, soils, and other earth materials. Discussions of geology and soils also cover geologic processes, such as erosion, faulting, and volcanic eruptions, and geologic hazards, such as earthquakes, landslides, and liquefaction. In the State of Hawai‘i, the fate and transport of chemical contaminants has been identified as an issue of concern; therefore, the discussion of geologic resources has been broadened to include the distribution and fate and transport of chemical contaminants in soils, sediments, and other geologic materials.

3.8.1 Introduction/Region of Influence

Because of the interrelationship between geology and hydrology, the ROI for geology incorporates the ROI for water resources. Laws or regulations that govern geologic resources at MMR and PTA include EPA Region IX PRGs, the State CZMP, and the Farmland Protection Act. Contaminant concentrations in soils are compared to EPA Region IX industrial PRGs for soils.

The purpose of comparing observed chemical concentrations in soils to the PRGs is to determine whether further assessment of health risks associated with on-site concentrations is needed. As described in the water resources section, PRGs are not promulgated cleanup standards, and higher or lower standards may be reasonably applied to sites based on site-specific exposure levels rather than the default exposure assumptions used to develop the PRGs.

In addition, it is usually not appropriate to rely on individual sample results for comparison to the PRGs; a better approach is to use a set of sample results collected over an area of exposure, or over a period of time, to evaluate the average concentrations to which people may be exposed. This increases the degree of confidence in the results and tends to better represent the actual exposures. The EPA recommends using a statistical sample and comparing the calculated 95 percent upper confidence limit (UCL) of the sample set to the PRGs. The UCL is a conservative estimate of the average concentration in a set of samples. Therefore, this comparison usually yields a conservatively protective estimate of the health risk associated with the chemical. This method was used to evaluate surface soil results for metals and selected contaminants where multiple detections were observed.

Some risks from individual contaminants are additive with the risks from other contaminants. An accurate determination of cumulative risks can be complex because, for example, not all chemicals affect the same organs,

and some chemicals when combined may have a greater effect than they would have individually. A screening level analysis is used to determine whether further assessment of risk is needed. If the risk from exposure to the principal chemicals of concern, based on comparison to PRGs, is within the acceptable risk range, and if the types of exposures that would occur at the site are similar to those assumed in the PRGs, then generally no further action is needed to address the chemicals at the site.

Geological issues identified in comments received during the public scoping process for the Mākua EIS included:

- Sediment transport;
- Soil contamination and its effects on groundwater and crops;
- Frequency of soil sampling;
- Soil erosion and land maintenance; and
- Landslides.

Mākua Military Reservation

The MMR ROI for geology and soils includes the Mākua Valley, the adjacent attached valleys in which live-fire training and associated activities will occur, the adjacent beach, and the nearshore area.

Pōhakuloa Training Area

The PTA ROI for geology and soils is all areas in which project-related activities may occur, including the footprint of each training range and the corridors of the military vehicle roads. It also includes adjacent areas that may be affected by geologic processes in the project area. An example would be downslope areas adjacent to a roadcut or embankment that might be affected by slope failure.

3.8.2 Geologic Setting

Mākua Military Reservation Regional Geology

O‘ahu was formed from two eruptive centers. The remnants of the oldest of these, the Wai‘anae Volcano, forms the Wai‘anae Range on the eastern side of the island. The highest peak in the Wai‘anae Range, Mount Ka‘ala, is south of MMR and rises to an elevation of 4,025 feet (1,223 meters) above msl.

The Wai‘anae Volcano became extinct about 2.75 million years ago. At about this time, the Ko‘olau Volcano, which had been forming beneath the ocean to the east of the Wai‘anae Volcano, began to emerge above sea

level. As with the Waiʻanae Volcano, two rift zones developed, trending to the northwest and the southeast, respectively. As the Koʻolau Volcano emerged, the saddle between the two volcanoes was filled, mainly with sediments eroded from the Waiʻanae Volcano. Later, it was overlain by basalt flows from the Koʻolau Volcano. As the Koʻolau Volcano waned, the saddle area was buried under alluvium from erosion of the volcano. Thus, the saddle area is underlain by alternating basalt flows and alluvial deposits. This saddle area contains the highly productive farmlands of the Central Plateau, an important high-level aquifer, groundwater recharge areas, and several military installations, including SBMR.

The Koʻolau Volcano accounts for about two-thirds of Oʻahu. The eruptive period of Koʻolau Volcano ended about 1.8 million years ago. It was followed by deep erosion of the volcano's caldera, thousands of feet of subsidence, and the first eruptions of the Honolulu basalts that began about 850,000 years ago.

Eruptions of the Honolulu basalts began on the Mōkapu Peninsula near the north side of the Koʻolau caldera, and then continued to the south to Leʻahi (Diamond Head), and west to Pearl Harbor. About 40 eruptions occurred in the period from 850,000 years to 6,000 years ago.

Although the last period of active volcanism on Oʻahu ended about 6,000 years ago, the quiet periods between volcanic events during the past 800,000 years have often exceeded 6,000 years, so it is not known for certain that eruptions will not occur again in the future. Small magnitude earthquakes occur frequently as a result of movement of magma into magma chambers beneath volcanoes, and in volcanic eruptions. Active volcanic activity is limited to the Island of Hawaiʻi. There are no major active faults. Oʻahu is no longer subsiding and now has the most stable elevation of the major islands in the Hawaiian Island chain.

Physiography

The Mākua Valley is bowl-shaped, with steep side slopes that rise sharply from a relatively broad valley floor. The valley can be subdivided into two parts. A smaller northern lobe of the valley, labeled as the Kahanahāiki ahupuaʻa on US Geological Survey topographic maps, is partially separated from the main valley by a ridge. The larger main valley is oriented approximately east-west. The main valley floor contains undulating low hills up to an elevation of about 400 feet (122 meters). Above this elevation, the slope rises steeply to the ridge of the Waiʻanae Range, which is at about 2,100 to 2,900 feet (640 to 884 meters) above msl.

The mouth of the valley slopes gradually to the sea. Farrington Highway, which is on a slightly elevated causeway that crosses the mouth of the valley and separates the beach from the reservation, acts as a linear hydrologic barrier to surface water flow. Runoff from the three streams that drain the valley is channeled through box culverts beneath the highway. The beach extends the entire width of the valley, bounded on both ends by emergent remnants of ancient reefs and by rock outcrops from the extension of the ridges that bound the valley. The beach sand is likely replenished by long-shore currents that transport sand southward from the massive dunes at Ka‘ena Point. Some of the sand may also be supplied by the streams that drain Mākua Valley, although this is probably a much less important source due to the normally low quantity of runoff from the valley.

Geology of Mākua Valley

The ridges and underlying bedrock of the Mākua Valley consist of basalt rocks of the Wai‘anae Volcanics series (Figure 3.8-1). The older part of this sequence, the Pālehua member of the Wai‘anae Volcanics, is exposed in the lower part of the ridge that forms the southern boundary of the valley and probably underlies the valley floor. The higher ridges are formed of the Kamaile‘unu and/or Lualualei members of the Wai‘anae Volcanics (Oki 1998). The valley floor is underlain by Quaternary (less than 1.8 million years old) alluvial deposits of unknown thickness. Near the coast, the surficial deposits consist of beach dune sands underlain by calcareous cemented sands and rubble and the remnants of an emerged ancient reef. The calcareous sand and remnant reef deposits are relatively thin near the shore, where they overlie the Wai‘anae Volcanics (Halliburton NUS 1994). MMR is within the northwest rift zone of the Wai‘anae Volcano and is northwest of the eruptive center of the volcano. As such, the basalt flows generally dip toward the northwest but are intersected by a dense network of vertical or nearly vertical dike intrusions that are visible in the walls of the valley.

Soils

A complex mixture of soils occurs in Mākua Valley as a result of the many microenvironments and variations in slope (Figure 3.8-2). The side slopes of Mākua Valley are too steep to hold more than a thin covering of soil and are generally classified as Rocky or Stony Land. The south-facing slope of the Kahanahāiki Valley, east of Punapōhaku Stream, also is classified as Stony Land, although a small enclave of Helemano silty clay occurs on colluvial deposits in the upper eastern part of this valley. Helemano soils are well-drained silty clays that occur in V-shaped gulches. The erosion hazard is severe to very severe. Most of the channel of Mākua Stream and some of the lower reach of Kaiahi Gulch is

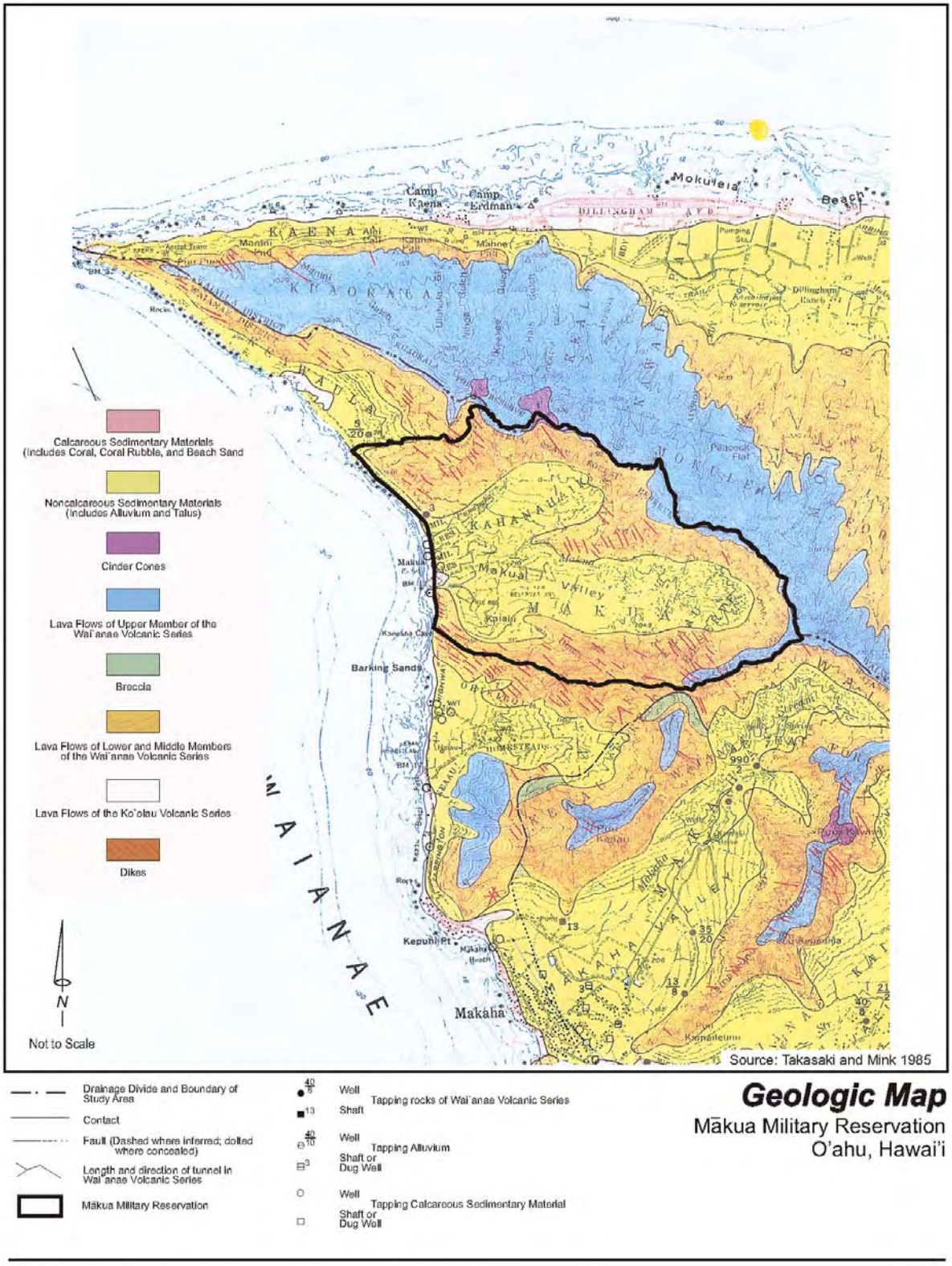


Figure 3.8-1 Geologic Map, MMR

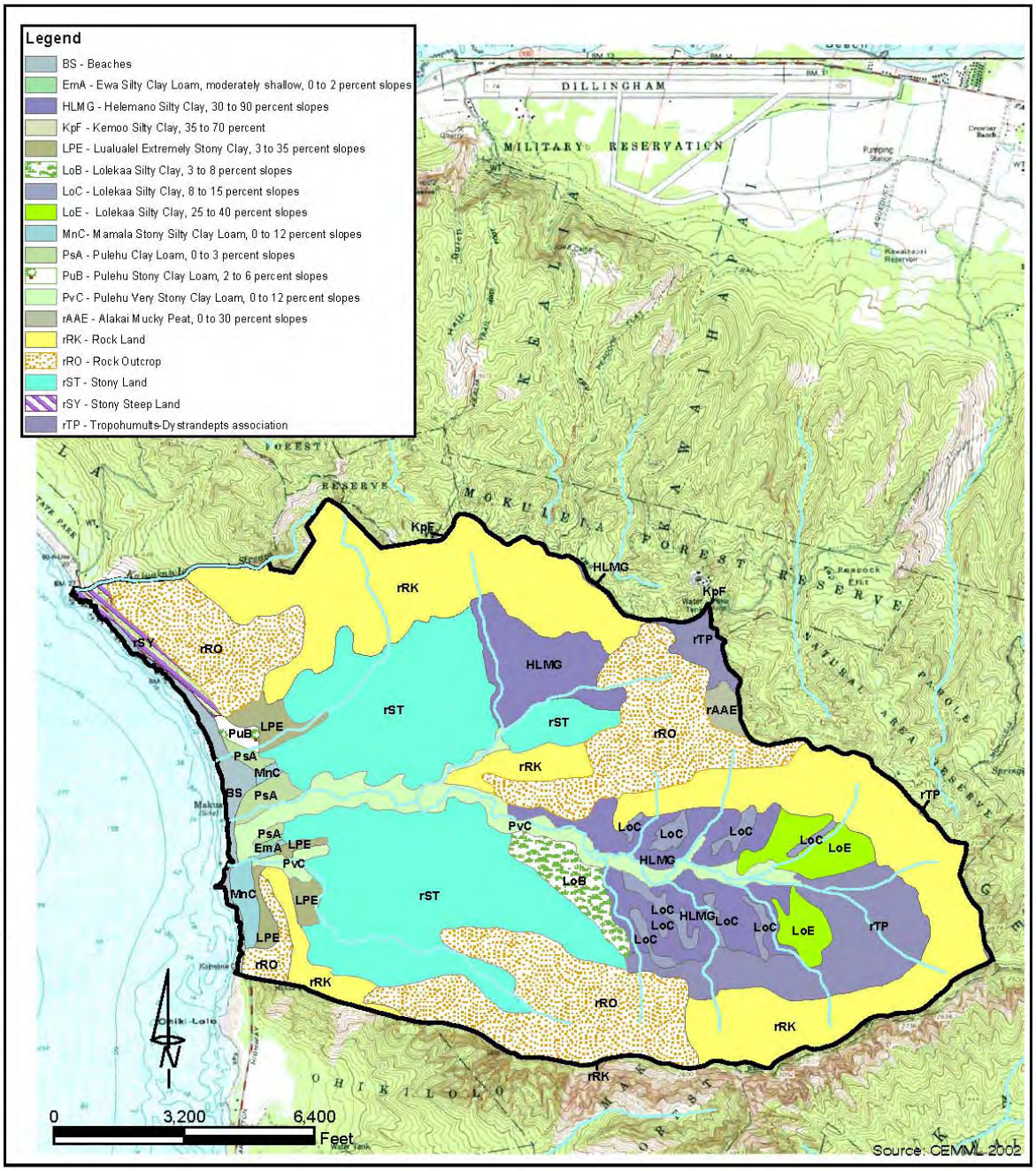


Figure 3.8-2 Soil Map, MMR

underlain by Pulehu very stony clay loam. The soil is developed on alluvial fans and stream terraces. Permeability is slow, and the erosion hazard is slight. The soil is generally about 5 feet (2 meters) thick and underlain by coarse gravelly or sandy alluvium. This soil type is used for sugarcane, truck crops such as ginger and taro, and pasture, but as 3 percent of the surface area is covered by stones, the soil is difficult to work. Pulehu clay soils, with fewer stones, also are found along the low-lying lands inland from Farrington Highway. Some of these soils are developed on land that is subject to flooding. The upper portion of the main lobe of alluvial deposits in Mākua Valley, which includes the OB/OD area and most of the area in which live-fire training exercises occur, is underlain by Lolekaa silty clay soils.

Lolekaa soils vary somewhat depending on the slope and elevation at which they occur. They consist of well-drained soils developed in old gravelly colluvium and alluvium on fans and terraces. According to the Natural Resources Conservation Service (NRCS), annual rainfall in areas with these soils is 70 to 90 inches (178 to 229 centimeters), and these soils occur at elevations from sea level to 500 feet (152 meters). However, mean annual rainfall in the portion of Mākua Valley where these soils occur may be in the range of 40 to 60 inches (102 to 229 centimeters), and the elevation ranges from about 400 to over 1,000 feet (122 to 305 meters). Access to the area in which these soils are mapped has been closed for some time due to military activities and the possible presence of UXO.

Near the mouth of Mākua Valley, at low elevation, are a variety of soils covering small areas. On the middle reaches of both Kaiahi Gulch and Punapōhaku Stream is Lualualei extremely stony clay. These are well-drained soils developed in colluvium on coastal plains, alluvial fans, and talus slopes at elevations up to 125 feet (38 meters). Runoff is medium to rapid, and erosion hazard is moderate to severe. Cultivation is impractical unless the stones are removed.

South of the outlet of Ko‘iahi Gulch (also known as Kaiahi Gulch), between the beach and the ridge, the predominant soil is Mamala stony silty clay loam. These soils form in alluvium deposited over coral limestone and consolidated calcareous sand. The soil is dark reddish-brown, with a consolidated coral or calcareous sand at depths of 8 to 20 inches (20 to 51 cm). The permeability is moderate, runoff is very slow to medium, and erosion hazard is slight to moderate. Figure 3.8-2 shows the soils found within an approximately 500-foot wide corridor along the two principal trails connecting DMR and MMR. A shoreline trail, the Kaena Point Trail, follows an existing paved road for about three miles west of DMR, after which the road is unpaved, but lies within a broad bench

above the elevation of the beach. The other trail, the Kuaokala Access Road and Trail, follows an existing improved road up the north-facing slope of the Waiʻanae Range from the east side of DMR. Near the crest of the range, at an elevation of about 1,500 feet, the trail breaks from the improved road to an existing pedestrian trail that continues to the Kuaokalā Ridge. The trail follows westward along the ridge for about one mile and then descends into Mākua Valley along the west side of Punapōhaku Stream.

Most of the shoreline trail traverses land that is classified as Rock Outcrop, Rock Land, or Stony Steep Land. The following soils are adjacent to or interspersed with the rocky land on the north shore:

- Stony soils (Waialua stony silty clay, Lualualei extremely stony clay, and a quarry);
- Sandy soils (Jaucas sand near the west end of DMR and beach sand); and
- Small patches of other soils (Mokuleia clay loam near DMR and Lualualei clay near Kaʻena Point).

Along the shoreline trail south of Kaʻena Point, the trail follows an unpaved road that is in poor condition. The road is highly eroded with deep potholes. The slope above the road is very steep, but most of the road is deeply incised and poorly drained. Near Kaʻena Point a landslide has removed a short section of the road. The potholed section of trail ends at the northern end of the public beach at Kaʻena State Park. The trail continues south along the paved Farrington Highway for the remainder of the distance to MMR. Most of the soils within the potholed road segment between Kaʻena Point and the public beach are classified as Stony Steep Land. The paved portion of the inland trail overlies many soil types, on moderate to steep slopes, but the soils are not exposed. Above 1,500 feet (457 meters), where the pedestrian trail begins, it mainly traverses Kemoo silty clay soils on 35 to 70 percent slopes, or Helemano silty clay soils on 30 to 90 percent slopes. Kemoo soils are well-drained deep soils developed on basalt rocks on uplands, mainly on windward slopes.

The Kemoo soils in the trail alignment occur on side slopes along drainage ways, where runoff is rapid, and the erosion hazard is severe. The soil is thin, and includes eroded spots, stony areas, and rock outcrops. Helemano soils, which have been described above, are also subject to severe erosion. The south-facing ridges in the trail alignment are underlain by Rock Land at the higher elevations and by Stony Land near the valley floor. As the names imply, Rock Land is made up of 25 to 90 percent exposed rock. The soils that remain between outcrops tend to be very

sticky and plastic clays, with high shrink-swell potential. Rock Land is susceptible to sliding when the soil is saturated. Stony land consists of boulders and stones deposited by water and gravity over 15 to 90 percent of the surface, with silty clay loam soils found among the stones. The soils are thin, but generally provide sufficient substrate for plants.

Pōhakuloa Training Area

Regional Geology

The Island of Hawai‘i is the youngest of the Hawaiian Islands and is the only island that is still growing. Therefore, the landscape is younger and less affected by erosion than other islands. Also, the island is larger and higher than the other islands. The bulk of the Island of Hawai‘i was formed from the eruptions of five shield volcanoes. Kohala, the oldest, is extinct. Mauna Kea last erupted about 3,500 years ago and is considered dormant. Hualālai last erupted in 1801. Mauna Loa and Kīlauea are both active.

Physiography

PTA is in the Humu‘ula Saddle between the two major peaks on the Island of Hawai‘i; Mauna Kea lies to the northeast, and Mauna Loa lies to the south. The cantonment area, which is adjacent to Saddle Road that traverses the northeast corner of PTA, is at an elevation of 6,400 feet msl (1,950.7 meters). The slope of the Mauna Kea volcano rises steeply (about a 26 percent slope) from Saddle Road to an elevation of 13,796 feet msl (4,207 meters) over a distance of about 6 miles (14.5 kilometers). The slope of Mauna Loa, by contrast, rises to the southwest at about a 4 percent slope to an elevation of 13,678 feet msl (4,169 meters) over a distance of about 20 miles (32.2 kilometers). To the west of these two peaks is the Hualālai volcano (about 8,690 feet msl, 2,650 meters). Elevations within PTA range from 4,030 to 8,650 feet msl (1,228 to 2,637 meters).

The military vehicle trail from Kawaihae Harbor to PTA runs south inland of Highway 270 and rises to an elevation of about 250 feet (76.2 meters) near the junction with Highway 19. The trail continues east, paralleling Highway 19 along the foot of the Kohala Mountains to the western edge of Waimea (Kamuela). This segment rises to an elevation of about 2,500 feet (762 meters) over a distance of about 10 miles (16.1 kilometers). Near Wai‘aka, on the outskirts of Waimea, the trail turns south and runs west of Highway 190 approximately following the 2,400-foot (731.5-meter) elevation contour until the junction with Saddle Road (Route 200). The trail crosses Highway 190 west of a small volcanic cone called Nahonaoahe and continues upslope, roughly parallel to Saddle Road, until it reaches PTA at a point near the Pu‘u Ke‘eke‘e cinder cone.

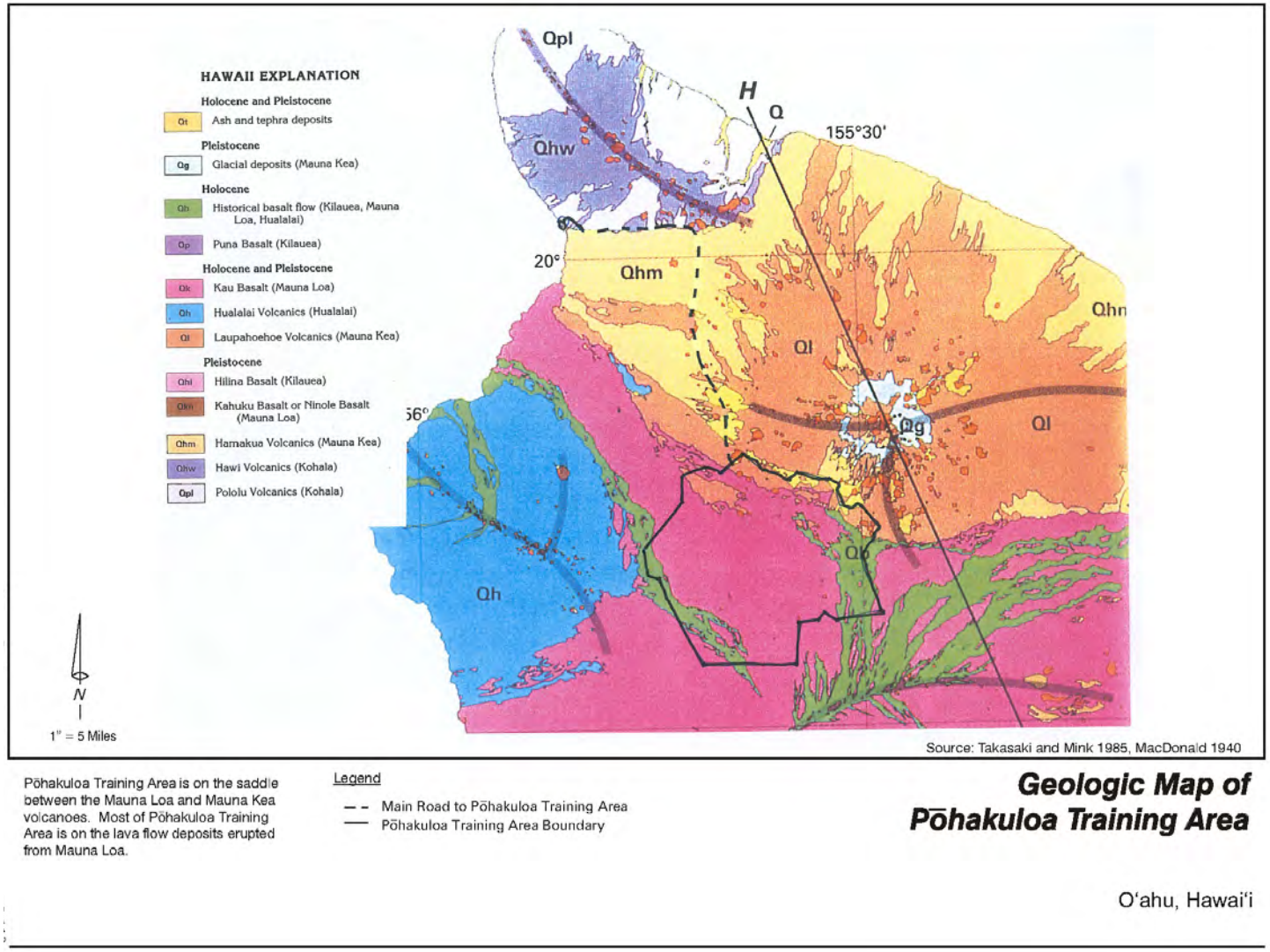
Geology of the Pōhakuloa Training Area

Figure 3.8-3 is a geologic map of the northern portion of the Island of Hawai‘i, showing the locations of PTA and PTA Trail. PTA is on the saddle between the Mauna Loa and Mauna Kea volcanoes. Most of PTA is on lava flow deposits erupted from Mauna Loa, the largest active volcano in the world. Lava from Mauna Loa’s last eruption, in 1984, covered 16 square miles (41.4 square kilometers) of land in three weeks. The lava erupted from the Northeast Rift Zone, which extends northeast from the Mauna Loa crater and skirts the southeast boundary of PTA. The lava flowed within 4 miles (6 kilometers) of Hilo (USGS 1997a).

PTA is underlain by overlapping basalt flows erupted from Mauna Loa and Mauna Kea. The three most recent flows responsible for the surface deposits at PTA are Hāmākua flows from Mauna Kea that occurred during the Pleistocene, Laupāhoehoe flows from Mauna Kea that occurred during the Holocene, and Ka‘ū flows from Mauna Loa that have occurred as recently as 1935 (USARHAW and 25th ID[L] 2001c). The more recent flows have not entered the PTA boundary.

These flows have gradually built up a broad, relatively gently sloping surface that appears smooth from a distance but is actually very rough and highly variable in texture close up. There is little woody vegetation, due to a number of factors, including elevation, climate, wind, thin soil, and soil chemistry. Soil forms or accumulates in low areas, on older volcanic flow surfaces, and in areas overlain by volcanic ash deposits. The relatively smooth terrain is broken in places, such as along the western edge of PTA, by small cinder cones. Some of the cinder cones have been quarried for material used in construction or to surface roads.

During volcanic flows, the surface of the lava cools and forms a hard crust, while the lava below the crust continues to flow. Under some the molten lava may run out, leaving behind an empty tubular shell of hardened lava. Some lava tubes are hundreds of feet long and tend to collapse over time or become filled by subsequent flows or sedimentation. Some tubes may become plugged at both ends, leaving a subsurface cavity with no manifestation at the surface. Such cavities are often encountered during drilling in basaltic lava terrain. Some lava tubes can be conduits for water. There are probably many lava tubes underlying PTA, but they have not been mapped and are not accessible to the public.



Pōhakuloa Training Area is on the saddle between the Mauna Loa and Mauna Kea volcanoes. Most of Pōhakuloa Training Area is on the lava flow deposits erupted from Mauna Loa.

Legend

- - Main Road to Pōhakuloa Training Area
— Pōhakuloa Training Area Boundary

Geologic Map of Pōhakuloa Training Area

O'ahu, Hawai'i

Figure 3.8-3 Geologic Map, PTA

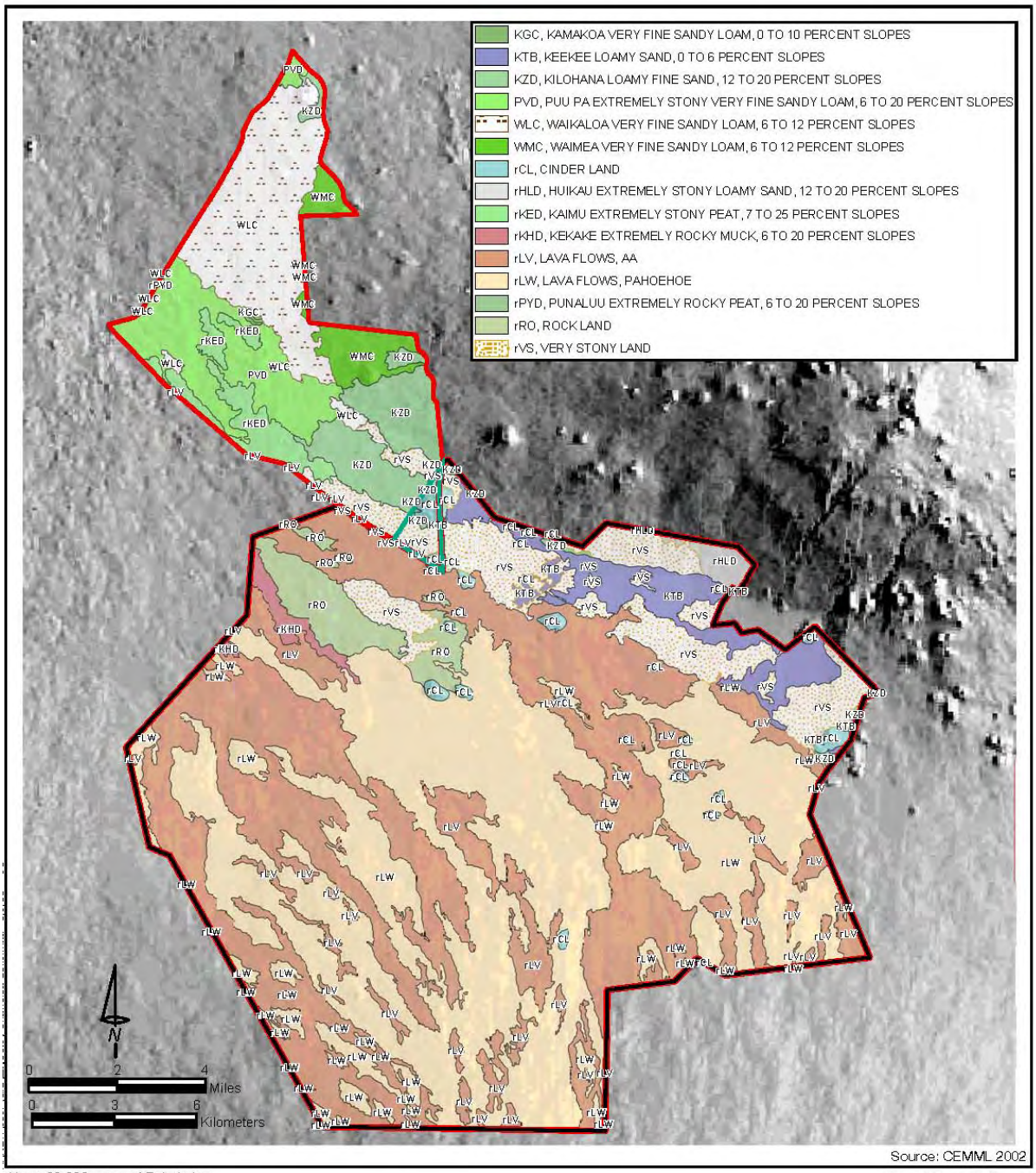
The lower half of the WPAA is within the Waimea Plains, which were formed by lava flows from Mauna Kea that butted up against the older Kohala Mountains. The Kohala Mountains are now covered with a blanket of volcanic ash soils. The lava is predominantly pāhoehoe and ʻaʻā basalt flows, scoria (cinder), and ash deposits of the Hāmākua Volcanics Series (Wolfe and Morris 1996). Hawaiian basalts have a high iron content, and the composition of many basalts is over 40 percent iron-containing minerals (Wolfe and Morris 1996). In some cases, the high iron content makes it difficult to discriminate ordnance from rock, and weathered basalt cobbles can look similar to oxidized ordnance (Earth Tech 2002). The parcel is dotted with cinder cones associated with the Mauna Kea volcano. The cinder cones are deposited on the upper layer of the Hāmākua Volcanic Series, which is covered by a layer of up to about 3 feet (0.9 meter) of Pahala ash erupted about 39,000 years ago.

The term "Pahala ash" has been widely used to describe nearly all the thick soils on Hawaiʻi, although it technically refers to ashes erupted from Mauna Loa or Kīlauea that were deposited mainly on the southern flanks of the island. Ash deposits along the Hāmākua coast are mainly from older explosive eruptions of Mauna Kea.

Soils

Pōhakuloa Training Area. Soils are thin and poorly developed on PTA. Recent lava flows cover about 80 percent of the land surface. The low precipitation, rapid runoff, and high altitude reduce the rate of weathering, and the high slope and wind tend to prevent soils from accumulating. Figure 3.8-4 shows the soil types within PTA. About 88,000 acres (35,612 hectares) of PTA are classified by the US NRCS as lava flows, of which about half are ʻaʻā flows and half are pāhoehoe flows. An additional 1,400 acres (567 hectares) are classified as cinder land. About 12,500 acres (5,059 hectares) are classified as either rock land or very stony land. The remaining approximately 10,000 acres (4,047 hectares), almost all of which is along the northern boundary of PTA near Saddle Road within training areas 1 through 17 and 22, are classified as soils formed on volcanic deposits.

The predominant soil is Keʻekeʻe loamy sand on 0 to 6 percent slopes, which accounts for nearly 7,500 acres. This is a mildly to strongly alkaline soil consisting of stratified sand developed in alluvium from volcanic ash and cinders. Permeability is rapid, and runoff is slow. The hazard of wind erosion is moderate to severe. Similar sandy soils developed on slightly steeper slopes are found in the same general vicinity, including Huikau extremely stony loamy sand on 12 to 20 percent slopes, and Kilohana loamy fine sand on 12 to 20 percent slopes.



About 88,000 acres of Pōhakuloa Training Area are classified as lava flows of which about half are 'a'ā flows (highly fractured and blocky) and half are pāhoehoe flows (dense, smooth, or ropy).

Legend

- Pōhakuloa Training Area Boundary
- P7 West Pōhakuloa Training Area Land Acquisition Area
- 1010 Land Acquisition Area
- P3/P4 Pōhakuloa to Kawaihae Trail

Soils Map
Pōhakuloa Training Area

Island of Hawai'i, Hawai'i

Figure 3.8-4 Soils Map, PTA

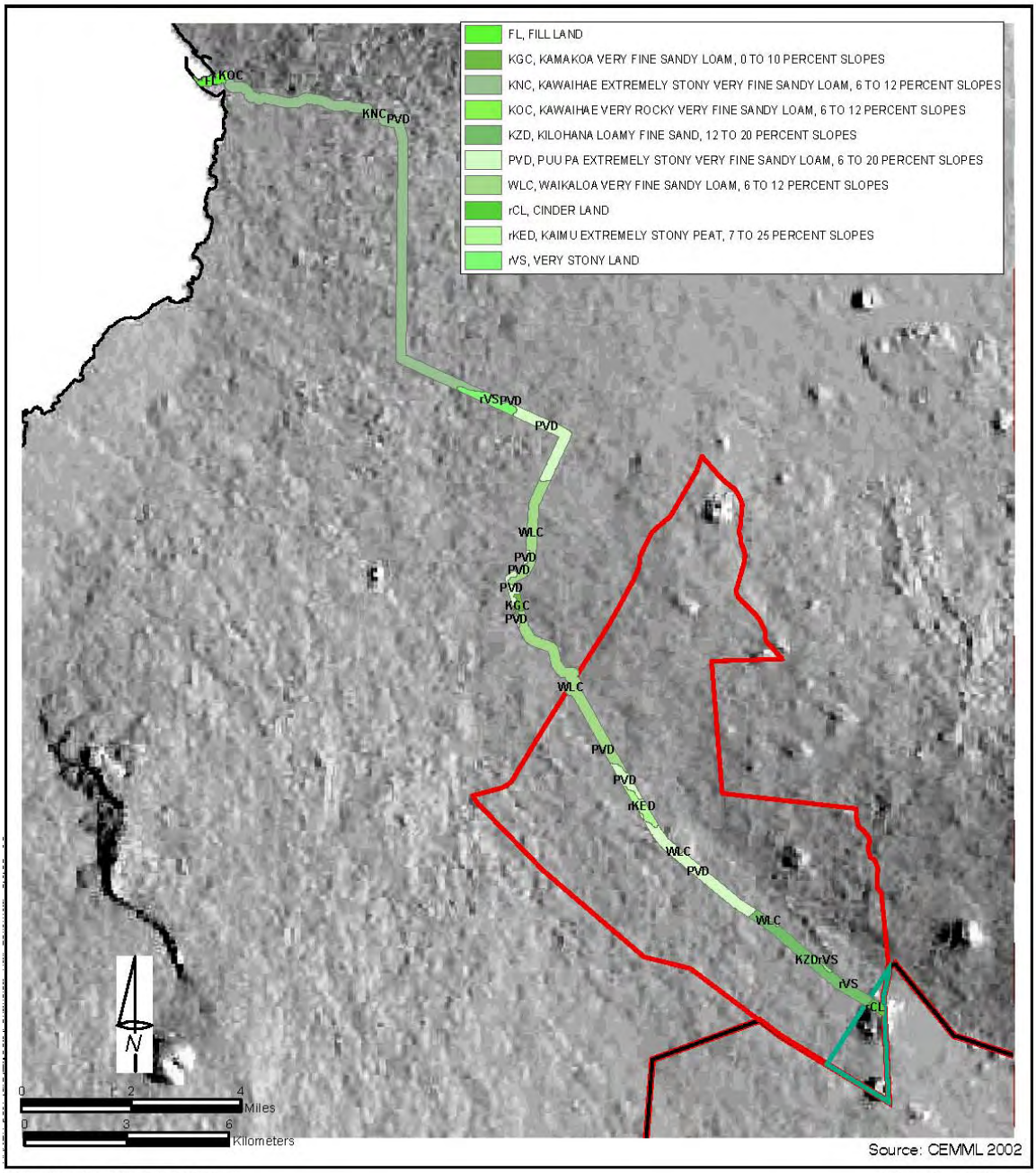
The proposed CALFEX range at PTA would be in the Twin Puʻu area, covering about 1,000 acres (405 hectares). Most of the area is pāhoehoe lava, with the northern portion rock land. Cinder cones are at the northern and southern edges of the proposed range.

Shallow gulches dissect the parcel; the largest of these are Waikiʻi Gulch and ʻAuwaiakeakua Gulch. The soft, permeable soils form thicker deposits in some areas. The Puʻu Pa soils contain a calcium carbonate cemented layer in some areas that impedes percolation of water. Although there are no perennial streams, rainfall keeps the subsoils moist along the gulches. There are areas of peat soil, where rapid cycles of vegetation growth and a moist, temperate environment have caused organic material to accumulate. The Waikaloa and Puʻu Pa soils are easily eroded by wind and water.

Kawaihae to PTA Trail. Figure 3.8-5 shows the soils along PTA Trail. From Kawaihae Harbor to about midway to Waimea, PTA follows the route of an existing military vehicle trail. The Kawaihae Harbor area is built on imported fill and is paved over. The foot of the slope just east of Kawaihae Harbor is composed of Kawaihae very rocky very fine sandy loam (KOC). The trail continues upslope over Kawaihae extremely stony very fine sandy loam on slopes of 6 to 12 percent (KNC). Kawaihae soils are moderately deep, somewhat excessively drained soils that formed in material weathered from volcanic ash. The soils have a very weak structure and are very friable (crumble easily). The soil occurs at elevations up to 1,500 feet (457.2 meters) on the leeward side of Hawaiʻi, where rainfall is 5 to 20 inches (12.7 to 50.8 centimeters). These soils are used mainly for grazing.

About 3 miles (5 kilometers) from Kawaihae Harbor, and just east of Kemole Falls, the trail turns south from the highway and approximately follows the 1,200-foot (366-meter) elevation contour. The route crosses the former Lalamilo Firing Range, just downslope of a rock wall, following the western boundary of the Puʻu Pā Military Maneuver Area (Earth Tech 2002). The underlying soil on this traverse is still the Kawaihae extremely stony very fine sandy loam

About 4 miles (6 kilometers) south of the highway, near Kamakoa Gulch and about 1 mile (1.6 kilometers) northeast of Waikoloa, the trail turns nearly straight upslope in the direction of the Saddle Road Junction, continuing along the southern boundary of the Puʻu Pā Maneuver Area, and rising about 800 feet (244 meters) in 3 miles (5 kilometers). A road from here crosses the rock wall and ends at a water tank and two wells. The lower portion of this upslope segment is underlain by Kawaihae



Soils along the Pōhakuloa Training Area trail. From Kawaihae to the Pōhakuloa Training Area Boundary.

Legend

- Pōhakuloa Training Area Boundary
- P7 West Pōhakuloa Training Area Acquisition Area
- 1010 Land Acquisition Area
- Hawai'i Coast Line

Soils Map
Pōhakuloa to Kawaihae Trail

Island of Hawai'i, Hawai'i

Figure 3.8-5 Soils Map, PTA – Kawaihae Trail

extremely stony very fine sandy loam, which lines the gulch. Just beyond the water tank, the road crosses the gulch and continues on very stony land (rVS) from an elevation of about 1,400 feet (427 meters) to about 1,600 feet (488 meters).

At about the 1,600-foot (488-meter) elevation contour, the trail crosses about 1 mile (2 kilometers) of Pu‘u Pa extremely stony very fine sandy loam on 6 to 20 percent slopes (PVD). Like the Kawaihae soils, Pu‘u Pa soils are moderately deep, well-drained soils that formed in material weathered from volcanic ash, have a weak structure, and are very friable. They are distinguished from Kawaihae soils mainly by occurrence at elevations between 1,000 to 2,500 feet (305 to meters), where slopes range from 6 to 100 percent and annual rainfall is 20 to 35 inches (51 to 89 centimeters). Permeability is moderately rapid, and runoff is medium. The soils are used mainly for pasture. At an elevation of about 1,900 feet (579 meters), the trail turns abruptly south again for about 4 miles (6 kilometers), following an existing unpaved track for about 2 miles (3 kilometers), and then continues above the 1,800-foot (549-meter) contour, where there is no existing track, until it intercepts a paved road. The trail continues upslope along the paved road for a distance of about 4 miles (6 kilometers), alongside ‘Auwaiakeakua Gulch, to the ‘Auwaiakeakua Water Tank at Highway 190.

The soil along about the last 7 miles (11 kilometers) of this segment is mainly Waikaloa very fine sandy loam on 6 to 12 percent slopes (WLC). The Waikaloa soil is interspersed with Pu‘u Pa and Kamakoa very fine sandy loam on 6 to 12 percent slopes (KGC). Waikaloa soils are deep to very deep, well-drained soils that formed in basic volcanic ash. Slopes range from 2 to 20 percent. The mean annual rainfall is about 15 inches (38 centimeters). The soil has weak structure throughout the profile and is friable. Depth to bedrock is greater than 5 feet (1.5 meters). A strongly cemented layer containing calcium carbonate occurs in most locations at a depth of about 4 feet (1 meters).

Highway 190 marks the western boundary of the WPAA. The rest of the route, through the WPAA, is generally straight up the slope. The route passes over approximately equal amounts of Waikaloa and Pu‘u Pa soils, encountering a short segment underlain by Kaimu extremely stony peat on 7 to 25 percent slopes (rKED). The Kaimu soil occurs south of Popoo Gulch and east of Ke‘āmuku, at an elevation of between 3,200 and 3,400 feet (975 and 1,036 meters). The Kaimu soil is moderately deep, somewhat excessively drained, and highly organic. This soil formed in organic material mixed with minor amounts of basic volcanic ash in ‘a‘ā lava. The soil occurs in areas where the mean annual rainfall is about 35 inches (89 centimeters).

About 3 miles (5 kilometers) downslope from the 1010 Parcel, at an elevation of about 4,300 feet (1,311 meters), the trail encounters Kilohana loamy fine sand on 12 to 20 percent slopes (KZD), interspersed with very stony land. The Kilohana soil is deep, somewhat excessively drained, and forms in material weathered from volcanic ash. Kilohana soils are on uplands, generally at elevations of 5,000 to 6,500 feet (1,524 to 1,981 meters) with slopes of 12 to 20 percent. Mean annual rainfall is about 30 inches (76.2 centimeters), and depth to bedrock is more than 6 feet (2 meters). The soils are very highly permeable and runoff is slow. Outcrops of ʻaʻā lava flows are common. In the 100 Parcel, the trail intercepts Keʻekeʻe Road, an unpaved road that runs along the northwest side of Puʻu Keʻekeʻe cinder cone, where the soils are classified as cinder land.

3.8.3 Soil Contamination

Past and current activities at MMR and PTA have resulted in contamination of soil by explosives and other chemicals. The following is a brief summary of the results of past and recent studies that provide information about the nature and extent of soil contamination. The focus of these studies is on work done at MMR. Much of the information on PTA is from studies done in support of the 2004 SBCT EIS. PTA findings are summarized below.

Mākua Military Reservation

Ordnance Use, 1929 to 1950

A 1984 Installation Assessment indicated that the Army began acquiring Mākua Valley in 1929 (USATHAMA 1984). The beach and other areas of the Waiʻanae coast were used for joint Army and Navy maneuvers during the 1930s, but the land was returned to the territory of Hawaiʻi between 1940 and 1941. After the attack on Pearl Harbor in December 1941, the valley was again used for military training. Since then, it has reportedly been used for aerial bombing practice, ship to shore artillery practice, amphibious landing training, and live-fire exercises involving small arms and artillery (Char 1977). The range continued to be used after World War II and through the Korean War. Range clearing operations were conducted in 1949 and 1950 to remove UXO, and approximately 11,000 rounds of artillery, mortars, and bombs, plus bulk explosives, were reportedly detonated either in place or in the OB/OD area (USATHAMA 1984; Sox 1977).

Waste Disposal Open Burn/Open Detonation Area

Shown in Figure 3.11-1, the OB/OD area at MMR is an inactive RCRA treatment facility in delayed closure status from the HDOH, Solid and Hazardous Waste Branch. The area is downslope of the access road. Army, Air Force, Navy, and Marine Corps personnel used this area from

the 1960s into the 1990s. This site was reportedly the only safe disposal site in Hawai‘i for hazardous materials. Ammunition was doused with large amounts of fuel and waste oils in the bottom of a trench and ignited using incendiary grenades, blasting caps, or time bombs (Char 1977). Larger munitions (such as mines) were buried in specially designed trenches and detonated. Trenches were used only once, and each detonation consumed approximately 1 ton (908 kilograms) of waste. Detonations could be sequenced in 15-second intervals (USATHAMA 1984). After destruction of the munitions, the trenches were inspected to ensure complete destruction and were backfilled with soil. No nuclear, radiological, chemical, or biological agents were disposed of at the OB/OD area (Geotechnical and Structures Laboratory 2002).

The OB/OD area had three primary purposes, including the mass destruction of unserviceable ordnance; engineer training with large demolition and mine munitions, such as bangalores; and the burning of excess propellant (Char 2003). Quantities of ordnance disposed of in the OB/OD area varied from year to year, but approximate total quantities disposed of per year included 12 tons (11 metric tons) by the Army, 6 tons (5 metric tons) by the Air Force, and 60 to 70 tons (54 to 64 metric tons) by the Navy.

The last time ammunition was destroyed by open burning at the OB/OD area in 1992. Unserviceable munitions are now shipped back to ammunition depots in the CONUS for final disposition (Akasaki 2003).

Results of Past Soil and Sediment Investigations

Several studies of sediment and soil have been conducted over the years. Char (1977) collected shallow soil and sediment samples from the ordnance impact area at MMR and background sites and determined metals concentrations in the samples, in an attempt to estimate the rates of metal loading due to sediment transport to the ocean. Char estimated an annual sediment discharge rate from Mākua Valley of approximately 1,000 metric tons (1,100 tons) per year. These results were consistent with the average sediment yield estimated by the state of Hawai‘i for leeward O‘ahu of 670 pounds/acre/year (250 kilograms/acre/year) applied to the 4,000-acre (1,619-hectare) area of the valley (HWRRS 1975).

Char estimated that the rate of sediment loss from the 4-acre (2-hectare) active portion of the OB/OD area alone was about 100 metric tons (110 tons) per year, because of the exposed disturbed soils at the site. He also noted that actual sediment yields could vary widely from year to year depending on rainfall. Since that time, roads have been improved with crushed coral to reduce erosion, and grassy vegetation cover in the valley

has increased. These changes may have significantly reduced erosion rates in the OB/OD area and from the valley side slopes in general.

In 1993, a soil and groundwater investigation was conducted by Halliburton NUS (1994). The investigation was intended to characterize potential impacts associated with past OB/OD operations and to support the RCRA Subpart X permitting process for the OB/OD area; Subpart X addresses closure requirements for miscellaneous RCRA sites, including OB/OD areas. The sediment and soil samples were analyzed for semivolatile organics, metals, cyanide, sulfides, energetics, nitrates/nitrites, and nitrites. The investigation report concluded that none of the soil or groundwater samples from outside the OB/OD area contained contaminant concentrations above health-based criteria.

In 1999, the EPA and the HDOH performed an investigation of sediment samples from the *muliwai* west of Farrington Highway (Baylor 1999). Samples were collected from the pond bottom sediments and analyzed for metals. The investigation found that cadmium, chromium, and copper exceeded the NOAA Effects Range-Low and nickel exceeded the NOAA Effects Range-Medium in both the Mākua and reference *muliwai* samples. The NOAA Effects Range is a measure of the risk to ecological receptors and designates chemical concentrations as low, medium, or high. Because it is known that concentrations of some metals are naturally elevated in Hawaiian soils, and because elevated concentrations of these metals were found in the reference (background) *muliwai* location, the investigation report could not determine whether the elevated metals concentrations originated from human activities or were naturally occurring.

Scope of the 2002/2003 Hydrogeologic Investigation

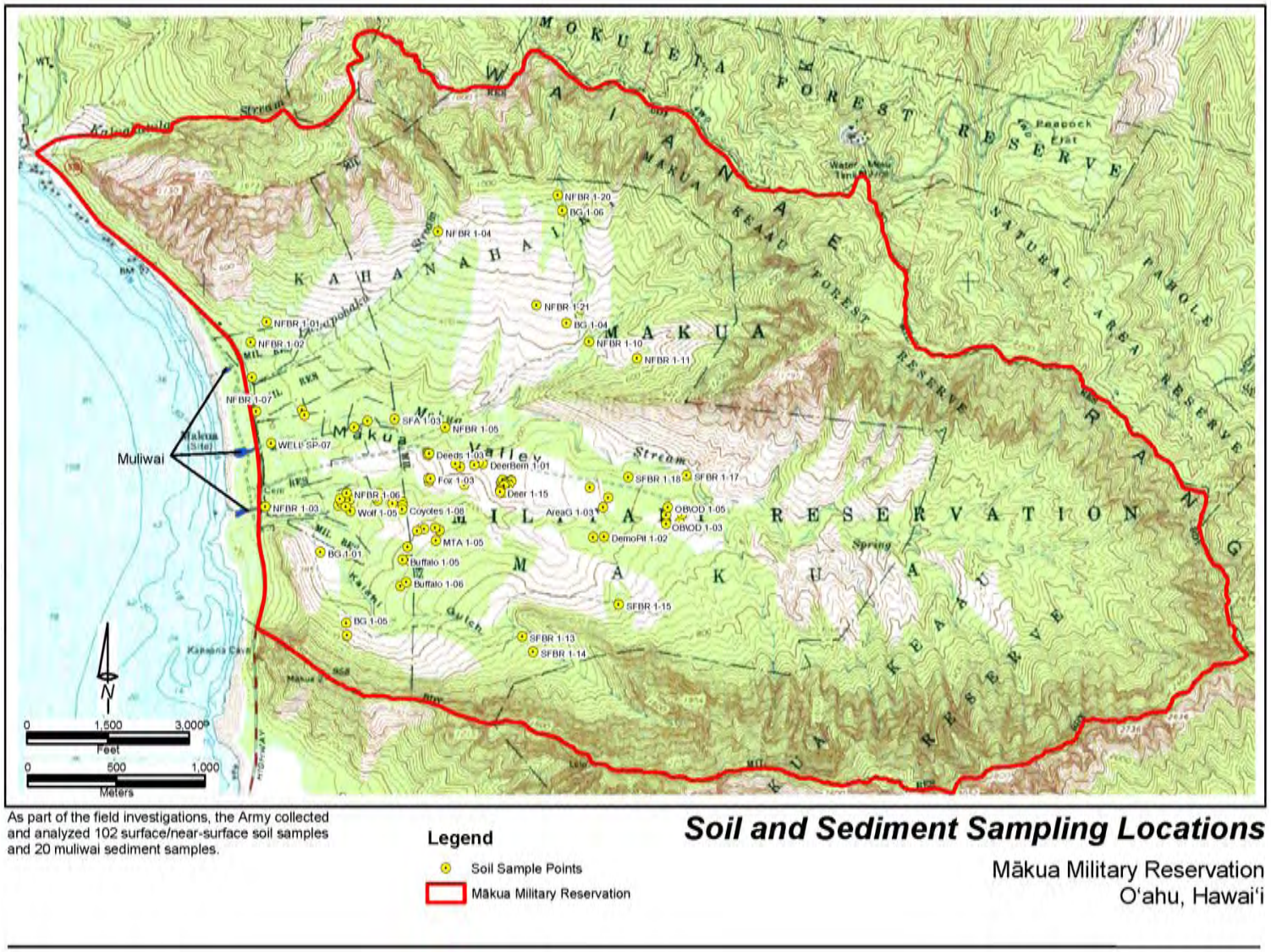
The Army initiated a hydrogeologic investigation to further characterize soils, sediment, surface water, and groundwater at MMR. Figure 3.8-6 shows locations of soil sampling points within MMR, and Figure 3.8-7 shows locations of background soil sampling points outside MMR. The following discussion is based on the Draft Hydrogeologic Investigation Report for MMR (USACE 2006) that is presented in Appendix G-1. Groundwater monitoring and data interpretation are expected to continue after completion of this EIS.

As part of the investigation, 102 surface/near-surface soil samples were collected and analyzed. To assist in evaluating the fate and transport of any chemicals that may be present in surface soils at MMR, 11 streambed sediment samples were collected. Eighteen subsurface soil samples also were collected and analyzed to assist in evaluating vertical migration of chemicals from the surface to the subsurface. These subsurface soil samples were collected from borings drilled in areas with the greatest

likelihood of surface soil contamination as a high bias for subsurface transport modeling. As part of the investigation of vertical transport, soil samples were collected from vadose zone soils at various depths to gauge the moisture in the soil column. The surface/near-surface, streambed, and subsurface soil samples were analyzed for metals, explosives, volatile organic compounds (VOC), semivolatile organic compounds (SVOCs), chlorinated pesticides, polychlorinated biphenyls (PCBs), nitrates/nitrites, organophosphate, and other anions. Summary tables showing the concentrations of detected compounds are presented in the Draft Hydrogeologic Investigation Report in Appendix G-1 of the EIS. In addition, Appendix G-2 of the EIS contains charts that show the distributions of the metals and selected explosives concentrations in the samples.

Most, if not all, of the metallic elements included in the analytical suite used in the hydrologic study occur naturally in soils in the study area, because they are present in the minerals in the basalt rock from which the soils derive. The range of concentrations of each element depends on the mineral content of the rock, as well as the nature of the soil-forming process. Some Hawaiian soils, including those found at MMR, are highly enriched in aluminum, iron, and manganese, for example.

The soil sample results were statistically compared to EPA Region IX PRGs for soils at industrial sites. This statistical evaluation included a calculation of the 95 percent UCL of the sample data set. The 95 percent UCL in a set of samples representative of a site is considered by the EPA to be a conservative estimate of the average concentration in the soils at a site. The industrial soil PRGs are conservative health-based concentrations, designed to be protective of the health of workers in an industrial exposure setting. The assumptions used in setting the industrial soil PRGs included that adult workers would be exposed to these concentrations for a normal work week over a period of 20 years, without ill effects.



As part of the field investigations, the Army collected and analyzed 102 surface/near-surface soil samples and 20 muliwai sediment samples.

Legend

- Soil Sample Points
- Mākua Military Reservation

Soil and Sediment Sampling Locations

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.8-6 Soil and Sediment Sampling Locations, MMR

Background soil samples were collected at six locations.

Background Soil Sampling Locations

Legend

Background Sampling Location

Mākua Military Reservation

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.8-7 Background Soil Sampling Locations, MMR

The health effects are separated between carcinogenic and non-carcinogenic effects, and both types of effects may be involved for some chemicals. The effects of exposures to multiple chemical hazards can be cumulative, although the ways in which chemical effects interact can be quite complex, and assessment of these cumulative effects requires sophisticated analysis. The PRGs were developed to be used as a screening tool to determine if further sophisticated analysis of the health effects at a site may be needed. Generally, if PRGs are not exceeded at a site, there is no need to do further sophisticated analysis, because significant health effects are not likely to occur as a result of the concentrations present.

Pōhakuloa Training Area

Scope of the 2002 Pōhakuloa Training Area Investigation

The USACE, Sacramento District, conducted a surface soil and surface water investigation at PTA from November 12 to November 14, 2002, in support of the SBCT EIS. Study objectives were to support the description of current conditions and to provide evidence of the effects of past training activities on surface soils and surface water. The investigation was not intended to be a comprehensive study of the distribution of contaminants on the ranges.

A total of 46 soil samples were collected from Range 5 (the Grenade Range), Range 9 (the Engineering Demolition Range), Range 10 (temporary Range 9 (the Engineering Demolition Range), Range 10 (temporary impact area), Range 11 (impact area), various firing points (firing points 309, 311, 420, 802, and 804), and Range Control (considered to be an ambient background site). No surface water was observed and, therefore, no water samples were collected. Greater discussion on the investigation findings are found in the SBCT EIS.

3.8.4 Mākua Military Reservation Contaminants of Concern

During training, explosive munitions residues, fragments of metal casings from munitions items, and projectiles (including lead-antimony alloy bullets) are deposited on the ranges. The surfaces of metal fragments and projectiles may dissolve slowly and leach metals, including lead, antimony, iron, nickel, and others, into the soil and water. Munitions contain a number of chemical constituents, depending on the types of munitions, including explosives, metals, plastics, and other constituents. While most of the original chemicals are burned or vaporized when the munitions are fired or detonated, some of the material may not be fully destroyed, leaving residues that may be deposited on the soil.

3.8.5 Chemical Residues from Past Activities Mākua Military Reservation

Explosives

The results of the MMR hydrogeologic investigation (Appendix G-1) indicate that three surface soil samples contained detectable concentrations of RDX (400 to 700 µg/kg). The samples were collected from the OB/OD area and the demolition pits area, where past disposal practices, rather than detonations from CALFEX exercises, may account for some or all of the detected RDX.

In addition, samples from five locations contained concentrations of 2,4-DNT from 0.28 mg/kg to 76 mg/kg. In one of these locations, 2,6-DNT was also detected at 0.14 mg/kg. DNT is a component of some high explosives mixtures, but it is also a product that forms from the breakdown of TNT in the environment. HMX was detected in two of the soil samples in which RDX was detected at concentrations of 0.37 mg/kg and 0.5 mg/kg. Only one surface soil sample contained a detectable concentration of 2,4,6-TNT at 0.34 mg/kg. None of these concentrations of explosives were found at concentrations greater than the respective industrial soil PRGs, indicating that none of the individual explosive analytes poses a health threat under the assumptions of the PRGs.

While these results suggest that there are no significant concentrations of explosives residues in soils from past live-fire training, the soils were further analyzed to evaluate whether these results are reasonable based on what we know about the quantities of explosives used in live-fire exercises. The analysis was based on the data from studies performed by the USACE Cold Regions Experimentation Lab (CREL) (Jenkins, no date; Jenkins et al. 2000). Since it contains calculations and technical detail that may interest only a few readers, the analysis is presented in Appendix G-2 and is summarized below.

The work performed by CREL demonstrates that small quantities of explosives residues remain unburned after proper detonation of high explosive ordnance items. These residues represent a minute fraction of the original explosive mass, but the unburned residues from many explosives detonations could accumulate over time. Larger quantities of residues result from explosives that do not detonate properly and must be blown in place by Explosive Ordnance Demolition personnel using an external explosive charge. The analysis presented in Appendix G-2 suggests that explosives concentrations would be undetectable in soils over most of the live-fire training area. The total mass of the residue of the most abundant explosives compound, RDX, resulting from a typical CALFEX, is estimated to be in the range of about 0.2 gram. When

dispersed in surface soils, the concentration would be negligible. It would require the total RDX residue from about 100 CALFEXs to contaminate one cubic yard of soil so that the concentration exceeded the EPA Region IX industrial soil PRG. The same result applies to the other common explosives compounds: TNT, DNT, and HMX. Therefore, the observed low concentrations in soil samples from the hydrogeologic investigation are consistent with expectations.

Metals

In addition to explosives residues, metals contained in various munitions may also be deposited on the ranges as a result of live-fire training activities and past disposal practices. Among the metals present in some explosives are lead and mercury. Lead is also used in the projectiles of small arms ammunition.

Appendix G-2 of the EIS summarizes the analytical results of metals in surface soil samples, compared to Region IX industrial soil PRGs. The table includes the average concentration, the 95 percent UCL, and the carcinogenic and non-carcinogenic risk factors for each metal. The results in the table are further compared to concentrations in background soils from a study of soil on the Island of Hawai‘i (Halbig et al. 1985). Background metals concentrations in soils on the Island of Hawai‘i may differ from those in Mākua Valley, or elsewhere on O‘ahu, but they provide an indication of the normal range in soils derived from Hawaiian basalts.

Comparison of the metals concentrations to background concentrations in soils from the Island of Hawai‘i shows that the 95 percent UCL for most of the metals in samples from MMR are within the background range (Halbig et al. 1985). The exceptions are arsenic, lead, and selenium. Referring to Table 1 in Appendix G-2 of the EIS, it can be seen that of these three metals, only arsenic exceeds the industrial soil PRG based on a carcinogenic endpoint.

Referring to the frequency distribution graphs for these metals in Appendix G-2 of the EIS, it can be seen that although the arsenic concentrations tend to be skewed to the right side of the graph, with one sample containing a concentration of 19 mg/kg, there is no separate peak in the arsenic graph that would suggest that arsenic is present above background levels in the MMR soils. Arsenic is used in rodenticides and wood preservatives and is a common contaminant in developed areas of O‘ahu. Based on these observations, it appears that although some of the arsenic found in the soil samples may not be from mineral sources, the arsenic is widely distributed, perhaps as a result of past use of pesticide. If it derived from military activities, there would likely be localized

occurrences of higher than average concentrations in areas where military activities are focused, and this does not appear to be the case.

As shown in Table 1 in Appendix G-2 of the EIS, although the hazard index for the combined non-cancer risks for the individual metals is 1.7, which exceeds the threshold of 1.0 that is sometimes used as a basis for assessing non-cancer risks, the metals that contribute to this result include iron, aluminum, and manganese, all of which are present at typical background soil concentrations. This is further supported by the frequency distribution graphs for these metals in Appendix G-2, which indicate normal distributions. If the contributions of these metals are ignored, then the overall hazard index for the metals is well below 1.0, and no further action is required.

Dioxins

Dioxins were detected in a large number of surface soil samples at MMR and could be a potential group of chemicals of concern. As with the results from the groundwater samples, the reported concentrations of the various isomers of dioxins were converted to their respective equivalent toxicity values relative to the 2,3,7,8-TCDD isomer, for comparison to the EPA Region IX industrial soil PRG. For the 102 surface/near-surface soil samples reported in the USACE April 2003 report, the mean TCDD equivalent concentration was 0.00266 μg/kg with a 95 percent UCL of 0.00743 μg/kg. Using this potential exposure level, the carcinogenic occupational risk value is 4.64 times 10^{-7}, which is a considerably lower risk than the EPA's conservative 1 times 10^{-6} acceptable risk standard for occupational part-time exposure to these soils. Furthermore, similar concentrations of dioxins were detected in soil samples from background locations outside the boundaries of MMR. Dioxins are known to be widely distributed in the environment from atmospheric deposition from a variety of sources (for example, burning of plastics), and the detected concentrations do not indicate a significant on-site source of the dioxin.

Other Chemicals of Potential Concern

Other chemicals that were detected in the surface/near-surface soils included volatile organic compounds, such as benzene, semivolatile organic compounds, and pesticides. These chemicals were found in few samples, and at low concentrations that were less than the PRGs and do not significantly add to the combined non-carcinogenic or carcinogenic risk value; therefore, they are not considered to be health-based chemicals of concern from past or present activities at MMR.

Many organochlorine pesticides degrade very slowly in the environment and may persist for many years after they are no longer in use. The USGS has found high levels of organochlorine pesticides in sediment and fish

tissue in urban and mixed land use sites on O‘ahu (Brasher and Anthony 1999). USGS scientists note that aldrin, chlordane, and heptachlor were heavily used as termiticides in urban areas of O‘ahu until they were banned in the 1980s, and DDT was widely used until 1972. All of these pesticides have been detected at low concentrations in samples from MMR. Dieldrin was also detected in some samples; although it was not widely used in Hawai‘i, dieldrin’s presence may be attributable to the fact that aldrin rapidly degrades to dieldrin in the environment.

Pōhakuloa Training Area

Explosives

The USACE conducted a surface soil investigation in 2002, collecting 46 samples at PTA. The sampling detected six explosives included 2,4,6-TNT; 2,4-DNT (a degradation product of TNT); RDX, HMX, nitroglycerin, and perchlorate. Four samples had detectable concentrations of TNT, ranging from 0.8 to 1.5 mg/kg. None exceeded the industrial soil PRG of 57 mg/kg. The detections were in three samples from the Range 9 Demo Area and in one sample from Range 5. Three samples contained 2,4-DNT, at concentrations ranging from 0.18 to 2.0 mg/kg. The industrial soil PRG for 2,4-DNT is 1,200 mg/kg. Perchlorate was detected in one sample, from firing point FP309 in the northwest corner of Training Area 8. The concentration was below the industrial soil PRG. Of these six explosives, five samples of RDX exceeded its industrial PRG of 15.6 mg/kg.

Metals

Metals occur naturally in soils, and Hawaiian soils are no exception. However, human activities may also contribute to the background levels of metals in soils. Even in natural conditions, metals concentrations are expected to vary. One reason for different concentrations of metals in soils from different areas of PTA is that different lavas may have different compositions and concentrations of metals. Soils at PTA are relatively thin, poorly developed, and have not had much time to be mixed or redeposited. Therefore, the metals concentrations in soils developed on different flows of different ages may vary. Frequency distribution plots can be used to help identify the normal ranges of metals in soils and to identify unusually high concentrations. The high concentrations may be from natural sources, too, but if the concentrations are very different from the “typical” range of concentrations, then it is more likely that the metals are from human sources.

Among the metals that were analyzed in the samples, the most abundant metals in basalt minerals are aluminum, barium, chromium, iron, nickel, and zinc. Other metals would generally be expected to be present at lower

concentrations. Except for iron, none of these metals were detected at concentrations above the industrial soil PRGs. Chromium, nickel, and zinc were detected in one sample from Range 11 at much higher concentrations than in the other samples but still less than the industrial soil PRGs. Iron did not exceed the industrial PRG in any samples. Zinc showed a clustered distribution in the range of 100 to 200 mg/kg, with a few much higher detections. The highest detected concentrations were in samples from Range 5 and Range 11.

Looking at other, less abundant metals, most were detected at concentrations below their respective industrial soil PRGs. The highest concentrations were generally detected in a single sample from Range 11 (R11TANK-01), or in samples from Ranges 9 or 10. Exceptions to this were beryllium and selenium, higher concentrations of which seem to be randomly distributed. In fact, the highest concentrations of these seemed to be in the "background" samples from near the Range Control office.

The highest lead concentrations were detected in samples from Ranges 9, 10, and 11. Two samples (one from Range 10, and sample R11TANK-01) contained concentrations above the industrial soil PRG.

Based on these results, it appears that both elevated metals concentrations and detectable explosives concentrations were generally found in the impact areas of Ranges 5, 9, 10, and 11. Few of the concentrations exceeded industrial soil PRGs.

The combined noncancer occupational health risk associated with exposure to the observed metals concentrations from the soil investigation is 0.9, or just below the threshold of 1 for no further action. Excluding the calculated values for iron, aluminum, and manganese, i.e., known naturally occurring metals, the combined risk would be 0.29, which mainly results from lead. The combined carcinogenic risk from metals is 7.0×10^{-6}. This is above the one in one million cancer risk threshold, but within the range of 10^{-4} to 10^{-6}, which is considered acceptable under some circumstances.

Other Chemicals of Potential Concern

From samples collected at PTA, metals, explosives, and several semi-volatile organic compounds (phthalate esters and polynuclear aromatic hydrocarbons) were detected. The phthalate esters are plasticizers and are ubiquitous in the environment. They may have been present because of plastic parts in munitions. PAHs are also common in the environment at low concentrations. They are a product of combustion of heavy organic compounds, including wood, oils, and tars. None of the semi-volatile organics exceeded industrial soil PRGs, although benzo (a) pyrene was

detected in one sample from the Range 9 Demo Area at 0.190 mg/kg, which is close to the industrial soil PRG of 0.211 mg/kg.

3.8.6 Geologic Hazards
Mākua Military Reservation

Seismic Hazards

Seismic hazards can occur when people or structures are present in an area subject to fault rupture, strong ground motion, or ground failure that happens as a result of a seismic event. Most earthquakes in the Hawaiian Islands are the result of volcanic activity beneath the Island of Hawai‘i. Some are caused by intrusion of molten rock (magma) into fractures in the earth’s crust, which forces the surrounding rock to move out of the way. This movement occurs frequently and generally results in small earthquakes. Other earthquakes are thought to result from settlement or collapse of the rock surrounding magma chambers. This type of movement can produce large earthquakes, but it happens infrequently (USGS 1997).

The USGS has estimated that there is a low (about 10 to 12 percent) chance of an earthquake causing ground shaking, with a peak bedrock acceleration in excess of 10 percent of gravity in the next 50 years (USGS 1996). Bedrock transmits seismic wave energy relatively efficiently compared to soft, loose sediments, so ground shaking is usually least in areas underlain by bedrock. However, the intensity of ground shaking can be magnified by soft alluvial sediments, such as underlie Mākua Valley. Also, loose sandy sediments with a high water table are subject to liquefaction in a strong earthquake. These conditions may exist in the lower portion of the valley, closest to the Farrington Highway; no formal delineation of liquefaction-susceptible areas has been performed.

Slope Failure

Steep slopes at the margins of the Mākua Valley may be subject to slope failures, such as rock slides; however, most of the land area used for military training has moderate slopes. Figure 3.8-8 shows areas with slopes greater than 30 percent.

Pōhakuloa Training Area

Seismic Hazards

The Island of Hawai‘i is the locus of most of the earthquake activity that occurs in the Hawaiian Islands. A magnitude 7.2 earthquake in 1975 that originated beneath Kīlauea was the largest earthquake to originate in Hawai‘i during the past century. Hazards associated with earthquakes include ground shaking, liquefaction, landslides, and tsunamis. The 1975

earthquake generated a tsunami that killed two people and damaged property along the coast (USGS 1997a).

The USGS has prepared maps showing the horizontal ground acceleration in firm rock, as a percentage of the acceleration of gravity, for a given probability of exceedance within a given number of years. Acceleration is the rate of change in speed or direction of an object, and it is what makes buildings come apart in a strong earthquake. A 10 percent probability of exceedance in the next 50 years means that there is a 10 percent chance that a larger event will occur in the next 50 years. PTA is in an area in which there is a 10 percent probability that an earthquake will cause a ground acceleration of more than 40 to 60 percent of gravity in the next 50 years, with the likely size of the earthquake increasing to the south, in the direction of Kīlauea and the south coast.

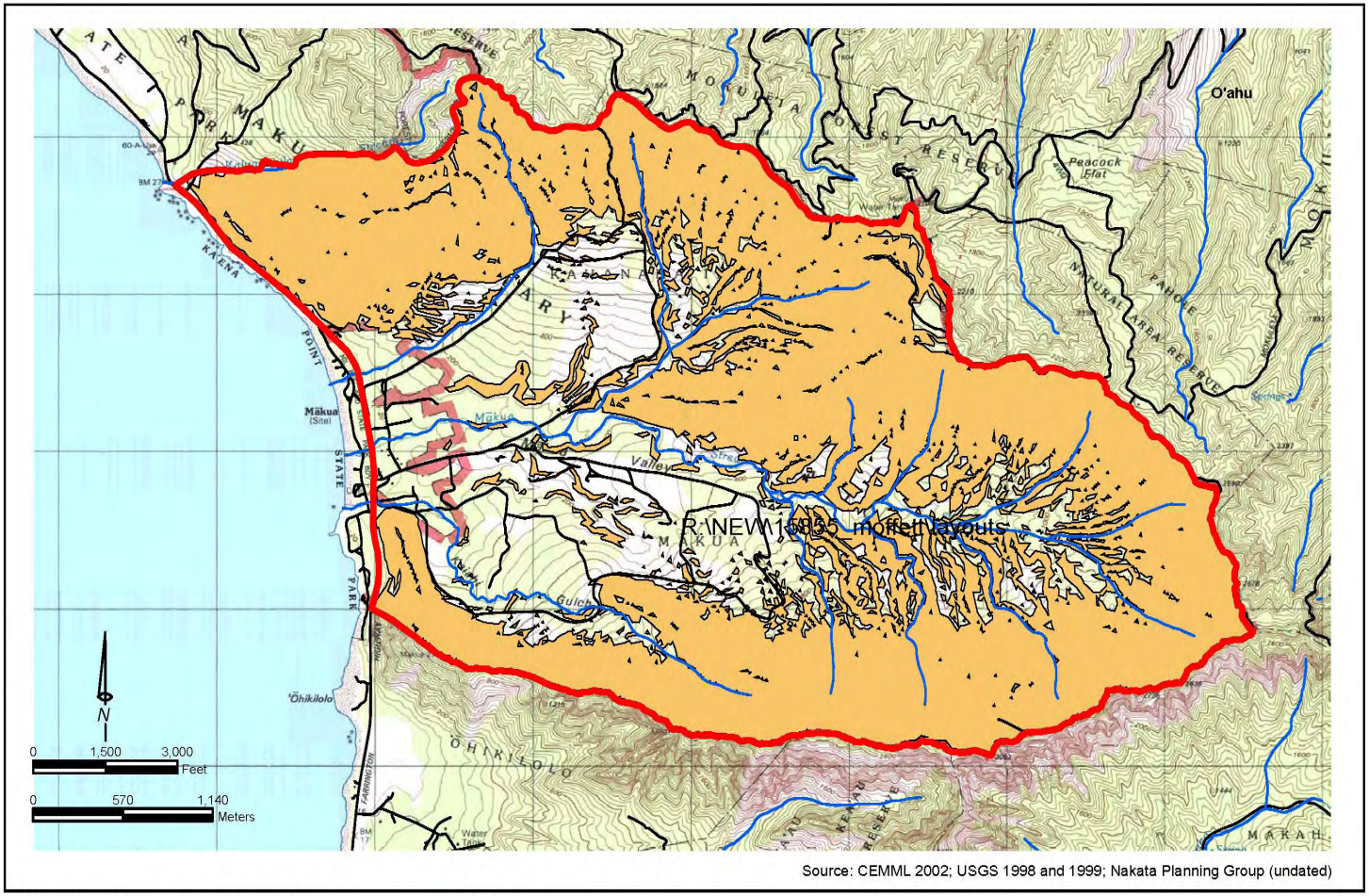
Slope Failure

In the PTA area of the Island of Hawai‘i, areas with slopes greater than 30 percent are primarily limited to the slopes of Mauna Kea, north of Saddle Road, and to the southern portion of PTA, on the north-facing slope of Mauna Loa (Figure 3.8-9).

Volcanic Eruption Hazards

The USGS has divided the Island of Hawai‘i into Lava Hazard Zones based on the probability of coverage by lava flows. Other hazards from volcanic eruptions are not classified in this system. Zone 1 has the highest risk and Zone 9 has the lowest. PTA overlies areas categorized as zones 2, 3, and 8 (County of Hawai‘i 2002a). Zone 2 includes areas in which 15 to 25 percent of the land area has been covered by flows since 1800; the eastern margin and northeastern corner of PTA are in Zone 2. Zone 3 has had 1 to 15 percent coverage by lava flows since 1800; most of PTA is in Zone 3. Zone 8 has had no lava coverage over the past 750 years, and only a few percent of the area was covered in the past 10,000 years. Zone 8 represents areas near or north of Saddle Road that are underlain by lava erupted from Mauna Kea. PTA Trail is located entirely within Zone 8.

Infrequently, Hawaiian volcanoes erupt explosively. In 1790, Kīlauea erupted explosively, creating a surge of hot gases and fine dust that killed a group of Hawaiian warriors and their families near the summit.



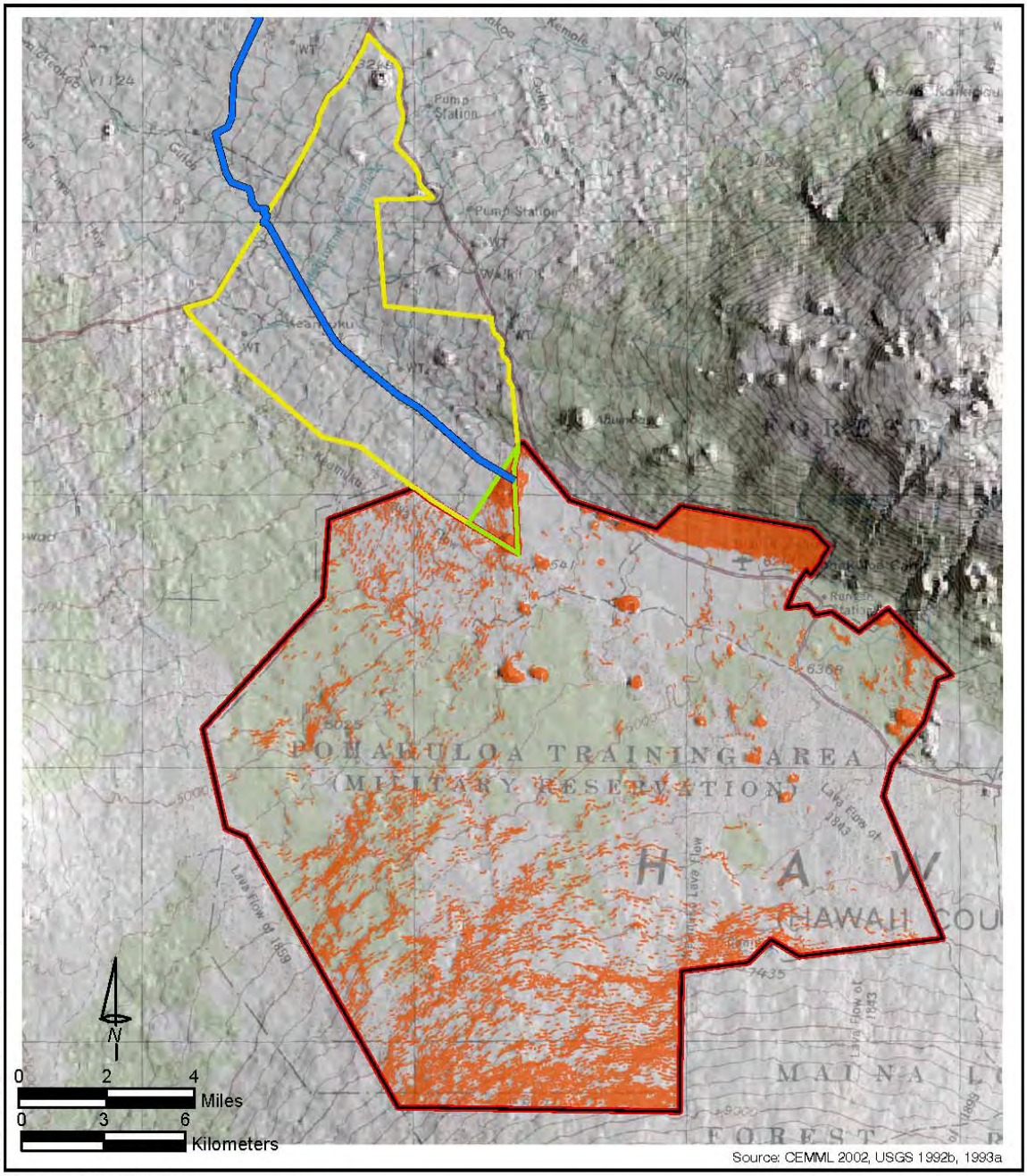
Steep slopes at the margin of Mākua Valley may be subject to slope failures such as rock slides.

Legend
- Mākua Military Reservation
- State Land Use District Boundary
- Rivers
- Roads
- Slopes Greater than 30 Degrees

Steep Slopes

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.8-8 Steep Slopes, MMR



Slopes greater than 30 percent are primarily limited to the slopes of Mauna Kea, north of Saddle Road, and to the southern portion of Pōhakuloa Training Area on the north-facing slope of Mauna Loa.

Legend

- Pōhakuloa Training Area Boundary
- P7 West Pōhakuloa Training Area Acquisition Area
- 1010 Land Acquisition Area
- Slopes Greater than 30 Percent
- P3/P4 Pōhakuloa to Kawaihae Trail

Steep Slopes at Pōhakuloa Training Area

Island of Hawai'i, Hawai'i

Figure 3.8-9 Steep Slopes, PTA

Another hazard of Hawaiian volcanoes is emission of sulfur dioxide gas and other toxic constituents. The gas forms a strong acid, hydrogen sulfide, when it reacts with moisture in the atmosphere or in peoples' lungs. The particulates and gases form a mixture called "vog," meaning volcanic smog, that can range from a dispersed atmospheric haze resembling smog to a ground-hugging cloud resembling fog (USGS 2000b).

Slope Failure

In the PTA area of the Island of Hawai‘i, areas with slopes greater than 30 percent are primarily limited to the slopes of Mauna Kea, north of Saddle Road, and to the southern portion of PTA, on the north-facing slope of Mauna Loa (Figure 3.8-9).

Volcanic Eruption Hazards

The USGS has divided the Island of Hawai‘i into Lava Hazard Zones based on the probability of coverage by lava flows. Other hazards from volcanic eruptions are not classified in this system. Zone 1 has the highest risk and Zone 9 has the lowest. PTA overlies areas categorized as zones 2, 3, and 8 (County of Hawai‘i 2002a). Zone 2 includes areas in which 15 to 25 percent of the land area has been covered by flows since 1800; the eastern margin and northeastern corner of PTA are in Zone 2. Zone 3 has had 1 to 15 percent coverage by lava flows since 1800; most of PTA is in Zone 3. Zone 8 has had no lava coverage over the past 750 years, and only a few percent of the area was covered in the past 10,000 years. Zone 8 represents areas near or north of Saddle Road that are underlain by lava erupted from Mauna Kea. PTA Trail is located entirely within Zone 8.

Infrequently, Hawaiian volcanoes erupt explosively. In 1790, Kīlauea erupted explosively, creating a surge of hot gases and fine dust that killed a group of Hawaiian warriors and their families near the summit.

Another hazard of Hawaiian volcanoes is emission of sulfur dioxide gas and other toxic constituents. The gas forms a strong acid, hydrogen sulfide, when it reacts with moisture in the atmosphere or in peoples' lungs. The particulates and gases form a mixture called "vog," meaning volcanic smog, that can range from a dispersed atmospheric haze resembling smog to a ground-hugging cloud resembling fog (USGS 2000b).

3.9 BIOLOGICAL RESOURCES

3.9.1 Introduction/Region of Influence

Mākua Military Reservation

This section describes biological resources around MMR. As shown in Figure 3.9-1, the ROI includes the following:

- MMR and a buffer area around it that corresponds with that identified in the 2007 BO (USFWS 2007b);
- Trails where troop marches are proposed or are currently conducted, plus a 164-foot (50-meter) buffer area paralleling both sides of these trails; and
- Coastal areas adjacent to project activities.

The coastal portion of the ROI is made up of Mākua Beach, in its entirety, and contiguous waters out to 0.5 mile (0.8 kilometers). The coastal portion of the ROI was determined based on a combination of helicopter use patterns and high-use dolphin habitat (Dollar 1999; Lammers 2003a).

For the 2007 ESA Section 7 consultation, the action area was determined by running the fire spread model Fire Area Simulator (FARSITE) (Finney 1998). This model accounts for the area that would be impacted by an unsuppressed fire ignited at the outer perimeter of the potential ignition area for all weapons, with high risk weather conditions. The model calculated fire spread based on hourly inputs of weather data and GIS-generated maps of vegetation fuels, canopy characteristics, slope, elevation, and aspect.

The extent of the ROI for this EIS is based on the following:

- Types of vegetation /fuel load;
- Fire history;
- Natural and human-made barriers;
- Fire fighting resources and capabilities of state, federal, and Army;
- The extent of noise and visual impacts along the trails and coastal edge of MMR (beach, shoreline, and a portion of the coastal waters over which aircraft maneuvers may occur); and
- Trampling and erosion in areas where troop marches are proposed.

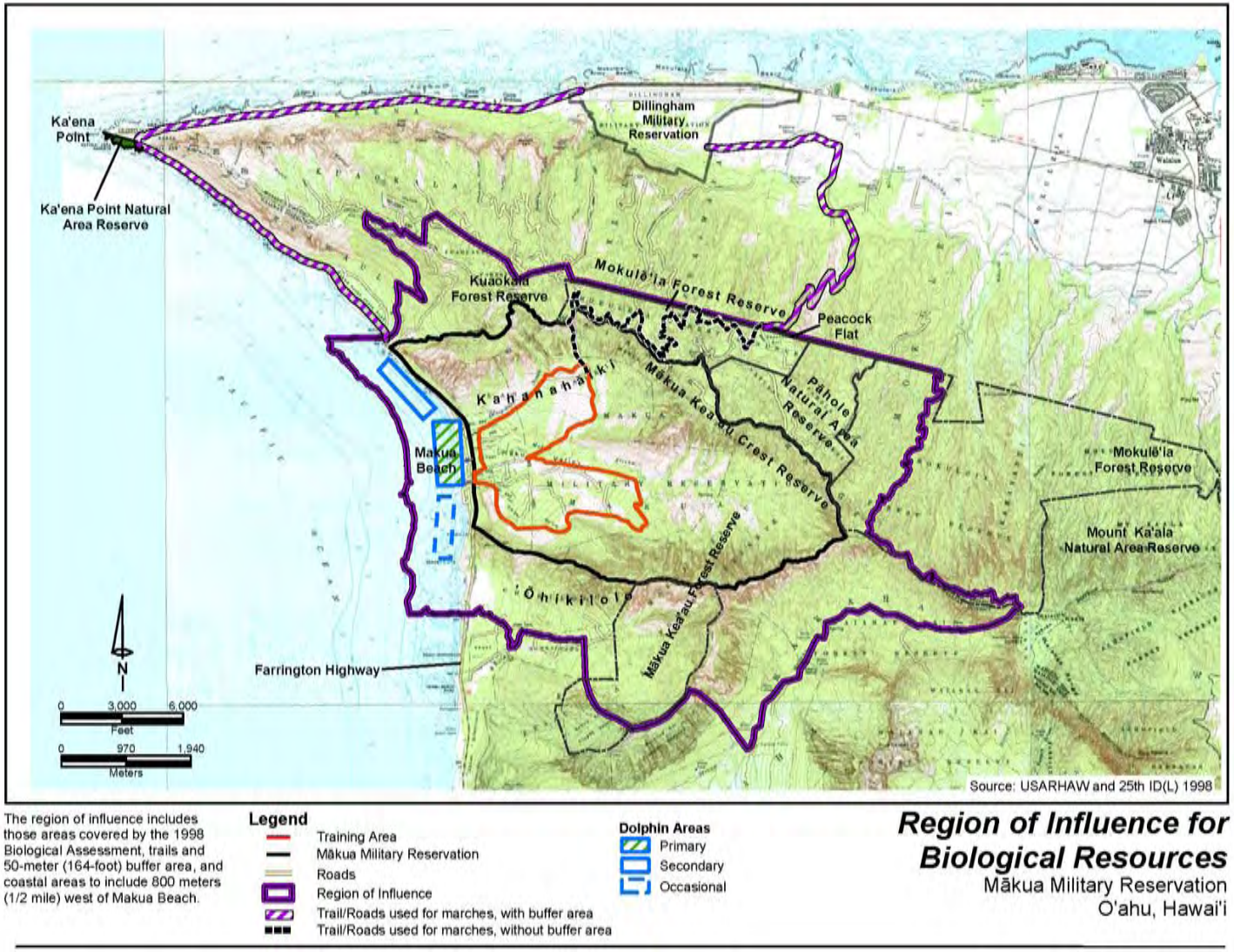


Figure 3.9-1 Region of Influence for Biological Resources, MMR

Vegetation, wildlife, sensitive habitats, and special status species that have been recorded in or that have the potential to be found within this ROI, based on the presence of suitable habitat, are discussed in this section. Damages to the native, listed, and nonnative communities and species from the July 2003 prescribed burn (described in the Chapter 3 introduction) are discussed in this section as appropriate. Figure 3.9-2 presents the ROI for biological resources.

Biological resources in the ROI include those that are limited in number or habitat or restricted in movement (e.g., plants and small mammals). The resources also include those that are more mobile and can range onto and off the property from surrounding habitat areas (e.g., fish, birds, and terrestrial, and marine mammals). Marine wildlife and organisms, including coral, are evaluated when they occur adjacent to or in the vicinity of the terrestrial ROI.

Neighboring lands along the Waiʻanae Mountain ridges include Pāhole Natural Area Reserve, Mokulēʻia Forest Reserve, and Kuaokalā Forest Reserve (Figure 2-2). The Mākua Keaʻau Forest Reserve and private lands border MMR to the south. The lowland portions of MMR are mainly composed of nonnative plants and wildlife, as the result of years of agricultural use and, more recently, disturbance from training activities. The Waiʻanae Mountains, which border MMR to the north, east, and south, are less disturbed and are known to harbor many native and protected species. The coastal area adjacent to MMR has been disturbed by recreational activities but remains an important habitat for marine wildlife species (see Figure 3.9-1).

In addition to the project description in Chapter 2, the following assumptions were used for the analysis of project impacts:

- No smoking would be allowed during marches;
- Soldiers would be restricted to established trails or roads when on marches, and marching formation would conform to the width of the trail;
- Trails would be surveyed before and after each march by a qualified natural resource staff person, capable of determining if there has been damage to the trail and the surrounding flora and fauna that would contribute to species and habitat deterioration;
- DPW Environmental staff would brief Soldiers on sensitive area restrictions;

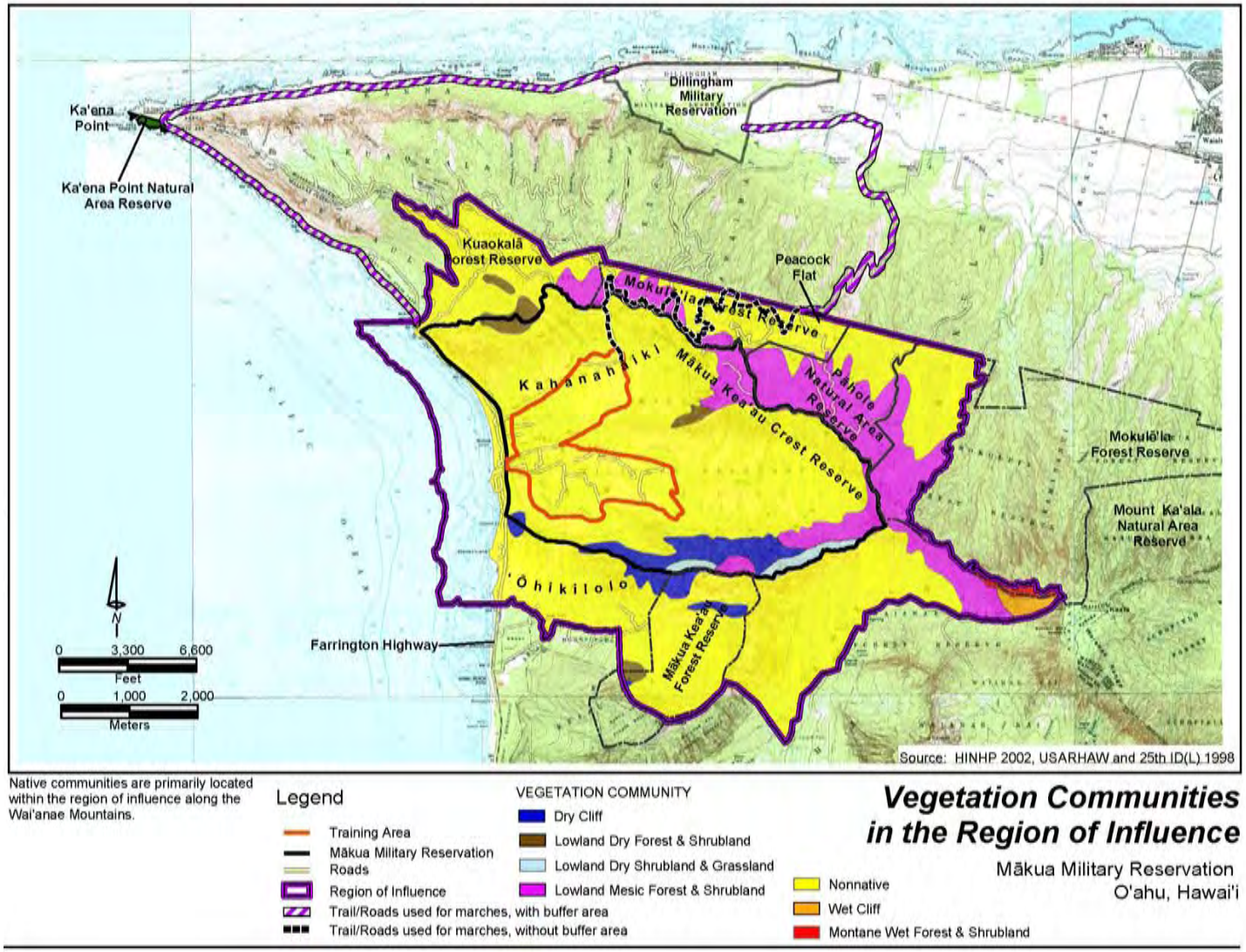


Figure 3.9-2 Vegetative Communities in the Region of Influence, MMR

- To ensure that Soldiers stay on the trails, trails would be marked with flagging tape prior to the march;
- If damage is detected to surrounding habitat, then the march protocol would be modified;
- Cadence would be prohibited along Ka‘ena Point Trail marches during the Laysan albatross breeding season (November to July);
- All aircraft fire would be directed and confined to the ordnance impact area;
- Aircraft operations under Alternatives 1, 2, and 3 would be conducted as part of CALFEX training; and
- Ammunition would not be fired at areas outside the existing CCAAC firebreak road.

These assumptions are based on previous measures outlined in USFWS consultations, state Natural Area Reserve System (NARS) regulations, and Integrated Natural Resource Management Plan (INRMP) program statements.

Comments received during the scoping process by the public regarding biological resources include the following:

- Wildlife endangerment;
- Direct and indirect contamination of native plant and wildlife species;
- Measures to ensure ecosystem recovery;
- Alterations in marine mammal behavior;
- Threats to nesting patterns and habitat of native birds;
- Destruction of native plants and animals that are common sources of medicinal and nutritional benefits; and
- Land use management.

The history of fire at MMR and fire-inducing activities is discussed in Section 3.14, Wildfires. In addition, that section presents improvements the Army has made in recent years regarding fire management and provides an overview of the IWFMP.

Pōhakuloa Training Area

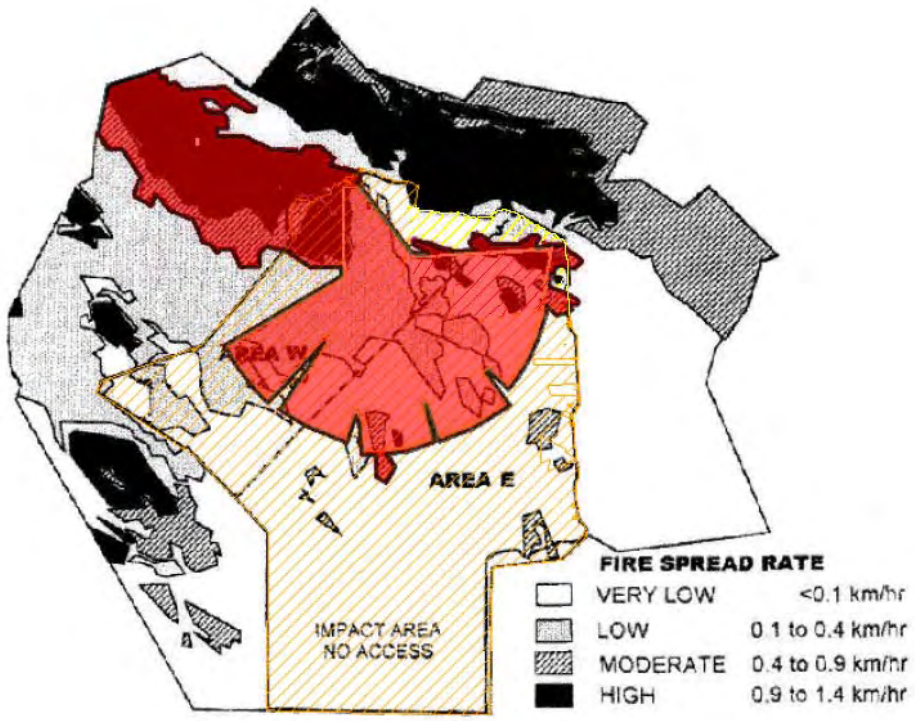
This section describes biological resources around the PTA range site alternative. As shown in Figure 3.9-3, the ROI for the Proposed Action includes the range footprint and the moderate to high fire spread rate areas that would be impacted by an unsuppressed fire ignited at the outer perimeter of the potential ignition area for all weapons, with high risk weather conditions.

The moderate to high fire spread rate areas that could result from fire ignition were determined by vegetation types of highest flammability and fire spread rate.

Vegetation (Figure 3.9-4), wildlife, sensitive habitats, and special status species that have been recorded in or that have the potential to be found within this ROI, based on the presence of suitable habitat, are discussed in this section.

Biological resources in the ROI include those that are limited in number or habitat or restricted in movement (e.g., plants and small mammals). The resources also include those that are more mobile and can range onto and off the property from surrounding habitat areas (e.g., birds and terrestrial mammals). The following assumptions were used for the analysis of project impacts:

- No smoking would be allowed within the training area or along routes used for marches or other dismounted activities;
- To avoid damage to sensitive habitat, Soldiers would be restricted to established trails or roads when on marches and marching formation would conform to the width of the trail;
- Trails would be surveyed before and after each march by a qualified natural resource staff person, capable of determining if there has been damage to the trail and the surrounding flora and fauna that would contribute to species and habitat deterioration;
- DPW Environmental staff would brief Soldiers on sensitive area restrictions;
- To ensure that Soldiers stay on the trails, trails would be marked with flagging tape prior to the march;
- If damage is detected to surrounding habitat, then the march protocol would be modified;
- All aircraft fire would be directed and confined to the ordnance impact area;

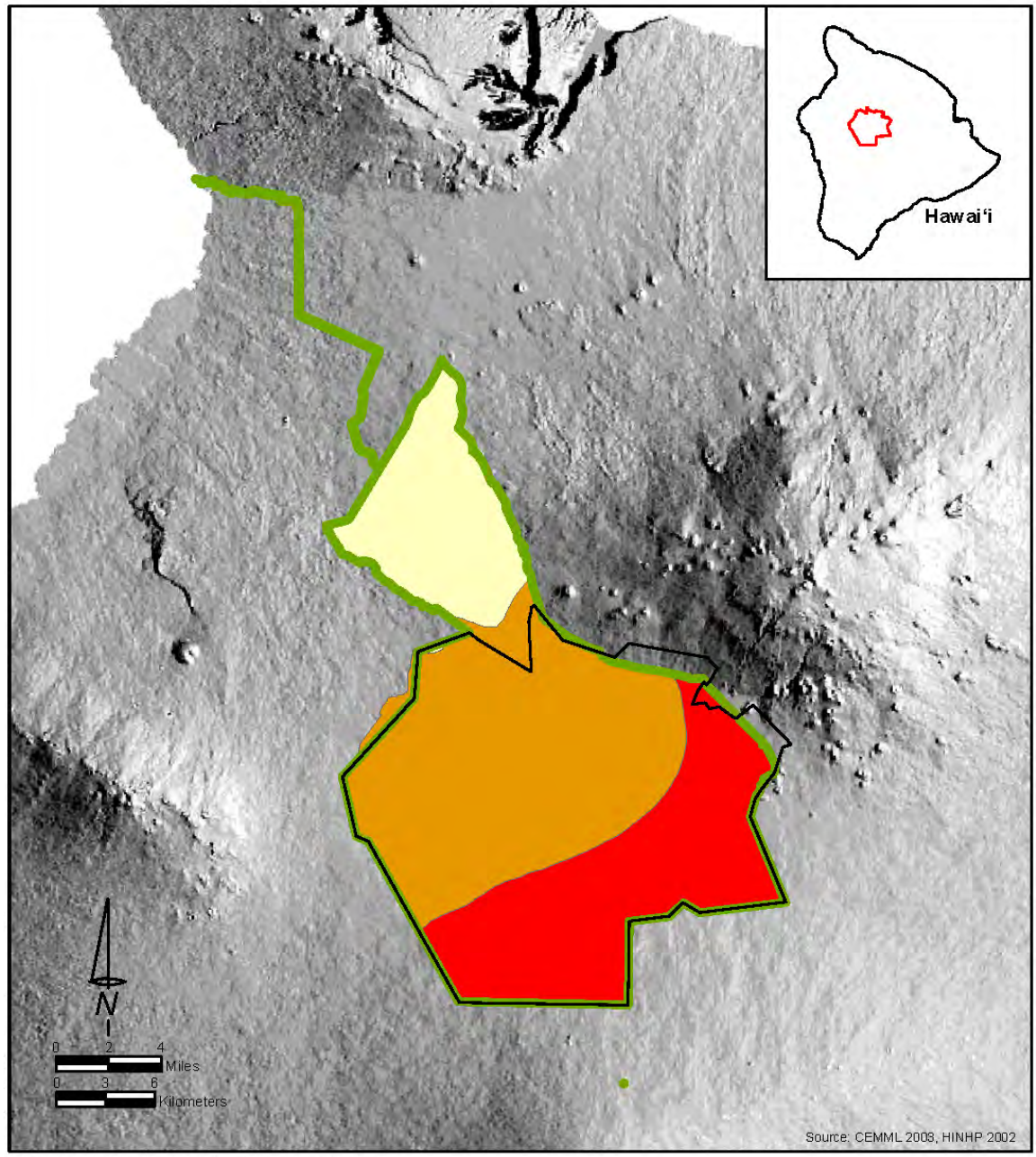


Legend

Region of Influence

Impact Area

Figure 3.9-3 Terrestrial and Aquatic Biological Region of Influence, PTA



The twenty eight sub-groups of vegetation communities occur within the main types identified here.

Legend

- Pōhakuloa Training Area Boundary
- Region of Influence

COMMUNITY

- Montane Dry Forest & Shrubland
- Nonnative
- Subalpine Dry Forest & Shrubland

Vegetation Communities at the Pōhakuloa Training Area Terrestrial Biological Region of Influence

Island of Hawai'i, Hawai'i

Figure 3.9-4 Vegetative Communities, PTA Terrestrial Region of Influence

- Aircraft operations would be conducted as part of CALFEX training; and
- Ammunition would not be fired at areas outside the existing impact area.

3.9.2 Biological Resource Management Mākua Military Reservation

The environmental regulatory history of MMR includes consultation under ESA Section 7 for federally listed species and their federally designated or proposed critical habitat. During 1989 to 1991, the Army consulted with USFWS regarding the O‘ahu tree snail. In 1991, the USFWS released a BO, a legally binding memorandum produced at the end of formal consultation with that agency, stating that there would be “no jeopardy” to this species as long as the Army agreed to the following conditions:

- Eliminate the use of high fire-risk ordnance, such as flares and rockets;
- Limit firing of high-explosive and tracer munitions to inside the CCAAC firebreak road; and
- Produce semiannual reports of fires that escape control (USARHAW and 25th ID[L] 2001a).

In 1998, the Army initiated formal consultation with the USFWS under ESA Section 7 to determine if routine military training at MMR would jeopardize the continued existence of 41 endangered species. The Army also prepared a BA detailing routine training and conservation measures for 13 sensitive plant species considered stable in MMR. The remaining 27 plant species and one snail species are the subjects of a Mākua Implementation Plan (MIP).

In July 1999, the USFWS issued a BO of “no jeopardy” for routine training at MMR that addressed the impacts of the proposed projects and conservation measures on threatened and endangered species (USFWS 1999c). A supplemental BO followed in October 2001, in which another no jeopardy opinion was issued (USFWS 2001a). The 2001 supplemental BO was issued as a result of additional Army restrictions to training (voluntary withdrawal of tracers, incendiary munitions, and inert TOW missiles) and the discovery of additional sensitive species in the management area.

The no jeopardy opinion depended on the Army doing the following:

- Creating an IWFMP;
- Implementing management actions for the 13 endangered species considered stable or for which only small portions of the population occur in the action area; and
- Preparing an implementation plan for other protected species.

The Army has been implementing these measures to achieve the following:

- Minimize negative effects on listed species and habitat to prepare for when the Army returns to training at MMR; and
- Help stabilize the population of these species.

As part of these measures, the Mākua Implementation Team (MIT) has developed a number of versions of the MIP (collectively referred to herein as the MIP) (MIT et al. 2003; US Army, Directorate of Public Works 2004, 2005) in a collaborative effort among the Army, the USFWS, the State of Hawai‘i, the Honolulu Board of Water Supply, The Nature Conservancy of Hawai‘i, and endangered species or ecosystem experts. The MIP was developed to offset impacts associated with an action area that does not include the Ka‘ena Point trailor the impacts of sniper training on C-Ridge (the ridge between the north and south lobes of the training area). The MIP also was developed to offset impacts associated with the types of weapons systems and munitions proposed for Alternatives 1 and 2 (including tracers and inert TOW missiles), but not for Alternative 3 (155mm HE howitzers, 2.75-inch rockets, and Javelin anti-tank missiles). The plan identifies 28 target species, including federally listed plants and one snail. The USFWS deemed the Army responsible for stabilizing these species and stipulated that a MIP was needed to detail how the Army can halt species decline and protect habitat. The plan includes the following notable features:

- A timeframe for completing implementation;
- Identification of priority management areas;
- Definitions of success;
- Methods for managing the species and habitats (including monitoring);
- Calculation of the goal stable population size for each species; and
- A cost estimate for implementation.

In addition to the development of a MIP, the Army was tasked with implementing high-priority stabilization actions for those species at highest risk of fire from military training, which included the following measures listed in the BO As of 2007, the Army has completed all of the urgent actions; which consisted of the following:

- Upgrade the Pāhole Mid-Elevation Facility to meet quarantine standards;
- Develop a database to track information on collection and propagation efforts of rare species;
- Collect an adequate genetic representation of the following sensitive plant species: *Chamaesyce celastroides* var. *kaenana*, *Cyanea superba* ssp. *superba*, *Hibiscus brackenridgei* ssp. *mokuleianus*, *Lipochaeta tenuifolia*, *Neraudia angulata*, and *Tetramolopium filiforme*;
- Fund a seed storage facility for the collected material of the plants listed in the above action;
- Hire an Army horticulturist;
- Hire three additional staff to implement collection, weed control, and ungulate control in naturally occurring populations, as well as species reintroduction of *Cyanea superba* ssp. *superba*;
- Conduct plant surveys for *Chamaesyce celastroides* var. *kaenana*, *Neraudia angulata*, and *Tetramolopium filiforme*;
- Search for additional genetic material for *Cyanea superba* ssp. *superba* in herbarium specimens and propagated specimens;
- Fund genetic analysis of any new material collected on this species;
- Continue implementation of the IWFMP pre-suppression actions; and
- Prepare a fire management plan for the Kaluakauila management unit.

In 2004, the Army reinitiated ESA Section 7 Consultation with USFWS for newly designated critical habitat for 41 threatened and endangered plant species and to comply with the requirement from the 1999 BO to consult in the event of a fire escaping the firebreak road. This consultation was based on training and maintenance operations as described in the 1999 BO (USFWS 1999c) and 2001 Supplemental BO (USFWS 2001a) and the July 2003 wildfire that resulted from a prescribed burn. USFWS issued a BO in September 2004 (USFWS 2004) completing this

reinitiation and finalizing the 2001 conference opinion on the effects of training on O‘ahu ‘elepaio designated critical habitat. USFWS concluded that the proposed actions would have no adverse modification on designated critical habitat, based largely on conservation measures that the Army incorporated into the project. A species list appears in Appendix H-2.

In July 2005, the Army initiated ESA Section 7 consultation with the USFWS on the following:

- Addition of tracers, inert TOW missiles, 2.75-inch rockets, Javelin, UAVs, and Stryker vehicle firing platforms; and
- Troop marches on Kuaokalā Trail.

Any training activities not already the subject of ESA Section 7 consultation would undergo such consultation prior to being conducted at MMR.

On June 22, 2007, the USFWS issued its BO, in which it concluded that implementing the proposed action was not likely to jeopardize the continued existence of any species or to adversely modify or destroy designated critical habitat covered in the opinion. Training at Ka’ena Point and C-Ridge (the ridge between the north and south lobes of the training area) and the use of illumination munitions were not covered in this ESA formal Section 7 consultation. However, due to the potential need to use these sites and munitions in the future, the Army assessed the environmental impacts associated with these actions. The Army would initiate and fulfill separate ESA Section 7 consultation prior to using illumination munitions, Ka`ena Point, or C-Ridge.

Implementing the 2007 BO requirements for stabilization of extremely vulnerable species will ensure that any local destructive event (i.e., fire ignition and spread of invasive species by non-military sources) will not have tragic consequences on the species as a whole. A major factor in minimizing wildfire risk by the mission is the required implementation of weapons restrictions, which are discussed in greater detail below.

The 2007 BO requires that, until the Army has achieved the expedited stabilization for the 12 most at risk species, it could not utilizefire tracers, 2.75 rockets, AT-4/M136, shoulder-launched multi-purpose assault weapons, or Javelin missiles. In addition, the Army would not be able to use mines, simulators, mortars, and artillery/howitzers under higher burning indexes until stabilization occurs. The Army estimates that

expedited stabilization will take anywhere from 10 to 15 years to complete.

At the same time, the Army would pursue stabilization of the remaining 16 plant species and the O‘ahu tree snail. Stabilization is achieved when there are three naturally reproducing plant populations with all of the threats controlled and eight snail populations with at least 300 individual snails.

Until all 29 species have been stabilized, the Army would not be able to fire inert TOW missiles at MMR (USFWS 2007b). This is due to the fire starting potential of using a propellant to fire the TOW, even though the TOW itself is inert.

Weather and fuel moisture restrictions on weapons systems, combined with additional fuel modifications, would lessen future fire impacts on sensitive species. Specifically, the use of weapons on MMR would be contingent on the Army removing and reducing grass around *Hibiscus* and *Chamaesyce* plants, completing 197 feet (60 meters) of fuel modification (e.g., mowing the grass) along the inside perimeter of the south lobe of the firebreak road and maintaining on-site fire suppression helicopter staffing (USFWS 2007b).

Impacts on native species would also be minimized and mitigated through required implementation of programs to control weeds and nonnative fauna (such as cannibal snails, rats, and feral ungulates [cattle, goats, pigs, and sheep]). In addition, if any area of plant critical habitat were burned, the Army would implement a post-fire vegetation plan to restore the area. Within the 23 priority management units, weed control would generally be prioritized to areas of high native plant cover, around target taxa individuals, and at potential augmentation/reintroduction sites. Ungulate control, where necessary, would include a combination of monitoring, fencing, hunting, and snaring. The Army is also required to remove all ungulates from within MMR and has already succeeded in removing all goats from the area. In addition, the Army has just about completedan ungulate-proof fence encircling the installation’s boundary. Rats would be controlled with such approved applications as aerial rodenticides and trapping.

Impacts from ground training would be minimized by excluding Ka‘ena Point trail from any training activities, prohibiting any open fires anywhere, restricting marches on Kuaokalā Trail to established trails or roads, with marching formation conforming to the width of the trail, prohibiting smoking on trails, and surveying trails before and after use.

The USFWS's no jeopardy and no adverse modification of critical habitat conclusions are based on the following:

- The Army conservation and stewardship programs that would increase the baseline number of individuals according to the criteria stipulated in the MIP for 29 species;
- Weapons restrictions, fuels management, fire suppression, and construction of fuelbreaks and firebreaks to minimize the risk of wildland fire;
- Invasive species control, such as rat baiting, ungulate removal, and invasive plant management;
- The Army's multiple actions to minimize and reduce the risk of fire, to minimize introduction and spread of nonnative species, and to increase the current baseline for primary constituent elements of critical habitat; and
- The Army restoring critical habitat should a fire escape the firebreak road.

The USFWS concluded that any losses that occur after implementation of these actions would be short-term and would not result in permanent destruction or alteration of the physical and biological features of critical habitat.

In August 2007 a fire ignited on private land within the Waialua area and burned a significant number of the endangered *Hibiscus brackenridgei* (ma‘o hau hele) resulting in a very large change to the status of the species. The Army reinitiated consultation with the USFWS in January 2008 due to the significant change in status of endangered plant. The resulting June 2008 amendment to the August 2007 BO identifies the conservation measures to be implemented on private land within Waialua to minimize the overall impacts on the hibiscus. The most significant measure is the establishment of an 86-acre (34.8 hectares) fuelbreak extending from Pu‘ulu to Ala‘ihe‘ihe. In addition, the Army is working with the private landowner to install a fence around the plants that have resprouted in the Waialua area to protect them from non-native hoofed mammals (i.e., ungulates), and install a separate fence along the boundary of the gulch below the plants where the Army would hire someone to graze animals as a means to maintain the firebreak.

On MMR, in addition to the 2007 BO requirements, the Army would implement the following measures to reduce potential impacts on the hibiscus:

- All live and dead grass will be removed from within 10 feet (3 meters) of all *H. brackenridgei* within the Lower Ohikilolo Management Unit such that total grass cover is maintained at less than one percent. Fuel will also be reduced within the remainder of the weed control area.

- Fuel within the 7.6-acre (3.l-hectare) area between the firebreak road and the *H. brackenridgei* population and within 66 feet (20 meters) of the outer perimeter of the *H. brackenridgei* weed control area, will be mowed prior to the use of any weapon or prescribed burning.

- Vegetation within a 197-foot (60 meter) strip along the inside edge of the south lobe of the firebreak road will be maintained by mowing.

The conservation measures are to be completed within three years of the issuance of the BO. Within the Puʻulu to Alaʻiheʻihe Gulches, the fuelbreaks are also to be completed within three years provided permission is secured and maintained by the landowner and lessee. In conclusion, the nondiscretionary measures contained within the 2007 and 2008 BOs, along with the other conservation plans and actions being implemented at MMR, are anticipated to appreciably reduce the significance of the action's impacts on listed species and critical habitat.

The Army has also consulted with the National Marine Fisheries Service (NOAA Fisheries), which is responsible for protecting most marine mammals under the ESA and the Marine Mammal Protection Act (MMPA). ESA Section 7 consultations on this project with NOAA Fisheries began in January 2006 and concluded in October 2006, when NOAA Fisheries issued a concurrence letter with the Army's determination that the proposed action was not likely to adversely affect (NLAA) listed species under NOAA Fisheries' jurisdiction (NOAA Fisheries 2006). As part of this consultation the Army has committed to implementing specific monitoring and mitigation measures (see Chapter 4). These measures would minimize potential training effects on sensitive marine protected species. In addition, these measures will be incorporated into the Army's existing SOPs for MMR, and a copy of this revised SOP will be provided to NOAA Fisheries for their documentation. A copy of the NLAA letter is in Appendix H-3.

Pōhakuloa Training Area

The environmental regulatory history of PTA includes consultation under ESA Section 7 for federally listed species and their federally designated or

proposed critical habitat. During the 1990s and into the 2000s, a number of formal consultations were initiated with the USFWS on actions occurring within or in proximity to the ROI for this alternative.

On July 27, 1998, the USFWS issued a BO to the US Department of Transportation, Federal Highway Administration, for the Saddle Road Realignment and Improvement Project. Though this project takes place at a considerable distance from the ROI, the BA and the EIS for the project identified the MPRC (area to the southwest of range) as partial mitigation for the loss of Palila critical habitat. The BO issued by the USFWS made it clear that their finding of "no jeopardy" to the Palila and *Silene hawaiiensis* and "no adverse modification" to Palila critical habitat was "based in large part on the conservation measures built into the project…" To offset loss of Palila critical habitat resulting from the planned Saddle Road realignment, the Army agreed that 4,045 acres (1,637 hectares) of the Kīpuka Alala (within the MPRC area) would be Palila habitat mitigation. In order to protect and enhance a large portion of *Sophora chrysophylla/Myoporum sandwicense* (māmane/naio) forest as potential Palila habitat in Kīpuka Alala, a large fence unit was constructed around the area and feral ungulates were removed. The fence was completed in January 2001 and to date, the Kīpuka Alala is ungulate free. A Memorandum of Understanding (MOU) Regarding Implementation of the Saddle Road Palila Critical Habitat Impact Mitigation (1998) details the agreement between the Army, the Federal Highway Administration, and the USFWS regarding Kīpuka Alala. Almost all signatories agreed to participate in the development of a comprehensive, interagency fire plan as well as coordinated fire prevention and suppression activities and planning.

Informal consultation with the USFWS for the Routine Military Training and Other Current Activities at PTA officially began in 1997. The consultation was amended to include the SBCT. In April 2003, the USAG-HI initiated programmatic formal consultation with the USFWS for routine training and transformation activities (SBCT) on PTA with the submission of two separate BAs:

1. Pōhakuloa Training Area, Biological Assessment for Programmatic ESA Section 7 consultation on Routine Training and Related Activities, 25th Infantry Division (Light) and US Army, Hawai‘i.

2. Programmatic Biological Assessment for Transformation of the 2nd Brigade 25th Infantry Division (Light), US Army, Island of Hawai‘i.

The USFWS concluded in its BO (USFWS 2003c) that implementation of the Proposed Actions are not likely to jeopardize the continued existence

of any species covered in the BO or adversely modify or destroy critical habitat. Their non-jeopardy and no adverse modification opinions were based, in large part, on the conservation measures and the development and execution of the PIP as described in the Conservation Measures section of the BO. The PIP, which is near completion, outlines the management actions necessary to ensure the long-term survival of endangered species at PTA and is designed to assure proper conservation of species as construction and use of ranges and facilities occur.

The PIP was prepared to guide conservation efforts that will result in the conservation of federally listed threatened and endangered plant and animal species and Palila critical habitat that could be affected by military training activities at PTA on the Island of Hawai‘i. In addition, monitoring protocols were developed for each species to evaluate success of these management actions. Major management actions identified in the PIP include propagation and outplanting, weed control, survey protocols for flora and fauna, rodent control, ungulate control, large-scale fencing, invasive invertebrate control, and an incipient weed program. The majority of actions are planned on Army lands. If at any time there is a change in the training areas or action areas, a change in the species status, or the discovery of additional taxa, the Army would be required to reinitiate consultation with the USFWS.

Example mitigation measures that are to be implemented by the Army at PTA include:

- Enclosure fencing of sensitive plant species to eliminate impacts from human disturbance and ungulates;
- Development and implementation of a fire fuel reduction plan;
- Development and implementation of an alien rat control plan to protect sensitive species;
- Expansion of monitoring programs in potential areas of impact for sensitive species;
- Establishing signage to identify areas that are off limits due to the presence of federally listed species;
- Providing education for each set of new Soldiers regarding the importance of avoiding listed species and disturbance to their habitats;
- Collection of seeds and propagation material from plants in the BAX construction footprint to be used for planting in other areas;

- Conducting surveys to determine presence of the Hawaiian hoary bat; and species presence, abundance, and habitat use by Hawaiian Dark-rumped Petrel or ‘ua‘u, Hawaiian Goose or nēnē, and Hawaiian Hawk or ‘io;

- Implementation of a nonnative invasive plant monitoring program within, and adjacent to, landing zones, trails, and roadsides. Newly identified nonnative plants shall be eradicated using the most effective means for those species; and

- Thoroughly cleaning vehicles (training and construction) before moving onto PTA.

The USFWS anticipates that take of Hawaiian hoary bats will occur in the form of harm (due to the loss of habitat), harassment, and injury or death as a result of Army activities described in the BO. The USFWS anticipates that an average of approximately 240 acres (97 hectares) may burn annually for five years within the treeland vegetation outside the Impact Area that provides suitable roosting habitat for bats. After the first five years, they anticipate that the effective implementation of the WFMP will reduce the take of bats and no more than 119 acres (48 hectares) of habitat would be lost per year outside of the impact area.

The USFWS issued the following Reasonable and Prudent Measures to minimize incidental take of Hawaiian hoary bat. The measures described below are nondiscretionary and must be implemented.

- Minimize direct and indirect effects on survival and reproduction of Hawaiian hoary bats in the action area. Implement measures such as;
- Avoid construction in certain areas during breeding and peak lactation periods;
- Develop and implement conservation plan;
- Minimize loss and degradation of roosting habitat for Hawaiian hoary bats in the action area. Implement measures such as;
- Monitor trends in: treeland vegetation cover in fence units and Fire Management Areas to determine the extent of enhanced survival and regeneration of tree species, and numbers of Hawaiian hoary bats present in the action area;
- Determine the number of bats per area of treeland roosting habitat in selected vegetation types within the action area, in order to refine take estimates measured indirectly by the amount of lost

roosting habitat and to determine when those take levels are exceeded;

- Minimize noise and ground disturbance to Hawaiian hoary bats associated with military activities in the action area; and
- Include Hawaiian hoary bat in the Environmental Awareness Program to inform installation users of the need to avoid and minimize impacts to bats.

Within PTA is an approximately 51,003 acres (20,640 hectares) central impact area that is the primary danger area for all indirect fired weapon rounds (not in line of sight). The impact area effectively subdivides PTA into an eastern and western section and is off-limits to unauthorized personnel due to munitions hazards of UXO. Because the impact area is unsafe for human activity, surveys for listed species cannot be conducted, nor can it be accurately determined which species will be lost, or the magnitude of the loss. Vegetation destruction within this large, central impact area fragments natural habitats for the Hawaiian hoary bats, thereby diminishing the abundance and distribution of the subspecies on PTA. Fires in the impact area are not controlled due to the presence of UXO and uncontrolled fires may potentially spread from the impact area to other areas of the installation, though implementation of the WFMP will reduce the fire frequency and intensity at PTA.

The USFWS has determined that there is a high probability that any listed plant species or roosting habitat for the Hawaiian hoary bat within the impact area will be lost through time due to fire or direct impact of live-fire munitions. Even anticipating the loss of listed plants and bat habitat within the impact area, the USFWS still determined that the Proposed Actions would not jeopardize any listed species or result in the destruction or adverse modification of designated critical habitat. In essence, all the conservation and management efforts employed by the Army benefit the species to a much greater extent then the negative impacts on the species resulting from military actions on PTA.

For the SBCT action on PTA, the NEPA and ESA Section 7 consultation requirements covered the area designating the ROI for this action alternative. However, the Proposed Action within the Twin Pu‘u range footprint would elevate the threats to the endangered species and habitat within the ROI by increasing the possibility of wildfire and potential spread of invasive species. Due to this fact, if Alternative 4 was selected, the Army would reinitiate formal consultation with the USFWS to address the threats to listed species within the ROI. Even accounting for these new potential threats, the nondiscretionary measures contained within the 2003 BO, along with the other conservation plans and actions being

implemented at PTA, would be anticipated to help lessen the significance of the action's impacts on listed species and habitat within the ROI.

3.9.3 Recovery Plans

Recovery plans are documents prepared by USFWS that detail the specific management practices and tasks needed for special status species to recover. They offer guidelines for private, federal, and state cooperation in conserving threatened and endangered species and areas on which they are presently or historically distributed. Under current law, recovery plans are to be developed for endangered and threatened species, unless the plan would not promote the conservation of the species. A plan must include the following components:

- A description of site-specific management actions necessary to achieve the plan's goal;
- Objective measurable criteria which, when met, would result in a determination that the species no longer needs the protection of the ESA and can be removed from the lists; and
- Estimates of the time and costs required to carry out the plan and to achieve intermediate steps toward the goal.

Plant and animal species with recovery plans that occur on the MMR ROI and the PTA ROI are identified in Appendix H-2 and Section 3.9.6, respectively. Recovery plans were/are used in the development of the MIP and PIP.

3.9.4 Vegetation Communities and Vegetation Mākua Military Reservation

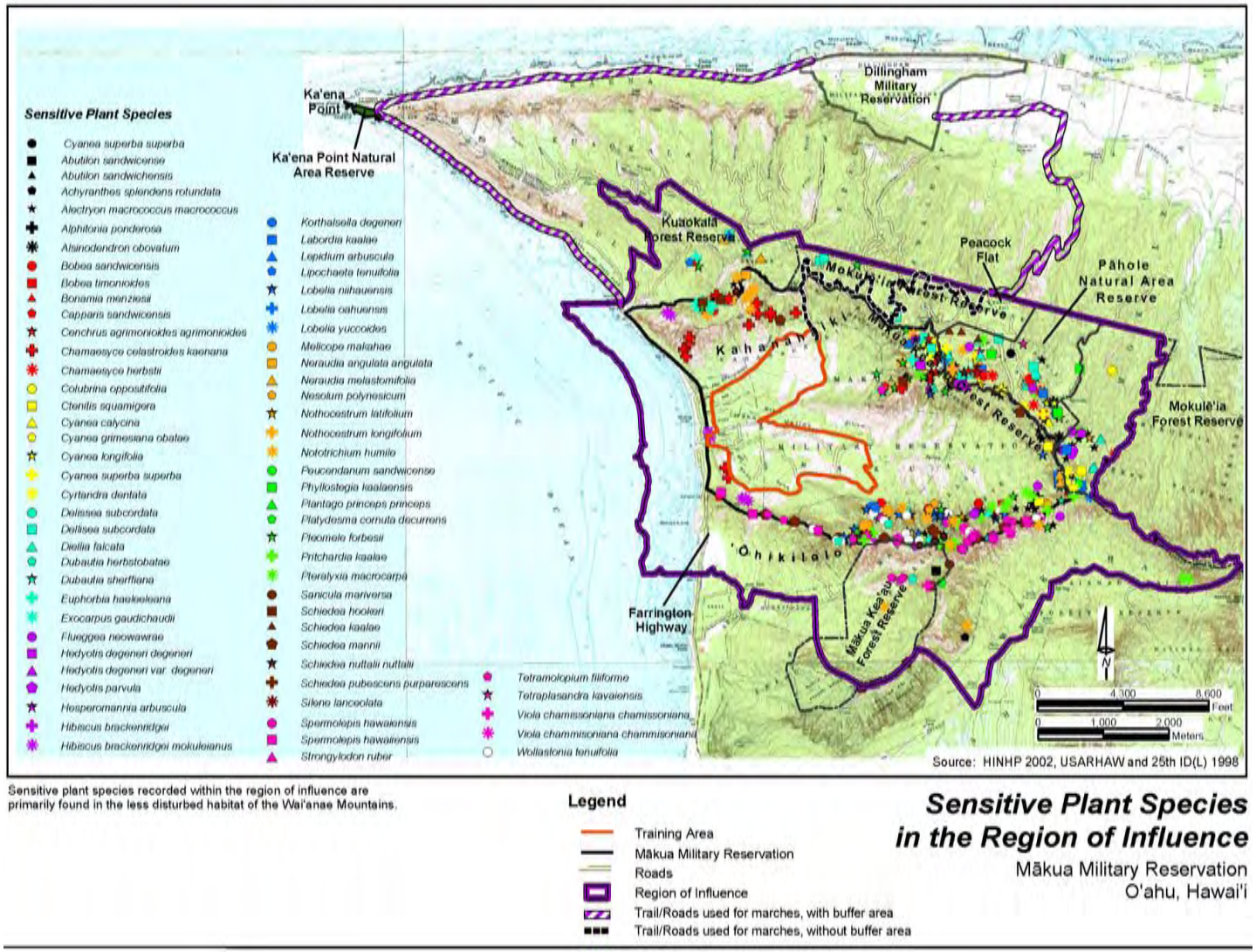
The vegetation communities of MMR are diverse and have been extensively studied. These were well documented in the 1998 BA, from which this discussion draws heavily.

MMR includes the following three ecological zones:

- Lowland native forest zone;
- Ridge crest vegetation zone; and
- Native shrub on cliff and slope zone.

Within these zones are vegetation communities of varying composition. There are two additional vegetation communities that are the direct result of human disturbance (USARHAW and 25th ID[L] 2001a). Figure 3.8-5 shows the distribution of vegetation communities in the ROI. Figure 3.9-5

shows the sensitive plant species in the Region of Influence and Figure 3.9-6 shows sensitive plant species in the biological ROI (PTA).



Sensitive plant species recorded within the region of influence are primarily found in the less disturbed habitat of the Wai'anae Mountains.

Legend

- Training Area
- Mākua Military Reservation
- Roads
- Region of Influence
- Trail/Roads used for marches, with buffer area
- Trail/Roads used for marches, without buffer area

Sensitive Plant Species in the Region of Influence

Mākua Military Reservation
O'ahu, Hawai'i

Figure 3.9-5 Sensitive Plant Species in the Region of Influence, MMR

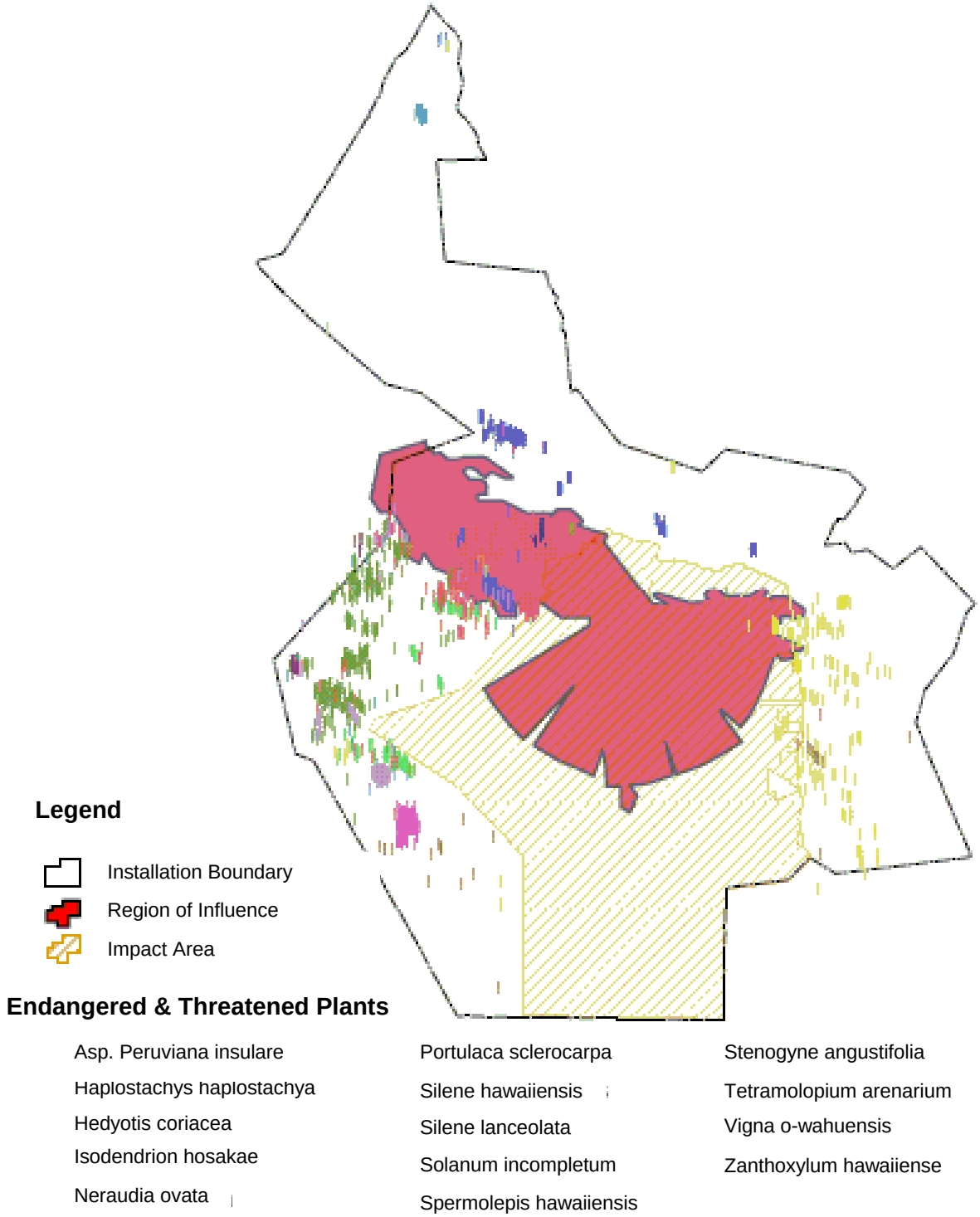


Figure 3.9-6 Sensitive Plant Species in the Biological Region of Influence, PTA

On July 22, 2003, a prescribed burn at MMR went out of prescription and escaped the firebreak road, burning 2,100 acres (850 hectares). Common native plants were burned, and endangered species were also impacted. At least 50 acres (20 hectares) of native dry forest and 150 acres (61 hectares) of native dry grassland were burned. Native forests do not reclaim the burned areas because they are invaded by nonnative, fire-prone grasses. Each fire that destroys native habitat brings the line of flammable nonnative grass dominated area closer and increases the chances of the area being impacted by a subsequent fire. The damages to habitat are discussed below where appropriate (NRS no date).

The Lowland Native Forest Zone

This zone includes six native natural community types. Two of these are rare (O‘ahu Diverse Lowland Moist Forest and Loulu Lowland Moist Forest); the other four types are not rare but support rare species.

Koa/‘Ōhi‘a Lowland Moist Forest

This community is centered on south-facing gentle slopes between 2,000 and 2,300 feet (610 and 701 meters) in elevation. The dominant plant species are koa (*Acacia koa*) and ‘ōhi‘a (*Metrosideros polymorpha*), but other natives include mehame (*Antidesma platyphyllum*), ‘ahakea (*Bobea sandwicensis* and *B. timonioides*), and two species of lama (*Diospyros sandwicensis* and *D. hillebrandii*). The understory plants include the native sedge ‘uki (*Dianella sandwicensis*) and the ferns pala‘ā (*Sphenomeris chinensis*) and palapalai (*Microlepia strigosa*). Rare plants in this community are ma‘aloa (*Neraudia melastomifolia*), ‘ume‘alu (*Cenchrus agrimonioides* var. *agrimonioides*), *Schiedea nuttallii*, and ‘alani (*Melicope sandwicensis*).

Lama Lowland Dry Forest

This community occurs on MMR between 1,000 and 1,300 feet (305 and 396 meters). In addition to the dominant lama *Diospyros sandwicensis* canopy, other natives, such as wiliwili (*Erythrina sandwicensis*) and olopua (*Nestegis sandwicensis*), also occur. The open understory is dominated by alahe‘e (*Psydrax odoratum*). Small patches of ‘a‘ali‘i (*Dodonea viscosa*) shrubland are adjacent to this community. The area also supports dryland mosses, herbs, and the kumuniu fern (*Cheilanthes viridis*). Two areas of native dry forest were impacted by the July 2003 fire. Damage to the perimeter of this native forest at Kaluakauila and South Kahanahāiki was significant. In Kaluakauila, corridors that connected patches of this native dry forest were destroyed, and the habitat size is permanently reduced (NRS no date).

Lama/ʻŌhiʻa Lowland Moist Forest

This is a moist community at MMR that occurs between 1,205 and 2,015 feet (367 and 614 meters). These forests are dominated by ʻōhiʻa and lama but include the rare species māhoe (*Alectryon macrococcus* var. *macrococcus*), halapepe (*Pleomele forbesii*), kalua (*Pteralyxia macrocarpa*), mehamehame (*Flueggea neowawraea*), keahi (*Nesoluma polynesicum*), and ʻaiea (*Nothocestrum latifolium*).

Loulu Lowland Moist Forest

This rare natural community type typically has shallow well-drained soil on moderate to steep slopes. This forest is dominated by the globally rare loulu (*Pritchardia kaalae*), although other common native species are present. While loulu occurs at other places in the Waiʻanae Mountains, this is the only instance in which it forms a closed canopy of trees. It blends gently into the surrounding ʻōhiʻa forest and shrubland communities. Other trees dispersed through the 1-acre (0.4-hectare) forest type include kōlea (*Myrsine lessertiana*) and kōpiko (*Psychotria* spp.).

Oʻahu Diverse Lowland Moist Forest

This diverse forest has no clear dominant canopy tree species. The substrate is rocky and sometimes steep, and at MMR it is present west of the eastern valley rim at 2,100 feet (640 meters). The native canopy trees include lama, ʻalaʻa, pāpala (*Charpenteria tomentosa*), kōpiko (*Psychotria* spp.), and kōlea. The three rare plants in this community are tree māhoe (*Alectryon macrococcus* var. *macrococcus*), kamakahala (*Labordia kaalae*), and the fern pauoa (*Ctenitis squamigera*). This is a rare natural community.

ʻŌhiʻa Lowland Mesic Forest

This community is common on Waiʻanae Mountains ridge crests and is notably well established in southeast MMR above 2,015 feet (614 meters). Rare plants that occur here are *Alsinidendron obovatum*, *Cenchrus agrimonioides* var. *agrimonioides*, *Schiedea nuttallii* and *S. pentamera*, and ʻalani.

<u>Ridge Crest Vegetation Zone</u>

This zone lies above 3,000 feet (914 meters) and covers the cool, wet, windy, and cloud-swept portions of the summit crest of the Waiʻanae Mountains. The dominant vegetation community is ʻōhiʻa lowland mesic shrubland. These communities are generally found along the southern and southeastern rim of the valley. Rare species that occur in this community include *Sanicula mariversa*, naʻenaʻe (*Dubautia herbstobatae*), loulu, *Tetramolopium filiforme*, halapepe (*Pleomele forbesii*), ʻalani, and nehe (*Lipochaeta tenuifolia*).

Native Shrub on Cliff and Slope Zone

Lowland dry shrubs and mosses that favor this moist habitat generally characterize this zone. These natural communities occur in the range of 1,500 to 2,400 feet (457 to 731 meters) beneath steep cliffs in ridges and slopes. With distance from the summit crest, conditions become much warmer and drier. At MMR, this community is predominantly located on steep vertical cliffs. Over 150 acres (61 hectares) of native grass and shrubland were destroyed in the July 2003 fire (NRS no date). The two plant communities in this zone are described below.

‘A‘ali‘i Lowland Dry Shrubland

This globally secure community type is dominated by ‘a‘ali‘i and includes other common native plants. It is found on moderate slopes. These communities are not particularly diverse, but they do contain native shrubs ‘ilima (*Sida fallax*) and alahe‘e. Rare plants have not been observed here.

Hawaiian Mixed Shrub Lowland Dry Cliff

This community includes the common species ko‘oko‘olau, ‘akoko, and ‘a‘ali‘i. Observed rare plants are the cliff-dwelling nehe, na‘ena‘e, *Tetramolopium filiforme, Sanicula mariversa,* pāmakani (*Viola chamissoniana* ssp. *chamissoniana*), ma‘aloa (*Neraudia angulata*), *Silene lanceolata,* kulu‘ī (*Nototrichium humile*), *Lobelia niihauensis,* and *Spermolepis hawaiiensis*.

Alien Grassland/Open Shrubland

Nonnative grass and shrubs compose most of the lowland vegetation structure at MMR. Many of these are aggressive species known to displace native vegetation when not controlled. Guinea grass (*Panicum maximum*) is the dominant species in the low dry areas of MMR and regenerates quickly after fire. Other grasses include natal redtop (*Rhynchelytrum repens*) and molasses grass (*Melinus multiflora*). This community also includes native shrubs such as ‘a‘ali‘i and ‘iliahi (*Santalum ellipticum*), but most of the open shrublands are dominated by koa haole (*Leucaena leucocephala*) and kiawe (*Prosopsis pallida*). The majority of damage from the July 2003 fire was to this nonnative community.

Nonnative Forest/Closed Shrubland

About half of the forested area at MMR is dominated by nonnative tree and shrub species, including Java plum (*Syzigium cumini*), Christmas berry (*Schinus terebenthifolius*), and guava (*Psidium cattleianum* and *P. guajava*). Christmas berry is a tree common to dry and moist areas of MMR and threatens native plants and communities by creating a dense canopy, changing the understory composition, and producing chemicals

that inhibit plant growth. Koa haole can create dense thickets on abandoned grazing lands and is one of the more widespread trees on MMR (Wagner et al. 1999). It too regenerates quickly after fire, displacing native plants (R. M. Towill Corp. 1997a). Populations of strawberry guava (*Psidium cattleianum*) are generally found around the lower slopes at the head of the valley, often in single-species stands. Many other nonnative species are present, and several could become serious pests (R. M. Towill Corp. 1997a).

Aquatic Natural Communities

The aquatic natural communities on MMR include intermittent streams and gulches, such as Punapōhaku Stream, Mākua Stream, and Kalena Stream. Although potential estuarine wetlands (*muliwai*) have been noted, there has been no formal identification or designation of them.

Ka‘ena Point Natural Area Reserve/Kuaokalā Access Road and Trail

Portions of the Ka‘ena Point Natural Area Reserve (NAR) are included within the ROI. The Hawai‘i NARS lands are first and foremost areas of refuge and not recreation, so their use is purposely restricted. The areas along the coast are dry and sandy, and the trail, while more inland, is in a dry rocky region. The trail begins outside of the NAR as a network of four-wheel drive roads. Motor vehicles are not permitted within the NAR, and state DLNR personnel randomly monitor the area, which is also critical habitat for the following plant species: ‘āwiwi (*Centaurium sebaeoides*), ‘akoko (*Chamaesyce celastroides* var. *kaenana*), pu‘uka‘a (*Cyperus trachysanthos*), mā‘oli‘oli (*Schiedea kealiae*), ‘ohai (*Sesbania tomentosa*), and *Vigna o-wahuensis.*

Kuaokalā Access Road and Trail extends from DMR, along agricultural fields, and up a paved road to a point on the ridge crest along the northern ridgeline of MMR. The low-elevation vegetation communities are predominantly nonnative, mixed with some common native species, such as wiliwili (*Erythrina sandwicensis*), ‘a‘ali‘i, and alahe‘e. The vegetation in the upper elevations is more native and is part of the USFWS critical habitat for plants on O‘ahu. The paved road provides access to a state endangered plant greenhouse/nursery facility at an old Nike missile site, while the trail branches off onto a dirt road that extends to the ridge crest.

Existing data on sensitive plant species identified in this area within the ROI include *Achyranthes splendens* var. *rotunda*, *Bonamia menziesii*, ‘āwiwi, ‘akoko, makaloa, *Delissea subcordata*, palapalai, ‘ānaunau, kulu‘ī, mā‘oli‘oli, ‘ōhi‘a, and *Hibiscus brackenridgei* ssp. *mokuleianus.*

Coral/Coastal Communities

Coral reefs are increasingly recognized as important ecological communities and assemblages and are protected by several federal regulations. Institutional significance for coral reefs was established through their formal designation as Special Aquatic Sites under the Clean Water Act (40 CFR Part 230.44/FR v.45 n.249). Special aquatic sites include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes. They are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general overall environmental health or vitality of the entire ecosystem of a region. In addition, coral reefs were given protection and status under EO 13089 and EO 13178 (which specifically refers to the Northwest Hawaiian Island corals). Although corals occur in isolated areas of rocky substrate in Mākua Bay, they do not occur in contiguous chains and are not considered coral reefs; therefore, the corals present do not qualify as Special Aquatic Sites under the Clean Water Act.

While there have been surveys of the coastal region (shoreline to 18 feet [5 meters] out from the shoreline) in and adjacent to the ROI, there are few published reports specifically relating to bottom topography or marine fauna right at Mākua Beach. However, there are surveys that have been done for the general Waiʻanae coast that includes Mākua Beach. According to work done by the Waiʻanae Ecological Characterization, the area off Mākua Beach consists predominantly of uncolonized hardbottom and macroalgae (Waiʻanae Ecological Characterization 2005). Coral cover is low along the Waiʻanae coast (one to two percent of bottom area), a condition typical of shallow, flat low-relief bottoms in this area (Waiʻanae Ecological Characterization 2005). Surveys have also found that the sandy beach is affected by substantial wave energy, especially through the winter due to its north-facing orientation (Dollar 1999; Waiʻanae Ecological Characterization 2005). Below the waterline, sand does not continue; instead, there is a limestone platform that extends several meters offshore. This platform was found to be “barren of macroinvertebrates or macroalgae (frondose) algae [leafy ‘sea weeds’] due to the concussive impact of the breakers” (Dollar 1999), though some short turf algae occurs. Macroalgae represent over 50 percent of the benthic cover in the Hawaiian coral reef ecosystem (Waiʻanae Ecological Characterization 2005). Red algae are the most common in Hawaiʻi, representing four of the five most common species. Green and brown algal species are found in most reefs in smaller numbers (Waiʻanae Ecological Characterization 2005).

There were few if any unattached benthic invertebrates, such as sea urchins, with the exception of the short-spined sea urchin (*Tripneustes gratilla*), which is not found in the nearshore sandy area but more along the boulder zone south of Punapuhaku Stream. The inshore flat portion of the limestone platform is devoid of benthic organisms (Dollar 1999). Beyond 30 to 60 feet (10 to 15 meters) from the shoreline, the limestone platform drops off abruptly. Although the upper part of the platform is relatively bare, the deeper vertical portion contains reef corals, such as cauliflower coral (*Pocillopora meandrina*), lobe coral (*Porites lobata*), and crust coral (*Lepastrea purpurea*).

The Wai‘anae coast has few locations with complex habitat (areas providing shelter and nooks) that reef fish prefer. Most of the reef along the coast has low species diversity and biomass. However, the deeper vertical portion of Mākua Beach that contains reef corals also creates a shelter for some reef fish, most commonly kala (*Naso unicornis*), maikoiko (*Acanthurus leucopareius*), manini (*A. triostegus*), adult (weke) and juvenile (oama) ta’ape (*Mulloidichthys flavolineatus* and *Lutjanus kasmira*). Less common but potentially present are the mamo (*Abudefduf abdominalis*), lau wiliwili (*chaetodon miliaris*), and hinalea (*Thallosoma duperrey*). Living corals were limited to depths below 6 feet (2 meters). The only marine algae noted in the area were common brown algae (*Padina* spp.) and red algae (*Liagora* spp.). It is possible that other species of algae are present in the summer, when the wave impacts lessen. Unattached benthic invertebrates (living on or in the sea bottom), such as sea urchins, were rare (Dollar 1999). There is no living coral seaward of the limestone platform found south of Punapuhaku Stream; the entire offshore area consists of sandy bottom past this platform.

Invasive Species and Disturbed Habitat

Executive Order (EO) 13112, Invasive Species (February 3, 1999), requires that where feasible, federal agencies should use their authorities to prevent the introduction of invasive species, to detect invasive species, and to eradicate and control such species in a cost-effective and environmentally sound manner. This EO also limits the ability of federal agencies to authorize or fund activities that are believed to introduce and spread invasive species in the United States, unless the benefits of the proposed activity clearly outweigh the harm and all feasible and prudent measures to minimize the harm are implemented. This order, along with the State of Hawai‘i Noxious Weed Rules, which require that noxious weeds be controlled (USDA no date), and which is supported by AR 200-5 Pest Management have guided Army environmental management actions. Army actions include those outlined in the INRMP and the MIP.

Invasive and noxious weeds that are not yet widespread on MMR are black wattle (*Acacia mearnsii*), weeping grass (*Ehrharta stipoides*), fire tree (*Morella faya*), perfumed passionflower (*Passiflora suberosa*), and prickly Florida blackberry (*Rubus argustus*). Current control efforts target West Indian raspberry (*Rubus rosifolius*), oi (*Stachytarpheta dichotoma*), cathedral bells (*Kalanchoe pinnata*), daisy fleabane (*Erigeron karvinskianus*), strawberry guava, Christmas berry tree (*Schinus terebenthifolius*), kukui (*Aleurites moluccana*), ti plant (*Cordyline fruticosa*), silk oak (*Grevillea robusta*), chinaberry tree (*Melia azedarach*), lākana (*Lantana camara*), tree daisy (*Montanoa hibiscifolia*), and koa haole (*Leucaena leucocephala*). These and other widespread weed species will be controlled where they threaten native plants and communities.

Populations of feral pigs (*Sus scrofa*) and goats (*Capra hircus*) have directly affected native plants and contributed to numerous ecological problems (Juvik and Juvik 1998). These wild pigs and goats trample and graze the native plants and advance erosion and landslides (USARHAW and 25th ID[L] 2001b; PCSU 1999, 2000, 2001). Water collects in the rutted ground, providing a perfect breeding place for mosquitoes, which can carry avian malaria (HINHP no date b) and have devastated native bird populations. Browsing and destroyed native vegetation has encouraged nonnative plants to become established, severely affecting the habitat. Fencing prevents additional pigs and goats from moving into MMR from the south and east, and trapping removes the smaller pests, such as feral cats, mongooses, and rats. Approximately 5,577 feet (1,700 meters) of this fencing was burned in the July 2003 fire. Fire ruins the galvanized coating on the wire, so this fencing will need to be replaced to ensure continued protection from pigs and goats (NRS no date). Since 2006, no goats have been observed at MMR.

A threat to māhoe (*Alectryon macrococcus* var. *macrococcus*) and mehamehame (*Flueggea neowawraea*) is the nonnative black twig borer (*Xylosandrus compactus*), which burrows into branches and introduces a pathogenic fungus that often kills the host.

Nonnative snails and slugs pose a threat to rare Hawaiian plants by preying on the seedlings' stems and fruit. This reduces regeneration of the host. Rats (*Rattus rattus* and *R. exulans hawaiiensis*) are also known to eat the fruit and strip bark from certain species of native plants, seriously affecting the reproduction of loulu and plants in the Campanulaceae and Gesneriaceae families. Rats also eat 'elepaio eggs and chicks.

Fires have occurred in the past at MMR. There are eight vegetative fuel classifications at MMR, and management of the threats to the natural resources of the installation from wildfire are included in the Army's IWFMP. A thorough discussion of the threat of wildfire is presented in Section 3.14, Wildfires.

Pōhakuloa Training Area

PTA is on the Island of Hawai‘i on the west side of Humu‘ula Saddle, a plateau formed by Mauna Kea and Mauna Loa. The surrounding lands are mostly designated as conservation district and are managed or leased by a variety of private landowners and the State of Hawai‘i. There are 24 vegetation communities on PTA (Shaw and Castillo 1997). Numerous introduced plant species make up a significant portion of many of these habitats, and introduced plants are components in all habitats on PTA. About 62 percent of the plants found at PTA are introduced species. Barren lava covers 25 percent of the installation. Lichens, such as *Stereocoulon vulcani,* and ferns, such as *Pella ternifolia,* are the first colonizers of these flows, though fountain grass is invading barren areas. Figure 3.8-6 shows the distribution of vegetation communities in the ROI (Shaw and Castillo 1997).

There are four types of *Metrosideros* treeland, ranging from sparse to mixed intermediate. The dominant canopy vegetation in these areas is generally ‘ōhia. There are three types of *Dodonaea* shrubland: open, dense, and mixed. ‘A‘ali‘i *(Dodonaea viscosa)* is the dominant plant in each community, along with other native species, including ‘ilima *(Sida fallax),* ‘aheahea *(Chenopodium oahuense),* and naio. *Leptecophylla* occurs either as a mixed shrubland community or as a component of *Leptecophylla-Dodonaea* shrubland. *Chamaesyce* treeland is generally found hosting native species of *Chamaesyce olowaluana* (a species of concern), ‘ilima, ‘aheahea, and ‘a‘ali‘i. *Chenopodium* shrubland and *Eragrostis aptopioides* grassland are similar communities with different dominant species. The remainder of the native natural communities is a combination of *Chamaesyce, Myoporum,* and *Sophora* species, with divisions based on the densities of species. (US Army and USAEC 2008)

The information below was obtained from Appendix E of Hawai‘i Stryker BA: Plant Communities, SBCT--Island of Hawai‘i; and Pōhakuloa Training Area Community Types (Shaw and Castillo 1997).

<u>Twin Pu‘u Area</u>
Pennisetum Grassland (area within Pu‘u footprint) occurs frequently in burned areas in the impact area and in Kīpuka Kālawamauna. Woody vegetation is sparse, not surviving frequent and intense fires. An

occasional *Dodonaea viscosa*, *Myoporum sandwicensis*, or *Sida fallax* may be present. For the most part, these grasslands are monocultures of *Pennisetum setaceum* (fountain grass).

Open *Metrosideros* Treeland with sparse shrub understory (east side bordering Pu‘u and to the south) has an overstory of *Metrosideros polymorpha*, and an understory of *Dodonaea viscosa*, *Styphelia tameiameiae*, and *Osteomeles anthyllidifolia*. *Dubautia linearis* may also be present.

Open *Dodonaea* Shrubland (within the northwest area of Pu‘u, just a finger coming in on a northwest-southwest angle; and alongside the west side of Pu‘u footprint) is found predominantly on older Mauna Kea substrates located on the northern and western parts of the installation. *Dodonaea viscosa* is the dominant taxon with *Sida fallax* and *Chenopodium oahuense* as co-dominants. Herbaceous cover is primarily *Eragrostis atropioides*.

Myoporum Shrubland (just offsite footprint to the southwest and south of footprint on eastern half) is scattered across the northern part of PTA, along the margins of Kīpuka Kālawamauna and in an isolated kīpuka on the western boundary. *Myoporum sandwicensis* shrubs are the characteristic overstory species. Other species include *Dodonaea viscosa* and *Chenopodium oahuense*. Herbaceous species tend to be alien in origin.

Myoporum-Dodonaea Shrubland (to north of Pu‘u area) has a similar distribution to the *Myoporum* Shrubland,but three times the shrub density. *Myoporum sandwicensis* is a dominant overstory species with an occasional, larger *Dodonaea viscosa*. Smaller *Dodonaea viscosa* and *Chenopodium oahuense* shrubs characterize the understory. Most of the herbaceous species are alien in origin.

Dodonaea Mixed Shrubland (just south of Pu‘u footprint on western side and a sliver on the eastern Pu‘u) is the most dense shrubland type. Found on Kīpuka Kālawamauna on very old lava flows, the *Dodonaea viscosa* is the dominant taxon. Other shrub species include *Bidens menziesii*, *Chenopodium oahuense*, and *Chamaesyce multiformis*, along with less common plants of *Sida fallax* and *Dubautia linearis*. Herbaceous cover is dominated by *Eragrostis atropioides*.

Invasive Species and Disturbed Habitat

EO 13112, Invasive Species (February 3, 1999), requires that, where feasible, federal agencies should use their authorities to prevent the

introduction of invasive species, to detect invasive species, and to eradicate and control such species in a cost-effective and environmentally sound manner. This EO also limits the ability of federal agencies to authorize or fund activities that are believed to introduce and spread invasive species in the US, unless the benefits of the proposed activity clearly outweigh the harm and all feasible and prudent measures to minimize the harm are implemented. This order, along with the State of Hawai‘i Noxious Weed Rules, which require that noxious weeds be controlled (USDA no date), and which is supported by AR 200-1 Pest Management chapter, have guided Army environmental management actions.

PTA has federal and state listed noxious weeds. Though kikuyu grass (*Pennisetum clandestinum*) is included in this category, it is exceptional at PTA and is not invasive at high-elevation dry ecosystems (US Army and USACE 2004; Shaw and Castillo 1997). Invasive and noxious weeds that are targeted for control on PTA include banana poka (*Passiflora mollissima*), fountain grass (*Pennisetum setaceum*), and Russian thistle (*Salsola kali*). Other widespread weed species are controlled where they threaten native plants and communities.

Of all the nonnative, invasive species affecting PTA, fountain grass is the most troublesome. Fountain grass is a highly aggressive, fire-adapted species that readily outcompetes native plants and rapidly reestablishes after burning. It is one of the few nonnative plants to invade young lava flows and disrupt primary succession at an early stage. This grass also alters the natural fire regime in Hawai‘i and is a major threat to native plants and natural communities. It raises fuel loads, which increases the intensity and spread of a fire, and results in severe impacts to native, dry forest species that are not adapted to such altered fire regimes (Plant Conservation Alliance’s Alien Plant Working Group fact sheet May 05).

3.9.5 Wildlife
Mākua Military Reservation

Regular biological surveys have been conducted at MMR that focus on special status invertebrates, birds, and mammals; information on the general wildlife is provided as well. No specific reptile or amphibian surveys have been conducted because there are no native terrestrial reptiles and amphibians on the Hawaiian Islands. Natural resource surveys conducted by Walker (USARHAW and the 25th ID(L) 2001b; Cooper et al. 1996), University of Hawai‘i, Bishop Museum Hawaiian Heritage Program, and HINHP (no date a) are cited in the paragraphs below. These natural resource surveys were used in preparing the following resource assessments:

- *Biological Inventory and Management Assessment at MMR for USARHAW* (HINHP no date a);
- *Endangered Species Management Plan Report, O‘ahu Training Areas* (R. M. Towill Corp. 1997a);
- *O‘ahu Training Areas Natural Resource Management Report* (PCSU 2001); and
- *O‘ahu Training Areas INRMP* (USARHAW and 25th ID(L) 2001b).

The following sections describe general invertebrate, amphibian, reptile, terrestrial mammal, bird, fish, and marine wildlife species in the ROI. Special status species are discussed in Section 3.9.6.

Invertebrates

The native and endemic invertebrates at MMR include the O‘ahu tree snail (*Achatinella mustelina*), six achatinellid land snail species (*Acuriculella ambusta*, *A.* spp. aff. *castanea*, *A.* spp. aff. *perpusilla*, *Elasmuius* spp., *Partulina dubia*, and *Tornatellides* spp.), and two amastrid land snail species (*Amastra rubens* and *Leptachatina* spp.). Three other native species, the endodontid land snail (*Cooke concha* spp.), a helicarionid land snail (*Philonesia* spp.), and succineid land snail (*Succinea* spp.), were also observed at MMR (HINHP no date a; R. M. Towill Corp. 1997a; USARHAW and 25th ID(L) 2001b). Hawai‘i Natural Heritage Program surveys of MMR in 1993 detected the following nonnative snails: giant African snail (*Achatina fulica*), bradybaenid land snail (*Bradybaena similaris*), cannibal snail (*Euglandina rosea*), and zonitid land snail (*Hawaiia minuscula*). Humans have purposely or accidentally introduced these species to O‘ahu, and they now threaten the native snail species through competition for resources, predation, and the spread of disease.

Amphibians

There have been no specific amphibian surveys at MMR. Nonnative amphibians found on O‘ahu include the bullfrog (*Rana catesbeiana*), wrinkled frog (*R. rugosa*), giant toad (*Bufo marinus*), Cuban tree frog (*Osteopilus septentrionalis*), greenhouse frog (*Eleutherodactylus planirostris*), and coqui frog (*E. coqui*). These species were introduced into O‘ahu from other countries and have inhabited areas where adequate aquatic habitat and surrounding vegetation exist. However, the coqui frog is not restricted to areas near aquatic habitat (surface water) as it does not require this habitat type to complete its life cycle.

Reptiles

There have been no specific reptile surveys at MMR. There are no native terrestrial reptiles on the Hawaiian Islands. Nonnative reptiles found on O‘ahu include the green anole (*Anolis carolinensis*), mourning gecko (*Lepidodactylus lugubris*), stump-toed gecko (*Gehyra mutilata*), tree gecko (*Hemiphyllodactylus typus*), Indo-Pacific gecko (*Hemidactylus garnotii*), house gecko (*H. frenatus*), metallic skink (*Lampropholis delicata*), and gold dust day gecko (*Phelsuma laticauda laticauda*). There is only one known terrestrial snake occurring on the Hawaiian Islands, the island blind snake (*Ramphotyphlops braminus*), which can be found on O‘ahu.

Terrestrial Mammals

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) was last observed at MMR in 1998 (USARHAW and 25th ID(L) 2001b). However this sighting is believed to have been a transient bat, and no resident or individuals are thought to occur on O‘ahu. Through the 1999 and current ESA Section 7 consultations, the USFWS determined that the Army was not required to consult on the Hawaiian hoary bat because the single sighting in 1998 was considered to be most likely transient and not representative of a resident population. The hoary bat is the only native terrestrial mammal on the Hawaiian Islands. The following nonnative species may occur on MMR: feral pigs, feral goats, feral cats (*Felis catus*), feral dogs (*Canis familiaris*), Norway rats (*Rattus norvegicus*), black rats (*R. rattus*), Polynesian rats (*R. exulans hawaiiensis*), and the house mouse (*Mus musculus*). Pigs have been observed throughout the moderately moist areas of the Mākua and Kanahāiki Valleys, and goats have been known to use the southern side of Mākua Valley and adjacent Mākaha and Makaleha Valleys (USARHAW and 25th ID(L) 2001a).

Birds

The following indigenous forest bird species have been recorded at MMR: O‘ahu ‘elepaio (*Chasiempis sandwichensis ibidis*), O‘ahu ‘amakihi (*Loxops virens chloris*), white-tailed tropical bird (*Phaethon lepturus dorotheae*), Pacific golden-plover (*Pluvialis fulva*), and pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*). Seabird nesting has increased dramatically at Ka‘ena Point NAR over the past decade. Most of these nesting seabirds are the wedge-tailed shearwater (*Puffinus pacificus*) and Layson albatross (*Phoebastria immutabilis*). Both are pelagic (open water) species that come to land to breed. The wedge-tailed shearwater nests in burrows (NatureServe 2002). There are almost a thousand shearwater burrows in the Ka‘ena Point NAR, and, as predator control increases, the populations are expanding (Liesemeyer 2003). Laysan albatross, a ground-nesting species, has recently begun breeding again on

O‘ahu, at Ka‘ena Point NAR. Both species feed on fish and squid and can be found foraging offshore of the NAR.

The Albatross diet appears to consist mostly of fish, fish eggs, fisheries offal, and especially squid, foraging in both the day and night (Fernandez et al. 2001)

Nonnative bird species known to occur on MMR include the red-billed leiothrix (*Leiothrix lutea*), white-rumped shama (*Copsychus malabaricus*), Japanese bush warbler (*Cettia diphone*), rock dove (*Columbia livia*), spotted dove (*Streptopelia chinensis*), zebra dove (*Geopelia striata*), common myna (*Acridotheres tristis*), red-vented bulbul (*Pycnonotus cafer*), and Japanese white-eye (*Zosterops japonicus*). The nutmeg manikin (*Lonchura punctulatua*), red-crested cardinal (*Paroaria coronata*), barn owl (*Tyto alba*), Erchel’s francolin (*Francolinus erckelii*), ring-necked pheasant (*Phasianus colchicus*), and northern cardinal (*Cardinalis cardinalis*) are also species that have been introduced by humans to O‘ahu.

Freshwater Fish

No fish data have been gathered from MMR streams (USARHAW and 25th ID(L) 2001b), and no formal surveys of the intermittent streams at MMR have been conducted, so little information is available (Kawelo 2003).

Marine Resources

The Army conducted a marine resources study on fish and *limu* (seaweed) in 2007 and then supplemented the study in 2008 by testing shellfish. The purpose of the study, per the requirements of the 2007 Settlement Agreement (SA) between Mālama Mākua and the Army, was to; 1) determine whether marine resources near Mākua Beach and in the Mākua *muliwai* are contaminated with constituents primarily associated with proposed training activities at MMR; 2) evaluate the potential that activities at MMR contribute to any contamination detected in the marine resources; and 3) evaluate whether the proposed training activities at MMR pose a human health risk to area residents that rely on marine resources for subsistence. The study found substances in marine resources at both Mākua and background sites that are associated with the proposed training at MMR, but none were unique to military training; therefore, proposed military activities are anticipated to have little influence on contaminant levels within marine resources in the Mākua nearshore or *muliwai* areas. With respect to MMR’s contribution to contaminants in the marine resources, this and other reports have not provided any definitive evidence that links military training to such contamination, nor do they definitively exclude the possibility that such substances in the fish,

shellfish, and *limu* are a result of activities conducted at MMR. However, it needs to be reemphasized that there are numerous other natural and anthropogenic sources that contribute substances to the Mākua and background areas. Considering the level of substances found within the Mākua area, the numerous sources with which these substances are associated, and the ability of these substances from multiple sources to be transported by rain flow and ocean currents, it was determined that it is not likely for future activities at MMR alone would contribute substances to the marine environment at a level sufficient to cause a human health risk. Even though it is not likely that future activities at MMR alone would cause this risk to human health, they could add to existing contamination in marine resources (U.S. Army 2009).

The Army was presented with responsible scientific opposition to both the methods and conclusions of the Marine Resources Study. The crux of public concern essentially comes down to the following categories: the selection of background sites and inclusion of testing a "pristine" background site; disclosure of the "absolute" risk of consuming the marine resources at Mākua without subtracting "background" contamination; the lack of statistical planning in the Army's collection plan; the location and quantity of samples collected; the speciation of arsenic detected in samples; and some commentors indicated that the samples collected could have been more closely tied to the marine resources most commonly eaten. The original MRS and comment responses are included in the 2008 Supplemental Draft EIS at Appendix G-8. The final revised MRS and 2009 comments are included in the Final EIS at Appendix G-8. Greater discussion of the study results and Army responses to public concern are found in Section 3.7.2 of this EIS.

Marine Fauna

The project ROI includes a small segment of beachfront and a nearshore coastal area (part of the Wai‘anae coast) that extends approximately 0.5 mile (0.8 kilometer) out into the waters adjacent to this portion of the beach. The Mākua Beach and nearshore environment are included in the ROI to encompass potential project impacts on marine biological resources.

There are no specific coral reef areas of management concern in the ROI (CRAMP 2003). The closest coral assemblages that have designated concern status by the state is several miles south, at the nearshore area of Kahe Point (CRAMP 2003).

The Pacific waters and coastlines of the Hawaiian Islands provide habitat for a variety of marine wildlife. Numbers and types of animals are not consistent, as the distribution and abundance of both marine mammals and

sea turtles in Hawaiian waters vary seasonally, from nearshore to offshore, and spatially (i.e., from island to island and between different sides of the islands) (Calambokidis et al. 1998; Mobley et al. 2001a; NOAA Fisheries 2000a, 2000b).

The portion of the Wai‘anae coast adjacent to MMR faces west-southwest. This side of O‘ahu is protected (in the lee) from prevailing northeasterly trade winds. Thus, the waters are generally calmer on this side than on the other sides of the island, providing for a preferential habitat for certain kinds of behaviors (e.g., resting, nursing) with certain species (e.g., spinner dolphins). The shore area adjacent to MMR provides suitable beach habitat for some marine wildlife that exit the water, such as sea turtles or monk seals. The nearshore coastal waters along Mākua Beach provide habitat for several marine wildlife species. These waters are not included in the Hawaiian Islands Humpback Whale National Marine Sanctuary. Most of the marine mammals and sea turtles known to occur in Hawaiian waters are not considered likely to occur in the ROI. The ones that are considered likely are detailed in the next section below (if only MMPA-protected) or under in Section 3.9.6 (if ESA-listed). The other species known, but not expected, in the ROI are discussed in Appendix H-2 of the EIS.

All marine mammal species are protected under the MMPA, regardless of whether they have additional protection under the ESA. MMPA-protected and ESA-listed marine wildlife species that may occur in the ROI seasonally, regularly, or as transients are listed in Table 3.9-1. Most of marine mammal species in the ROI are transient, occurring with unpredictable frequency and staying in the area only in the short-term. Humpback whales (*Megaptera novaeangliae*) in the Hawaiian islands may occur with increasing frequency as their season progresses, beginning in mid-December and continuing into January, when they first arrive and their numbers are low, through their peak in mid-February and March, to late April when their numbers decline again as they begin their migration northward. For the Wai’anae Coast, anecdotal data suggest that humpback whales are visible almost daily earlier in the season, from mid-December through mid-January. Spinner dolphins (*Stenella longirostris*) do occur regularly in the ROI and can be considered “residential” (i.e., staying in the area); residential individuals are expected to occur daily or frequently for consistent periods of times.

Five species of sea turtles inhabit waters of the Hawaiian Islands: green (*Chelonia mydas*), loggerhead (*Caretta caretta gigas*), leatherback (*Dermochelvs coriacea schlegelii*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*). They are all listed under the ESA and are discussed further in Section 3.9.6; the monk seal is also discussed in that section.

Table 3.9-1
Sensitive Marine Wildlife Occurring or Potentially Occurring in Hawaiian Waters Near the Region of Influence *

Scientific Name	Common Name	[1]Federal Status	[2]State Status	Habitat	Likelihood of Occurrence in ROI	Notes
Cetaceans and Pinnipeds						
Balaenoptera acutorostrata	Minke whale	*	-	May occur in nearshore or offshore waters	U	Most common northwest of the main seven-island chain or on leeward side of islands. May be incidentally sighted in waters adjacent to MMR.
B. Borealis	Sei Whale	E*	-	Most likely in deeper offshore waters	U	Rarely sighted in Hawaiian waters.
B. edeni	Bryde's whale	*	-	May occur in nearshore or offshore waters	U	Most common northwest of the main seven-island chain. May be incidentally sighted in waters adjacent to MMR.
B. musculus	Blue whale	E*	-	Most likely in deeper offshore waters	U	Heard in Hawaiian waters.
B. physalus	Fin whale	E*	-	Most likely in deeper offshore waters	U	Heard but rarely sighted in Hawaiian waters.
Berardius bairdii	Baird's whale	*	-	Most likely in deeper offshore waters	P	May be incidentally sighted in waters adjacent to MMR.
Delphinus Delphis	Common dolphin	*	-	Most likely in deeper offshore waters	U	May be incidentally sighted in waters adjacent to MMR.
Eubalaena glacialis	Pacific right whale	E*	-	Unknown if depth is a criteria	U	Most likely stray individuals from more northern population.
Feresa attenuata	Pygmy killer whales	*	-	May occur in nearshore or offshore waters	C	Occasionally seen in the channels between the main islands. Has been documented off the coast of O'ahu.
Globicephala macrorhynchus	Short-finned pilot whale	*	-	May occur in nearshore or offshore waters	C	Occasionally seen in the channels between the main islands. Common in nearshore or offshore areas in waters adjacent to MMR.
Grampus griseus	Risso's dolphin	*	-	Most likely in deeper offshore waters	U	More common sighted offshore. May be seen in offshore areas in waters adjacent to MMR
Kogia breviceps	Pygmy sperm whale	*	-	Most likely in deeper offshore waters	P	Prefers deeper waters but occasionally seen in the channels between the main islands. May be incidentally sighted in waters adjacent to MMR.

Table 3.9-1
Sensitive Marine Wildlife Occurring or Potentially Occurring in Hawaiian Waters Near the ROI

Scientific Name	Common Name	[1]Federal Status	[2]State Status	Habitat	Likelihood of Occurrence in ROI	Notes
K. simus	Dwarf sperm whale	*	-	Most likely in deeper offshore waters	P	Prefers deeper waters but occasionally seen in the channels between the main islands. May be incidentally sighted in waters adjacent to MMR.
Monachus schauinslandi	Monk seal	E*, CH, D	-	More common in nearshore waters or hauled out on the coast.	C	Most common northwest of the main seven-island chain. Incidental individuals may haul out along the coast of the islands' north shores. Anecdotal sighting on MMR beach.
Megaptera novaeangliae	Humpback whale	E*	-	May occur in nearshore or offshore waters	C	Occurs throughout the main seven-island chain January through April. Occurs in waters adjacent to the islands' north shores.
Mesoplodon densirostris	Blainsville's whale	*	-	Most likely in deeper offshore waters	C**	Prefers deeper offshore waters but has been sighted off coast of O'ahu.
Orcinus orca	Killer whale	*	-	May occur in nearshore or offshore waters	C**	Occasionally seen, especially in the channels between the main islands and at the northwest island chain. May be incidentally sighted in nearshore or offshore waters adjacent to MMR.
Peponocephala electra	Melon-headed whale	*	-	May occur in nearshore or offshore waters	C**	Occurs especially in the channels between the main islands and at the northwest island chain. May also occur in nearshore or offshore areas adjacent to MMR.
Physeter macrocephalus	Sperm whale	E*	-	Most likely in deeper offshore waters	U	Most common off the north and eastern shores of the main seven islands. May be sighted in waters adjacent to the islands' north shores.
Pseudorca crassidens	False killer whale	*	-	May occur in nearshore or offshore waters	C**	Occasionally seen in the channels between the main islands. May be sighted in nearshore or offshore waters adjacent to MMR.
Stennella attenuate	Spotted dolphin	*	-	Most likely in nearshore, leeward coastal waters	C	Common along the coastline, especially on the leeward sides of the island. Occurs in nearshore or offshore areas in waters adjacent to MMR.
S. coeruleoalba	Striped dolphin	*	-	May occur in nearshore or offshore waters	P	More strandings sighted than live individuals.
S. longirostris	Spinner dolphin	*	-	Most likely in nearshore, leeward coastal waters	C	Common along the coastline. Occurs in nearshore or offshore areas in waters adjacent to MMR.
Steno bredanensis	Rough toothed dolphin	*	-	Most likely in deeper offshore waters	C**	Prefers deeper offshore waters but has been sighted off coast of O'ahu.
Tursiops truncates	Bottlenose dolphin	*	-	May occur in nearshore or offshore waters	C	Common along the coastline. Occurs in nearshore or offshore areas in waters adjacent to MMR. Also common offshore in project area waters.

Table 3.9-1
Sensitive Marine Wildlife Occurring or Potentially Occurring in Hawaiian Waters Near the ROI

Scientific Name	Common Name	[1]Federal Status	[2]State Status	Habitat	Likelihood of Occurrence in ROI	Notes
Ziphius cavirostris	Cuvier's beaked whale	*	-	Most likely in deeper offshore waters	C**	Most common of the beaked whales in project area waters. Prefers deeper offshore waters but can be common in nearshore or offshore areas in waters adjacent to MMR.
Caretta caretta	Loggerhead turtle	T	-	In project area; prefers nearshore waters	U	Considered uncommon in MMR waters.
Chelonia mydas	Green turtle	T	-	In project area; prefers nearshore waters	C	Nests annually on Hawaiian beaches; common in nearshore areas of any of the main seven islands; most abundant sea turtle in MMR waters.
Dermochelvs coriacea	Leatherback turtle	E	-	In project area; prefers offshore waters	C	Primarily occurs over deep oceanic waters; sighted equally as frequently off any of the main seven islands.
Eretmochelys imbricate	Hawksbill turtle	E	-	In project area; prefers nearshore waters	U	Considered uncommon; a small number nest on the Island of Hawai‘i.
Lepidochelys olivacea	Olive ridley turtle	T	-	In project area; prefers offshore waters	U	Infrequently seen in Hawaiian offshore waters.

Sources: NOAA Fisheries 2000a-bb; ONR 2002
Status:

[1]Federal:

E = Endangered
T = Threatened
* = Protected under MMPA
D = Depleted under the MMPA
CH = Critical habitat designated
** = presence confirmed from aerial surveys but found at a distance offshore from the MMR coastline, so discussed in appendix rather than text.
*** = All species listed in table have been observed at least once in the nearshore or offshore Pacific waters of the Hawaiian Islands at some point in the last decade.

[2]State

/-/ = No Status

Likelihood of occurrence in the project site

C = Confirmed
P = Potentially may occur
U = Unlikely to occur

Spinner Dolphins

The Hawaiian Islands group of spinner dolphins is a distinct stock, with an overall population estimate of approximately 4,000 animals (Lammers et al. 2000; Mobley et al. 2001a). Spinner dolphins are very common and abundant, and they occur year-round in Hawaiian waters (NOAA Fisheries 2000q). They are often seen in large groups of over 400 animals (Dollar 1999), although there may be seasonal changes in abundance. The group's movement pattern around the islands has been well documented and is considered predictable and cyclical (Norris 1991; Lammers et al. 2000; Lammers 2003a). Spinner dolphins typically occupy shallow inshore waters in the morning and afternoon then move farther offshore in the late afternoon or early evening to forage. They tend to rest on the leeward sides of the islands, especially in nearshore or offshore areas with sandy bottoms. This period of rest is considered very important for tissue regeneration and overall health and also appears to be important in establishing or reaffirming social relationships (Lammers 2003a). Spinner dolphins in general show a strong preference for waters both inside or near the 10-fathom (60-foot) isobath between the early morning and late afternoon periods (Dollar 1999; Pickering 2003; Lammers 2003a).

Local subpopulations are often residential to the various islands (NOAA Fisheries 2000q) or to parts of the islands (Lammers 2003a). Along the western coastline of O‘ahu, spinner dolphins are found mainly at three general shallow water (less than 10 fathoms) sites (Lammers et. al. 2000; Lammers 2003a). One of these is located adjacent to MMR and is known as the northern Wai‘anae site. The population that is found here, within the ROI, is considered residential and is part of the Wai‘anae spinner dolphin group (Lammers 2003a). Ninety-five percent of the time surveyed, spinner dolphins were sighted in front and just north of Mākua Beach at this site (Lammers 2003a). Numbers near MMR do vary seasonally, but typically the MMR pod group size ranges from between 35 and 200 animals (Pickering 2003; Lammers 2003a). The number varies depending on which of the "subpods" appear, as well as on the varying formations of groups that may occur at one time. The dolphins occur throughout the day and night near MMR, but typically peak concentrations are when the animals are resting. Spinner dolphins typically occupy shallow inshore waters in the morning and afternoon, then move farther offshore in the late afternoon or early evening to forage (Lammers 2005). Recent studies (Benoit-Bird and Au 2003, 2004) show that prey of the resident spinner dolphins (and other marine mammals) show a distinctive movement pattern (diurnal migration). The prey moves within the water column so that it is usually in deeper water by day and in the midwater or surface waters by night. In addition, there is a horizontal component of movement by this foraging layer of prey. It moves

nearshore, coming within 0.6 mile (1 kilometer) of the shoreline during the middle of the night (Benoit-Bird and Au 2004).

Preferred locations of the Wai‘anae spinner dolphin group are shown on Figure 3.9-1.

As evidenced by their frequent sightings, the shallow location at Mākua Beach is preferred habitat by the spinner dolphins. It provides excellent resting habitat due to several factors. This site is the most protected from trade winds; thus, the waters are often calm and more sheltered than adjacent areas (Lammers 2003a; Dollar 1999). The area also is adjacent to dolphin foraging grounds near Ka‘ena Point. The site is thought to afford protection from sharks due to the sandy bottom, which allows for excellent visibility and avoidance of attacks (the bottom substrate consists mainly of large stretches of white sandy bottom). The animals have been documented resting in the early mornings through early afternoon, recovering from the long feeding bouts that they engage in farther offshore at night. In the late afternoon, usually sometime after 3:00 PM and sometimes as late as 5:00 PM, the dolphins come out of their resting and milling mode to move into deeper waters to feed. At this time they commence a period of renewed social activity, moving rapidly and “spinning” (leaping) out of the water (Lammers et al. 2000; Lammers 2003a) while they gather in preparation of foraging. The animals move out of the bays in the late afternoon to feed in water at depths of 600 to 6,000 feet (180 to 1,800 meters) (Dollar 1999; Norris 1994). Lammers (2003a) surmises that “the ability to rest while minimizing predation risks is undoubtedly the primary reason spinner dolphins occupy the nearshore habitat during daylight hours.”

Hawaiian waters in general have been identified as “acoustic hot spots” (NRDC 1999); that is, the habitat is considered to be both of ecological significance and yet currently acoustically impacted (i.e., it is considered to be exposed to high levels of human-made noise). A number of existing factors may be placing marine wildlife in Hawaiian waters under some degree of existing stress that is impossible to quantify; these factors include the acoustic status of the waters, the increasing numbers of tour operations and programs where people swim with dolphins, and other invasive human practices. Spinner dolphins are known to react to swimmers (Richardson et al. 1995, p. 410; MMPA Bulletin 1999) and have been documented to be sensitive, possibly more than other dolphin species, to aircraft (Richardson et al. 1995, p. 248).

The Wai‘anae dolphin group is the focus of approximately four to six boat operators daily (Lammers 2003a), and the public and tourists frequently approach them for “swim with” programs, even though it is illegal. No studies have been published assessing what limits this group has in terms of their adaptability to disturbance from humans, and no published studies

have assessed what the current or near-term costs may be to them (e.g., increased predation, reduced reproductive fitness, increased levels of stress) from existing human interaction.

Figure 3.9-7 shows sensitive wildlife species in the ROI (MMR). Figure 3.9-8 shows sensitive wildlife species in the ROI (PTA).

Pōhakuloa Training Area

Zoological field surveys that have been conducted on PTA include those by Shallenberger (1977), David (1995), and Freed (1991). More recent surveys targeting native rare invertebrates, mammals, and birds were also conducted (Gon et al. 1993; HINHP 1998; USARHAW and 25th ID [L] 2001b; CEMML and PTA NRS 2005, 2006, and 2007), as were entomology surveys of the PTA lava tubes (Garcia and Associates 2003). There have been no specific reptile surveys on PTA because there are no native terrestrial reptiles and amphibians on the Hawaiian Islands. Surveys of PTA were conducted by the University of Hawai‘i, the Bishop Museum Hawaiian Heritage Program, the HINHP, and PTA NRS, which are cited in the following section. These natural resource surveys have been used for resource assessments, to include the PTA INRMP, the 2003 Biological Assessment, and the PTA Implementation Plan. The following section describes the general presence of invertebrate, mammal, bird, and fish species.

<u>Invertebrates</u>

Native and endemic invertebrates on PTA include the Hawaiian helicoverpa moth (*Helicoverpa confusa)* and the Giffards rhyncogonus weevil (*Rhyncogonus giffardi*). Snails documented at PTA are *Letachatina* spp., *Euconulus gaetanoi*, *Nesopupa subcentralis*, *Nesovitrea hawaiiensis*, *Striatura* spp., and *Vitrina tenella.* The helicarionid land snail *(Philonesia* spp.*)* and succineid land snail *(Succinea konaensis)* were also observed on PTA (HINHP 1998; R. M. Towill Corp. 1997a; USARHAW and 25th ID [L] 2001b). Some underground caves can contain standing water and may support species of arthropods. Howarth et al. (1996) found at least 90 species of arthropods (at least 60 native) and six other invertebrates (including a rare native snail, *Leptachatina* sp.), in PTA caves and lava tubes. Three endemic caterpillar species, *Schrankia* sp., were noted during recent surveys for native invertebrates at PTA lava tubes (Garcia and Associates 2003). Surveys of PTA by HINHP in 1993 detected the following nonnative snails: giant African snail, bradybaenid land snail, cannibal snail, and the zonitid land snail. Humans have purposely or accidentally introduced these species to the Island of Hawai‘i. They now threaten the native snail species through competition for resources, predation, and the spread of disease (PCSU 1999).

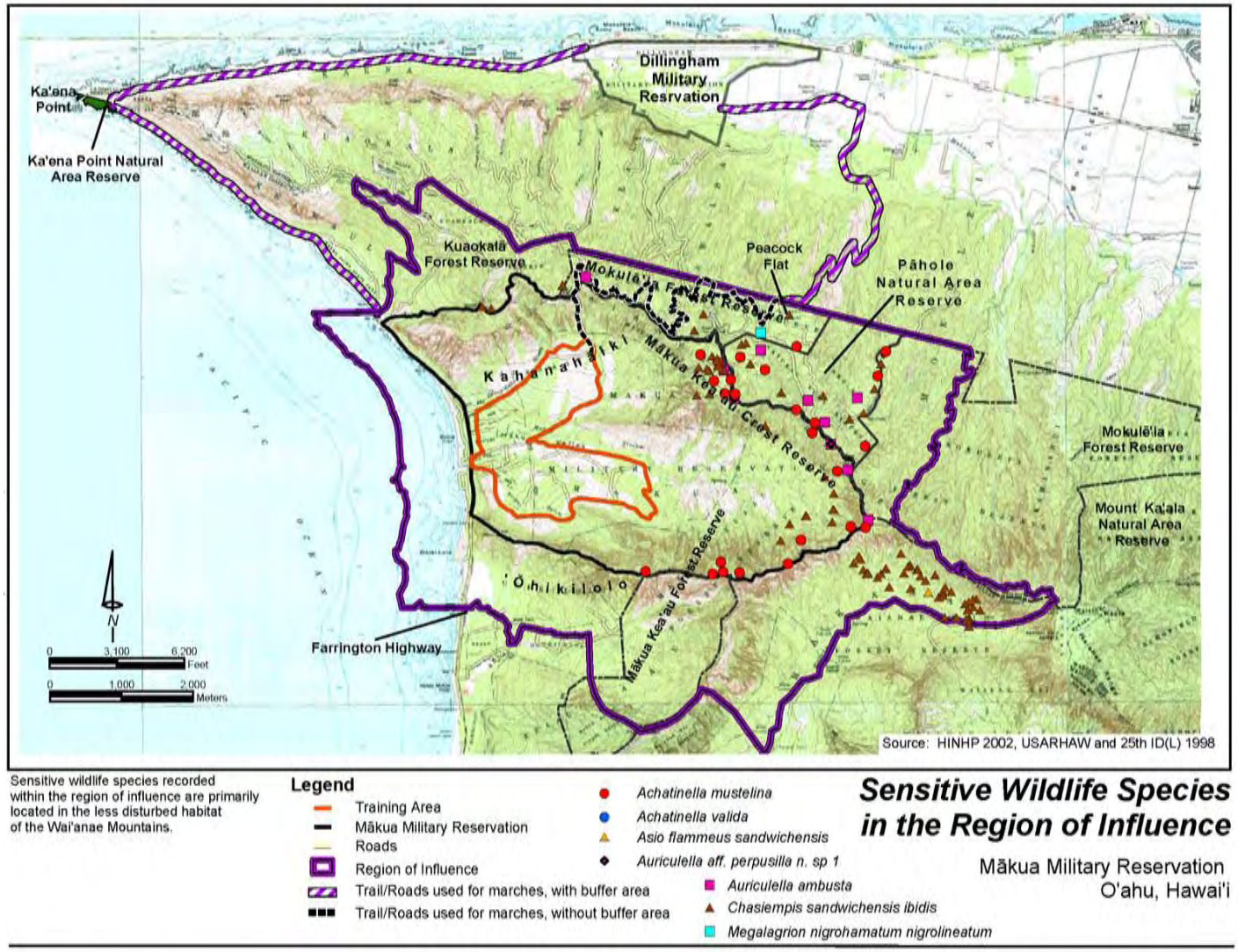


Figure 3.9-7 Sensitive Wildlife Species in the Region of Influence, MMR

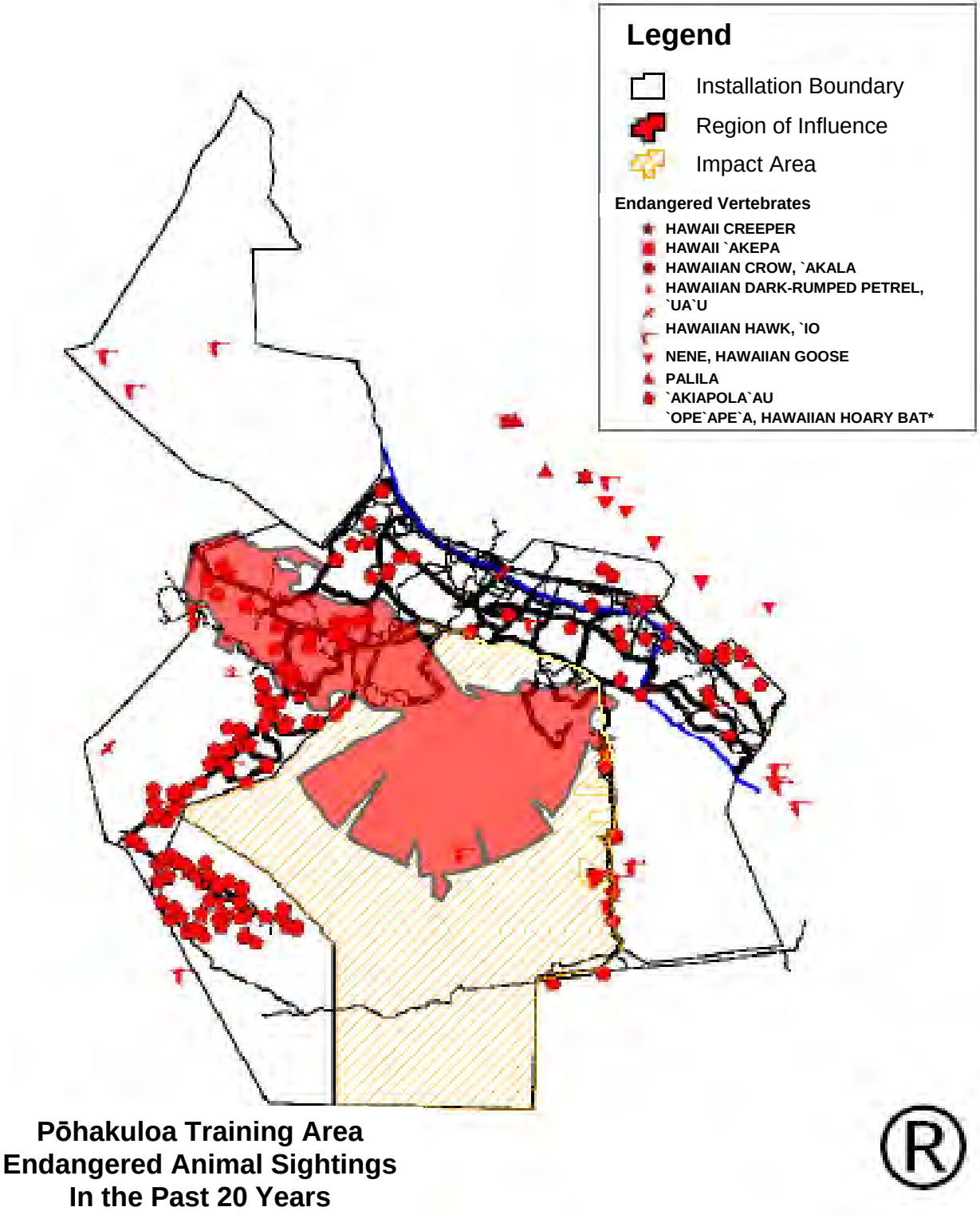


Figure 3.9-8 Sensitive Wildlife Species, PTA Terrestrial Region of Influence

Amphibians

There are no native terrestrial amphibians on the Hawaiian Islands. Nonnative amphibians found on the Island of Hawai‘i include bullfrog, wrinkled frog, coqui frog, giant toad, and Cuban tree frog. These species were introduced into Hawai‘i from other countries and have inhabited areas of adequate aquatic habitat and surrounding vegetation. To date, no amphibians have been found at PTA.

Reptiles

There are no native terrestrial reptiles on the Hawaiian Islands. Nonnative reptiles found on the Island of Hawai‘i include the green anole, mourning gecko, stump-toed gecko, tree gecko, Indo- Pacific gecko, house gecko, metallic skink, and gold dust day gecko. Sometime in the 1980's the blind snake was introduced to the islands of Hawaii in potting soil from plants (probably from the Philippines). These small snakes with tiny eye-spots, eat small termites, ants and other arthropods. As termites and ants are also introduced animals, these snakes pose no great threat to ecosystems in Hawai‘i. To date, none of these species have been found at PTA.

The following nonnative species have been documented as occurring on PTA: feral pig, feral goat, feral cat, feral dog, Norway rat, black rat, feral sheep *(Ovis aries)*, mouflon sheep *(O. musimon)*, mongoose *(Herpestes auropunctatus)*, and house mouse. The Polynesian rat may occur on PTA. The only native terrestrial mammal found on PTA is the Hawaiian hoary bat (*Lasiurus cinereus semotus*), which is a species listed as endangered under the ESA.

Birds

Endemic species fairly common to PTA are apapane and Hawaiian amakihi. Endemic species with declining populations less common to, but identified on, PTA are ‘i‘iwi, and ‘ōma‘o *(Myadestes obscurus)* (USARHAW and 25th ID [L] 2001b). The dark-rumped petrel *(Pterodroma phaeopygia sandwichensis)* is a federally listed endangered species that may occur on PTA. A survey to determine presence of the dark-rumped petrel was conducted in 2007 (CEMML and PTA NRS 2008). No birds were seen or heard during the monitoring period; however, because of the difficulty in detecting the petrel, surveys will continue. The ‘elepaio is native, but only two individuals are known at PTA. The ‘io (*Buteo solitarius*) is occasionally seen on PTA and the nēnē (*Branta sandvicensis)* is seasonally observed on PTA. Up to 20 nēnē were seen in Range 1 in 2007, but the area of the sighting is outside the ROI for this proposed Alternative. Nonnative bird species known to occur on PTA include lavender waxbill (*Estrilda caerulescens*), Erchel’s francolin *(Francolinus erckelii)*, black francolin *(F. francolinus)*, California quail

(Callipepla californica), and Japanese quail *(Coturnix japonica)*. The house finch *(Carpodacus mexianus)* and Eurasian sparrow *(Paser domesticus)* are also species that have been introduced by humans on the Island of Hawai‘i.

Migratory Birds

A minimum of eleven species of migratory bird species have been observed at PTA. These birds are protected by the Migratory Bird Treaty Act (MBTA) and EO 13186. Under the MBTA (16 U.S.C. 703), unless permitted by regulation (i.e., waterfowl hunting, incidental taking during DoD training and testing), it is illegal to “take” migratory birds, their eggs, feathers or nests. “Take” includes by any means or in any manner, any attempt at hunting, pursuing, wounding, killing, possessing or transporting any migratory bird, nest, egg, or part thereof. Under the MBTA, only the direct “take” of migratory birds requires authorization by USFWS. Actions that may adversely impact or indirectly “take” birds such as habitat destruction or manipulation are not a violation of the MBTA unless migratory birds are killed or wounded during the activity. However, the MOU between the DoD and the USFWS to promote the conservation of migratory birds that was developed pursuant to EO 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, address’ both direct and indirect take of migratory birds. The MOU identifies specific activities where cooperation between USFWS and DoD will contribute substantially to the conservation of migratory birds and their habitats. This MOU does not authorize the take of migratory birds.

On February 28, 2007, the USFWS published the final rule on the take of migratory birds by the Armed Forces. This rule authorizes and explains the conditions for which the Armed Forces, and contractors performing a military readiness activity in association with the Armed Forces, can unintentionally take migratory birds during military readiness activities (USFWS 2007c). If the Armed Forces determine that a proposed or an ongoing military readiness activity may result in a significant adverse effect on a population of a migratory bird species, then they must confer and cooperate with the USFWS to develop appropriate and reasonable conservation measures to minimize or mitigate identified significant adverse effects. Under certain circumstances, such unintentional take authorization is subject to withdrawal to ensure consistency with the provisions of the migratory bird treaties.

Fish

The semi-arid climate and permeable soils of PTA support no standing or running surface water; thus, no natural aquatic systems occur on PTA (USARHAW and 25th ID [L] 2001b). Although Wai‘ula‘ula Gulch and

Makeahua Stream cross the proposed PTA Trail alignment, no fish data are available for the PTA ROI.

Marine Biological Resources

The near-shore and offshore Pacific waters between O‘ahu and the Island of Hawai‘i, the Pearl Harbor area of O‘ahu, the Kawaihae Harbor area of the Island of Hawai‘i, and coastlines adjacent to the harbors were included in the PTA SBCT ROI. These areas were considered to be included in the ROI for this PTA action alternative; however, there would be no increase in the frequency of vessel transport of troops for this action. Soldiers that would be transported to PTA for SBCT or other training, would also undergo their required CALFEX training, which would limit the need and frequency for vessel transportation between O‘ahu and the Island of Hawai‘i.

As discussed in the PTA SBCT FEIS, some of the transit areas for the vessels between the two islands are within or in close proximity to the Hawaiian Islands Humpback Whale National Marine Sanctuary waters. Designated sanctuary waters surround the entire western portion of the Island of Hawai‘i and include waters just outside and surrounding Kawaihae Harbor. Designated sanctuary waters also occur outside of O‘ahu at Penguin Banks, which would be part of the transit route for crew-transporting vessels. Any adjacent coastline areas in the ROI may provide shore habitat for some marine wildlife, such as sea turtles, monk seals, and spinner dolphins.

There is a coral reef area of management concern (known as a “hot spot”) in the PTA SBCT ROI. Located at Kawaihae Harbor, this reef is identified as at risk both from extensive development at the commercial harbor and from recent and continued development at the small boat harbor. While the main issue affecting this reef is harbor construction, other causes of decline for this reef system include interruption of long-shore transport due to harbor development, consequent siltation of Pelekane Bay, and close proximity to important cultural sites (i.e., Pu‘u Kohola Heiau) that causes increased recreational use and human presence (CRAMP 2003).

In addition to this reef identified as a management concern, there were other coral reefs identified in the coastal waters of the PTA SBCT ROI. One that is well known is Puako reef, approximately 8 to 10 miles (12.9 to 16.1 kilometers) from Kawaihae Harbor. There are no coral reef areas of management concern outside Pearl Harbor on O‘ahu (CRAMP 2003). Marine wildlife occurs in the PTA SBCT ROI in both the near-shore and offshore regions of Pacific waters. The harbor areas and adjacent coastline areas also provide habitat for marine wildlife. Kawaihae Harbor is on the

leeward side of the island, where waters are calmer and more protected. These waters provide good habitat for humpback mother and calf pods and for resting dolphin pods as well as sea turtles, potentially monk seals, and other marine wildlife.

Distributions and abundance of marine mammals and sea turtles in Pacific waters vary seasonally and spatially; that is, numbers and types of animals may vary in the near-shore versus offshore regions, as well as by the time of year (Calambokidis et al. 1997; Leatherwood et al. 1982; Mobley et al. 1999, 2000; NOAA Fisheries 2000x through 2000bb). Many marine mammal species occur year-round in Pacific waters.

All marine mammal species are protected under the MMPA, regardless of whether they have additional protection under the ESA. Informal consultation with NOAA Fisheries was initiated for marine mammals in the SBCT ROI. NOAA Fisheries concurred with the Army that slow speeds (less than 11 knots) of the logistic support vessels (LSV) would make collisions with protected species unlikely, and therefore, not likely to adversely impact such species. Both MMPA and ESA protected marine wildlife species that may occur in the PTA SBCT ROI seasonally, permanently, or as transients, are detailed in US Army and USACE 2004.

3.9.6 Sensitive Status Species and Habitats Mākua Military Reservation

Sensitive species include special status, or regulated, species, such as ESA-listed species, USFWS- or State of Hawai‘i-listed endangered, threatened, candidate, or proposed species, MMPA species, federal and state species of special concern, and locally regulated species. Species that have had rapid population decline or whose habitat has markedly decreased in recent years are also considered sensitive.

The vast majority of the terrestrial sensitive species found within the ROI inhabit the Wai‘anae Mountains that border MMR. Coastal habitats, including portions of the Ka‘ena Point Trail, also offer important habitat to sensitive species discussed in this section. ESA Section 7 consultation for routine training at MMR covered 46 listed plant species identified at MMR, the O‘ahu tree snail, the O‘ahu creeper, the O‘ahu ‘elepaio and its critical habitat (proposed at the time), and the Hawaiian hoary bat (USARHAW and 25th ID(L) 1998; USFWS 1999a, 2001a and 2001b). The 1999 BO, 2001 supplemental BO, and 2007 BO cover all the federally listed species discussed in this section, with the exception of marine mammals and marine reptiles. The 2007 BO provides an updated and more comprehensive status review of each threatened and endangered species addressed in the consultation; that level of review is required by

the ESA and is above and beyond the scope (or "exceeds the requirements") of an EIS. For additional information, the corresponding pages within the 2007 BO that address a species are provided.

Sensitive Vegetation Species

Presented below is the natural history information for sensitive status vegetation species known or considered likely to occur in the ROI that could be affected by Army activities. Species location is provided when known, and all species are represented in genetic storage facilities with cuttings or seeds unless otherwise noted. An extensive key to status codes is provided in Appendix H-2, along with sensitive status vegetation identified as occurring only historically in the ROI and those sensitive species that are considered unlikely to occur. Briefly, the status information included below indicates the level of federal protection (FE = endangered, T = threatened, C = candidate for federal listing as an endangered species) and the Heritage Ranking (G1-G6), which is a rarity rating developed by The Nature Conservancy. The table indicates whether or not critical habitat has been designated for the individual species. The ROI identified for most species refers to the training portion of the ROI unless noted otherwise.

Table 3.9-2 contains a list of these plant species and associated level of regulation, habitat preferences, and likelihood of occurrence in the ROI. Figure 3.8-7 shows the locations of sensitive plant species confirmed within the ROI. Figure 3.9-9 shows the designated critical habitat in the ROI (MMR). Figure 3.9-10 shows the designated critical habitat in the ROI (PTA).

Table 3.9-2
Sensitive Plant Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	Global[3] Status	Habitat	Date Last Surveyed	Likelihood of Occurrence
Alectryon macrococcus var. *macrococcus*	'Ala 'alahua, māhoe	E, CH	G2	Native-dominated moist forest and gulch slopes	2005	C
Alsinidendron obovatum	NCN	E, CH	G1	Lowland diverse moist forest	2005	P
Bobea sandwicensis	'Ahakea	-	G2	Gulch slopes in dry to moist forest	2005	C
B. timonioides	'Ahakea	-	G2	Ridges and gulch slopes of dry to moist forest	2000	C
Bonamia menziesii	NCN	E, CH	G2	Dry to moist forest	2005	C

Table 3.9-2
Sensitive Plant Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	Global[3] Status	Habitat	Date Last Surveyed	Likelihood of Occurrence
Cenchrus agrimonioides var. *agrimonioides*	NCN	E, CH	G1	Ridges and slopes of dry to moist forest	2005	C
Centaurium sebaeoides	‘Āwiwi	E, CH	GH	Coastal, dry rocky substrates	1976	U
Chamaesyce celastroides var. *kaenana*	‘Akoko	E, CH	-	Coastal dry shrubland	2006	C
Ctenitis squamigera	Pauoa	E, CH	-	Moist forest understory	2002	C
Cyrtandra dentata	Ha‘iwale	E, CH	G1	Moist to wet forests	2005	C
Cyperus trachysanthos	Pu‘uka‘a	E	-	Mud flats, wet cliff seeps, coastal cliffs	1999	U
Cyanea superba spp. *suberba*	Hāhā	E, CH	G1	Moist to wet forest slopes	2005	U
Delissea subcordata	NCN	E, CH	G1	Moist forest understory	2005	C
Diellia falcata	Palapalai lau li‘i	E, CH	G1	Deep shade in dry forest	2005	C
Dubautia herbstobate	Na‘ena‘e	E, CH	-	Dry coastal ridges	2005	C
D. sherffiana	Na‘ena‘e	-	G1	Moist inland ridges	2005	C
Euphorbia haeleeleana	‘Akoko	E, CH	-	Lowland moist to dry forest slopes	2005	C
Flueggea neowawraea	Mehamehame	E, CH	-	Dry forest	2005	C
Abutilon sandwicense	NCN	E, CH-	G1	Dry to mesic lowland forest	2005	C
Chamaesyce herbstii	‘Akoko	E,CH	G1	Mesic *Acacia koa-Metrosideros polymorpha* lowland forests or diverse mesic	2005	C
Colubrina oppositifolia	Kauila	E, CH	G1	Lowland dry and mesic forests dominated by *Diospyros sandwicensis*	2005	C
Cyanea grimesiana ssp. obatae	Hāhā	E, CH	G1	Mesic to wet lowland forests	2005	C

Table 3.9-2
Sensitive Plant Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	Global[3] Status	Habitat	Date Last Surveyed	Likelihood of Occurrence
Cyanea longiflora	Hāhā	E, CH	G1	Mesic *Acacia koa-Metrosideros polymorpha* lowland forest	2005	C
Gouania vitifolia	NCN	E, CH	G1	Dry to mesic forests	2005	C
Hesperomannia arbuscula	NCN	E, CH	G1	Dry to wet forest dominated by *Acacia koa* and *Metrosideros polymorpha*	2005	C
Isodendrion laurifolium	Aupaka	E, CH	G1	Diverse mesic or dry forest dominated by *Metrosideros polymorpha, Eugenia reinwardtiana,* or *Diospyros sandwicensis*	2005	C
Isodendrion longifolium	Aupaka	T, CH	G2	Mixed mesic or lowland wet *Metrosideros polymorpha-Dicranopteris linearis* forest	2005	C
Isodendrion pyrifolium	Kula wahine noho	E, CH	G1	Bare rocky hills and in wooded ravines in dry shrublands	2005	C
Mariscus pennatiformis	NCN	E, CH	G1	Mesic and wet *Metrosideros polymorpha* forest and *Metrosideros polymorpha-Acacia koa* forest	2005	C
Melicope pallida	Alani	E, CH	G1	Steep rock faces in lowland dry or mesic forests	2005	C
Neraudia angulata var. angulata	NCN	E, CH	G1	Lowland mesic or dry forest	2005	C
Peucedanum sandwicense	Makou	T, CH	G2	*Metrosideros polymorpha* lowland mesic forest	2005	C

Table 3.9-2
Sensitive Plant Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	Global[3] Status	Habitat	Date Last Surveyed	Likelihood of Occurrence
Phyllostegia kaalaensis	NCN	E, CH	G1	Mesic forest or *Sapindus oahuensis* forest	2005	C
Schiedea kaalae	NCN	E, CH	G1	Diverse mesic and wet forests	2005	C
Solanum sandwicense	‘Aiakeakua, popolo	E, CH	G1	Talus slopes and streambeds in open, sunny areas	2005	C
Hedyotis degeneri var. *degeneri*	NCN	E, CH	-	Moist forest understory and upper elevation shrublands	2005	C
H. parvula	NCN	E, CH	-	Exposed ridges	2005	C
Hibiscus brackenridgei ssp. *mokuleianus*	Koki‘o ke‘oke‘o, Ma‘o hau helema‘o hau hele	E, CH	G1	Lowland dry areas	2006	C
Lepidium arbuscula	‘Ānaunau, naunau, kūnānā	E, CH	G1	Open dry ridges and cliffs	2005	C
Lipochaeta tenuifolia	Nehe	E, CH	-	Multiple habitat types, from dry coastal cliffs to moist forest understory	2005	C
Lobelia niihauensis	Kuhi‘aikamo‘o wahie	E, CH	G2	Exposed dry cliffs	2005	C
Melicope makahae	‘Alani	C	G1	Moist forest	2005	C
M. sandwicensis	‘Alani	-	G2	Moist forest	2005	C
Neraudia angulata	Ma‘aloa, ma‘oloa, ‘oloa	E, CH	G1	Dry forest and shrubland	2005	C
N. angulata var. *dentata*	Ma‘aloa, ma‘oloa, ‘oloa	E, CH	G1	Diverse forest	2005	P
Nothocestrum latifolium	‘Aiea	C	-	Mesic and diverse mesic forests	1999	P
Nototrichium humile	Kulu‘ī	E, CH	G2	Dry forest understory and dry cliffs	2005	C
Plantago princeps var. *princeps*	Ale, laukahi kuahiwi	E, CH	-	Moist cliffs	2005	C
Platydesma cornuta var. *decurrens*	Pilo kea	C	G2	Mesic forests	2005	C

Table 3.9-2
Sensitive Plant Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	Global[3] Status	Habitat	Date Last Surveyed	Likelihood of Occurrence
Pleomele forbesii	Halapepe	C	G1	Dry and moist forests	2005	C
Pritchardia kaalae	Loulu	E	G1	Moist valley floors and windswept moist forest	2005	C
Pteralyxia macrocarpa	Kaulu	C	G2	Diverse moist forests	2005	C
Sanicula mariversa	NCN	E, CH	/-	Moist sites in deep soil	2005	C
Schiedea hookeri	Mā‘oli‘oli	E, CH	G1	Moist forest understory	2005	C
S. nuttallii var. nuttallii	Mā‘oli‘oli	E, CH	G1	Moist forest understory	2005	C
S. kealiae	Mā‘oli‘oli	CH	-	Moist forest understory	Unknown	P
Silene lanceolata	Lanceleaf catchfly	E, CH	G1	Dry to moist shrubland	2001	C
Spermolepis hawaiiensis	NCN	E, CH	G1	Lowland dry shrubland	2004	C
Tetramolopium filiforme	NCN	E, CH	-	Seaward cliffs	2005	C
Viola chamissoniana spp. chamissoniana	‘Olopū, pāmakani	E, CH	G3	Moist cliffs	2005	C

Sources: USFWS 2002a, 2002b; USARHAW and 25th ID (L) 2001b; Kawelo 2003
NCN = No common name
Status:

[1]Federal:
E = Endangered
C = Candidate species for listing
CH = Critical habitat designated

[3]Heritage Global Rank:
G1 = Species critically imperiled globally (typically 1-5 current occurrences)
G2 = Species imperiled globally (typically 6-10 current occurrences)
G3 = Species very rare with restricted range
/-/ = No Status

[2]State
/-/ = No Status

Likelihood of occurrence on the project site
C = Confirmed P = Potentially may occur U = Unlikely to occur

Abutilon sandwicense (FE/G1) (2007 BO, pp.110 and 526 [USFWS 2007b]; 2008 BO, pp. 16 and 39 [USFWS 2008])

This shrub typically grows on steep slopes in dry forests between 1,000 and 2,000 feet (300 and 600 meters) elevation. The species is endemic to O‘ahu, and there are 14 occurrences with approximately 400 individuals on federal, state, private, city, and county lands. The unique threats to *A. sandwicense* are the black twig borer (*Xylosandrus compactus*) and the Chinese rose beetle (*Adoretus sinicus*). Less then 10 percent of the total

number of individuals occurs within the training portion of the ROI. All the individuals of *A. sandwicense* within the training portion of the ROI are at risk from training-related wildfires. Approximately 4 acres (1.6 hectares) (less than 1% of the critical habitat in unit A) occurs within the Puulu to Alaiheihe fuelbreak area of the ROI.

Alectryon macrococcus var. macrococcus (FE/G2) (2007 BO, pp. 113 and 388)

This species is generally found in native moist forest in gulches and on lower gulch slopes. It is known to occur at lower Mākua Valley, Kahanahāiki Valley, and on the east rim of MMR. Populations on O‘ahu grow at numerous sites in the Wai‘anae Mountains and rarely in the Ko‘olau Mountains. The number of plants in the Wai‘anae Mountains is estimated at 300 (MIT et al. 2003). The greatest threat is the black twig borer, which affects all trees of the species to varying degrees (MIT et al. 2003). Other threats include feral pigs and goats, which disturb habitat, and rats that prey on the seeds. Alien grasses also change the species' habitat, ultimately increasing the frequency and size of fires (Wagner et al. 1999).

Alsinidendron obovatum (reclassified as Schiedea obovata) (FE/G1) (2007 BO pp. 273 and 517)

This erect subshrub (stems woody at the base) is a short-lived perennial that grows up to 3.3 feet (1 meter) tall. It occurs on ridges and slopes in lowland diverse mesic forests dominated by *Acacia koa* and *Metrosideros polymorpha*, at elevations of 1,837 to 2,494 feet (560 to 760 meters). Plants generally flower after two years of growth and are normally self-fertilizing. Population units in the wild have been known to disappear for a number of years and then reappear after large rainfall events, apparently owing to persistence of seeds in the soil seed bank. Most of the known individuals of this species occur within the ROI in zones of low and very low fire risk. *Schiedea obovata* is particularly vulnerable to predation by nonnative slugs and snails. Most importantly, population units of *S. obovata* are vulnerable to extirpation from naturally occurring events, such as rockslides, and by reduced reproductive vigor due to small population size and limited distribution. The population is being managed for stabilization as specified by the MIP.

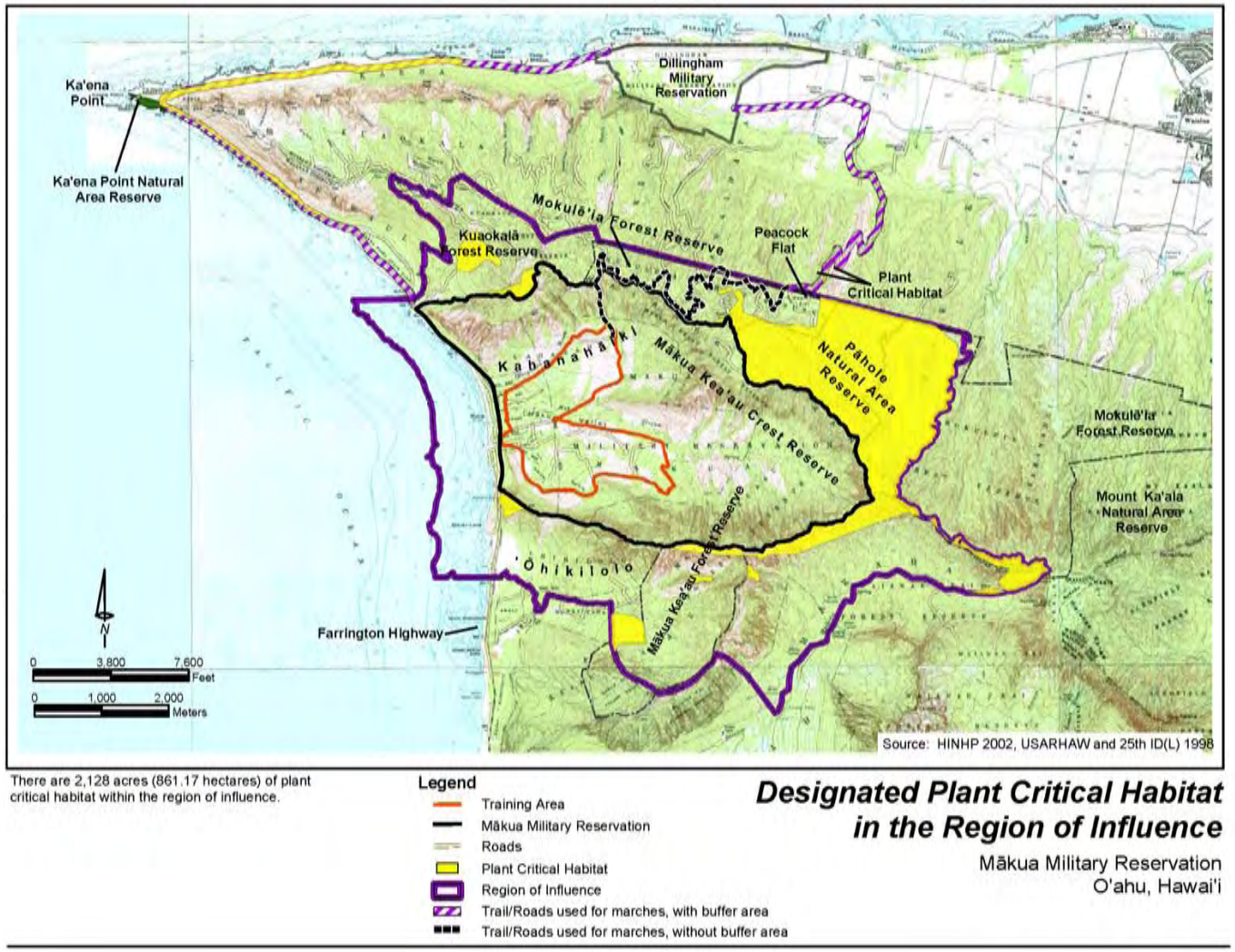


Figure 3.9-9 Designated Critical Habitat in the Region of Influence, MMR

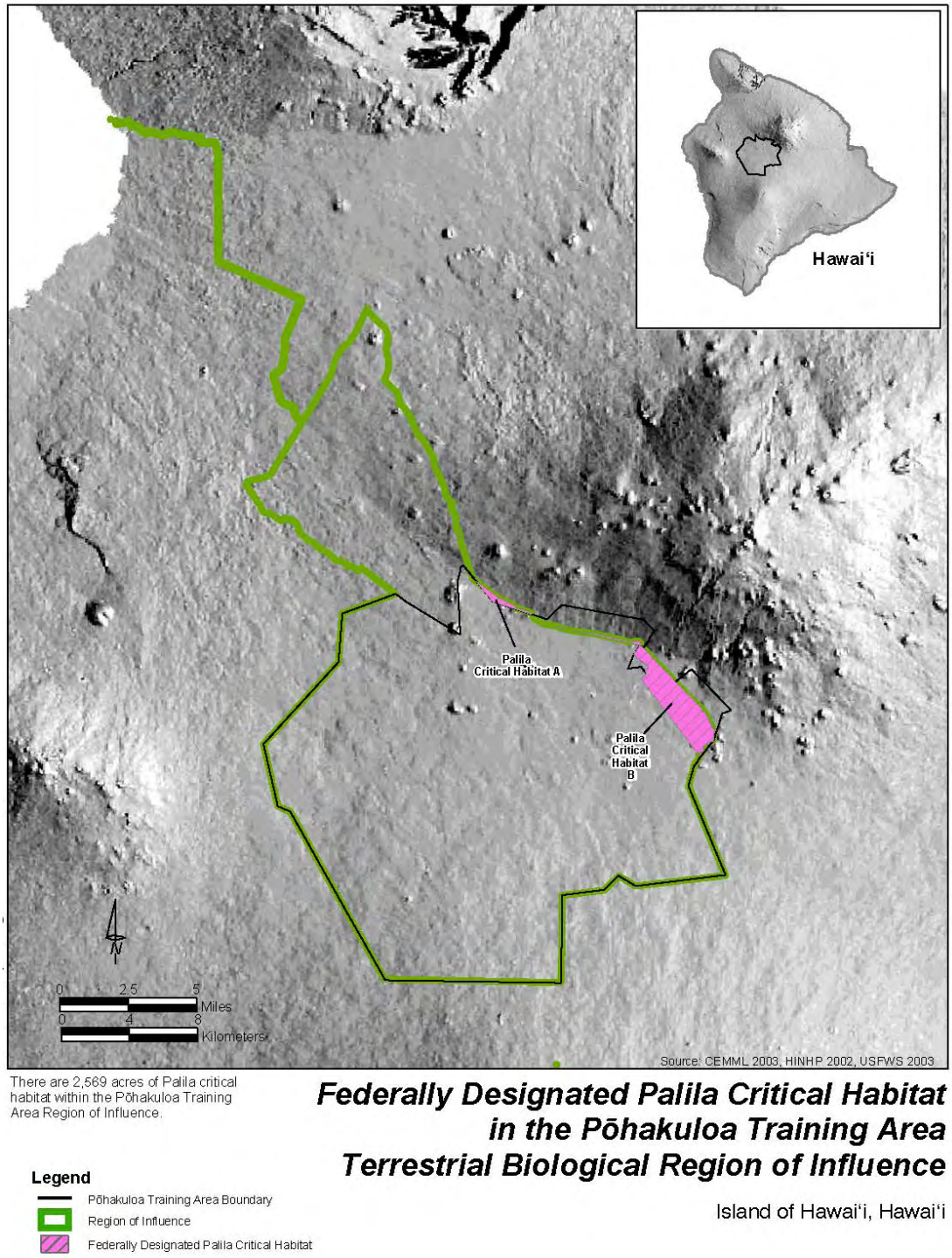


Figure 3.9-10 Designated Palila Critical Habitat, PTA Terrestrial Biological Region of Influence

Bobea sandwicensis (‘ahakea) (G2)

The ‘ahakea tree grows in dry to moist forests, generally on gulch slopes, ridges, or old lava flows. It is represented on MMR by 25 individuals in ‘Ōhikilolo (the southernmost ridge), Kaluakauila (the northern ridgeline), and lower Mākua Valley. This species can grow to nearly 33 feet (10 meters) (Wagner et al. 1999). Two trees were destroyed in the July 2003 fire.

B. timonides (G2)

This tree can grow to 33 feet (10 meters) high. It is found in dry to occasionally moist forest and benefits from weed removal in its habitat. There are currently only two individuals in Kahanahāiki Valley.

Bonamia menziesii (FE/G2) (2007 BO, pp. 117 and 529; BO. pp. 18 and 40)

This woody-stemmed vine inhabits dry to moist forest. There is one known documented species at Kaluakauila on MMR. This species has several thousand individuals at different locations throughout the state. O‘ahu has no more than 60 individuals, on MMR, Lualualei Naval Reservation, and private and state land. The greatest threat to this species is fire. Four percent (69 acres [28 hectares]) of all *B. menziesii* critical habitat designated on the Island of O‘ahu is located in two units located entirely within the training portion of the ROI. Approximately one percent (14 acres [6 hectares]), of its designated critical habitat in Unit C is located in the proposed Pu‘ulu to Ala‘ihe‘ihe fuelbreak portion of the ROI.

Cenchrus agrimonioides var. agrimonioides (FE/G1) (2007 BO, pp. 122 and 391)

‘Ume‘alu is a perennial bunchgrass generally inhabiting ridges and upper gulch slopes. Populations of this species occur in Kahanahāiki Valley. Longevity in the wild is undocumented. There are approximately 700 plants in four populations on O‘ahu. Threats include predation and associated habitat degradation by wild and feral hoofed animals, alien plant competition for light, water, and nutrients, and the spread of alien grasses that increase the risk of wildfires. Human trampling is an additional threat to one of the Wai‘anae populations, which is at the side of an often-used trail. The July 2003 fire burned within 49 feet (15 meters) of a population of this species.

Chamaesyce celastroides var. kaenana (FE) (2007 BO, pp. 126 and 395)

This endangered species of ‘akoko grows generally in coastal dry shrubland and on slopes covered with rock debris. Populations are known from Ka‘ena Point and within MMR (MIT et al. 2003). This beach

shrub/small tree fruits throughout the year, and individuals live from 5 to 10 years. The ten remaining known populations are on federally and state-owned land and contain fewer than 600 plants. Major threats include damage from coastal recreational activities, fire, and alien species, particularly koa haole. Current management has included restricting off-road vehicle access to sensitive areas; also, the National Tropical Botanical Garden collects seeds and propagates the plants (USFWS 1998b; Wagner et al. 1999). Thirty-seven plants from two populations were destroyed in the July 2003 fire; that represents nine percent of the population within MMR.

C. herbstii (FE/G1) (2007 BO, pp. 132 and 464)

This small tree grows only to a height of 9.8 to 26.2 feet (3 to 8 meters). It typically grows in gulch bottoms and slopes at elevations between 1,420 and 3,044 feet (433 and 928 meters). It usually occurs in mesic forests dominated by a diverse mix of tree species. All known individuals of *C. herbstii* are within the ROI. About 41 percent of the critical habitat for this species is in areas at risk of training-related wildfires. Because all known individuals occur within the action area, *C. herbstii* has a very high background risk of species extinction, and any additional threats would eliminate the expectation of its long-term persistence. This population unit of *C. herbstii* is being managed for stabilization, as specified by the MIP. Army Natural Resources staff and state biologists bag fruits and collect seed for use in augmenting sites in the Pāhole portion of the Kapuna to Pāhole population unit. The Army also assists with weed control in the Pāhole portion.

Colubrina oppositifolia (FE/G1) (2007 BO, pp. 136 and 574)

Less than one percent of the total state-wide critical habitat for *C. oppositifolia* is within the ROI. The critical habitat is in the northeastern portion of the action area and is in an area of low fire risk. The threats to the primary constituent elements are habitat degradation and predation by feral goats and pigs, damage from the black twig borer and Chinese rose beetle, and potential impacts from military activities. This critical habitat is also threatened by the nonnative plant species *Aleurites moluccana*, *Lantana camara*, *Pennisetum setaceum*, *Psidium cattleianum*, *Schinus terebinthifolius*, and *Syzygium cumini*, which compete with associated native plants. The Army is controlling ungulates and nonnative plant species within the area.

Ctenitis squamigera (FE) (2007 BO, pp. 137 and 534)

This is a fern with a short, slow-growing horizontal stem. It is known to occur at Makaleha, lower Ka‘ala NAR, and lower Mākua Valley, where it

is represented by four individuals. Large populations of this fern are located elsewhere on O‘ahu.

Cyanea grimesiana ssp. obatae (FE/G1) (2007 BO, pp. 140 and 469)

This single-stemmed or sparingly branched shrub grows to 3.3 to 10.5 feet (1 to 3.2 meters) and is typically found on steep, moist shaded slopes in diverse mesic to wet lowland forests at elevations between 1,325 and 3,528 feet (404 and 1,075 meters). *C. grimesiana* spp. *obatae* plants in the Pāhole to West Makaleha population unit are in an area at very low fire risk zone for training-related wildfires. Within the ROI, this species is particularly vulnerable to predation by rats and slugs. Critical habitat in the area is at high, low, and very low risks of training-related wildfires. *C. grimesiana* ssp. *obatae*, is being managed for stabilization as specified by the MIP. These individuals are located within the Pāhole and West Makaleha Management Units. The Pāhole Management Unit is fenced and a small exclosure in the West Makaleha Management Unit protects the plants there. As of 2005, genetic storage goals were about eight percent complete. In addition, there were 15 plants growing in the Army nursery.

C. longiflora (FE/G1) (2007 BO, pp. 146 and 474)

C. longiflora is a short-lived perennial shrub that grows to 3.3 to 9.8 feet (1 to 3 meters). It usually grows below ridge crests and on upper gulch slopes in mesic *Acacia koa-Metrosideros polymorpha* forests at elevations between 479 and 3,906 feet (146 and 1,191 meters). This shrub and its critical habitat within the ROI are in zones that are at low and very low risks of training-related wildfire. *C. longiflora* in the ROI is particularly vulnerable to slug predation. None of the naturally occurring plants in the Kapuna to West Makaleha population unit are within fences and are at risk of habitat degradation by feral pigs and ungulates. The Kapuna to West Makaleha, and Pāhole population units are being managed for stabilization as specified by the MIP. In 2005, genetic storage goals were about 21 percent complete, with 31 plants from the three existing population units combined meeting the goals outlined in the MIP. In addition, there were five plants growing in the Army nursery.

Cyanea superba ssp. superba (FE/G1) (2007 BO, pp. 151 and 479)

This plant is considered to be critically globally imperiled. The last wild individual was extirpated, but over 200 plants have been planted within the training area at Kahanahāiki Gulch. Feral pigs degrade its habitat by rooting, alien plants compete for light, water, and nutrients, the increased risk of wildfires in the habitat area threatens it, and rats, slugs, and snails eat its seeds.

Cyrtandra dentata (FE/G1) (2007 BO, pp. 157 and 401)
This shrub is found in moist to wet forests in the Waiʻanae and Koʻolau Mountains and has been observed flowering and fruiting from May to November. Ninety-seven plants are known from Kahanahāiki Gulch on MMR. The primary threats to this species are feral pigs and goats and the associated habitat degradation, competition for light, space, and nutrients with aggressive alien plants, and fruit and seed predation by slugs, snails, and rats. Seeds or cuttings of this species have not been stored to preserve genetic integrity. Coordination must be made with the State of Hawaiʻi.

Delissea subcordata (FE/G1) (2007 BO, pp. 161 and 483)
This is a small shrub, with few plants remaining. Suitable habitat exists in the training area and Waiʻanae Mountains, and one individual exists at Kahanahāiki Gulch. It grows in moist forest, either under tree canopy or in sunny spots and is often found growing with *Cyanea* species. Only approximately 185 plants remain.

Diellia falcata (FE/G1) (2007 BO, pp. 166 and 537)
This is a terrestrial fern that is found generally in deep shade or open understory in dry forest. It can be found on the east rim of Mākua Valley and in Kahanahāiki Valley within the ROI.

Dubautia herbstobatae (naʻenaʻe) (FE) (2007 BO, pp. 170 and 405)
This small spreading shrub flowers from May to July and is found on dry ridge tops. Threats to this Hawaiʻi native include its very restricted habitat, fires, and damage from feral hoofed animals. The vast majority of the remaining population is found on ʻŌhikilolo Ridge (MIT et al. 2003).

D. sherffiana (G1)
This species overlaps the range of *D. herbstobate* slightly and seems to have broader range through the Waiʻanae Mountains than does *D. herbstobate*. It is found mostly on wetter inland ridges. There are two populations on MMR, on ʻŌhikilolo Ridge. Threats from feral ungulates have been almost completely eliminated on ridge tops and within fenced areas, although after 20 years of impacts, the habitat has degraded from alien species invasions, and the threat and damage from wildfires has greatly increased.

Euphorbia haeleeleana (FE) (2007 BO, pp. 173 and 541)
This small tree is considered to be critically globally imperiled. It is found in the northern Waiʻanae Mountains, mostly on lowland moist or dry forest slopes. One population is documented in the Kaluakauila Gulch area of MMR. Individuals of this species total approximately 100 on Oʻahu. Threats from feral ungulates are no longer an issue at this

population site, as extensive fencing protects it. The July 2003 fire burned within 98 feet (30 meters) of this species. The primary constituent elements of critical habitat on O‘ahu include dry forest dominated by *Diospyros* sp. and containing one or more ofthe following associated native plant species: *Dodonaea viscosa, Erythrina sandwicensis, Pleomele* sp., *Psydrax odorata, Reynoldsia sandwicensis,* or *Sapindus oahuensis;* and elevations between 512 and 1,725 feet (156 and 526 meters). .

Flueggea neowawraea (FE) (2007 BO, pp. 177 and 410)

Mehamehame is a tree that can grow to almost 100 feet (30 meters) tall. Flowering appears to depend on weather patterns and is not necessarily synchronized. Almost half of the O‘ahu population is in the ROI, in Kahanahāiki Valley (MIT et al. 2003). It grows in low-moisture forests, although some remaining trees are mostly found on north-facing gulch slopes and bottoms. Threats include the black twig borer, which introduces pathogens, weakens the tree, and causes premature death; Chinese rose beetles can reduce the leaves to skeletons. Other threats include farming, ranching, development, alien plants, and feral goats and pigs.

Gouania vitifolia (FE/G1) (2007 BO, pp. 183 and 487)

This species is a climbing shrub or woody vine that occurs on the sides of ridges and gulches in dry to mesic forests at elevations of 128 to 3,208 feet (39 to 978 meters). Plants tend to occur in patches, which may consist of clones of a single or few individuals. Over 95 percent of all the known individuals of this species are within the ROI in the Kea‘au population unit. This unit is in the very low fire risk zone on private land in the southeastern part of the area; however, this species requires expedited stabilization due to its restricted distribution (i.e., only or mostly on O‘ahu), low numbers, and limited reproduction. The Army and the USFWS are developing a draft stabilization plan for *G. vitifolia*. General stabilization goals to improve the status of this species include management to attain three stable population units, each with a minimum of at least 50 mature, reproducing individuals (the general criterion for short-lived perennials).

Hedyotis degeneri var. degeneri (FE) (2007 BO, pp. 188 and 415)

This shrub has been reported to flower and fruit at various times throughout the year. It is native to the northern Wai‘anae Mountains, primarily on the windward side. There are 280 individuals left, 160 of which are in the ROI (MIT et al. 2003). With additional discoveries made since 2003, there are now 322 known individuals of this shrub. Eleven individuals are known in Kahanahāiki Valley. It frequently grows in the understory of moist forests and also in areas where upper gulch slope

scrub forest changes to shrubland on ridges. Major threats include habitat disturbance and browsing by feral goats and pigs. Other threats include alien plant invasions, erosion, and increased risk of impacts from wildfire.

H. parvula (FE) (2007 BO, pp. 192 and 419)

An erect to sprawling shrub that grows typically on exposed ridges or cliff faces, it is native to the Waiʻanae Mountains. The three populations total approximately 418 plants, with about 40 percent of them on MMR on ʻŌhikilolo Ridge. Feral pigs and goats are a major threat. Alien plants alter the habitat, compete for valuable nutrients and light, and increase the incidence of wildfires.

Hesperomannia arbuscula (2007 BO, pp. 196 and 423)

A long-lived perennial shrub that grows to 6.6 to 10.8 feet (2 to 3.3 meters) tall and may reach up to 25 feet (7.6 meters). In the Waiʻanae Mountains, this shrub typically grows in mesic forest on upper gulch slopes and ridge tops at elevations of 1,960 to 3,000 feet (597 to 914 meters). Only one mature plant, representing about four percent of all known individuals on Oʻahu, is within the ROI on state land in the Kapuna population unit. The ROI contains a total of 527 acres (213 hectares), or 12 percent of this species' total critical habitat. This shrub has a very high background risk of extinction due the extremely low number of known individuals. Genetic storage goals are about three percent complete, with six plants meeting the goals outlined in the MIP. In addition, there are eight plants growing in the Army nursery.

Hibiscus brackenridgei ssp. mokuleianus (maʻo hau hele) (FE/G1) (2007 BO, pp. 200 and 492)

MMR has burned twice in the last 10 years, but this population survives. There are currently 16 individuals found at ʻŌhikilolo Ridge. At the start of summer, this shrub goes dormant. New growth appears at the onset of the wet season. This species was previously more widespread in lowland dry areas, but habitat has been disturbed from centuries of habitation and agriculture. Primary threats include damage by the introduced Chinese rose beetle, habitat degradation, and increased threat of wildfire from encroachment of nonnative grasses, such as molasses grass (USFWS 2007b). A 2007 fire within the Waialua area killed over 95 percent of the *H. brackenridgei* ssp. *mokuleianus* and impacting approximately 85 percent of the species on Oʻahu. In the Waialua area, the plant occurs in dry gulches, gulch bottoms, and lower to middle gulch slopes in mixed and native dry forest. The primary constituent elements for two of the critical habitat units on Oʻahu include slopes, cliffs, or arid ledges in lowland dry forest or shrubland at elevations 105 to 1,607 feet (of 32 to 490 meters). .

Isodendrion laurifolium (Aupaka) (E/G1) (2007 BO, pp. 207 and 577)

This plant occurs in Diverse mesic or dry forest dominated by *Metrosideros polymorpha*, *Eugenia reinwardtiana*, or *Diospyros Sandwicensis* at elevations between 590 and 3,146 feet (180 and 959 meters). The critical habitat identified within the northeastern area is a low fire risk area. Threats to the critical habitat include military training, habitat degradation and destruction by feral goats and pigs, and competition from nonnative plant species, such as *Aleurites moluccana*, *Cordyline fruticosa*, *Grevillea robusta*, *Psidium cattleianum*, *Schinus terebinthifolius*, and *Toona ciliata*. In addition, rats, slugs, the black twig borer, and the Chinese rose beetle impact native habitat. Nonnative plants and ungulates are controlled within a portion of the area.

I. longifolium (Aupaka) (FT/G2) (2007 BO, pp. 208 and 580)

The habitat for this species is mixed mesic or lowland wet *Metrosideros polymorpha-Dicranopteris linearis* forest. Critical habitat for this plant occurs within the northeastern area of the ROI and is a low fire risk area. The primary threats to the critical habitat include habitat degradation or destruction by feral goats and pigs, a risk of habitat degradation from naturally occurring unforeseen events, and fire caused by military training activities. Fencing is planned for the area where the critical habitat is located.

I. pyrifolium (Aupaka) (FE/G1) (2007 BO, pp. 209 and 583)

The habitat for this species is bare rocky hills and wooded ravines in dry shrublands and elevations from 121 to 2,270 feet (37 to 692 meters). Only a very small percentage of this species' critical habitat is within the area, and primary threats to the critical habitat are believed to be feral ungulates, nonnative plant species, and fire. A small portion of this critical habitat is within a fenced area, and the Army is working to control nonnative plants to reduce the risk of fire.

Lepidium arbuscula (FE/G1) (2007 BO, pp. 210 and 545)

This plant is commonly found in the Wai‘anae Mountains, on exposed ridges and cliffs. It occurs at Kahanahāiki Gulch and ‘Ōhikilolo Ridge.

Lipochaeta tenuifolia (Melanthera tenuifolia) (nehe) (FE) (2007 BO, pp. 217 and 427)

This perennial herb is found only in the northern Wai‘anae Mountains. There are an estimated 3,250 individuals, of which MMR contains approximately 1,500. Habitat extends from very dry seaward cliffs to mesic forests. It is most often on rocky ridge sides and cliff faces on north-

facing slopes. Twenty-nine plants were destroyed in the July 2003 fire, which is one percent of the total population within MMR.

Lobelia niihauensis (FE/G2) and L. oahuensis (FE) (2007 BO, pp. 213 and 548)

L. niihauensis occurs rarely on moist to dry cliffs in the northern Wai‘anae Mountains and is known to occur on MMR. It is a sparingly branched shrub, federally listed as an endangered species.

Mariscus pennatiformis (2007 BO, pp. 216 and 586)

The primary constituent elements of this species' critical habitat units on O‘ahu include mesic and wet *Metrosideros polymorpha* forest and *M. polymorpha-Acacia koa* forest and elevations between 1,391 and 3,385 feet (424 and 1,032 meters). Approximately 410 acres (166 hectares) of the designated critical habitat is in one unit in the northeastern portion of the ROI. The major threats to the primary constituent elements of the critical habitat include habitat degradation by feral pigs and wildfire from military training activities. However, critical habitat is entirely in an area of low fire risk. Ninety-six percent (344 acres [139 hectares]) of the critical habitat in the ROI is within management units where the MIP is being implemented.

Melicope makahae (alani) (FC)

This shrubby tree grows in moist forests in the Wai‘anae Mountains. The plants that occur within the ROI account for around five percent of the statewide population.

Melicope pallida (Alani) (FE/G1) (2007 BO, pp. 222 and 589)

A very small percentage of critical habitat for this species occurs within the northeastern portion of the ROI. The primary constituent elements of critical habitat include steep rock faces in lowland dry or mesic forests, elevations between 768 to 2,758 feet (234 to 841 meters), and one or more of the following associated native plant species: *Abutilon sandwicense*, *Acacia koa*, *Alyxia oliviformis*, *Bobea elatior*, *Cibotium* sp., *Dryopteris* sp., *Metrosideros polymorpha*, *Pipturus albidus*, *Psychotria mariniana*, *Sapindus oahuensis*, *Syzygium sandwicensis*, *Tetraplasandra* sp., *Wikstroemia oahuensis*, and *Xylosma hawaiiense*. The major threats to the primary constituent elements of the critical habitat include the black twig borer, fire from military training activities, habitat degradation by feral pigs, and unforeseen events. Nonnative plants, especially *Andropogon virginicus*, *Clidemia hirta*, *Psidium cattleianum*, *Pterolepis glomerata*, and *Toona ciliata*, compete with associated native plants for light, space, and nutrients. In addition, predation of associated native plants by rats, slugs, and the Chinese rose beetle threaten critical habitat.

Neraudia angulata (FE/G1) (2007 BO, pp. 223 and 497)

Ma‘aloa is an upright shrub recorded throughout the Wai‘anae Mountains. The current population contains about 90 plants, with 30 in the ROI (MIT et al. 2003). Fires at MMR have damaged the habitat of this species. It is typical in dry forests and shrublands and occasionally in mesic areas. Some can be found on gulch slopes and others on nearly vertical cliff faces. The range of this plant extends to lower elevation lands, which are no longer used for grazing, but on other lands, cattle still pose a threat.

Nototrichium humile (kulu‘ī) (FE/G2) (2007 BO, pp. 229 and 430)

Kulu‘ī is a basal-branching perennial shrub with its heaviest flowering in summer and spring. Of the remaining 1,250 plants on O‘ahu, 700 to 900 are in the Mākua ROI (MIT et al. 2003). It is found throughout the Wai‘anae Mountain range on windward and leeward sides on gulch slopes and bottoms in understory of dry forests or on sparsely vegetated dry cliff faces and ledges. These plants are more susceptible to fire damage, as their habitat extends to the lower drier reaches of the Wai‘anae Mountains. Major threats include feral goats and pigs and associated habitat destruction. Alien grasses that are highly flammable contribute to the habitat degradation and possible wildland fire damage to *N. humile*. Five plants were impacted in the July 2003 fire, which is less than one percent of the total MMR population. The primary constituent elements of critical habitat units on O‘ahu include cliff faces, gulches, stream banks, or steep slopes in dry or mesic forests often dominated by *Diospyros sandwicensis* or *Sapindus oahuensis*, at elevations between 607 and 2,644 feet (185 and 806 meters).

Peucedanum sandwicense (Makou) (FT/G2) (2007 BO, pp. 234 and 551)

This herb is a short-lived perennial that grows in cliff habitats from sea level to above 3,000 feet (900 meters) and is associated with native species such as *Artemisia australis*, *Chamaesyce* sp., *Diospyros sandwicensis*, *Eragrostis variabilis*, and *Metrosideros polymorpha*. Little is known about the life history of *P. sandwicense*. The primary threats to *P. sandwicense* are habitat degradation and browsing by feral ungulates, trampling by hikers, and landslides. Nonnative plants compete with *P. sandwicense* for light, space, and nutrients.

Phyllostegia kaalaensis (FE/G1) (2007 BO, pp. 237 and 502)

Phyllostegia kaalaensis is a short-lived perennial herbaceous plant in the *Lamiaceae* (mint family). Currently, there is one population unit, with only two augmented immature plants. This is on state land in the Keawapilau to Pāhole population unit, within the ROI and the Schofield Barracks Military Reservation action area, respectively, where they are in

zones of very low risk to training-related wildfire. *P. kaalaensis* typically was found in mesic to dry-mesic areas in gulch bottoms and upper gulch slopes at elevations of 1,610 to 2,500 feet (490 to 760 meters). It occurred most commonly in forests dominated by the native trees *Diospyros sandwicensis* and *Sapindus oahuensis*, or in forests containing a mix of several tree species, under forest canopy and in sunny openings. Flowering and fruiting occur from January to June. Populations of *P. kaalaensis* in rocky gulch slopes and bottoms are vulnerable to trampling because of the plant's extensive rhizome growth. The species is also particularly vulnerable to extirpation from naturally occurring events, such as rockslides, and by reduced reproductive vigor due to small population size and limited distribution.

Plantago princeps var. princeps (kuahiwi laukahi) (FE) (2007 BO, pp. 241 and 436)

This woody shrub lives in mesic cliff habitat in the Wai‘anae Mountains. Known individuals total about 350 plants, about 42 of which are found on ‘Ōhikilolo and Pāhole in the ROI. Feral pigs and alien plant species are the major threats to these plants.

Platydesma cornuta var. decurrens (pilo kea) (FC/G2)

This erect palm-like shrub is found only in the mesic forests of the Wai‘anae Mountains. Populations can be found on ‘Ōhikilolo in the ROI.

Pleomele forbesii (halapepe) (FC/G1))

These trees occur on O‘ahu, mainly in dry and diverse mesic forests. Although statewide estimates of the population numbers are very low, over 100 are known to live in the ROI.

Pritchardia kaalae (loulu) (FE/G1) (2007 BO, pp. 247 and 441)

This plant is a rare fan palm, reaching up to 33 feet (10 meters) tall and found only in the northern Wai‘anae Mountains. About 475 exist on ‘Ōhikilolo in MMR. It is found in moist to dry zones, on moderately to very steep cliffs. Four populations totaling fewer than 100 plants currently exist on MMR, at Mount Ka‘ala.

Pteralyxia macrocarpa (kaulu) (FC/G2)

Known only from the two mountain ranges on O‘ahu, this plant is scattered in valleys and on slopes in moist forests. It is found throughout MMR.

Sanicula mariversa (FE) (2007 BO, pp. 252 and 507)

This plant is considered to be critically globally imperiled. A perennial herb with a thick underground storage root, this species generally grows

on moist sites on north slopes, usually in deep soil. The vast majority of these plants occur in the training area on ‘Ōhikilolo Ridge and in the nearby Kea‘au Valley (MIT et al. 2003). The plants are dormant through summer, with new growth appearing with the onset of the wet season. Goats are a major threat, mainly because they degrade the slopes where the plants grow and hasten erosion. Alien shrubs and trees are a threat to the livelihood of *S. mariversa*, but the shorter alien grasses do not seem to have serious negative impacts.

Schiedea hookeri (FE/G1) (2007 BO, pp. 257 and 553)

S. hookerii is found in diverse moist forest in the north and central Wai‘anae Mountains. It will often grow alongside koa and ‘ōhi‘a. There are five individuals in one population of *S. hookerii* on MMR. *S. hookerii* is found at Kaluakauila Gulch. Feral pigs and goats are a major threat, as is the habitat disturbance associated with these invaders. Alien plants alter the habitat and compete for valuable nutrients and light. The increased incidence of wildfires is also associated with alien grasses, and snails and slugs destroy seedlings and immature plants. The July 2003 fire burned within 66 feet (20 meters) of this species.

S. kaalae (2007 BO, pp. 262 and 444)

This short-lived perennial is consistently found on steep slopes and shaded sites in the understory of diverse mesic forest and wet forest, usually in gulch bottoms or low to mid gulch slopes, at elevations between 689 and 2,592 feet (210 and 790 meters). It often grows on slopes with sparse groundcover and occasionally in cracks in rock embankments. A total of 2,726 acres (1,103 hectares) in six separate units was designated as critical habitat, some of which is located in the ROI. *S. Kaalae* is found in the Pāhole Natural Area Reserve.

S. nuttallii (FE/G1). (2007 BO, pp. 267 and 512)

This is an erect subshrub in diverse moist forest, scattered through exterior valleys of the Wai‘anae Mountains. There are 33 individuals on MMR in the Kahanahāiki Valley.

Silene lanceolata (FE/G1) (2007 BO, pp. 278 and 558)

This plant is considered to be critically globally imperiled. It is a small sprawling shrub with smooth leaves found rarely in dry to moist shrubland areas. One of the two O‘ahu populations exists on MMR. Feral pigs and goats are a major threat to this plant, as is the habitat disturbance associated with these invaders. Alien plants alter the habitat and compete for valuable nutrients and light. Fire has had a negative impact on the populations, and increased incidence of wildfires is associated with alien grasses.

Solanum sandwicense (Popolo aiakeakua) (FE/G1) (2007 BO, pp. 281 and 592)

Critical habitat for this species occurs within the northeastern portion of the ROI. The ROI contains the primary constituent elements of talus slopes or streambeds at elevations between 1,545 and 3,300 feet (471 and 1,006 meters), which occur in open sunny areas that contain the associated native plant species *Pisonia* sp. and *Psychotria* sp. Threats to primary constituent elements of the critical habitat in the area include habitat degradation by feral pigs, competition from nonnative plant species, and fire from military training activities. This critical habitat unit provides habitat for the conservation of one population of *S. sandwicense*.

Spermolepis hawaiiensis (FE/G1) (2007 BO, pp. 282 and 561)

This plant is a slender herbaceous annual found in ‘Ōhi‘a forests and lowland dry shrubland and occasionally in cultivated fields at lower elevations. Approximately 350 plants exist on the lower portions of ‘Ōhikilolo Ridge on MMR. There is little information about the life history of this species. Major threats are habitat degradation by feral goats, competition with alien plants, and fires.

Tetramolopium filiforme (FE/-) (two varieties) (FE/-) (2007 BO, pp. 286 and 448)

This dwarf shrub is considered to be critically globally imperiled. It usually flowers in late winter and spring. It is native to the northern Wai‘anae Mountains, and its center of abundance is on ‘Ōhikilolo Ridge. Over 2,500 total individuals are present on MMR (USFWS 2007b). Its habitat occupies the low, dry, seaward end of the ridge, generally on rocky ridges and on sparsely vegetated cliff faces, but sometimes in cracks in the rocks. This species is one of the most threatened by increased potential for wildfire. Weeds and erosion from hoofed animal habitat degradation can cause landslides, which further reduce the habitat area. The July 2003 fire burned within 66 feet (20 meters) of this species.

Viola chamissoniana ssp. chamissoniana (FE/G3) (2007 BO, pp. 290 and 451)

This is a woody shrub found on both the windward and leeward sides of the Wai‘anae Mountains. Over two-thirds of the 600 remaining individuals are on ‘Ōhikilolo Ridge (USFWS 2007b). It is generally found in moist habitats on cliffs and cliff faces with sparse to moderate vegetative cover. It usually grows in association with other natives. Alien plants alter the habitat and compete for valuable nutrients and light. The increased incidence of wildfires is also associated with alien grasses.

Sensitive Wildlife Species

Several sensitive terrestrial wildlife species have been observed or have the potential to occur in the ROI. The HINHP and natural resources staff described sensitive animal locations on MMR (HINHP no date a; USARHAW and 25th ID(L) 2001b). Table 3.9-3 lists sensitive terrestrial wildlife species and their likelihood of occurrence in the ROI. Figure 3.8-6 shows the locations of sensitive wildlife confirmed within the ROI.

Discussed below is the natural history information of sensitive status wildlife species known or considered likely to occur in the ROI or that potentially would be affected by MMR activities, as well as the location of these species (when known). Sensitive status wildlife identified as occurring only historically in the ROI and those species that are considered unlikely to occur are identified in Appendix H-2.

Invertebrates

Achatinella mustelina (FE/SE/G1) (2007 BO, pp. 295 and 595)

O‘ahu tree snails, also known as pūpū kani‘oe, are native to O‘ahu. They live in trees and bushes and feed on fungi found on the surface, primarily that growing on native plants (HINHP no date a). *Achatinella* snails are active during the night and remain sealed in leaves during the day. The breeding season is not known. Although this species is limited to the Wai‘anae Mountains, it is believed to have historically occurred from sea level on O‘ahu’s windward coast to the uppermost reaches of the Ko‘olau Mountains (HINHP no date b). The presence of this species at MMR was confirmed when 171 live *A. mustelina* individuals were discovered in 1982. The Army Natural Resources field crew marked 412 *A. mustelina* in a mark/recapture study at MMR (PCSU 2001). This species also has been seen in the southeastern corner of Mākua Valley, in the easternmost tip of MMR, in the divide between MMR and the Pāhole Natural Area Reserve, and within the Mokulē‘ia Forest Reserve and the Mākua-Kea‘au Ridge (HINHP no date c). Some of the greatest threats to this species are introduced plants and animals, habitat degradation, fire, and collection. The July 2003 fire burned within 492 feet (150 meters) of this species.

Table 3.9-3
Sensitive Terrestrial Wildlife Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	State[2]/Global[3] Status	Habitat	Date Last Observed	Likelihood of Occurrence
Invertebrates						
Achatinella mustelina	Pūpū kuahiwi, pūpū kanioe, kāhuli/O‘ahu tree snail	E	E/G1	Native Hawaiian shrublands, forests, and bogs above 1,000 feet.	2006	C
Amastra rubens	-/Amastrid land snail	-	-/G1	Areas with native vegetation; specific preferences not available.	1983	P
Auriculella ambusta	-/Achatinellid land snail	-	-/G1	Areas dominated with native vegetation.	1993	P
A. spp. aff. *castanea*	-/Achatinellid land snail	-	-/G1	Areas dominated with native vegetation.	1982	C
A. spp. aff. *perpusilla*	-/Achatinellid land snail	-	-/G1	Areas dominated with native vegetation.	1985	C
Cookeconcha spp.	-/Endodontid land snail	-	-/G1	Areas with native vegetation; specific preferences not available.	1980s	C
Leptachatina spp.	-/Amastrid land snail	-	-/G1	Areas with native vegetation; specific preferences not available.	1988	P
Partulina dubia	-/Achatinellid land snail	-	-/G1	Areas dominated with native vegetation.	1983	C
Pleuropoma sandwichiensis	-/Helicinid land snail	-	-/G1	Areas with native vegetation; specific preferences not available.	1983	C
Birds						
Asio flammeus sandwichensis	Pueo/Hawaiian short-eared owl	-, +,^	E*/G5T3	Pastures, grasslands, dry and wet forests that are dominated by either native or nonnative vegetation; sea level to 7,900 feet.	2005	C
Chasiempis	O‘ahu ‘elepaio/-	E, CH	E/G4T1	Native Hawaiian forest.	2005	C

Table 3.9-3
Sensitive Terrestrial Wildlife Species Occurring or Potentially Occurring in the Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal[1] Status	State[2]/Global[3] Status	Habitat	Date Last Observed	Likelihood of Occurrence
sandwichensis ibidis						
Paroreomyza maculata	‘Alauahio/O‘ahu creeper	E	E/G1	Native Hawaiian shrublands, forests, and bogs.	1976	C
Phoebastria immutabilis	Laysan albatross	+,^	-/G3	Pelagic, nests on ground in sheltered areas and open grassy areas of islands.	2002	C
Puffinus pacificus	‘Ua‘u kani/ Wedge-tailed shearwater	+, ^	-/G4	Pelagic, nests in burrow, crevice, sometimes on ground surface on islet, atoll, barren headland.	2004	C
Mammals						
Lasiurus cinereus semotus	-/Hawaiian hoary bat	E	E/G5T2	Bare rock, cliff, hardwood forest, grassland/herbaceous, hardwood woodland, riparian habitats.	1998	U**

Sources: USARHAW and 25th ID (L) 2001b; DLNR 2002; HINHP, no date a; R. M. Towill Corp. 1997a; NatureServe 2001; Virginia Tech 1998
NCN = No Common Name
*The state endangered listing refers only to the populations on O‘ahu, Lanai, and Moloka‘i.
**Contemporary sitings are limited to transient individuals, no residence or breeding population is thought to be extirpated from O‘ahu
Status:

[1]Federal:
E = Endangered
CH = Critical habitat designated
+ = Birds of conservation concern
^ = MBTA species

[3]Heritage Global Rank:
G1 = Species critically imperiled globally (typically 1-5 current occurrences)
G4 = Species apparently globally secure
G5 = Species demonstrably globally secure
T1 = Subspecies critically imperiled globally (typically 1-5 current occurrences)
T2 = Subspecies imperiled globally (typically 6-10 occurrences)
T3 = Subspecies either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range, or because of other factors making it vulnerable to extinction throughout its range (21-100 occurrences).

[2]State: E = Listed as endangered /-/ = No Status

Likelihood of occurrence on the project site: C = Confirmed P = Potentially may occur U = Unlikely to occur

Amastra rubens and *Leptachatina* sp. *(G1)*

Amastrid land snails are native to the Hawaiian Islands. The historical distribution of *A. rubens* includes Ka‘ala, Kukui‘ula, Mokulē‘ia, Mākaha, and Hale‘au‘au within the Wai‘anae Mountains (HINHP no date b). This species is confirmed within the ROI. Individuals and shells of *A. rubens* were observed during MMR surveys in 1982 and 1983 (USARHAW and 25th ID(L) 2001b). Amastrid land snails are likely threatened by habitat loss and introduced predators that compete for resources and spread disease.

Auriculella ambusta (G1), A. sp. aff. castanea (G1), A. sp. aff. perpusilla (G1), and Partulina dubia (G1)

Achatinellid land snails are endemic to the Hawaiian Islands. They live in trees and shrubs, primarily on native vegetation (R. M. Towill Corp. 1997a; HINHP no date b). Current life history information is not well studied or understood for these species. Achatinellid land snails are known to feed on leaf fungi. The three *Auriculella* species and *Partulina dubia* have been observed at MMR. *A. castanea* was found at the easternmost part of MMR, along the summit ridge trail in 1982 (HINHP no date a). Two sightings of *A.* sp aff. *perpusilla* were recorded at Pāhole Natural Area Reserve at MMR in 1983 and 1985 (HINHP no date a). These species are expected within the ROI, based on availability of suitable habitat. Achatinellid land snails are likely threatened by habitat loss and introduced species that prey on them, compete for resources, and spread disease.

Cookeconcha sp. *(endodontid land snail) (G1)*

This snail is most likely threatened by habitat loss and introduced predators that compete for resources and spread disease. Species were identified at MMR from 1983 to 1989 at the Pāhole Natural Area Reserve (HINHP no date a). Although no individuals or shells were discovered during a 1993 survey of MMR, endodontid land snails could occur in the project ROI, based on the presence of suitable habitat.

Pleuropoma sandwichiensis (G1)

The helicinid land snail is native to the Hawaiian Islands, historically found on all eight Hawaiian Islands. *P. sandwichiensis* was observed at the northeastern corner of Mākua Valley in 1983 and at the head of Kaiahi Gulch in 1993 (HINHP no date a). This species is expected to occur within the ROI, based on availability of suitable habitat. Helicinid land snails are likely threatened by habitat loss and introduced species that prey on them, compete for resources, and spread disease.

Birds

Chasiempis sandwichensis ibidis (FE/SE/G4T1) (O‘ahu ‘elepaio) (2007 BO, pp. 301 and 600)

This subspecies is endemic to O‘ahu, where it inhabits native Hawaiian forest and forests dominated by nonnative plants. It is most common in riparian habitats, in moist forests with tall canopy and an extensive understory (Shallenberger and Vaughn no date; USFWS 2001b). The ‘elepaio appears to tolerate introduced vegetation and disturbed environments, as demonstrated by its use of such environment. However, it is estimated to inhabit less than eight percent of its former range and is now confined to the Ko‘olau and Wai‘anae Mountains (USFWS 2001b). The July 2003 fire burned within 230 feet (70 meters) of an area known to be used by individual males of this species.

Critical habitat has been designated for the O‘ahu ‘elepaio within the ROI (USFWS 2001b), and this species is known to occur on MMR. In 1993, at least nine individuals were observed in the area, seven of which were in the southeastern portion of MMR (HINHP no date a). ‘Elepaios were also at the head of the Kahanahāiki Valley near a plateau (HINHP no date a). Approximately 150 acres (61 hectares) of O‘ahu ‘elepaio critical habitat burned in the July 2003 fire.

Generally the ‘elepaio breeds from January to June, building nests on native and nonnative plants. It feeds on insects and spiders. Threats to this species include habitat loss, predation, and spread of disease. Nonnative species, such as black, Norway, and Polynesian rats, cats, and mongooses, are believed to be a significant cause of predation to this species (USFWS 2000). The transmission of avian pox by mosquitoes is a major cause of lowered survivorship in adult ‘elepaio (USFWS 2000).

At MMR, ‘elepaio are known from Kahanahāiki, Kaluakauila, and Lower Mākua MUs and the East Rim Ungulate Control Area. The population of ‘elepaio in Kaluakauila was comprised of two unpaired males, which were monitored biannually. NRS have been unable to relocate these birds since 1999 and believe that they may have perished (PCSU 2004). In 2004, a pair in Kahanahāiki had at least two nesting attempts. The first nest appeared to have failed, with no subsequent activity observed at this nest after numerous checks and a second nest was found with 2 nestlings were observed being fed in the nest by both parents on 28 June (PCSU 2004). In 2001, NRS initiated predator control efforts for the pair that was known from the Lower Mākua MU and in 2002 a new pair was discovered. No pairs were observed in East Rim Ungulate Control Area, though this area was partially restricted during the time of the surveys, so all suitable habitat has not been surveyed (PCSU 2004).

Phoebastria immutabilis (MBTA, BCC/-/G3)

The Laysan albatross, a native Hawaiian migratory bird, is a pelagic species that nests in grassy areas on islands. It breeds on most northwestern Hawaiian Islands in the fall and winter and feeds primarily on squid (NatureServe 2002). Long-line fisheries, lead contamination, and loss of nesting habitat threaten this species (NatureServe 2002). The Laysan albatross has nested in the grassy areas along Ka‘ena Point and alongside the Ka‘ena Point Trail in recent years. Banding efforts in 2004 demonstrated that there are at least 130 albatross using Ka‘ena Point. Laysan albatross use this area as part of the breeding cycle from November to July (Hoffman 2003). Adults generally arrive in November to prepare for nesting. Egg laying begins in December. The last to leave are the young, which disperse to a pelagic habitat in July. This species is considered confirmed within the ROI.

Asio flammeus sandwichensis (MBTA/SE/G5T3)

Pueo, also known as the short-eared owl, is a native Hawaiian species. It is found in a range of habitats, such as pastures, grasslands, and dry or wet forests, with either native or nonnative dominated vegetation and up to 7,900 feet (2,408 meters) above sea level (HINHP no date a). Pueo feed heavily on introduced mammals, such as house mice and rats. They are active during the day, which is unusual for most owl species. Pueo nest on the ground, usually on grass (HINHP no date a). Young pueo have been observed in nests from March to November. Threats to this species include habitat loss and introduction of large mammals, such as mongooses, that prey on their eggs. This species is believed to forage the grasslands in the lower elevations of the training area and may nest in the northern section of MMR identified as the C-9 Management Unit, based on pueo behavior and vocalizations observed in the area (PCSU 2002).

Puffinus pacificus (MBTA/G4G5)

The wedge-tailed shearwater is a pelagic bird that nests in burrows and crevices along coasts and cliffs. In Hawai‘i, migrants begin to arrive in nesting areas in March. One egg is laid, usually in June, although nesting success is often reduced by introduced predators (mongoose, dogs, cats, common myna). This species is common in the Ka‘ena Point NAR, where they have been known to burrow along the trail. There is believed to be more than 2,000 wedge-tailed shearwater pairs in this area. The dramatic improvement in breeding success is due to improved habitat protection, specifically predator control, exclusion of off-road vehicles, signs that have been put up, and patrols of the area to deter people from straying from the trails and crushing burrows or nests.

Pluvialis fulva (MBTA, BCC/-/G5)

The Pacific golden plover, a native migratory bird, winters in Hawai‘i and breeds in Alaska and other more northern areas. It spends August through April in the Hawaiian Islands, where it inhabits short-grass prairie, pastures, mudflats, sandy beaches, and flooded fields (NatureServe 2002). Because this species is likely to occur in the open areas of the Ka‘ena Point Trail, it is expected to occur within the ROI. The Pacific golden plover is an insectivore, eating beetles and other ground-dwelling insects, along with worms, some small mollusks, and crustaceans. Threats to this species include collisions with human-made structures and predation by owls (NatureServe 2002).

Marine Fauna

Whales and Seals

Six species of endangered whales are known to occur in the Pacific tropical waters around the Hawaiian islands. This includes five types of baleen whales, including the humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), blue (*B. musculus*), sei (*B. borealis*), and Pacific right (*Eubalaena glacialis*). The other type of whale is a toothed whale, the sperm whale (*Physeter macrocephalus*). The only seal that occurs is the federally listed endangered monk seal (*Monachus schauinslandi*). This species has critical habitat in the northwestern portion of the Hawaiian Island chain.

Of these marine mammals, the only occurrences considered possible in the ROI would be the humpback whale or the monk seal. All of the other species are highly unlikely. Table 3.9-1 lists the likelihood of occurrence of these species within the project area. Associated habitat information can be found in Appendix H-2.

Humpback Whale (FE, MMPA)

The waters off the coasts of the Hawaiian Islands are known for their seasonal population of humpback whales, which are also the most abundant marine mammal throughout the Hawaiian waters (Mobley et al. 2001a). The Hawaiian Islands serve as an important breeding ground for this species (Calambokidis et al. 1997). The humpback whale is the only one of the five endangered baleen whales potentially occurring in Hawaiian waters that is known to be present in reasonably large numbers. The International Whaling Commission and NOAA Fisheries consider the Hawaiian population of humpbacks to be a separate stock (NOAA Fisheries 2000a). Humpback whales are found throughout the island chain and are most abundant in coastal waters of the main Hawaiian Islands, including Hawai‘i and O‘ahu, from November through April, with peak abundance occurring from late February through mid-March (Baker and Herman 1981). Approximately two-thirds of the entire North Pacific

humpback whale population (approximately 4,000 to 5,000 whales) migrate to Hawaiian waters to breed, calve, and nurse (NOAA Fisheries 2000a). These whales are generally found in shallow waters shoreward of the 600-foot (183-meter) depth contour (ONR 2000).

Humpback whale mothers and calves prefer the calmer shallower waters often found on the leeward sides of the islands (Smultea 1992), and they prefer very shallow water of less than 60 feet (18 meters) (ONR 2000; Smultea 1992). Some results suggest that habitat use patterns of females and calves in nearshore areas may decrease as a result of increasing vessel traffic and human activities (ONR 2000). Humpback whales are vulnerable to human disturbance in Hawaiian waters and possibly to vessel strikes. Hawai‘i regulations prohibit boats from approaching within 100 yards (91 meters) of adult whales and within 300 yards (274 meters) of mother/calf pairs. Humpback whales (of varying pod sizes and types, including mother and calf pods) are commonly sighted off the O‘ahu coast and are confirmed in project area waters, with unknown frequency, from January through April (Pickering 2003; Dollar 1999; Clark and Tyack 1998). Mother/calf pods are known in the MMR beach area (Dollar 1999; Pickering 2003).

Monk Seal (FE, MMPA, D)

The monk seal is the only pinniped (seal species) known to occur in the Hawaiian archipelago, and it is endemic. This species may occasionally occur in the waters or shore of the ROI. However, it is more common in the northwestern Hawaiian Islands. Incidental transients are known to be present at all of the main seven islands, and there is a small uncounted population on the Island of Ni‘ihau (NOAA Fisheries 2000w). The species was designated as depleted under the MMPA in 1976, following a large decline in animal counts from the late 1950s through the mid-1970s. The monk seal was also listed as endangered under the ESA in 1976. In 1988, NOAA Fisheries designated critical habitat for the Hawaiian monk seal; this area is not near the ROI. It is designated in 10 areas of the northwestern Hawaiian Islands, extending from shore to a distance offshore to 20 fathoms (180 feet [55 meters]) of depth. The species is managed as one stock, although each island may in fact have its own subpopulations (NOAA Fisheries 2000w). Virtually nothing is known about its distribution and movement patterns when it is at sea. Current estimates indicate that the monk seal population is declining and is believed to include approximately 1,000 animals. Hawaiian monk seals breed primarily at Laysan Island, Lisianski Island, and Pearl and Hermes Reefs but also are known to use the Midway Islands, among other northwest Hawaiian Islands (NOAA Fisheries 2000w).

Sea Turtles

Five species of ESA-listed sea turtle species occur in Hawaiian waters and occasionally on the shorelines: green (*Chelonia mydas*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*). Of these marine reptiles, the only likely occurrence in the ROI would be the green sea turtle and, rarely, the leatherback turtle (although this species is much more common offshore). Table 3.9-1 lists the likelihood of occurrence of these species within the project area. Associated habitat information can be found in Appendix H-2.

Both green turtles and hawksbills nest annually on Hawaiian beaches (ONR 2000), although no nests have been documented in the ROI. Hawksbills are considered uncommon in Hawaiian waters, although a small number nest on Hawai‘i and Moloka‘i each year (NOAA Fisheries 2000y). Loggerheads and olive ridleys are known to occur in Hawaiian waters, as they are found as bycatch in the longline fishery. Loggerheads are known to spend 40 percent of their time at the surface; olive ridleys are only at the surface 20 percent of the time and tend to be found in shallower waters than loggerheads (Polovina et al. 2000). Olive ridleys are the most abundant sea turtles in the world (Polovina et al. 2000), although they are less common than green sea turtles in Hawaiian waters. Most records of olive ridley turtles are from entanglements and strandings (NOAA Fisheries 2000aa). Adult leatherbacks are commonly sighted in the waters off the outer Hawaiian Islands (NOAA Fisheries 2000z).

Green sea turtle (FT)

The green sea turtle is considered the most abundant turtle in Hawaiian waters (Zug et al. 2002; ONR 2000; NOAA Fisheries 2000x-z, 2000aa, 2000bb). The Hawaiian population of nesting green sea turtles makes up a distinct genetic unit (Zug et al. 2002). Except during their post-hatching pelagic phase, this species spends the majority of time in coastal waters, shallow bays, and nearshore areas, where foraging is optimal (Brill et al. 1994; Zug et al. 2002). Juvenile and subadult green turtles are especially abundant in the nearshore areas. These turtles have nested on all of the seven main islands (Dollar 1999). The most accurate abundance estimates for adult female green turtles that nest annually on Hawaiian beaches are from 450 to 475 animals, with the majority of reproduction taking place at the French Frigate Shoals (Balazs 1980; NOAA Fisheries 2000x, 2000y). Submergence intervals vary by behavior. When the animals are resting, they have regular, long submergence intervals. When they are feeding, submergence intervals are short and irregular (Brill et al. 1994). In Hawai‘i, 40 to 60 percent of immature green sea turtles suffer from fibropapillomatosis, a disease that causes tumor growth (Work et al.

2003). Studies are currently ongoing to assess the impacts of these tumors on the animals' behavior.

Green sea turtles are expected to occur in the ROI in waters off MMR or on the beach. This species is known to feed on marine plants that occur in the ROI and in the nearshore areas at MMR. The ROI could serve as sea turtle foraging and resting areas. Green sea turtles in some Hawaiian areas have been shown to remain within a small portion of a habitat area if foraging and rest habitat is optimal there, and to have short submergence intervals (Brill et al. 1994)

During the breeding season, adult green sea turtles undertake long-distance oceanic migrations from feeding areas throughout the Hawaiian archipelago to nesting beaches at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl Reef and Hermes Reef, Cure Atoll, and Midway Island. It is hypothesized that green turtles in the Hawaiian archipelago could be a genetically distinct subpopulation (NOAA Fisheries 2000x). The majority (90 percent) of green turtle nesting in the Hawaiian Islands occurs a far distance from the ROI at the French Frigate Shoals, the portion of the islands that are 800 miles (1,482 kilometers) northwest of the main Hawaiian Islands, consisting of a string of 11 small island regions.

Leatherback sea turtle (FE)

Leatherbacks do not nest regularly or in great numbers in the Hawaiian Islands (NOAA Fisheries 2000x, 2000aa). Adult leatherbacks are commonly sighted in the Pacific Ocean near the Hawaiian archipelago, primarily over deep oceanic waters. Leatherbacks could occur equally as frequently off any of the main seven islands, but they are often sighted off the north shores of both O‘ahu and the Island of Hawai‘i (NOAA Fisheries 2000z; ONR 2000). They are considered unlikely in ROI waters, as they are more typically sighted along the north shore or in offshore waters (NOAA Fisheries 2000z). However, transients could occur in the waters off MMR and, rarely, on the coastline.

<u>Sensitive Habitats</u>

Ecologically Sensitive Areas

As described in Section 3.9.4, three ecological zones have been designated for MMR, based on climate, topography, and elevation, as follows:

- Lowland Native Forest zone occurs between 1,000 and 2,700 feet (300 and 823 meters). Both the O‘ahu Diverse Lowland Mesic Forest and the Loulu Lowland Mesic Forest have Natural Heritage Foundation Global Ranking of G1.

- Ridge Crest Vegetation zone lies above 3,000 feet (914 meters) and covers the cool, wet, windy and cloud-swept portions of the summit crest of the Wai‘anae Mountains.
- Lowland dry shrubs and mosses that favor this moist habitat generally characterize Native Shrub on Cliff and Slope zone. These natural communities occur in the range of 1,500 to 2,400 feet (457 and 732 meters) beneath steep cliffs in ridges and slopes. With distance from the summit crest, conditions become much warmer and drier.

Plants

Plant critical habitat was determined for 1,079 acres (437 hectares) within the ROI (USFWS 2007b). This is outside the boundary of MMR but within the action area determined by USFWS for plant stabilization. The Army reinitiated ESA Section 7 consultation with USFWS on potential effects on the designated critical habitat within the ROI but outside MMR. The plants for which critical habitat is designated in the ROI are described in Section 3.9.6 and are shown in Figure 3.9-5. For the plant critical habitat designated for O‘ahu in 2003, the USFWS determined that lands under Army jurisdiction on O‘ahu do not meet the definition of critical habitat under the ESA based on the Army’s continuing commitment to management and stabilization of sensitive species and that, according to ESA Section 4(b)(2), the benefits of excluding Army lands from critical habitat outweigh the benefits of inclusion (USFWS 2003a). Because areas of critical habitat that could be affected by training activities are within the ROI but outside MMR, the Army is responsible for addressing potential impacts on those areas. For the proposed training activities, the USFWS concluded that implementing the proposed action would not adversely modify or destroy the designated critical habitat addressed in the 2007 BO. The Army has completed the INRMP, the IWFMP, the Ecosystem Management Plan, and the Endangered Species Management Plan. These documents outline specific strategies and programs in place to stabilize species and habitats on its land. These management activities in some cases surpass management by other federal, state, and private landowners (USFWS 2003a). Should the status of Army commitment to these resources change, the USFWS will reconsider whether these lands meet the criteria for critical habitat. It is important to note that the number of populations of target species on installations is applied to the overall conservation goal for each species because management of lands under the INRMP is consistent with USFWS recovery goals. Approximately 6 acres (2.4 hectares) of designated plant critical habitat were burned in the July 2003 fire at MMR. This critical habitat was on adjacent state reserve land and was designated for *Schiedea hookeri, Bonamia mensezii, Neraudia angulata*

var. *dentata*, *Nototrichium humile*, *Euphorbia haeleeleana*, and *Gouania vitifolia.*

Wildlife

The USFWS designated critical habitat at MMR for the O‘ahu ‘elepaio on December 10, 2001 (USFWS 2001b) (Figure 3.9-1). There are 2,734 acres (1,106 hectares) of federally designated critical habitat for the O‘ahu ‘elepaio within the ROI. In the July 2003 fire, 150 acres (61 hectares) of ‘elepaio critical habitat were burned. NOAA Fisheries designated critical habitat for the Hawaiian monk seal in May 1988. The habitat was designated in 10 areas of the northwestern Hawaiian Islands and extended from the shore out to a distance offshore where the water depth is 20 fathoms (180 feet [55 meters]) of depth (NOAA Fisheries 2000w).

Biologically Significant Areas

The Hawai‘i Natural Heritage Program has defined three types of biologically significant areas (BSAs) for managing the important natural communities. There are 868 acres (351 hectares) of BSAs within the MMR ROI, divided into the following categories:

- BSA1 contains a high density of federally listed species. It totals approximately 778 acres (315 hectares), has the most endangered species, and includes globally imperiled ecological communities, the O’ahu diverse lowland moist forest, and loulu lowland moist forest (Figure 3.8-5). It extends around the rim of the Mākua Valley and part of Kahanahāiki Valley, from approximately the 800-foot (244-meter) elevation to the ridge crest (over 3,000 feet or 314 meters).
- BSA2 contains all or some of the following:
  - Lower densities of federally listed endangered or proposed endangered species;
  - Candidate species or other species of concern that are expected to be upgraded to federal protected status within the next few years; and
  - Areas judged likely to contain high densities of federally listed species, based on habitat assessment, despite the lack of any record of such occurrence to date.

  BSA2 is near the front of Mākua Valley, near Farrington Highway. It contains four rare plants and is thought to have been at one time connected to the BSA1 area on its southwest. Separation was probably the result of repeated wildfires in the area, which destroyed vegetation and allowed introduced alien plant species a competitive edge.

- BSA3 represents stands of intact native vegetation with few or no known occurrences of rare species. MMR contains no BSA3 areas.

Also found within the ROI is sensitive snail habitat. Although this habitat has not been federally designated or proposed as critical habitat, it has been identified as containing the habitat requirements necessary for supporting the federally listed snail species of concern on O‘ahu. This area is shown with the BSAs in Figure 3.9-2.

Figure 3.9-11 shows O’ahu ‘elepaio Federally designated critical habitat in the ROI and Figure 3.9-12 shows biologically sensitive snail habitat in the ROI.

Pōhakuloa Training Area

On PTA, there are 17 federally listed species recorded as onsite and 12 of these have been recorded within the ROI for this Alternative (Tables 3.9-4 and 3.9-5). One federally listed species, the Palila, is recorded as contiguous but 4,957 acres (2,006 hectares) of critical habitat for this species has been designated on the northeast side of the installation. Within the ROI, there are eight federally listed plant species and two federally endangered animal species (Table 3.9-4). An area including Pu‘u Kapele was fenced in 1981, and a 111-acre (45-hectare) area within the fencing is managed as a sensitive plant area, with significant concentrations of *Haplostachys haplostachya*.

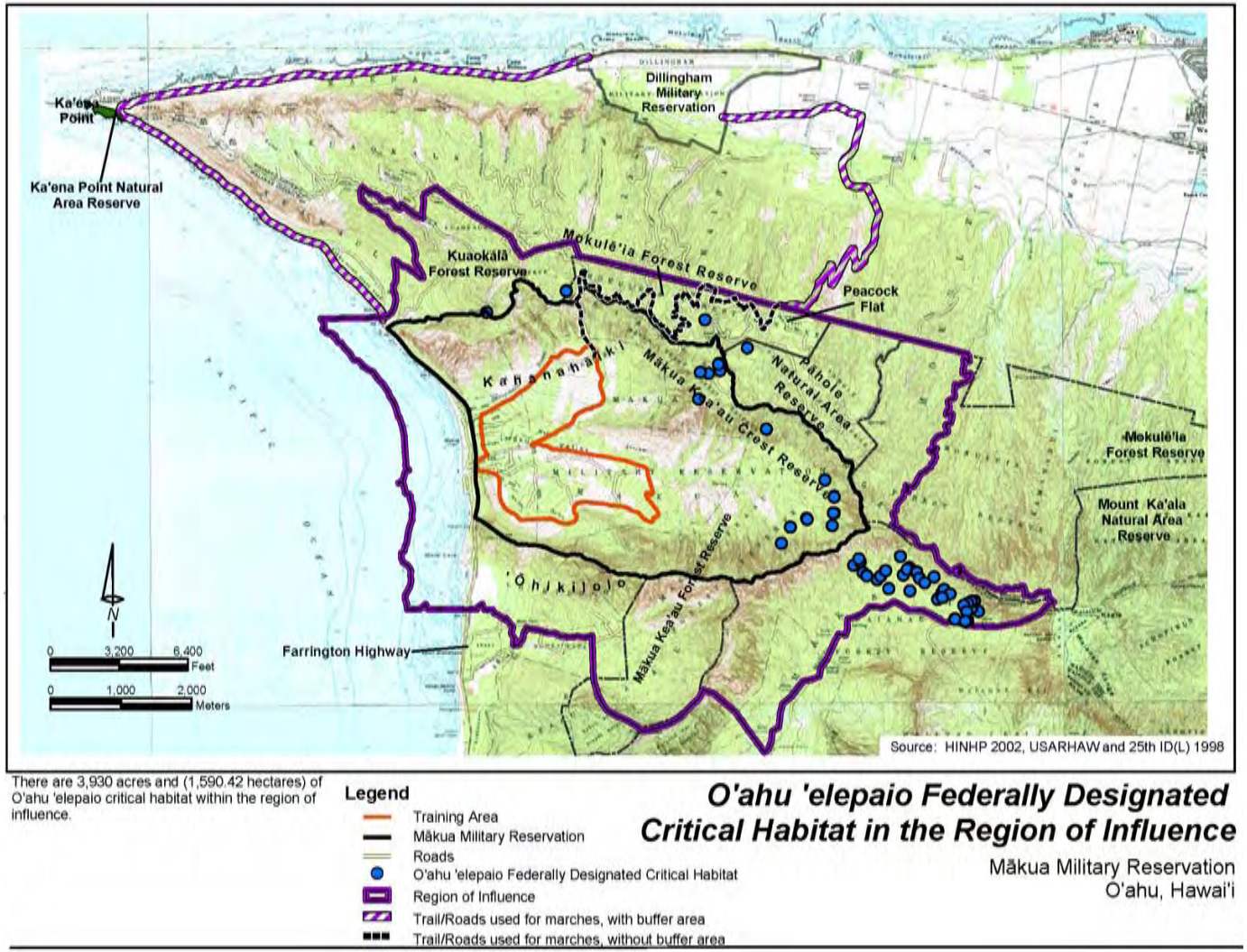


Figure 3.9-11 O'ahu 'elepaio Federally Designated Critical Habitat in the Region of Influence, MMR

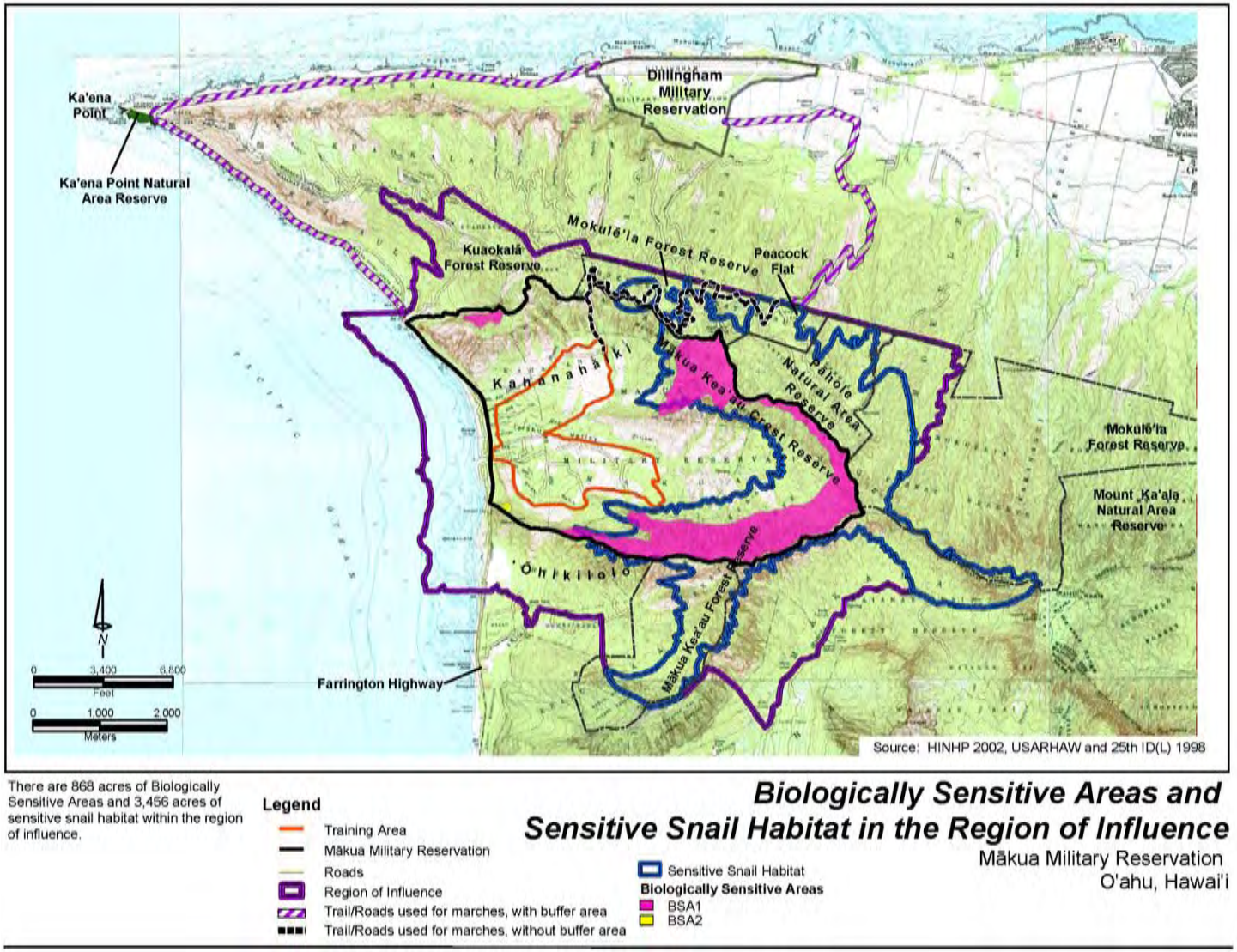


Figure 3.9-12 Biologically Sensitive Snail Habitat in the Region of Influence, MMR

Table 3.9-4
Federally Endangered and Threatened Plant Species Within the PTA ROI

Scientific Name	Hawaiian Name/Common Name	Federal Status	PTA Plant Management Priority*	Critical Habitat
Asplenium fragile var. *insulare*	None	E	PS2	ESA 4(b)(2) Exclusion**
Haplostachys haplostachya	Honohono / Hawaiian mint	E	PS4	No CH
Hedyotis coriacea	Kioʻele / Leather-leaf sweet-ear	E	PS1	4(b)(2) Exclusion
Neraudia ovata	None	E	PSI	4(b)(2) Exclusion
Silene hawaiiensis	None	T	PS4	4(b)(2) Exclusion
Silene lanceolata	None	E	PS2	4(b)(2) Exclusion
Solanum incompletum	Popolo ku mai	E	PS1	4(b)(2) Exclusion
Stenogyne angustifolia	None	E	PS4	No CH
Tetramolopium arenarium ssp. *arenarium*	Mauna Kea pamakani	E	PS1	4(b)(2) Exclusion
Zanthoxylum hawaiiense	Aʻe / Hawaiian yellow wood	E	PS2	4(b)(2) Exclusion

* Priority Species 1 (PS1) - < than 500 individuals and/or five or fewer populations remaining statewide; Priority Species 2 (PS2) - 500 to 1,000 individuals and/or six to 10 populations remaining statewide; Priority Species 3 (PS3) - 1,000 to 2,000 individuals and/or 10 to 20 populations remaining statewide; Priority Species 4 (PS4) - 2,000 to 5,000 individuals and/or 20 to 40 populations remaining statewide; Priority Species 5 (PS5) - >5,000 individuals and/or >40 populations remaining statewide.
** ESA 4(b)(2) – The USFWS may exclude any area from critical habitat if they determine that the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat, unless they determine, based on the best scientific and commercial data available, that the failure to designate such area as critical habitat will result in the extinction of the species.

Table 3.9-5
Federally Endangered Wildlife Species Found Within or Potentially Within the PTA Region of Influence

Scientific Name	Hawaiian Name/Common Name	Federal Status	Date Last Observed	Recent Observed Location(s) on PTA	Likelihood of Occurrence in ROI*
Branta sandvicensis	Nēnē / Hawaiian Goose	E	2008	South of ROI and southeastern PTA; Keʻāmuku parcel	C**P
Buteo solitarius	ʻIo / Hawaiian Hawk	E	2005	Training Area 23	P
Chaseimpis sandwichensis	ʻElepaio	-	2005	One in Kīpuka ʻAlalā area	U
Hemignathus munroi	Akiapolaʻau / Honeycreeper	E	1984	Northeast PTA by Palila CH	U
Loxioides bailleui	Palila / Honeycreeper	E	1990	Northeast PTA by Palila CH	U
Petrodroma phaeopygia sandwichensis	ʻUaʻu / Dark-rumped Petrel	E	1990	South of ROI in Training Area 22	P
Lasiurus cinereus semotus	ʻŌpeʻapeʻa / Hawaiian hoary bat	E	2005	Within ROI	C
Rhyncogonus stellaris	Rhyncogonus weevil	-	2004	Within ROI, Training Area 19	C

***Likelihood of occurrence in ROI:** C = Confirmed; P = Potentially may occur; U = Unlikely to occur
** A 2007 incidental, seasonal sighting within ROI

Kīpuka Kālawamauna Endangered Plants Habitat is located in the northwest corner of PTA between the impact area and the historic boundary in portions of Training Areas 18, 19, 20, and 22. It was designated by the Army in 1997 with the discovery of the federally listed endangered plants, *Haplostachys haplostachya* and *Stenogyne angustifolia*. The area also contains other rare plants. While not federally identified as critical habitat, the Army recognized the biological significance of the area and manages (e.g., protective fencing, weed control, training restrictions, etc.) for the preservation of the ecosystem and the federally listed species present on the 7,854 acres (3,178 hectares).

Approximately 1,863 acres (754 hectares), or 24 percent, of the kīpuka is fenced. The southern section is pāhoehoe with an Open *Metrosideros* Treeland and a dense understory. Threats to the area include fire, feral ungulates in the unfenced portion, and the remaining ungulates in the fenced area. Other endangered species identified in the area include *Asplenium fragile* var. *insulare, Hedyotis coriacea, Silene lanceolata, Tetramolopium arenarium* var. *arenarium,* and *Zanthoxylum hawaiiense*. (USFWS 2003c)

Sensitive Vegetation Species

Presented below is the natural history information for listed plant species known to occur in the ROI (Figure 3.9-5) that could be affected by Army activities. Species location is provided when known, and all species are represented in genetic storage facilities with cuttings or seeds, unless otherwise noted. An extensive key to status codes is provided in Appendix H-2. The table indicates whether or not critical habitat has been designated for the individual species on the installation. For additional information, the corresponding pages within the 2003 BO and/or the 2006 to 2007 PTA Report for the Ecosystem Management Program that address a species are provided.

Asplenium fragile var. insulare (E)(2003 BO, pp 52; PTA 2006 Report, pp. 2-16; and PTA Draft 2007 Report, pp. 1-3)

This small to medium-sized fern is found within streamside hollows and grottoes that occur in mesic to dry subalpine shrubland dominated by *Leptecophylla tameiameiae* and *Sadleria cyatheoides,* with scattered *Metrosideros polymorpha.* On the Island of Hawai‘i, this fern grows in moist and dark areas in large lava tubes, pits, and deep cracks on varying ages of lava that have moderate soil or ash accumulation, and is associated with mosses and liverworts. There are between 626 and 1,071 individuals of this fern found on the Island of Hawai‘i; there are 34 known locations on PTA with varying number of individuals. Within the ROI, the fern is located in the Kīpuka Kālawamauna area approximately 4.5 miles west of the northern point of the Twin Pu‘u range footprint. Within the ROI, threats to this species include fire, browsing by feral sheep and goats,

competition with *Pertnisetum setaceum* (fountain grass), and habitat degradation or destruction of lava tubes.

Haplostachys haplostachya (Honohono) (E) (2003 BO, pp 56; PTA 2006 Report, pp. 2-19; and PTA Draft 2007 Report, pp. 1-6)

This short-lived subshrub of the mint family grows in dry exposed areas on ash-veneered lava, very stony, shallow soils, and lava outcrops. It often establishes in large cracks on rocky ridges and on pu‘us. Currently, the species is found in six different Intensive Management Units (IMUs) totaling over 20,000 individuals on the Island of Hawai‘i and all these occurrences are located in PTA. Within the ROI, they are located 1 mile (1.6 kilometers) to the west and northwest side of the Twin Pu‘u range footprint and stretch to the northwest in Training Areas 17, 18, 19, and 20. Part of the population unit within in the Kīpuka Kālawamauna area is also within the ROI. The primary threats to this species are feral sheep and goats that browse on the flowers; rooting by feral pigs; competition for light, space, and nutrients by fountain grass and other nonnative plants; and invasion by and conversion of habitat to a fire-based vegetation community.

Hedyotis coriacea (Kio‘ele) (E) (2003 BO, pp 60; PTA 2006 Report, pp. 2-26; and PTA Draft 2007 Report, pp. 1-16)

This small shrub is in the coffee family and occurs on pāhoehoe lava flows in sparse *Metrosideros* treelands and open *Metrosideros* treelands with sparse to dense shrub understories. It is found at elevations from 4,921 to 5,577 feet (1,500 to 1,700 meters) at PTA. One individual plant is currently known on the Island of Maui, and the remaining occur on PTA, approximately 175 to 225 individuals. Within the ROI, the species is found to the west of the Twin Pu‘u range footprint. The threats to this species include browsing pressure from feral sheep and goats; habitat degradation; introduction and expansion of invasive plant populations; military exercises that ignite fires which degrade habitat and subsequent invasion by nonnative plants; and due to the very limited distribution of this species, a single natural or human-caused environmental disturbance could be catastrophic.

Neraudia ovata (E) (2003 BO, pp 67; PTA 2006 Report, pp. 2-35; and PTA Draft 2007 Report, pp. 1-22)

A member of the nettle family, this species is a sprawling shrub that can develop into a small tree. This shrub occurs in dry forests, on open lava flows, and in subalpine forests on the leeward side of the Island of Hawai‘i at elevations from 377 to 4,987 feet (115 to 1,520 meters). At PTA, the species grows in Open Metrosideros Treelands with a sparse shrub understory and in Myoporum Shrublands. Over 90 percent (161 individuals) of the total N. ovata population occurs on PTA. The remaining individuals occur on State land adjacent to the installation.

Outplantings of the species in the Kīpuka Kālawamauna area occur within the ROI approximately one mile to the west of the proposed Twin Puʻu range footprint. Threats to this species include grazing pressure from ungulates, competition from invasive species, impacts of military training due to increased risk of wildfire, and the possibility of a natural or human-caused disturbance that could be catastrophic.

Silene hawaiiensis (T) (2003 BO, pp 71; PTA 2006 Report, pp. 2-44; and PTA Draft 2007 Report, pp. 1-30)

This species is a sprawling, short-lived shrub that typically grows in montane and subalpine dry shrublands on decomposed lava and ash, as well as on all ages of lava and cinder substrates at elevations from 2,953 to 4,265 feet (900 to 1,300 meters). The species has also been documented to resprout following fire. There are approximately 1,903 to 2,872 individuals of *S. hawaiiensis* distributed throughout the installation, but mainly on the eastern side in Training Area, 21BAAF. These occurrences represent approximately 71 percent of all naturally occurring individuals State-wide. The population unit in the Kīpuka Kālawamauna area to the west of Twin Puʻu range footprint is within the ROI. Records of *S. hawaiiensis* on the east side of the impact area (area E), west of the northern portion of Red Leg Trail, are within the ROI of the proposed range. The major threats to this species in the ROI include ungulate browse and increased risk of fire from mounted and dismounted maneuvers and bivouac. Military actions can also result in habitat fragmentation, dispersal of alien plant seeds, and increased potential for trampling of plants.

Silene lanceolata (E) (2003 BO, pp 73; PTA 2006 Report, pp. 2-49; and PTA 2007 Draft Report, pp. 1-34)

A member of the Pink family, this perennial shrub is recorded on the Islands of Molokai, Oʻahu and Hawaiʻi. On the Island of Hawaiʻi, this species grows on rocky tumuli or outcrops, on ʻaʻā lava, in deep ash deposits over pāhoehoe lava, and in Mauna Kea substrate in dry montane shrubland at elevations between 4,111 and 4,331 feet (1,253 and 1,320 meters). PTA estimates that there are over 10,000 individuals of the species found onsite. This clearly represents the majority of the species known to exist. A large portion of the population unit in the Kīpuka Kālawamauna area is within 1.5 miles (2.4 kilometers) to the west of the Twin Puʻu range footprint within the ROI. A few records of the species are also within the ROI extending to the northwest of the range footprint. *Silene lanceolata* is extremely susceptible to ungulate browsing and trampling. At PTA, military training activities increase the risk of fires due to live-fire training, bivouac and mounted and dismounted off-road activities. Other threats include trampling, dust, spread of invasive nonnative plants, and fragmentation of remaining habitat.

Solanum incompletum (Popolo ku mai) (E) (2003 BO, pp 76; PTA 2006 Report, pp. 2-56; and PTA Draft 2007 Report, pp. 1-40)

This plant is a member of the nightshade family that typically occurs as a woody shrub growing to 10 feet (3 meters) tall. On Army lands at PTA, the species is found on lava flows of various ages in Sparse Metrosideros Treelands and Myoporum Shrublands at an elevation of 4,675 feet (1,425 meters). The only natural occurrence of this species is at two disjunct sites at PTA that totals approximately 66 individuals. There have been over 1,100 outplantings of the plant on the installation. Outplantings of the species in the Kīpuka Kālawamauna area occur within the ROI approximately one mile to the west of the proposed Twin Pu‘u range footprint. Threats to the species include habitat degradation, browsing by feral ungulates, competition with non-native plant species, reduced reproductive vigor (e.g., limited gene pool), and the potential for a single catastrophic environmental event. The primary threat from military activities is the increased risk of fire.

Stenogyne angustifolia (E) (2003 BO, pp 80; PTA 2006 Report, pp. 2-64; and PTA 2007 Draft Report, pp. 1-47)

This plant in the mint family grows on relatively flat, ash-veneered lava and shallow soils in semi-arid shrublands and *Metrosideros* Woodlands at an elevation of 5,102 feet (1,555 meters). The species also occurs at an elevation of 3,396 feet (1,035 meters) in the transition zone between pastureland and the Ke‘āmuku lava flow. Between 1,864 and 1,936 individuals of *S. angustifolia* have been recorded in PTA at 545 locations and these individuals represent 100 percent of the naturally occurring individuals known statewide. Within the ROI, a large number of occurrences of the species are recorded to the west and northwest of the Twin Pu‘u range footprint in Training Areas 18, 19, and 20, and within the Kīpuka Kālawamauna area. Threats to the species include habitat competition from nonnative plants, particularly fountain grass; and conversion of habitat to a fire-based vegetation community. Army training such as mounted and dismounted off-road maneuvers, bivouac, and live-fire training increase the risk of fire, habitat fragmentation and alien plant seed spread.

Tetramolopium arenarium ssp. arenarium (Mauna Kea pamakani) (E) (2003 BO, pp 83; PTA 2006 Report, pp. 2-68; and PTA 2007 Draft Report, pp. 1-50)

This shrub species is in the sunflower family and grows up to 4.3 feet (1.3 meters) tall. At PTA the species is found in the *Dodonaea* Mixed Shrubland at elevations between 4,265 and 5,577 feet (1,300 and 1,700 meters). All of the approximately 577 individuals of the species occur within a 40-acre (16.2-hectare) area located within the ROI. The primary threats to this species are feral ungulates that browse on the plant; rooting

by feral pigs; competition from nonnative plant species such as fountain grass; and conversion of habitat to a fire-based vegetation community. Army training such as mounted and dismounted off-road maneuvers, bivouac, and live-fire training, increase the risk of fire, habitat fragmentation and alien plant seed spread. Due to the very limited distribution of this species, a single natural or human-caused environmental disturbance (i.e., fire) could be catastrophic.

Zanthoxylum hawaiiense (Aʻe) (E)) (2003 BO, pp 87; PTA 2006 Report, pp. 2-77; and PTA 2007 Draft Report, pp. 1-57)

This tree species is a member of the citrus family and at PTA, it is found on lava and in a variety of plant community types including sparse *Metrosideros* Treelands, Open *Metrosideros* Treelands with dense shrub understory, Intermediate *Metrosideros* Mixed Treelands, *Myoporum* Shrublands, and *Myoporum-Dodonaea* Shrublands. Between 72 and 86 percent of State wide population of this tree species occurs on PTA. The records of the species within 1 mile (1.6 kilometers) to the northwest (Training Area 18) of the Twin Puʻu range footprint and portions of the population unit 3 miles (4.8 kilometers) to the west of the footprint (Training Area 22) are within the ROI. In addition, one recorded individual in the northern portion of Area E (Range 11) appears to be within the ROI. Threats to species include habitat degradation and browsing by feral and domestic animals, competition from nonnative plant species, seed predation by rodents, fire; trampling, and effects of military activities (i.e., dismounted maneuvers and bivouac increase the risk of fire, promote habitat fragmentation, disperse alien plant seeds, and increase potential trampling of seedlings and young plants).

Sensitive Wildlife Species

Several sensitive terrestrial wildlife species have been observed or have the potential to occur in the ROI. The HINHP and natural resources staff described sensitive animal locations on PTA. Table 3.9-5 lists sensitive terrestrial wildlife species and their likelihood of occurrence in the ROI. Figure 3.9-6 shows the locations of sensitive wildlife confirmed within the ROI.

Discussed below is the natural history information of sensitive status wildlife species known or considered likely to occur in the ROI or that potentially would be affected by CALFEX activities, as well as the location of these species (when known).

Branta sandvicensis (Nēnē) (E) (2003 BA, pp 293; PTA 2007 Draft Report, pp. 2-61; and 2008 draft Section 7 reinitiation document for PTA)

This ground-nesting goose occurs on the Islands of Hawaiʻi, Maui, and Kauaʻi composing an estimated 349, 251, and 620 wild individuals,

respectively (USFWS 2004 draft recovery plan). Nēnē have between six and seven different populations on the Island of Hawai‘i that are actively managed and supplemented with captive bred individuals.

Nēnē have adapted to a terrestrial life and as such, do not need wetlands in their habitat. Their preferred habitat includes grasslands, shrub lands and dryland forests. Nēnē mate for life and remain close to each other throughout the year. They are known to have high nest site fidelity, meaning that they return to the same area to nest from year to year. The average lifespan of a nēnē is thought to be in excess of 10 years. Typically, birds will pair up for breeding between October and March in their second year. After breeding, nēnē will rejoin with larger family groups during flocking season. The flocking season is primarily from April through September. During flocking season (March to September), individuals from the above identified breeding populations migrate to areas of higher elevation and areas of greater food availability. It is during this time that individuals from the Pu‘u Wa‘a Wa‘a, Hakalau National Wildlife Refuge, and Keauhou populations have been seen on PTA in large numbers, specifically at Range one.

On the main portion of the installation, nēnē have been reported for years during flocking season (March through September) primarily on the ground at Range one. In addition to those found on the main installation, several pairs of nēnē were sighted in the Ke‘āmuku parcel during the 2007-2008 breeding season (October throughMarch), including one pair with an active nest. In August 2007, 18 Nēnē were reported at range 1, which is on the eastern side of the installation outside of the ROI.

The historic decline of the species was probably caused by hunting during breeding season, the capture of birds and eggs, flushing and frightening birds, ranching activities, introduced predators, competition from introduced bird species, and changes to habitat by introduced plants. Rarely observed on the installation, the Hawaiian Goose does not appear to be a resident species on PTA. The action’s effects on the species are not expected and would be coincidental, especially since there are no records of the goose within the ROI for this action.

Buteo solitarius (‘Io) (E) (2003 BA, pp 293; PTA 2008 Draft Report, pp. 2-63)

The ‘Io is a small, broad-winged raptor endemic to the Hawaiian Islands. The taxon occupies a variety of habitats, including lowland agricultural areas and forests dominated by alien plant species to mid-elevation pasture lands and native rain forests. Birds probably mate around 3 to 4 years of age. Mated pairs tend to use the same nest multiple years. The species is somewhat monogamous and demonstrates fidelity to breeding sites for multiple years. Hatching occurs from late May to late June and fledging

occurs in mid-August. The ‘io nests in six different tree species, suggesting tree type may be unimportant in nest-site selection. A combined home range for a pair is 1,500 to 2,128 acres (607 to 861 hectares), and overlapping home ranges are possible. Modified and nonnative habitats may not provide adequate perching and nesting sites.

The USFWS estimated 1,400 to 2,500 individuals present on the Island of Hawai‘i. The `Io has been sporadically recorded on PTA since the 1980s. In 1992, an ‘io was recorded approximately 2 miles (3.2 kilometers) to the northeast of the Twin Pu‘u range footprint. Per the requirements of the 2003 BO, surveys have been conducted for the ‘io on PTA in Training Areas 22 and 23. In December 2003, an ‘io was seen three straight days in Training Area 23. From 2004 through 2006, PTANRS conducted systematic ‘Io surveys at PTA in an effort to determine ‘Io presence, abundance and habitat use. No ‘Io sightings have ever been reported on these surveys, leaving incidental sightings as the only record of ‘Io presence on PTA. However, in November 2005, a juvenile hawk was seen in Training Area 23, but not during the survey period. Survey efforts continue, but the `Io is a rare and sporadically observed species on PTA.

The principal threat to the species is the conversion of forests to pastures and urban development. The necessity of a year-round food supply, small clutch size, long incubation and nesting periods, and prolong-fledgling dependency compared to temperate raptors are concerns. On PTA and within the ROI, the ‘Io does not appear to be a resident species and effects of the Proposed Action are not expected and would be coincidental.

Petrodroma phaeopygia sandwichensis (‘Ua‘u) (E) (2003 BA, pp 293; PTA 2007 Draft Report, pp. 2-68)

On the Island of Hawai‘i, this pelagic bird is currently found at Mauna Kea, Mauna Loa, and Kilauea at elevations from 6,562 to 9,842 feet (2,000 to 3,000 meters). The total population of ‘ua‘u is estimated to be from several thousands to 34,000 birds. In 1995, 48 active nests were documented on the southeastern side of Mauna Loa, Island of Hawai‘i. The species is known to nest in sparsely vegetated sites and in dry environments. Nesting burrows are commonly located among large rock outcrops, talus slopes, or along the edges of lava flows. Birds excavate tunnels between 3 to 6 feet (1 to 2 meters) deep. Nests are used from March to November, multiple years. The species is monogamous, generally pairs for life, and shows a high degree of nest-site fidelity. ‘Ua‘u exhibits a conservative reproductive strategy marked by late maturity, low replacement rates, and a long life span. As such, the species is unable to respond quickly to changing environmental conditions.

It is believed that the ‘ua‘u feeds primarily at night, catching its prey near the surface or by scavenging. Crustacean egg cases appear to be an important source of stomach oil for the dark-rumped petrel.

Other then a 1994 radar survey detecting three dark-rumped petrels flying over the eastern portion of PTA, surveys conducted on PTA have not detected the species. However, in 2002 in the southern portion of TA 23, three human-modified pits were discovered that may have historically been used by the dark-rumped petrel as burrows. An additional burrow with two nests from a previous nesting year was also found (Evans et al. 2002b). Limited nights were monitored during the 2007 `Ua`u breeding season, which extends from April through August, but no birds were seen or heard. Although no `Ua`u were recorded, the effort was not adequate to make conclusions about the status of this species on PTA at this time.

Predation is the single greatest threat to the taxon. The demise of the species on the Islands of Hawai‘i, Maui, and Molokai is attributed to *Herpestes auropunctatus* (mongoose), *Sus scrofa* (pig), *Felis catus* (cats), and possibly humans on O‘ahu. On PTA and within the ROI, the ‘ua‘u does not appear to be a resident species. However, the size of potential available nesting habitat at PTA makes the area attractive for petrels, and, although no birds have been sighted recently at PTA, their burrowing behavior and the discovery of previously used nesting sites suggest small undetected populations are possible. These areas of potential use by the ‘Ua‘u are quite a distance from the ROI and effects of the proposed action on the species are not expected and would be coincidental.

Lasiurus cinereus semotus (‘Ōpe‘ape‘a) (E) (2003 BO, pp 293; PTA 2007 Draft Report, pp. 2-64)

The ‘ōpe‘ape‘a is endemic to the State of Hawai‘i and is the only native terrestrial mammal in the state. It is one of three recognized subspecies of hoary bats, one of which (*L.c. cinereus*) is a very common and widespread bat in North America. The ‘ōpe‘ape‘a is resident to only Hawai‘i, Maui, and Kaua‘i, with the largest populations probably on Hawai‘i and Kaua‘i. ‘Ōpe‘ape‘a are thought to be most numerous on the Island of Hawai‘i, where they are uncommon but fairly widespread. There are no population estimates for the Hawaiian hoary bat and few historical or current records. Unsubstantiated population estimates across the State have ranged from hundreds to a few thousand (USFWS 1998a, 1999b). Data are limited because no feasible method currently exists for surveying the abundance and distribution of solitary, tree-roosting bats. Bats have been observed year-round in a wide variety of habitats and elevations.

A lot of key information is lacking or otherwise unknown about the ‘ōpe‘ape‘a’s such as average life span, age at first reproduction, breeding biology, survivorship, how age and reproductive condition affect its food

habits, habitat selection, home range size, movement patterns, roost tree selection, etc. Hawaiian hoary are known to forage in a variety of open and vegetated habitats, including open fields, lava flows, open ocean in bays near shore, and streams and ponds. Bats on Hawai‘i forage in both relatively closed habitats near vegetation (such as clearings in lowland mesic ‘ōhia forest or town parks) as well as in open habitats and forest edges (Jacobs 1993a; Tomich 1974).

Preliminary evidence indicates that pregnant and lactating female Hawaiian hoary bats on Hawai‘i may prefer roosting in lowland areas rather than in the cooler highlands, perhaps because the warmer lowland environment promotes faster juvenile growth (or, alternatively, because insect food sources may be more readily available).

PTA comprises about seven percent of the ‘ōpe‘ape‘a’s current range and about 13 percent of its range on Hawai‘i. The Island of Hawai‘i is thought to have the largest existing population of Hawaiian hoary bats and for that reason, PTA is important to the survival and recovery of the subspecies. Based on the limited information available, it appears that Hawaiian hoary bats are present in low numbers throughout PTA year-round and have been detected in a wide variety of habitat types, from barren lava to open ‘ōhia forests (Cooper *et al* 1996). Presence/absence surveys conducted on PTA in May-June and November-December 2005 detected bats throughout the installation with the summer survey showing the bat’s preference for dense woodland habitat types.

In 2006, automated bat detectors were used to detect bats before sunset and into the evening. Bats were detected at sites within the ROI to the west and far west of the Twin Pu’u range footpring. During 2007, a full scale, year-round, installation-wide Hawaiian hoary bat monitoring program was instituted at PTA to determine distribution and habitat use of the ōpe‘ape‘a. There was a fairly high estimate of bat occupancy throughout the survey sites. Low sample size combined with low detectability resulted in biased finding for habitat preference. The data obtained has not confirmed the presence of roosting or breeding bats on the installation.

The major threats to the ‘ōpe‘ape‘a on PTA are habitat loss and degradation, primarily the destruction and disturbance of available roosting sites. The primary threat to roosting and foraging habitat for the Hawaiian hoary bat in the ROI is the risk of wildfire resulting from military training. Direct injury or death of Hawaiian hoary bats in the ROI resulting from live-fire exercises is less likely, although still a threat. Mitigation actions described in the 2004 SBCT FEIS and the required efforts to minimize take as described in the terms and conditions of the

2003 BO would all substantially reduce impacts of the proposed action on the ‘ōpe‘ape‘a.

Rhyncogonus stellaris (rhyncogonus weevil) (2003 BA, pp 293; PTA Report, pp)

This flightless weevil was historically found in the North Kona and South Kohala districts along the coastal lowlands. It’s range is now believed to be restricted to PTA and they are only known from the Kīpuka Kālawamauna Endangered Plant Habitat. They are closely associated with a narrow range of plants, such as the 'aheahea shrub. The adults are leaf chewers and the larvae are associated with the roots of their host plants.

From March 2004 to September 2005, eight study sites of *C. oahuensis* and *Dodonaea viscosa* were surveyed early morning or at dusk to locate the rhyncogonus weevil. A total of 18 individuals were found August through September 2004 within the proposed ROI (TA 19). All were found amongst the crown of *C. oahuensis* and were exposed and easily visible.

Threats to the weevil include replacement of native plant hosts by the widespread occurrence of forage plants or escaped exotic grasses; also possible predation by ants or rodents. Its limited distribution within fire prone habitat on PTA is a management concern for this species. Also of concern are an introduced weevil (*Asynonychus godmanii*) that may be a potential threat or competitor with the rhyncogonus weevil, and the Argentine ant (*Linepithema humile*), which is known to be an aggressive predator of native insects, is a potential predator of the weevil.

3.10 CULTURAL RESOURCES

3.10.1 Introduction/Region of Influence

The Department of Defense statutorily defined cultural resource as any of the following:

- A building, structure, site, district, or object eligible for or included in the National Register of Historic Places (NRHP) maintained under Section 101(a) of the National Historic Preservation Act (NHPA, 16 USC 470a[a]);

- Cultural items, as that term is defined in Section 2(3) of the Native American Graves Protection and Repatriation Act (NAGPRA, 25 USC 3001[3]). These include human remains, associated and unassociated funerary remains, sacred objects, and cultural patrimony objects;

- American Indian, Eskimo, Aleut, or Native Hawaiian sacred sites for which access is protected under the American Indian Religious Freedom Act (AIRFA, 42 USC Section 1996);

- Archaeological resources, as that term is defined in Section 3(1) of the Archaeological Resources Protection Act of 1979 (ARPA, 16 USC 470bb[1]). These include any material remains of human activities that are of archaeological interest as determined under ARPA regulations; and

- Archaeological artifact collections and associated records as defined under 36 CFR Part 79: Curation of Federally Owned and Administered Archaeological Collections. Under these guidelines, collections include material remains, such as artifacts, objects, specimens, and other physical evidence, that are excavated or removed during a survey, excavation, or other study of a prehistoric or historic resource. Associated records include original records (or copies thereof) that document efforts to locate, evaluate, record, study, preserve, or recover a prehistoric or historic resource.

In addition to cultural resources defined by federal statute, regulation, and executive order for consideration and protection, additional sites and properties considered to be culturally important may exist on Army lands. These resources are referred to by the Army as Areas of Traditional Importance (ATI) and were identified as an issue of importance during the public scoping process. The Army continues to consult with Native Hawaiian groups and other members of the public to identify more of these sites, and, if appropriate, to evaluate their eligibility for inclusion in

the NRHP. ATI are discussed in more detail in Section 3.10.4. The ROI or area of potential effects for cultural resources at MMR includes the proposed training areas within MMR.

The ROI for the PTA alternative includes the range footprint and the moderate to high fire spread rate areas that would be impacted by an unsuppressed fire ignited at the outer perimeter of the potential ignition area for all weapons, with high risk weather conditions. Also included in the ROI is any transportation route utilized to move between Kawaihae Harbor and PTA.

Public scoping at MMR has helped to identify specific issues and areas of interest and revealed other general concerns. The Army has worked and will continue to work with the public in identifying and preserving important resources. The preparers of this EIS have addressed comments and concerns generated through the scoping process, and the document includes a discussion of previous, ongoing, and possible future regulatory compliance actions. A review of public comments appears below.

One major issue that is shared by many of the respondents is the ancestral responsibility that Native Hawaiians have for stewardship and protection of the islands as a whole. This issue deals with the spiritual affinity and important role that the natural environment plays in Hawaiian culture and the belief that it is not possible to separate the people from the land. This perspective makes it inappropriate for Native Hawaiians to support any actions that could affect or disturb the land. In this regard, many comments received were critical of past disturbances to the land and natural resources, such as reports of filling in ponds and wells at MMR for the filming of the movie “Hawai‘i.”

Comments were also made stating that effects need to be looked at from a broader perspective and that impacts to cultural activities may occur outside of the immediate area. Many in attendance at the public meetings were concerned with water quality issues, both inland and offshore as they relate to resource utilization. Fish and fishing off MMR was discussed as an important cultural activity that may have been affected by past activities.

Members of the public also requested that enough information would be gleaned from oral interviews to ensure a thorough assessment of traditional areas. Questions were also raised about the completeness of the archaeological survey s both aboveground and below. Other concerns dealt with how the Army’s Proposed Actions would affect cultural sites, how they have affected them over the years MMR has been in use, and

how past alterations to the environment may have fragmented cultural sites and geographic features.

Comments were received about how the disruption and fragmentation of cultural practices will affect future generations, and, unless preserved, knowledge transmitted will be degraded with each subsequent generation. This and the effect on the makaʻāinana (common people) need to be evaluated using past studies, including the Earthjustice report titled, *In the Footsteps of the Parent, Impacts of Military Use in Mākua Valley on Native Hawaiian Cultural Resources,* by Eric Enos.

It was also suggested that impacts to all resources in and around MMR be evaluated, including streams, springs, wells, caves, trails, sacred places, sandy beaches, surfing sites, turtle nesting sites, *muliwai*, bridges, shrines, historic sites, cemeteries, native plants, native fauna, ʻalae veins, historic walls, pō kāne (night marcher) routes, ponds, ʻauwai (taro irrigation ditches), trails, loʻi kalo (taro pond fields), *wahi pana* (named places), dunes, canoe landings, kilo iʻa (fish spotting sites), salt pond/pans, fishing grounds/fisheries, koʻa (fishing shrines), heiau (temples), imu, burials, archaeological sites, hunting areas, cultivation areas, hōʻailona (natural signs), sighting spots, lele (cliff jumping places), leina (jumping off point for souls to cross into the next world), ʻaumakua (ancestral deities) domain, puʻuhōnua (place of refuge), hōlua slides (slides for sleds), and basaltic adze/glass veins and quarries.

Other comments included the need for more information on the extent of mitigation efforts with respect to Hawaiian cultural practices, gathering rights and religion, land containing artifacts and burial grounds, Hawaiian rights to use archaeological sites, and fire safety protection plans. Other members of the public wanted assurance that all state and federal guidelines and laws were followed regarding resource preservation.

To document ATI or traditional cultural properties (TCPs) and to determine potential areas of concern, the Army completed a study consistent with the 2001 Settlement Agreement to determine cultural impacts from continued military use of MMR (Social Research Pacific 2003a). Results of the impact study are discussed in Section 4.10.

This section presents information and research conducted on the oral traditions, ATI, historical overview, archaeological sites, TCPs, paleontological resources, Army management of cultural resources, regulatory considerations, previous management actions, and current Army responsibilities in order to address public concerns and to comply with all applicable legislation.

3.10.2 Oral Traditions

Several Hawaiian traditions relate different aspects of cultural history relevant to Mākua and Kahanahāiki in the vicinities of MMR and PTA. More in-depth information is included in this section regarding the MMR area because members of the public specifically requested its inclusion. A summary of oral traditions regarding the PTA are included following those related to MMR.

Mākua Military Reservation

For the MMR vicinity, the account of the goddess Hiʻiaka at Mākua offers a rich description of many of the communities, and culturally important natural resources. The account is included here because members of the public requested that it be included in its entirety. Other important traditions include the naming of Mākua, Kāneana or Mākua Cave, the Moʻo of Mākua Valley, the ʻŌlohe or Haʻa People, the Mākua Mountain trail, and the maile lau liʻi of Koʻiahi.

The Goddess Hiʻiaka at Mākua

The story of the Goddess Hiʻiaka at Mākua, presented below, is a Native Hawaiian account of the legend of Pele and Hiʻiaka, excerpted unaltered from a report by Social Research Pacific entitled *Planning Level Oral History Survey, Mākua and Kahanahāiki Valley* (Social Research Pacific 2001).

The goddess Hiʻiaka traveled from the Island of Hawaiʻi to Kauaʻi with her companions Wahineʻōmaʻo and Pāʻū-o-palaʻa. The purpose of her journey was to fetch the chief Lohiʻau-ipo (Lohiʻau) from Haʻena, Kauaʻi. On the journey, Hiʻiaka and her party visited numerous locations on Hawaiʻi, Maui, Molokaʻi, and Oʻahu. Having reached Kauaʻi she found that Lohiʻau had died, and following the ceremonies, she revived him and began her journey with Lohiʻau to return to Pele's domain at Kīlauea, Hawaiʻi.

The excerpts below are from the epic account of the journey to Kauaʻi made by Hiʻiaka-i-ka-poli-o-Pele (Hiʻiaka), the youngest sister of the goddess Pele. Titled "He Moʻolelo Kaʻao no Hiʻiaka-i-ka-poli-o-Pele" (A Traditional Tale of Hiʻiaka Who is Held in the Bosom of Pele), this account was published in the Hawaiian newspaper, *Ka Hōkū o Hawana* (September 18, 1924, to July 17, 1928), and was compiled by Julia Keonaona, Stephen Desha Sr., and various contributors. While this version of the legend has yet to be translated in its entirety, the following English translations (by Kepa Maly) provide a synopsis of the Hawaiian texts, with emphasis on the main events of the narratives.

My fine readers of the wondrous tale, this account differs from some others which hold that Hiʻiaka departed from the canoe at Kaʻena. But in this account she departed at the place described above, and then traveled overland to Waiʻanae. It was while on her journey overland that she did a wondrous thing at the sheltered place near the sea, a little to the north side of Keawaʻula. Let us look at this event as we continue our journey in this story. At this shoreward place, mentioned above (Keawaʻula), is a place called Kīlauea, and it was there that Hiʻiaka caused the sweet water to appear, thus Keawaʻula had freshwater.

... Having departed from Kauaʻi on their canoe, Hiʻiaka chanted a greeting to her family at Kīlauea, on Hawaiʻi. When her mele (chant) was finished, the canoe was near ka lae o Kaʻena (the point of Kaʻena). It was then, that Hiʻiaka saw her elder relatives Ka-lae-o-Kaʻena and Pōhaku-o-Kauaʻi, and called out to them:

Aloha ʻolua e Kaʻena me Pōhaku-o-Kauaʻi /E noho mai la i ka lae kahakai ʻai ʻole i ola nō hoʻi i ka ʻehu a ke kai-e E inu ʻana i kuʻu wai kumu ʻole i ka pali e Eia mai hoʻi wau a pae aku e

Love to you Kaʻena and Pōhaku-o-Kauaʻi Who dwell at the point, of the foodless shore You live by the mist of the sea. Drinking my water which has no source dripping from the cliffs I shall land here

Finishing her chant of affection for her elders, Hiʻiaka then turned their canoe to the Waialua side of this famous point of Kaʻena. It was near the place called "Ka-leina-a-ka-ʻuhane" (The soul's leap). Hiʻiaka leapt from the canoe, and then told Wahineʻōmaʻo and her companions that they were to continue their journey by sea, while she would travel overland...

As she continued her overland journey, Hiʻiaka met with her elders Ka-lae-o-Kaʻena and Pōhaku-o-Kauaʻi, and asked them where the canoe landing of this land was... (November 16, 1926). They told her that it was there below, where the canoe could be seen in the canoe shed... Hiʻiaka bid her relatives *aloha* and then continued her journey overland, till she reached the place called *"Kipuka kai o Kīlauea."* There she saw that there were men and women resting at the place, and some of the people were adorned in garlands of *ʻilima.* The activity of many of these people that had gathered there was lele kawa (leaping and diving into the sea).

As Hiʻiaka drew near to the diving spot of these people of Mākua, they saw her beauty and their voices rose in speculation of where this beautiful stranger had come from. As Hiʻiaka drew near to the diving place, called *"Ke-kiʻo-kai-o-Kīlauea,"* the people became quiet, then some of them called out, inviting her to join them in the sport. Hiʻiaka declined the kind invitation of the natives, and at that time, one of the beautiful young women of the place, adorned with a lei of *ʻilima,* drew near to the leaping spot and leapt. When she fell into the water, she struck a large rock the appeared to push out into the sea. This stone was of a supernatural nature (*kupua*), and the girl was killed in the water.

Seeing the tragedy that had befallen the young native woman, a result of her careless leap, Hiʻiaka leapt into the water to retrieve her body. Having gotten her, Hiʻiaka swam to the shore at a place close to Mākua. The people saw this tragic event and that the stranger had leapt in to fetch the body of the girl. The natives drew near to the place where Hiʻiaka came on shore, and the girl's family lamented the loss of their cherished child. Hiʻiaka instructed them not to cry, telling them that she would try to restore life to their daughter who had carelessly leapt upon the stones. Setting the girl down, Hiʻiaka called out in a prayer to restore life to the dead girl:

E ka pua o ka ʻilima e,	Oh blossom of the *ʻilima*
Homai ana hoʻi he ola	Let life descend
E Mākua i ka nuʻa o ke kai-e	Oh Mākua of the ocean swells
Haʻawi mai ana hoʻi ua ola-e	Grant life
E ola kuʻu kama i ka hua o ke kai-e	That my child of the frothy sea may live
A ola hoʻi ia Kāne i ka wai ola-e	That life may be gained by the living waters of Kāne

Completing the prayer, Hiʻiaka stood up and held her supernatural pāʻū (outer skirt) in her hand and struck the girl on her right side and left side with the *pāʻū.* Hiʻiaka then kneeled down and breathed into the girl's mouth, and she was revived. Some parts of the girl's body were bruised from the fall upon the rock, and Hiʻiaka called to the girl's family instructing them in how to care for her wounds. Hiʻiaka told them:

There are many leaves in the forest, in the uplands of the mountain, these you must get to apply to the girls wounds. This must be done quickly to lengthen her life. And here is my task, to get the body of the stone which rises out at the place where you leap.

Hearing these words, some of the people were troubled, and asked how Hiʻiaka could remove that large stone which rises out of the depths of the sea. Hiʻiaka told the multitudes of Mākua, "Do not worry about how I will remove the stone, it is for me to do. This stone which brings death will be destroyed. Now, here is what you should do, take the girl to the house, and I will go to destroy this impertinent stone which rises out of the water to your leaping place..." The name of the stone was Pōhakuloa, and he was a supernatural being who dwelt in the waters of Mākua. He was a stone which destroyed canoes and killed people, and at times, he himself also took human form. It was because the young girl had refused his advances, that he caused her death at the leaping place...

This place is *ka pōnaha wai o Kīlauea* (the swirling water of Kīlauea). It is one of three places called Kīlauea. The second one is Kīlauea on Kauaʻi, and the third one is Kīlauea on the Island of Hawaiʻi—Hawaiʻi of the green ridges, in the bosom of Kāne. This thing which causes tragedy here among the stones, actually has the body of a man, and his true name is Pōhakuloa. I am going to leap in and fight him so that he will end his treachery at this place. That is, the destroying of canoes, and killing of people. When you look and see the ocean rise in a spout and fall upon Kulaokalā (Kuaokalā), then you will know that I have killed the human form of Pōhakuloa.

Finishing these words, Hiʻiaka then leapt into the sea of Kīlauea, where the water swirls. The ocean then rose up, as never before, rising upon the shore, with waves breaking upon the land, and the coral washing up with the waves onto the land. On the promontories the roar could be heard, and the people had never before seen such violent seas. When Hiʻiaka fell into the swirling sea at Kīlauea, she was lost from sight. (November 23, 1926)

The people of Mākua thought that this stranger, the woman, had died in the violent sea. They did not know that she was the supernatural being of Kīlauea, the youngest sibling of the great goddess and ruler of Kīlauea. They felt much compassion for this

woman who had been lost to them. While they were there discussing this among themselves, the people saw the water spout rise out of the sea and go directly above Kulaokalā. They saw this and then understood that the woman had not died, but the things that she had spoken of prior to diving into the swirling sea of Kīlauea had come to pass.

Then, a strong earthquake shook the entire Island of O‘ahu, and the people of Mākua heard a great roar from something nearby their place. Looking to the swirling water of Kīlauea, they saw a great black mass rise out of the swirling water of Kīlauea, and the people of Mākua cried out at the wondrous sight. This great black thing seemed to fly in the direction of the point of Ka‘ena.

Now what had happened was that when Hi‘iaka leapt into *pōnaha kai o Kīlauea* (the swirling water of Kīlauea), she met with the shark body (*kino manō*) of Pōhakuloa. This Pōhakuloa was one of the evil dual formed deities of the ocean of Wai‘anae. A great battle raged between Hi‘iaka and the shark form of Pōhakuloa. The two moved out into the depths of the dark sea and Hi‘iaka was victorious over the shark form of Pōhakuloa. Hi‘iaka then returned *to pōnaha kai o Kīlauea*, where she thrust her hand down into the core of that supernatural stone and tossed it into the sky. That is how the earthquake came to shake the whole Island of O‘ahu. Being thrown from the sea, the stone flew and fell upon the land. Hi‘iaka then returned to the shore at *pōnaha kai o Kīlauea* and stood near the people of Mākua. Everyone was filled with awe at what this woman, the stranger had done.

The stone fell on the side of the point of Ka‘ena, near to Waialua. To this day, the people of Waialua and Wai‘anae still call the stone “Pōhakuloa.” The people who ride the train can see the long stone among the multitude of stones near the point of Ka‘ena. At the time when the ocean became very rough, Wahine‘ōma‘o and Lohi‘au landed at the shore of Keawa‘ula, and that is how they were saved from the rough seas. Hi‘iaka went to meet her companions and then she spoke to the natives of the area, telling them to:

... take the girl who had lost her life and been revived, to bathe in the ocean five times—that is kua lima (doing something in fives, symbolic of a full hand, a complete task). Then, you are to bath her five times in freshwater. In completing the bathing ceremony, take

a crab, the ʻōhikimakaloa, and bury it at the foundation of the door to the house in which the girls lives.

Having finished her instructions to the natives of Keawaʻula, one of them spoke out and said: Oh! The great trouble of this place, is that there is no water. We have only brackish water which we drink. This is a ʻāina wai ʻole (waterless land) in which we live, and it has been this way since the time of our ancestors.

Hearing these words of the native, that there was no freshwater on their land, Hiʻiaka spoke to them:

This is a waterless land. When one travels from Waimanalo to Waialua, there is water at Waimanalo, water at Waiʻanae, and water at Waialua. Waialua, that is that land of Waia, is the child of Hāloa and Hinamauouluae. The water of this place is there below the surface of the sandstone flats (papa one). Follow me, and I will show you a place where you can find water for yourselves, a water source that is unknown to you.

Hiʻiaka led the natives of Keawaʻula to the place that she had pointed out, it was on the side of the cliff at Keawaʻula. Upon reaching the place, Hiʻiaka told them, "Break open this sandstone and dig a little below it, then you will find sweet water. But indeed, so you will not be burdened in digging, I will dig to the water for you." Hiʻiaka then pulled up her supernatural pāʻū (outer skirt), and drew it above her right shoulder, she then struck the base of the sandstone flats, and everyone heard the rumbling as a deep pit opened in the place where Hiʻiaka struck. All of the people of that place spoke in hushed tones among themselves at the astonishing thing done by Hiʻiaka. Hiʻiaka then told the people:

Here is the mouth of your hue wai (water gourd). You can hear the murmuring of the water below. This water flows below the surface of the land and reaches out to the depths of the sea at Kaʻieʻiewaho. This stream branch and the stream branches of the four mountains of Kaʻena, join together at this spot. Now I will continue my travels, but don't forget what I told you concerning the girl. Fulfill my instructions for her bathing in the sea five times, and then in the cold freshwater five times.

Finishing these words, Hiʻiaka then bid *aloha* to these people and went to join her companions. (November 30, 1926)

She told them, "It is good for you to go by sea, and I by the inland route, to the place where we will meet again." Now, the natives of this place, Keawaʻula, had followed, and met with Hiʻiaka at the canoe of Lohiʻau. These people told Lohiʻau, "Get on your canoe, and we will carry you into the ocean." Wahineʻōmaʻo agreed to these pleasant words of the natives of this place, and the people took up the canoe, carried it, and floated it in the ocean.

When the canoe was in the water, Wahineʻōmaʻo took up her paddle at the stern of the canoe and Pāʻū-o-palaʻa took up her paddle at the bow and they set off to continue their journey... Hiʻiaka then continued her journey over land, and came to the *"one ʻōpiopio o Mākua"* (clean white sands of Mākua). Hiʻiaka then saw the people of this place, and they were adorned with the *maile lau liʻi o Koʻiahi* (small leafed maile of Koʻiahi). They were indeed beautiful to behold along the shore, adorned in the famous *maile* of this mountain. Drawing nearer, Hiʻiaka also saw her relatives in the uplands, Mailelauliʻi and Koʻiahi, and her love for them overflowed. Hiʻiaka called out in a chant to them:

Aloha wale hoʻi ʻolua e nā wāhine-e	Love to you two women
E nā wāhine noho kuahiwi, noho kualono—e	The women who dwell on the mountain slopes and ridges
E Mailelauliʻi me Koʻiahi hoʻi—e	Oh Mailelauliʻi and Koʻiahi
I ke kilikili hau o Kaʻala e	In the fine dew of Kaʻala
ʻAʻala mai ana ka maile lau liʻi	With the fragrance of the small leafed *maile*
Hoʻolalawe i ke kino o ke aloha	Bearing affection to one's body
Aloha ʻolua e noho mai la i ke anu,	Greetings to you two who dwell in the coolness
Eia no hoʻi wau la ke hoʻi nei—a	Here I have returned
Aloha ʻolua, a aloha mai hoʻi a	Love to you, greetings of affection

Then continuing her on her way, she went to the place where the people had gathered on the shore of Mākua, and she greeted them, "Affection to you who dwell here upon the clean white sands of this land (*ke one ʻōpiopio o kēia ʻāina*) - *Aloha!"*

The people then asked Hiʻiaka, "You are a stranger, that has come to visit us here at Mākua?" Hiʻiaka confirmed this, saying, "Yes, I am a visitor from Hawaiʻi, having gone to Kauaʻi, and now I have

arrived here...I travel across the land, while my companions travel by the sea..." The people then inquired "What land do you come from?" Hiʻiaka answered, "My land is there in the east, in the fragrant hala (pandanus groves) of Keaʻau. It is like the place that you call Keaʻau. My land is at Puna with its walls of *hala*..."

The people then asked Hiʻiaka to call her companions to land on the shore and partake in a meal before continuing on the long journey. It was agreed, and before long, Wahineʻōmaʻo drew the canoe near to the shore and the people of Mākua helped to carry the canoe inland. Looking upon the visitors, the natives of Mākua recognized the beauty of their guests, and the most beautiful among them was the one whom they had first met, Hiʻiaka... The people of Mākua were skilled and quickly had a pig ready for the *imu*, along with chickens, broiled fish, and mixed bowls of *poi ʻuwala* (sweet potato poi). Others of the men and women went diving for *wana* (urchins), while others went to gather *ʻopihi* (limpets), and *ʻina and haukeuke* (other varieties of urchins). The *ʻinamona* (*kukui* nut relish) was set out in a bowl, and the people of Mākua had their welcoming feast prepared.

Calling to the *Aliʻi wahine* (chiefess) and people of this land, Hiʻiaka said that she would first offer a prayer of thanksgiving for the foods that had been set before them. Hiʻiaka chanted:

O Mākua ʻāina o Mailelauliʻi,	O Mākua, land of Mailelauliʻi
ʻāina aloha o Koʻiahi i ka uka	Land loved by Koʻiahi in the uplands
Ma uka hoʻi kāʻu hele ana mai	My journey takes me over land
I ka nopu hulili a ka lā	In the dazzling heat of the sun
La o lalo o Waiʻanae e	Sun which descends below Waiʻanae
O kuʻu nae aloha i ke oho o ke kupukupu,	The fragrant sprouts of the *kupukupu* fern are loved by me
O kupu o lāua ka manaʻo e ai,	The thought of them two is to eat
E ʻai i ka ʻai a ke aloha	Partake in the food made with love
Ua ʻai iho la wau e ke hoa e	I have eaten my companions
I kō ʻai leo ole, he hoʻokahi no leo	Of the food without a voice, there is only one voice

He mai, he ma-i hoʻi e.	Come, come partake
E kamau a hele aʻe ke kamahele,	That the journey of the companions may be continued
Ua ʻike iho la no hoʻi i ke one ʻōpiopio.	So seen are the fine clean sands (of Mākua).

Finishing her prayer, Hiʻiaka invited Lohiʻau to eat to his contentment. She called to him to eat of the generosity of the *Ali'i wahine* (chiefess) of Mākua, ʻŌhikilolo, and Keaʻau. Lohiʻau then partook of the feast... (December 7, 1926)

... The chiefess inquired, and learned that her beautiful visitor was Hiʻiaka-i-ka-poli-o-Pele, the woman with the lightning skirt of Halemaʻumaʻu. The chiefess herself was very beautiful, and Hiʻiaka compared her beauty to the fine clean sands of Mākua (*ka uʻi o ke one 'ōpiopio o Mākua*). Hiʻiaka called out in chant to the chiefess:

Onaona wale ka maile lauliʻi o Koʻiahi	The Mailelauliʻi of Koʻiahi is very fragrant
He ahi ke aloha, he ʻapa ka pauku kino...	Love is like a fire, rolling over the body...

As Hiʻiaka chanted, the sweet fragrance of the *maile and* hala surrounded the people who had gathered for the feast at Mākua. The fragrance of the *maile* came from the uplands of Koʻiahi, and the sweet essence of the hala came from the land of Keaʻau, which is there on the south side of Mākua, next to ʻŌhikilolo... Everyone partook in the feast that had been prepared by the natives of the land. And as they ate the *poi ʻuwala* (sweet potato poi), the pieces of pig, the *wana* (urchins), the *ʻina* (small urchins) in their gravy, poke *uhu momona* (raw fish made of the rich parrot fish), and various foods that had been prepared, three beautiful women arrived at the gathering.

One woman was completely covered with garlands of *maile lauliʻi.* Another woman was adorned in garlands of *lehua, lehua* of every color. And the other woman was adorned in garlands of *hala and hinano.* These women with all of their adornments were truly beautiful, but the beauty of Hiʻiaka surpassed them. Hiʻiaka knew that these women were her relatives, who dwelled in the uplands.

These women had heard Hiʻiaka's chant, and had descended from the uplands to greet her. Hiʻiaka called out to her relatives in chant:

O ʻoukou ʻia e nā wāhine kūpaoa i ke ʻala	So it is you, the women surrounded in fragrance
Onaona hala o Keaʻau me Maile lauliʻi	The fragrant hala of Keaʻau and small leafed *maile*
Kuʻu lehua nenehiwa pua hoʻohihi a ka manu	And my cherished lehua blossoms admired by the birds
He manu ke aloha, aʻohe lala kau ʻole	The birds are beloved, and there is no branch that they don't land on
Eia wau la o Hiʻi	Here I am, it is Hiʻi
Hiʻi pū no me ke aloha o ka ipo	Hi'i together with the loved one,
	the sweet heart (Pele's lover Lohiʻau)
O kuʻu ipo, naʻu anei?	My sweet heart, is he for me?

The three women then entered the area of the feast. They were Mailelauliʻi, Koʻiahi, and Hala-i-ka-ipo of Keaʻau, Waiʻanae. They greeted one another with kisses. Hiʻiaka then spoke the following words to Hala-i-ka-ipo.

Hala mai la no ʻoe ma kēia ʻaoʻao o kahi puʻu one o ʻoukou aʻe nei, o kaʻanapa mai la nō ia o ka wai liʻula i ke kula o ʻŌhikilolo, a kau mai la hoʻi ke one o Mākua nei i ka ʻōlapalapa?

(Did you perhaps pass by the side of the sand dunes, that glisten like the mirage forming waters on the plane of ʻŌhikilolo, and walk on the rumbling sands of Mākua?)

When Hiʻiaka said these words to one of her relatives, the chiefess of Mākua then spoke to Hiʻiaka... (December 14, 1926)

Hear me oh kind stranger, this is the place of my birth, where my food has been cooked, and I, along with the natives of Mākua have never seen the resonating sands of Mākua; sands like those of Nohili, Kauaʻi. If we go, and *see* it as you have said, it will truly be a great mystery, for we the multitudes of this land, have never before seen the sands that you describe...

After completing the feast, Hiʻiaka took the chiefess of Mākua along with her people, to see the *one kani* (resonating [barking] sands) of Mākua. When they arrived at the *puʻu one* (dunes), Hiʻiaka climbed to the top of the dune. As Hiʻiaka climbed up the dune, everyone was startled because of the ringing and sounds like purring, that rose from each place where Hiʻiaka stepped. It was like the growling of a dog. Then, from atop the dune, Hiʻiaka called to the chiefess of Mākua, inviting her to climb up to where she was standing. As she ascended the dune, everyone heard the same sounds as when Hiʻiaka had ascended the dune. Seeing this mysterious characteristic of the sands of their land, the natives of Mākua began to follow their chiefess up the dune. From the very top of the dune, Hiʻiaka said to the chiefess:

Say, oh chiefess of Mākua, if you will lay down with your head above and your feet below, I will call the chief (Lohiʻau) to come and pull you by your feet, then you will hear a different sound. This sound can be discerned as being different from the one heard when we climbed up the dune.

Hearing this, the chiefess of Mākua laid down, with thoughts of pleasure, at being pulled by the aliʻi of Kauaʻi. Hiʻiaka then called to Lohiʻau, to get the chiefess of Mākua and to pull her by her feet: Oh Lohiʻau-ipo, from the hala groves of Naue by the sea! Take the chiefess by her feet and pull her down. You will hear again, the resonating of the sands of Mākua (*ke kani o ke one o Mākua*), and indeed, you will think that it is the sound of the sands at the land of your birth ... With pleasure and desire for the chiefess of the fine clean sands of Mākua, Lohiʻau pulled the chiefess down the *puʻu one* (dune). A ghostly sound, like that heard in the night (*hanehane* o *ka pō*) rose up when the chiefess was pulled down the dune.

Now Mailelauliʻi, Koʻiahi, and Hala-i-ka-ipo, adorned in their finery saw this, and in them arose the desire to also be touched by the handsome chief of Kauaʻi. So they ascended the resonating dune of Mākua (*pu'uone kani* o *Mākua*) and laid down, asking Hiʻiaka to call Lohiʻau to pull them as well... Hiʻiaka cautioned her relatives not to become enamored with Lohiʻau, for he was chosen for Pele, and no others could enjoy his affections…Lohiʻau first took Maile-lauliʻi and as she was pulled down, her garlands of *maile* were ruffled. He then took Koʻiahi, followed by Hala-i-ka-ipo who was adorned in garlands of *hala* and *hinano.* As each of the chiefesses were pulled down the dune, the soft crying of the dune (*ka ʻuwe hone o ke puʻeone*) was heard by all.

Hiʻiaka then descended the *puʻu one,* joining the women and said to them:

You have truly been blessed by the handsome child of Kauaʻi, but I say to you that it is well to remember the words spoken by our ancestors, *"He ʻiʻimi loaʻa a na haʻi naʻe e inu ka wai."* (Searched for, it is found, but indeed, the water will be tasted by another).

Hiʻiaka then asked the chiefess of Mākua if she had been mistaken about the resonating sands of the land of her birth. She responded that yes she had been wrong in denying the presence of resonating sands of Mākua. But from her youth, she had played at the dune, and leapt down its slopes, and never heard the mysterious sounds...(December 21, 1926)

Most of the group then returned to the chiefess' compound, though some of the people of Mākua remained at the dune playing in the sands, with fond thoughts of this wondrous place... The chiefess of Mākua invited Hiʻiaka to spend the night at Mākua so that they could rest prior to continuing their journey. This was agreed to, and while they were talking, everyone was startled at hearing the sounds of wailing coming from along the *ala loa* (trail), from the Waiʻanae side. This voice filled with pain, was the cry of a man. His hands were clasped behind him and he was crying out. Hiʻiaka asked the people to bring the man to the house, so that they could inquire if they could be of help.

Brought to the house, Hiʻiaka asked, "Has someone died?" The man wiped his face, looked at Hiʻiaka, and with a trembling voice he said:

Yes, it is I who will die. I have been on a journey seeking knowledge. I have traveled around Oʻahu, and not found that thing which I seek. I then thought that perhaps I would find life at the hill of Haʻupu, Kauaʻi. Yet traveling around Kauaʻi, I did not find that which I seek. I have also been to Maui, Lanaʻi, and Molokaʻi, and not been able to find that which I seek.

Hearing this, Hiʻiaka asked, "Is it a riddle that someone has spoken to you that you seek the answer to?" Surprised, the man confirmed this and told Hiʻiaka that she was the first one to discern the trouble that had befallen him. "So here perhaps is the place where I can be rid of this trouble, and I will escape the death that awaits me..." (December 28, 1926)

> ... Hiʻiaka then asked the man to tell them the riddle that he had been given. The man said, "Let me tell you a little story and then I will tell you the riddle."
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> Hiʻiaka said, "Before starting your story, let me tell you, 'You are perhaps Kaulana-a-ka-lā, a chief of Molokaʻi.'" Astonished, the man confirmed this, and asked, "Are you a native of Molokaʻi, that you should know my name?" Hiʻiaka simply told him that she had traveled throughout the islands. She then told Kaulana-a-ka-lā:
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> It was at Waipiʻo, Hawaiʻi, that you received this riddle. And, if you can answer it, you will be awarded one half of Waipiʻo, but, if you are unable to find the answer, you will be killed. Is that not so?
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> The *Aliʻi* of Molokaʻi confirmed this, and he was filled with awe at the wisdom of Hiʻiaka. Hiʻiaka then continued:
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> You have journeyed around Hawaiʻi, and yet found no one who could explain the riddle to you. You have traveled around Maui, Kanaloa Kahoʻolawe and found no one who could answer it. Now arriving at Oʻahu, at the point of Koko, you have traveled and met with us here.
>
> The man confirmed that all of this was true. Hiʻiaka then asked Kaulana-a-ka-lā to tell them the riddle. Standing up the *Aliʻi* of Molokaʻi began to chant, offering a prayer first. He then spoke the riddle. Hiʻiaka then said that she would inquire of the natives of this land, if they could answer the riddle, and found that none could. Hiʻiaka then asked the chiefess of Mākua, "Is there not a fishpond at the side of the cliff of Kaʻena, and its name is Manini?" The chiefess answered:
>
> Yes there is a fishpond on the cliff side of Kaʻena, and it is named as you said. In that pond, I have seen all manner of fish, and there is one large fish, Moanawaikeʻoʻo (That is the *moanakai* as it is known from here to Kahuku).

The editor then notes that the paper with the next part of the story has been lost. And he observes that there is perhaps someone still living today, who remembers the riddle, and they might share it with us at *Ka Hōkū o Hawaiʻi*... (January 4, 1927 - a reader replied to the request on Jan. 18, 1927)

The account continues in describing a game of *kilu* played between the chiefess of Mākua and Lohiʻau. In *kilu*, a small coconut or gourd cup (quoit) is tossed at an item in front of an opponent; if the quoit hits the item, the one who tossed it wins a kiss from the other contestant. In a conversation during the contest, the chiefess mentioned a place called Puʻuohulu. Hiʻiaka asked:

> "Where is this place called Puʻuohulu, is it in Waiʻanae." The chiefess of Mākua responded that it was indeed in Waiʻanae, a place with which all of the people were familiar... Hiʻiaka then chanted:

Lele ka huna kai	The ocean mist flies
Piʻi aʻe la i ka makalae	Rising upon the coastal point
Aloha wale ka lae o Kaʻena i ka ehu kai	The point of Kaʻena greets the sea
Kai o lalo o Waiʻanae	The sea of Waiʻanae is there below
Ke heʻe nei i ka puʻeone	Sliding across the dunes
ʻOia one aloha o Mākua e	It is the beloved sands of Mākua
Mai hoʻomākua ke aloha o hewe au—e	Don't let this affection (for Lohiʻau) mature lest you be found at fault
O kou inoa ia la e Puʻu-o-hulu	Your name is Pu'u-o-hulu
Ua ʻike a hoʻi e…	So now it is revealed…(January 11, 1927)

Hiʻiaka's chant brought great pleasure to the people at Mākua, and the game continued for some time... The next day preparations were made, and Wahineʻōmaʻo Pāʻū-o-palaʻa, and Lohiʻau boarded the canoe to depart from Mākua and continue their journey through Waiʻanae. With one dip of Pāʻū-o-palaʻa's paddle the canoe was out in the deep sea beyond the clean sands of Mākua.

Hiʻiaka then turned and looked to the uplands of Waiʻanae and turning around, she saw two of their cherished elders, Kua and ʻAleikapōkiʻi. These were shark-formed elders (*kupuna mano*) of her family. These elders saw Hiʻiaka, and Kua said to

‘Aleikapōki‘i, “Behold, here is our descendant (grandchild), Hi‘iaka-i-ka-poli-o-Pele.” The other shark agreed with the words spoken by its companion. The two continued to speak among themselves, and they feared that perhaps Hi‘iaka would be angry with them (Earlier in the account, these two sharks had tried to stop Hi‘iaka from going to get Lohi‘au at Kaua‘i because they did not believe that a human was a good companion for Pele.). The two sharks were afraid that Hi‘iaka might try to kill them, and that they would have no way to escape from her great power. Kua told his companion, “We will not die if we go and hide.” The two sharks at first thought that they might go hide in their caves, but then they knew that they could be found, so they then thought that perhaps they should go and hide upon the land (*pae i kula o ka ‘āina*). So the two sharks agreed and went inland, where one lies on one side and the other lies near by (to this day). Hi‘iaka saw her shark elders swim away and hide, she called affectionately to them in a chant:

A makani Kaiaulu o lalo o Wai‘anae	The kaiaulu breeze blows to the lowlands of Wai‘anae
Ke wehe aku la i ka poli o ka hoa	Making known what is in the heart of the companions
Ha‘i ka nalu o Kua me ‘Aleikapōki‘i	The waves are broken by Kua and ‘Aleikapōki‘i
I hiki i moe aku i uka ka luhi o ke kai...	So that they may rest in the uplands away from the burden of the sea...

Hi‘iaka’s chant was carried to the shore and heard by Pōka‘ī, who saw that Hi‘iaka was drawing near. Pōka‘ī bent her head down and thought that perhaps Hi‘iaka would kill her. The canoe with Hi‘iaka’s companions then landed on the sandy shore of Wai‘anae, at the landing place called Ke‘a‘ali‘i. Joining them, Hi‘iaka looked all about this famous land of the wind *lau-niu.* Hi‘iaka’s tears then fell from her eyes down her cheeks, and Wahine‘ōma‘o inquired why Hi‘iaka was crying (*Ea! He mau waimaka aha ho‘i kēia e helele‘i wale mai no i ka lihilihi o ka lehua makanoe*-Why are the tears falling from the fringes of the dewy centered lehua blossoms?). Hi‘iaka responded to her companion, you have asked a good question, and the reason is that this is the land of the *kaiaulu* breezes which cause the coconut leaves to sway back and forth, and it is greatly loved. Here before me, I have had a vision, that there will be great treachery here, and the saying of the children shall be fulfilled. The saying is this, *“No ke kai ka hale, e noho ia*

e ka puna, no ka puna ka hale e noho ia ana e ke kai a mohala ka lau ke naenae" (The house is on the shore, situated there on the coral, the house is on the coral rocks there on the shore and the leaves of the *naenae* bloom forth). This is the reason that my tears are shed, my companion.

Hiʻiaka stopped speaking for a moment, then resumed her explanation of the prophesy, *"Ke kū ka makaiʻa a ke Aliʻi o Oʻahu nei i kēia wahi ma luna o ke kanaka o ke akua, a laila, No keia ʻāina o Oʻahu nei i ʻĀina one ʻai aliʻi"* (The chief of Oʻahu will bring forth treachery upon a man of the gods here, thus this land of Oʻahu will become a land in which the sands consume the chiefs.)... (January 18, 1927).

Now some people say that this name Pōkaʻī is a recent name, given from the time when Moʻikeha traveled from Kahiki, when he left his relative Olopana; but it is not so, because it is from the time when Pele came to these islands. Hiʻiaka then went a short distance inland, and the *kupua* (supernatural being) Pōkaʻī of Waiʻanae came face to face with her and they met with *aloha* (affection). Pōkaʻī instructed her people to go to the uplands to gather *lūʻau* (taro greens) and kalo (taro) from the taro lands of Lehano in the uplands of Waiʻanae. She also commanded that some of her people bake a pig and prepare food for the chief of Kauaʻi and Wahineʻōmaʻo. The sweet, tender *lūʻau* of upper Waiʻanae was gathered and cooked in the *imu* along with all the other foods. The baked pig, *poi uwōuwō* (thick poi) of Waiʻanae, were among the foods eaten by the Lohiʻau and his companions.

Pōkaʻī then said to Hiʻiaka, "My lord, I have no other gift to give you." Hiʻiaka responded, telling her that her hospitality had been more than adequate, for great indeed is the food which you have prepared for us to satisfy our hunger. And this is what I give to you ʻo Pōkaʻī, "Your dwelling upon the land shall be relieved by the gentle *kaiaulu* breezes. Your name shall be spoken by the generations which are yet to come. And I also tell you that Waiʻanae shall become the corner post (*pou kihi*) for this land of Oʻahu which consumes its chiefs (*ʻĀina ʻai aliʻi o Oʻahu nei*)."

There will be a day when one who betrays the gods shall stand here (this is a reference to the chief Kahahana who in betrayal ordered the death of his priest and bard, Kaʻopulupulu, at Nānākuli (see Kamakau 1961:134) ... Hiʻiaka and her companions then prepared to depart from Pōkaʻī. She told Lohiʻau and

Wahineʻōmaʻo that they would travel by canoe, while she would travel for a while over land, and that they would meet again at Kou (Honolulu)....Hiʻiaka then continued her journey along the upland trail. Now the trail upon which Hiʻiaka chose to travel, is the trail which passes above Pohakea. Hiʻiaka passed along the *kula* (plain) of Maʻili, and then turned to look at the uplands. She saw the dazzling light of the sun on the uplands of Lualualei and Hiʻiaka chanted:

Wela ka lā e! Wela ka lā e!	The sun is hot! The sun is hot!
Ua wela i ka lā ke kula o Lualualei	The heat of the sun is on the plain of Lualualei
Ua nau ʻia e ka lā a ʻokaʻoka...	The sun chews it up entirely.

Hiʻiaka then continued her ascent on the trail in the stifling heat of the sun and she chanted:

A Waikonene i ke alanui	The path is at Waikonene
Ka piʻina i Kamoaʻula	Ascending at Kamoaʻula
Ka lā wela i ka ʻumauma	The heat of the sun is upon the breast
Waha ka ʻio i ke kua o Puhamaloʻo	ʻIlio is born upon the back of Puhamalo'o
Ke hoʻohaehae mai la i ka naulu	The *naulu* winds rage
Moku kahawai, miha ka poli o Puhawai	Breaking the stream, but the breast of Puhawai is quiet
Ua hakakā, kipikipi ke kaiaulu me ke kanaka	The *kaiaulu* breeze seems to fight and rebel against the people
Ua kuikui wale a haena nā ihu	Striking and causing the noses to rage
Ua kā wale i ka hupe	The mucus flows freely
Ka lā wela o Lualualei e	In the hot sun of Lualualei.

Hiʻiaka then continued her journey onto the plains of Lualualei.

The Naming of Mākua

The word mākua translates in different ways, generally meaning parents or adults, and it does not necessarily differentiate between mothers, fathers,

aunts, or uncles. Handy et al. (1972: 306) used the word mākua in the context of kinship: "(T)he keiki (the little ones), particularly those avid for knowledge of their elders' ways … were instructed regularly in manners, in the more important of the kapu, and in practical manners by mākua (parents) and kūpuna (grandparents)."

Malo's use of the word mākua suggests that the term may apply to grownups (1951: 260). According to one source however, the word mākua "cannot be better than liberally translated. The word means 'full grown,' but whether it was named for some mighty chief of a bygone day, or for the wide and deep valley behind it, none can say" (Honolulu Star Bulletin, April 4, 1925, cited in Sterling and Summers 1978: 81). Another interpretation is that Mākua was the name of a fisherman who, with a chief named Kawela, fished off Ka'ena Point for the Traveling Uhu, a great fish of sacred power (Pukui and Curtis 1951; Kelly and Quintal 1977).

Kāneana or Mākua Cave

Kāneana, often referred to as Mākua Cave, lies at the *makai* end of the large ridge that separates Mākua Valley from 'Ōhikilolo Valley. The original entrance to the cave, destroyed in 1950 by road construction, was narrower and taller than it is today (Kelly and Quintal 1977: 9). According to McAllister (1933: 123), "Kāneana cave was the dwelling place of a shark goddess who held sway from Ka'ena Point to Kepuhi Point. When she took the form of a woman, she came up through a sea entrance and lived in the cave."

Kāneana may also mean cave of God…with *ana* translated as cave, and Kāne being the supreme deity of the ancient Hawaiian pantheon. According to an old Hawaiian who was born at Mākua village, *kahuna* performed religious ceremonies in the cave as recently as 1875 (Sterling and Summers 1978).

Kāneana is summarized as follows:

Once upon a time there was a shark god known as Kamohoali'i, who was king of all sharks. Kamohoali'i could change into a dignified and majestic man. He wooed a woman by the name of Kalei, who did not know he was actually the king of sharks, and married her. When it came time for the couple's child to be born Kamohoali'i warned Kalei to guard the child's body from the sight of man, and never allow it to eat the flesh of any animal. Kamohoali'i then disappeared. Kalei bore a man-child, and named it Nanaue. Kalei was very surprised to discover that the child had an opening in its back. She covered the opening with *kapa* and often

wondered about it. One day Nanaue plunged into the water and opened the mouth on his back to catch any passing prey. Kalei kept this secret to herself. The boy eventually grew to manhood and began eating with the men in the men's house. Nanaue stayed to himself and his dual nature developed. When the people of his village were deep-sea bathing or fishing, they would suddenly be visited by a shark that bit and tore at the limbs and dragged them down into deep water. Then one day, a man working beside Nanaue in a taro patch inadvertently tore the *kapa* from Nanaue's back. A shout went up "See the shark mouth! A shark man!" Nanaue escaped to the sea and wandered from place to place and island to island. The *kahuna* were asked to help, but it was some time later that Nanaue was actually captured and killed. At one time he lived near Kāneana. He would drag his victims into the cave through a subterranean channel at high tide. He would place his victim on a certain slimy stone to await his leisure and appetite (Honolulu Star Bulletin, September 9, 1939, cited in Sterling and Summers 1978).

The Moʻo of Mākua Valley

The term *moʻo* is translated as "lizard." *Moʻo* were not harmless small geckos, but rather they were large creatures with long and terrifying bodies (Kamakau 1964; Kelly and Quintal 1977). Traditionally, *moʻo* are associated with fish ponds, and they are considered guardian spirits (Kelly and Quintal 1977). The particular *moʻo* of Kalena stream and pond was said to have once been a beautiful girl who lived in the valley. Her parents changed her into a *moʻo* so that she could not marry the shark man of Kāneana (Kelly and Quintal 1977). The following story pertains to the *Moʻo* of Mākua:

In heavy rains, the *moʻo* came down the stream from Koʻiahi to meet her boyfriend, the shark from Kāneana Cave. When the stream flows strong, it breaks through the sand beach and flows into the sea. The *moʻo* goes into the sea and goes on the big rock next to the blow hole at the Waiʻanae end of the beach. The rock is called Pōhaku-kūlaʻilaʻi. On this rock, she would turn herself into a beautiful princess and call to him. The shark would come out of Kāneana Cave through the undersea channel and swim out to the blowhole. He would then swim into the underwater entrance, and be tossed ashore through the blowhole. He would then turn into a man, and he and the princess would make love. When they were ready they would go to live in the stream. And when the water is green the *moʻo* is in the stream. When it is clear, she is not. No swimming is allowed when the *moʻo* is in the stream (Kelly and Quintal 1977).

The ‘Ōlohe or Ha’a People

The ‘Ōlohe or Ha‘a people were a class of individuals skilled in the art of wrestling and bone breaking (*lua*). They reportedly pulled their hair out and smeared their bodies with oil to provide no hold to an opponent. Oral traditions portray these people as professional robbers with possibly cannibalistic habits who stationed themselves at a narrow pass along the highway to rob and kill travelers. Mākua Valley is a traditional haunt of the ‘Ōlohe or Ha‘a. Similar traditions occur in the islands of Maui and Hawai‘i (Beckwith 1940).

Mākua Mountain Trail

John Papa ‘I‘i relates the following concerning the Mākua Mountain Trail: “There was a mountain trail from Mākua to Kawaihāpai (*ahupua‘a* in Waialua) where it joined the trail from Ka‘ena. It was said that this was the trail on which the red-eyed one became lost, but it might have been another one. The saying was, ‘Red eyed person who strayed to Mākua’.” A slightly different version, which was eliminated from the text, read: “A red eyed one went from Mokulē‘ia intending to go to Mākaha but he went up by Kawaihāpai thinking that was the way to Mākaha. He found that it was not his destination and hence the saying for this was, ‘Red eyed one goes by mistake to Mākua’.” (John Papa ‘I‘i manuscript pp. 218-220, cited in Sterling and Summers 1978).

Maile Lauli‘i of Ko‘iahi

Maile lau li‘i o Ko‘iahi, the small-leafed maile was noted for its fragrance. The *maile* of Ko‘iahi was believed to have the finest leaf of any *maile* on O‘ahu. It was said to have been destroyed by goats (Pukui 1953, cited in Sterling and Summers 1978).

This famous plant also plays a role in the legend of Kalelealuaka, a warrior of supernatural prowess associated with the well known king Kakuhihewa (Thrum 1998). Kalelealuaka’s adventures take him to a number of districts around O‘ahu, where he appears adorned with *lei* representing the area, performs tremendous military feats, is promised the region as a spoil of war, and disappears again mysteriously. In the end, he inherits the kingdom from Kakuhihewa. In the legend’s Wai‘anae episode, Kalelealuaka appears bedecked in *maile lau li‘i*.

Mailelauli‘i was also the name of a beloved relative of Hi‘iaka, who greeted her at Mākua, as described in more detail in the Hi‘iaka tradition related above.

Pōhakuloa Training Area

Oral Traditions regarding the area around PTA indicate that the Ahu a ‘Umi heiau on the slopes of Hualālai south of PTA is said to have been built by the legendary chief ‘Umi a Līloa around 1600. Both ‘Umi and his father, Līloa, are credited, in different accounts, with unifying the Island of Hawai‘i and with creating the system of land division that persisted through the end of the traditional era. In a broad sense, the entirety of Mauna Kea, whose southwestern slopes form part of PTA’s base, is considered holy. From cultural practitioners to academic specialists to oral history informants, that sacredness has been expressed in a number of different ways that are briefly summarized here.

Attempts to translate the Hawaiian sense of Mauna Kea’s spiritual meaning for a general audience often focus on two concepts, hiapo (first-born, recipient of special privileges and responsibilities) and lōkahi (unity or harmony). The mountain is seen as the first-born child of Wākea and Papa, the original father and mother, and thus as a personal ancestor of living Hawaiians. It is also seen as the piko or navel through which the Island of Hawai‘i came into being. In addition, its height helps to make it sacred.

This sense of Mauna Kea as a living elder and holder and transmitter of tradition complements a sense of lōkahi, in which the mountain participates in the larger cycle of life, where each element has a crucial part to play. For example, its height attracts clouds, which bring precious rain. Through hiapo the mountain reaches up to the sacred realm, while through lōkahi it reaches out to the natural world—Hawaiian tradition did not see those two realms as separate.

Several deities are associated with the mountain, perhaps most famously Poli‘ahu, the snow goddess of the summit, and Lilinoe, embodying the mist and rain of the Pōhakuloa area. In legend, the region was also the scene of conflict between Poli‘ahu and the fire goddess Pele. In geologic terms, this conflict may be seen in the ancient meeting of volcanic fire and mountain ice that produced exceptionally high-quality basalt prized by traditional adze makers.

Water is an important part of the mountain’s sacred aspect. These sacred water sources include springs and their importance as part of cultural landscapes, rain clouds attracted by the peak, mist and snow representing its deities, and the icy water of Lake Waiau near the summit, prized for use in religious and medical practice. Water that had not touched the ground was considered especially precious, whether it collected in the cupped part of a taro leaf, in high Lake Waiau, or in the top of a bamboo

shoot. Interestingly, the ahupuaʻa that stretches from the Hāmākua shore to include both Mauna Kea and Mauna Loa peaks and much of the land base for PTA is named Kaʻohe, or bamboo—a plant that was often used as a water carrier.

3.10.3 Historical Overview
Mākua Military Reservation

Historical Setting of the Waiʻanae District

One ruler's name stands out from the early centuries of Waiʻanae history: Huanui-i-ka-lā-laʻilaʻi, born at ʻŌhikilolo and ruling the northern coast. His reign has been tentatively dated to either the 8th or the 11th century (Kelly and Quintal 1977; Eblé et al. 1995). Little seems to be known aside from his name and the fact of his reign.

Cordy (2002) suggests that around the 14th century, Hawaiians saw the formation of *moku* or larger districts and the development of a ruling class of *aliʻi*. By this time, the coast and lower valleys of Waiʻanae were probably settled. It would take another three centuries to settle the upper valleys. Waiʻanae and Waialua would have been part of the larger *moku* of ʻEwa. Centralized power in the Island of Oʻahu waxed and waned over the centuries. An ʻEwa chief named Laʻakona is thought to have unified Oʻahu in the early 15th century and ruled from Līhue in the central plateau of the island. The center of power probably moved to Waikīkī about a century later under the rule of Māʻilikūkahi. In the 17th century, a separate kingdom briefly arose in Waiʻanae under Nāpūlānahumahiki. A generation later, a strategic marriage between Kākuhihewa and an heir of the breakaway kingdom unified the island again.

The power Kākuhihewa established began to dissipate again under his descendants, as the *moku* chiefs gained strength at the expense of the center, until Kualiʻi reestablished centralized rule around 1720. The Waiʻanae uplands were the site of the last resistance to Kualiʻi. By this time, Waiʻanae constituted a separate district, and chiefs probably lived at Pōkaʻī Bay.

After the time of Kualiʻi, Waiʻanae was often a site of resistance or refuge. When Kahekili conquered Oʻahu in 1785, he faced a rebellion by the island's chiefs, who made their last stand in the Waiʻanae Mountains (Cordy 2002; McGrath et al. 1973).

With Kahekili 's death nine years later, war broke out between would-be heirs Kalanikupule and Kāʻeokulani. After various skirmishes and truces, Kāʻeokulani—who was actually encamped in Waiʻanae on his way home to Kauaʻi—made an abrupt about-face and, with the support of Waiʻanae

warriors, attempted an attack. He was defeated and killed (Cordy 2002; Kuykendall 1968). When Kalanikupule lost O‘ahu to Kamehameha I a year later, the Wai‘anae coast again became a refuge for those unwilling to submit to the new rule (McGrath et al. 1973).

Even after the islands were unified and pacified, political and cultural resistance continued to find a home in Wai‘anae. Chief of Wai‘anae and governor of O‘ahu until his disappearance at sea in 1829, the *ali‘i* Boki offered intermittent but sometimes bitter opposition to the queen regent Ka‘ahumanu and to the missionary faction. At times, he “seemed on the point of attempting to overthrow Ka‘ahumanu” (Kuykendall 1968: 123). Shortly after his disappearance, the “Pahikaua war,” another plot against the queen regent that briefly held O‘ahu in a state of siege, also had a strong Wai‘anae base (Kamakau 1992). Ka‘ahumanu’s death in 1832 signaled another brief “revolt against Puritanism” by the Wai‘anae chiefs (McGrath et al. 1973). After the death of the Liliha, widow of Boki, in 1839, Christianity began to make vigorous inroads on the Wai‘anae coast (Hall 1839; McGrath et al. 1973).

Issues common to all of Hawai‘i also played out on the Wai‘anae coast. The sandalwood trade, beginning in 1811 and intensifying after Kamehameha I ’s death in 1819, is widely believed to have caused famine and to have increased vulnerability to disease throughout the Hawaiian Islands. In Wai‘anae, inhabitants are said to have uprooted sandalwood saplings to avoid having to harvest them later (McGrath et al. 1973). Kelly and Quintal (1977) found no references to sandalwood harvesting in Mākua Valley specifically, but ample documentation indicates that the harvest took place in the Wai‘anae district in general.

The epidemics that battered the islands after contact with the West took their toll in Wai‘anae as well. Kuykendall (1968: 386) says “In those years (1848 through 1853) epidemic diseases, like a gigantic scythe, cut great swaths through the native population and its ultimate extinction came to be quite generally thought of as inevitable.”

McGrath et al. (1973) estimates that by 1854, the Wai‘anae coast population was at a quarter of its pre-Contact level.

<u>Role of Mākua and Kahanahāiki in the Wai‘anae District</u>

Handy et al. (1972) state that there were small villages in Mākua. Clark (1977:96) describes Mākua as a “densely populated valley with a thriving community,” mostly clustered inland at Pu‘u Pa‘i, well watered, and full of fruit-bearing trees. This description conflicts with the impression of aridity and poverty that some early European visitors reported after their

short visits to Mākua. In a setting where the rainfall varies seasonally and annually, these seemingly contradictory descriptions may be seen as presenting a range of variable conditions present at different times.

Kelly and Quintal (1977) and Cordy (2002) estimate the population in Mākua at between 300 and 420 persons around the time of contact with the West. Population on the northern Wai‘anae coast was sufficient in Levi Chamberlain ’s time (in the early 1800s) to support two schools, including one at Keawa‘ula and another at Mākua.

Cordy (2002:119) summarizes how the existing archaeological remains reflect the past settlement pattern in the area: “Based on some historical information and limited archaeological information, it appears that the bulk of the permanent housing of Mākua and Kahanahāiki was along the shore and in the immediately adjacent areas of the lower valley... Archaeological work has found some habitations (enclosures and platforms) on the sides of Ko‘iahi gulch at the front of Mākua valley and some scattered habitations in the back of the valley.”

The region under study is known to have been unified under a single ruler, Hua-nui-i-ka-lā-la‘ila‘i, many centuries before the arrival of Europeans. The portion of the coast from Keawa‘ula to Kea‘au also fronts what is said to be the richest part of the Wai‘anae coast fishery. It also shared a common post-Māhele fate in the sense that most of the large land areas that came under foreign control were devoted to a relatively “wild” form of cattle ranching, rather than to plantation agriculture.

Two well-known events of the late pre-Contact to early post-Contact era may be linked to Mākua. These events are the death of the *kahuna* Ka‘opulupulu and the attempt by Kamehameha I to invade the Island of Kaua‘i.

The Mākua and Wai‘anae shores have both been suggested as the place where the late 18th century O‘ahu king Kahahana betrayed his close adviser Ka‘opulupulu. Ka‘opulupulu and his son were summoned to Wai‘anae and killed. The act is believed to have cost Kahahana his credibility and support, and he soon thereafter lost his kingdom to the invading Maui chief Kahekili.

Before his death, the kahuna Ka‘opulupulu made a prophecy that has been paraphrased and translated a number of different ways. Pukui (1983) offers:

> E nui ke aho, e ku‘u keiki, a moe i ke kai, no ke kai la ho‘i ka ‘āina. Take a deep breath, my son, and lay yourself in the sea, for then the land shall belong to the sea.
>
> Mākua and Mākaha beaches offered the best canoe landings along the Wai‘anae coast, frequently used by travelers on their way to Waialua or Kaua‘i (McGrath et al. 1973; Kelly and Quintal 1977). One of the two was the likely site from which Kamehameha I launched his unsuccessful invasion of Kaua‘i in 1795.

Traditional Activities in the Mākua Military Reservation Vicinity

In oral history interviews, the most frequently mentioned crop in Mākua and Kahanahāiki was sweet potato (Kelly and Quintal 1977). Post-Contact era crops reportedly grown in the valley included watermelon, pumpkin, cucumber, tobacco, and cotton (Kelly and Quintal 1977). At one time, the *Territory* suggested that there were at least 550 acres (223 hectares) of agricultural land in Mākua Valley. However, in a letter from McCandless to Charles T. Bailey, Commissioner of Public Lands, McCandless doubted the presence of 500 acres (202 hectares) of agricultural land, and instead he stated that the number of acres farmed at any one time in lower Mākua Valley since 1900 was probably 100 acres (40 hectares) or less.

As in other places where rainfall was insufficient to support irrigated pondfields or *lo‘i*, the staple crop was sweet potato, although a small amount of taro may have been grown in Ko‘iahi Gulch and perhaps elsewhere. Few if any streams in the valleys of Mākua and Kahanahāiki flowed year-round, but careful seasonal planning allowed farmers to take advantage of seasonal rains to produce a sweet potato crop that was known for its size and sweetness. Plants growing wild on the lower and gentler slopes of the mountains supplemented the diet and also provided medicines.

Salt could be gathered easily from the lava rocks along the shore, particularly at Kalaeopa‘akai, a lava outcrop on the ‘Ōhikilolo shore, but also in Mākua. Numerous interviewees remembered the abundance and purity of the salt supply, now described as no longer present in significant quantity or quality due to various factors (Kelly and Quintal 1977).

The area south of Ka‘ena Point is one of the richest fishing grounds on O‘ahu, directly accessible from the Mākua and Kahanahāiki valleys. In addition to the ocean, streams, *muliwai*, and human-made fishponds were sources for fish. At least into the 1930s, Mākua residents participated in a community fishery mentioned in the Kelly and Quintal oral history interviews (1977). Participants remembered a wide variety of freshwater

sources in the valleys of Mākua and Kahanahāiki, especially at Koʻiahi Gulch, Laʻihau, and other inland places.

Early Written Documents

Perhaps the earliest written eyewitness account pertaining to the Mākua area is that of the missionary Levi Chamberlain, who toured Oʻahu in 1826 and again in 1828. "Mākua is situated on a sand beach and opens to the sea between two bold head lands S.E. and N.W. ... there are no trees in this place, a few clusters of sugar cane are seen here and there, potatoes are cultivated but not taro" (Levi Chamberlain Journals 1822-1849: cited in Sterling and Summers 1978: 84).

Early Historic Period Settlement

A sketch by missionary Hiram Bingham depicts a village apparently at Mākua Beach ca. 1821 to 1830 (Bingham 1847). The same sketch also indicates a few houses scattered on the lower slopes of the valley. This description is consistent with the expected settlement pattern of a small community living in a dry leeward setting. The expected pattern includes residences dispersed along the beach, as well as scattered agricultural fields in the interiors of the valley that supported smaller habitation compounds.

Based on census data from the 1800s and assuming a much larger pre-Contact population prior to the devastation brought by foreign diseases, Cordy (2002) estimates that 420 people once lived in Mākua and Kahanahāiki. Mākua and Kahanahāiki appear to have supported about the same size of pre-Contact population as most valleys in the Waiʻanae district, except for the much larger population in Waiʻanae Kai and the very sparse population in Keawaʻula. In this context, the *ahupuaʻa* of Mākua and Kahanahāiki may be seen as typical moderately populated valleys in a leeward Hawaiian setting.

Hawaiian Land Records

In 1848, the Great Māhele replaced the previously existing land use practice with a system of private ownership. *Kuleana* claims were petitions for land by Native Hawaiians based on ancestral use of certain areas that resulted in land commission awards (LCAs). LCAs were properties worked by generation after generation. *Kuleana* land was recognized as 111 acres (45 hectares) awarded to claimants in Mākua and 70 acres (28 hectares) awarded to claimants in Kahanahāiki (Kelly and Quintal 1977). The remaining land in the area became property of the Hawaiian government, and large sections of this land would later be leased and sold in smaller parcels as a source of income (Kelly and Quintal 1977).

Church

Levi Chamberlain noted the existence of mission schools at Mākua Valley and Keawaʻula in reports that he made in 1826 and 1828 (Chamberlain 1956, cited in Kelly and Quintal 1977). The first mention of actual parishioners in Mākua Valley was in 1860. The first Mākua Church was reportedly built of stone by Samuel Andrews, and the next was constructed of wood (Kelly and Quintal 1977). The second church was later moved to Pearl City and subsequently to Kuhio School in Moʻiliʻili. As an entity, Mākua Church was part of the Hawaiian Protestant Congregation, but it remained independent of the United Church Council. Its official name was Mākua Church, but its parishioners referred to it as Koʻiahi Church (Kelly and Quintal 1977).

Railroad

Construction of a railroad along the leeward portion of the Oʻahu coast was started in 1888 by Ben Dillingham. After several years, the railroad of the Oʻahu Railroad and Land Company extended into the Waiʻanae District, past Mākua, and around Kaʻena Point to Kahuku (Kelly and Quintal 1977: 61). "The existence of railroad transportation at that early date allowed easy movement of cattle and hogs from Mākua Ranch to slaughterhouses located in urban centers, as well as transportation for vegetable produce to urban markets. The railroad provided transportation to and from Mākua…for families as far away as Kahana Bay" (Kelly and Quintal 1977: 59).

Ranching Period

A series of ranchers acquired ownership and leases of land parcels in the Mākua and Kahanahāiki valleys. The following summary is synthesized from Kelly and Quintal (1977):

> The first lease of this area for ranching activities was issued to Joseph and John Booth in 1864, and it was to run for 25 years. This lease included Mākua Valley, Kahanahāiki Valley, and the government portion of Keawaʻula. In 1873, the lease was transferred to Samuel Andrews, and the lease was extended for an additional 21 years to terminate in 1910. In 1910, this ranch land was leased to L. L. McCandless, and the lease was up for renewal in 1920. These properties again became available for lease in 1925, when James Frank Woods obtained a 21-year lease. This lease included Kuaokalā, Mākua Valley, Kahanahāiki Valley, and the entirety of Keawaʻula. In 1929, Woods assigned these leases to L. L. McCandless, who had already purchased ʻŌhikilolo (directly to the south of MMR) in 1899. The McCandless Estate maintained control of these lands until the Army took over the area in 1941.

Historic Land Use

Mākua and Kahanahāiki Valley s correspond to traditional Hawaiian land units known as *ahupua‘a*, which incorporate the natural and cultural resources from the inner mountain ridge to the ocean. The concept of the *ahupua‘a* provides a context to understand daily, seasonal, and annual functions of society and relations with the natural environment. The *ahupua‘a* units in and adjacent to MMR are shown in Figure 3.9-3.

Soils in Mākua and Kahanahāiki Valleys evidently supported the growth of sweet potato and sugar cane, and non-Native Hawaiian ranchers in the 1800s reportedly grew watermelon, pumpkin, cucumber, tobacco, and cotton (Kelly and Quintal 1977). Sediment types in the area appear to include mostly rocky clay loam colluvial deposits derived from erosion of the basaltic mountains that surround the valleys. Variable silty and gravelly deposits are present in the streams and drainages.

Given the leeward setting of Mākua and Kahanahāiki Valleys, freshwater sources are limited and fragile. These same sources are vital to sustain traditional Hawaiian land uses in the area and to provide clean drinking water. The locations of streams very likely determined the distribution of traditional Hawaiian cultivation fields and associated residences in the valleys. A number of streams and drainages are present, generally following physiographic features of the landscape. Mākua Stream is the principal stream, roughly in the center of Mākua Valley, and likewise Kahanahāiki Stream (now referred to as Punapōhaku Stream) is roughly in the center of Kahanahāiki Valley. When flowing, these two streams join and issue into the ocean at the middle of the sandy beach. Stream flows have also been noted in the narrow Ko‘iahi Gulch (referred to in this EIS as Kaiahi Gulch) at the south edge of Mākua Valley and in Piko Gulch on the north edge of Kahanahāiki Valley (Zulick and Cox 2001).

Figure 3.10-1 shows cultural resource features at MMR.

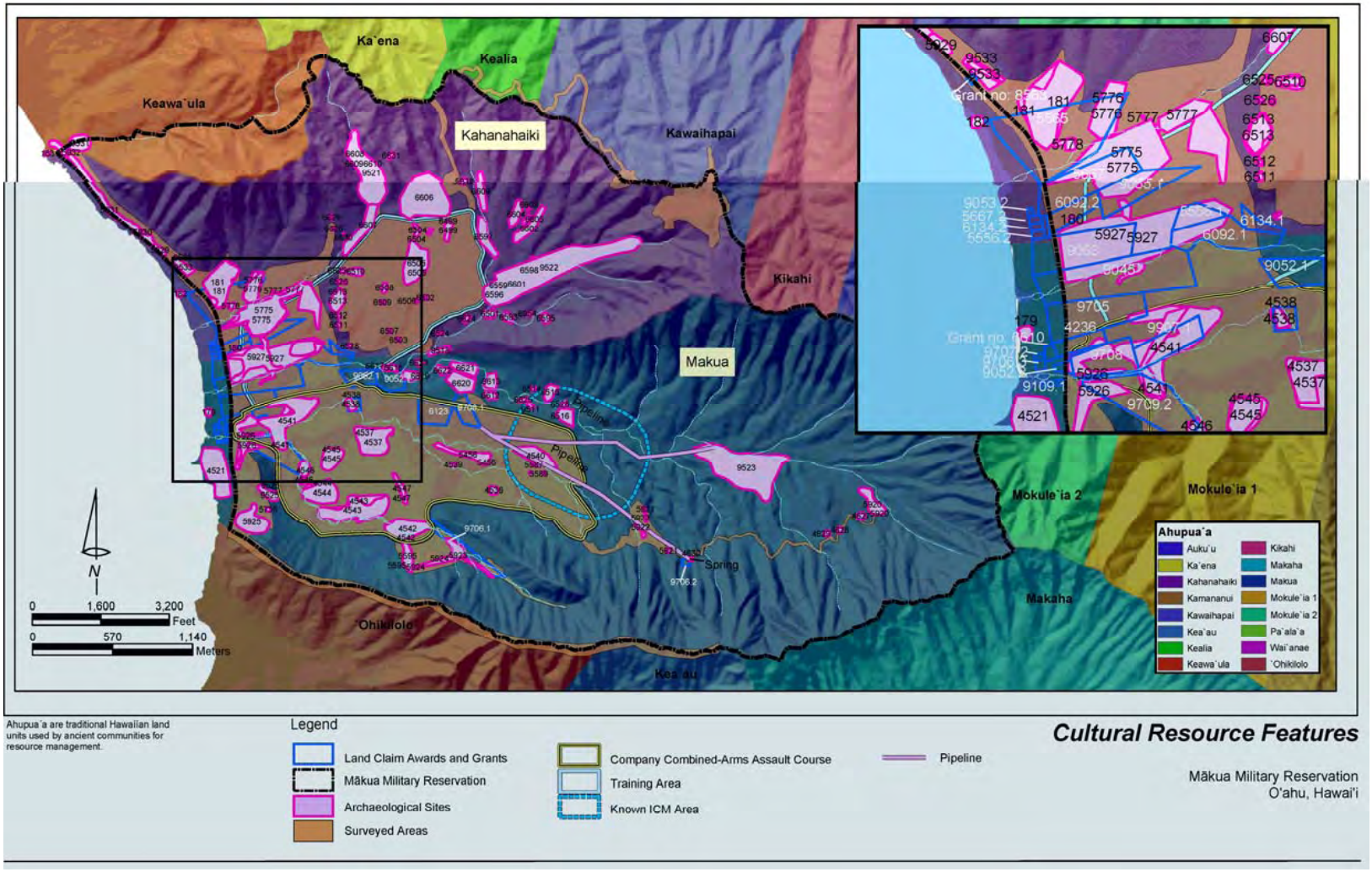

Figure 3.10-1 Cultural Resource Features, MMR

Stream flow in the Mākua and Kahanahāiki Valleys is at present intermittent. USARHAW and 25th ID(L) (2001a: 53) reports, "The Mākua Stream system is an intermittent system and flows only about 5 percent of the year. The stream rarely flows for two consecutive days." Zulick and Cox (2001: 6) comment, "This statement may actually be overly generous, as this percentage would indicate two weeks of flow a year, something that has not happened in the last five years." The apparent low volume of stream flow probably limited the kinds of cultivation practiced in Mākua and Kahanahāiki Valleys in the past, thereby contributing to a set of local adaptations of water-conserving techniques.

Limited rainfall may partially explain the intermittent quality of the streams. Mean annual rainfall is estimated at less than 20 inches at the beach and less than 50 inches at the backs of the valleys (Giamabelluca et al. 1986). This rainfall pattern is considered typical of leeward valleys in O‘ahu, where rain is minimal at the beach and moderate in the backs of the valleys. This pattern would seem to restrict large agricultural fields and especially irrigation complexes to the upper portions of Mākua and Kahanahāiki Valleys, whereas smaller fields and dryland (unirrigated) complexes would be more appropriate for the lower portions of the valleys.

Prior to historic and modern disturbances of Mākua and Kahanahāiki Valleys, the local vegetation was most likely typical of leeward Hawaiian valleys. Speaking generally of lowland grasslands and shrublands in dry leeward zones, Cuddihy and Stone (1990: 12) offer, "It is likely that endemic annual grasses of the genus *Panicum*, such as *kākonakona* (*P. torridum*), were formerly more important components of dry lowland vegetation, where they probably grew intermixed with native shrubs." Native shrubs may have included *‘a‘ali‘i* (*Dodonaea viscosa*), *‘ākia* (*Wikstroemia* spp.), *‘āweoweo* (*Chenopodium oahuense*), *ko‘oko‘olau* (*Bidens menziesii*), *pūkiawe* (*Styphelia tameiameiae*), *alahe‘e* (*Canthium odoratum*), and low-growing *‘ōhi‘a* (*Metrosideros polymorpha*) (Cuddihy and Stone 1990). The upper portions of Mākua and Kahanahāiki Valleys likely contained more diverse grasses, shrubs, and trees (Cuddihy and Stone 1990).

The local fauna in Mākua and Kahanahāiki consists of birds and rare fruit bats in the forested areas of the valleys, as well as diverse marine life at the coast and in the deep ocean waters off the coast.

US Military Period

Hawai‘i became a territory of the United States in 1898. Many commenters discussed the events of 1893 when the Hawaiian monarchy

was overthrown. PL 103-150, which was a joint resolution issued by the 103d Congress in 1993, "acknowledge[d] the 100th anniversary of the January 17, 1893 overthrow of the Kingdom of Hawai'i, and [offered] an apology to Native Hawaiians on behalf of the United States for the overthrow of the Kingdom of Hawai'i."

Prior to 1941, US military use of the Mākua and Kahanahāiki Valleys was limited to war games at Mākua Beach, as well as the takeover of one *kuleana* parcel (LCA 9052) and two parcels registered to the Territory of Hawai'i for the installation of gun emplacements (Kelly and Quintal 1977).

After the attack on Pearl Harbor in 1941, the US military assumed a defensive posture along the coastlines of all of the Hawaiian Islands, including the placement of barbed wire and pill boxes. In order to prepare Mākua and Kahanahāiki Valleys for simulated battle training, the military arranged to relocate residents from this area.

Pōhakuloa Training Area

PTA is part of a larger cultural landscape that includes the sacred mountains Mauna Kea and Mauna Loa and the Saddle area between them in addition to Mt. Hualalai. Research by Pualani and Edward Kanahele (1999), Kepā Maly (1997, 1999), Holly McEldowney (1982), Charles Langlas (Langlas et al. 1997), and Usha Prashad and Keone Nunes (SRP 2002), among others, has helped to identify some of the factors that make the area spiritually and historically one of the most important places in Hawaiian tradition and history.

The importance of Mauna Kea, Mauna Loa, and the surrounding landscape may be seen in the abundance of physical or archaeological remains and through the many oral histories that describe historical events and uses of the area (Maly 1999). The region around PTA contained a rich resource zone that supported traditional activities that included bird hunting for feathers and meat, quarrying volcanic glass, and lithic workshop locations for manufacturing the adzes made from Mauna Kea basalt. The Saddle region has numerous trails and served as a much-used passage for travelers moving both cross-island and to the Mauna Kea and Mauna Loa summits.

Evidence of occupation in the upland areas of PTA spans a period from the 10th through the 18th centuries. The The Ahu O 'Umi heiau on the slopes of Hualalai south of PTA is said to have been built by a legendary chief 'Umi a Liloa in the early 17th century. This chief and his father, Liloa, are credited with unifying the island and creating the traditional

system of land division. The chilly heights of the Saddle and the peaks are not thought to have been the locations of permanent residences, but many groups routinely exploited the natural resources of the area and also used the region for religious and spiritual reasons.

Cave shelters are abundant due to the extensive natural lava tube systems in the area. These shelters provided refuge from the elements and, because there is relatively low rainfall within the region, they also served as a source of capturing and collection of limited water. Archaeologists speculate that ancient Hawaiians practiced different economic activities in this uplands area. Radiocarbon dating of PTA sites (primarily caves) indicates occupation between the 12th and 18th centuries. Some reports indicate the presence of burials at PTA (Haun 1986; Athens and Kaschko 1989; Reinman et al. 1998). Past archaeological work has also suggested that Native Hawaiians planted sweet potato crops in stony excavated pit areas (Reinman and Schilz 1999), but more recent work supports the hypothesis that excavated pits were used for enhancing bird (petrel) habitat (Hu et al. 1996; Moniz-Nakamura 1999; Williams 2002a, 2002b).

Traditional Activities in the Pōhakuloa Training Area Vicinity

It is considered unlikely that the chilly heights of the Saddle area and above were ever the site of permanent homes, but many people passed through the region in pursuit of the numerous and unique natural resources available. These individuals included bird hunters, and gatherers of various plants and other forest resources, and craftsmen in search of high quality wood and fine quality basalt for adze manufacturing. Lava that cooled quickly on the frigid mountaintop yielded an especially fine-grained form of basalt that could be turned into high quality adzes and other tools in the days before metal was available. Quarry sites were probably workshops, with associated shrines and temporary dwellings located in caves at lower warmer elevations, some of them within PTA.

Craftsmen turned to the high forest when they needed particularly large trees from valuable upland hardwoods such as māmane. According to Kanahele and Kanahele, the upper slopes were considered more sacred than the lower forests and were left alone as much as possible as conservation areas; when one of the larger and more valuable trees was taken, a major offering, often a human sacrifice, was given in return.

Perhaps the most valuable of the traditional forest resources were the birds. Songbirds were snared for their plumes, and seabirds that nest were hunted as food. Participants in early 20th century interviews remembered a variety of bird-catching techniques, from tethering alive ‘io (hawk) next to a trap, to setting tiny nooses alongside lehua blossoms, to snaking a

gummed snare made of ‘ie‘ie vines into a shallow cave to catch ‘ua‘u chicks, a delicacy reserved for the ali‘i. Most techniques required a great deal of finesse and patience and, in the case of the larger birds, strength and speed as well. Natural holes in the lava beds were improved to make them more attractive nesting places. Birds hunted for their feathers were, hunters recalled, released again in viable condition (Reinman et al. 1998a; Moniz-Nakamura 1999).

Cows, sheep, and other ungulates are a post-contact introduction, but as they were released into the uplands and multiplied, hunting them became a pastime and sometimes a living, pursued by Hawaiian and non-Hawaiian alike. For decades, hunting of the wild/feral creatures continued as more structured and privately owned ranching began to grow. Hawaiian participation, both in the wild hunts and in ranching, has become an island tradition in its own right.

People using the upland resources, as well as people traveling cross-island, developed a network of trails in the prehistoric and early historic eras. Some of those trails are now underneath lava flows, others lie under modern roads, and others may be of questionable location and antiquity, but it is clear that a number of trails crossed the Saddle region connecting the various coastal districts around the island with one another. The Ahu a ‘Umi heiau derives some of its importance from its location at the juncture of several of these trails.

The sacredness of the area and Native Hawaiian connection to the Mauna Kea landscape manifests itself in many ways. Oral testimony (Maly 1997) has revealed a number of activities and traditional practices that have been less documented than the ones described above, possibly because they are not as readily reflected in the archaeological or archival record. Some of these practices involve secret family worship, a place of refuge from enemies, and a general sense of the magical deity-inspired restorative and healing power of the higher elevations of Mauna Kea. Prayer and worship are reported to continue to this day (Maly 1997).

Water from Lake Waiau (the small lake on the summit platform of Mauna Kea, described above) is considered sacred and is associated with the god Kåne. Healing power and a spiritual connection is associated with the water, and it is still used by Native Hawaiians. Many generations are reported to have deposited their children’s umbilical cords (piko) into the lake, as well as on the summit peak of Pu‘u o Kukahau‘ula, and this tradition is still practiced by some families (Maly 1997). In addition to reported historic burials, some use Mauna Kea as a place to spread the cremated remains of their deceased loved ones (Maly 1997).

It is likely that in historic times, the landscape and forms of Mauna Kea and Mauna Loa were used as navigation aids both at sea and on land. Mountains to this day are used as physical and emotional benchmarks that help people regain their sense of place. Astronomy, although an important Native Hawaiian traditional component, has not been directly tied to Mauna Kea in the archival record. Because of the "significant association of gods and deity whose forms are seen in the heavens and whose names are also commemorated at locations on Mauna Kea…it is very likely that practices of the native kilo hoku occurred on Mauna Kea" (Maly 1999, 20).

The area of the cloud line is considered wao akua (inhabited by gods and spirits, the creators of life), and as such, the kama ʻaina (children of the land, or natives) have an even greater respect for these higher elevations. Most of the population were commoners, or makaʻāinana, whose daily activities did not involve lands in the wao akua region and were not likely to have visited. However, according to Maly (2004) an elite few, the akua (gods), aliʻi (royalty), or kahuna (priests) of high rank, and the class of specialized practitioners who gathered resources or worshipped in the wao akua and mountain region areas in which they practiced cultural activities made use of natural resources and cared for both natural and cultural resources in the area.

It is difficult to describe the emotional and spiritual link that exists between Native Hawaiians and the natural setting. Hawaiians generally believe that all things in nature have mana, or a certain spiritual power and life force. A custodial responsibility to preserve the natural setting is passed from generation to generation, and personal strength and spiritual well being are derived from this relationship. Because of this belief, Mauna Kea may be the most powerful and sacred natural formation in all Hawaiʻi.

Historic Context

In the late 1800s in the PTA area, the owners of two large ranches competed over the rights to raise cattle and sheep and to hunt feral animals in the Saddle Region. John Parker II held a lease to the Kaohe lands of PTA from before 1876 through 1891. The Waimea Grazing and Agricultural Company leased Humuula east of PTA from Kamehameha III around 1860 to raise sheep and hunt wild cattle for their hides. The company built a wagon road through PTA from its sheep station along the current Saddle Road in Humuula to the harbor at Kawaihae. A portion of this road is still in PTA and to the east (US Army and USACE 2004).

By 1891, the Humuula lease was held by the Hackfield's Humuula Sheep Station Company, which also obtained the lease for the east side of Kaohe. The company built a number of stonewalls. Standing stonewalls in the northeast part of PTA may be the ones referred to in the oral history documents. After 1900, Parker obtained control of the Humuula Sheep Company and controlled most of the saddle. Military use of PTA began in 1942 with the construction of the Kaumana Road (now the Saddle Road, SH200) for access between Hilo and Waimea. The Saddle Training Area, which included BAAF and the PTA cantonment area, was developed later. Most of the cantonment area consists of Quonset huts built between 1955 and 1958 (US Army and USACE).

Hawaiian Homelands

In 1920 the US Congress established the Hawaiian Home Lands Program, which provides a means by which eligible Native Hawaiians can obtain 99-year leases on Hawaiian Home Lands. Hawaiian Home Lands are intended for three purposes: residences, agriculture, and ranching (Department of Hawaiian Home Lands 2003). The Humu‘ula and Pi‘ihonua Hawaiian Home Land parcels, consisting of 52,315 acres (21,171 hectares), are adjacent to PTA's western boundary, and the Kawaihae parcel, consisting of 10,153 acres (4,109 hectares), is on the coast north of KMR.

Military History

Kawaihae Military Reservation is located on fill land built onto the reef of Kawaihae Bay in the ahupua‘a of Kawaihae in the district of South Kohala. From Kawaihae Harbor, the proposed military vehicle trail will extend southward and inland through the other ahupua‘a that make up South Kohala, Kawaihae, and Waimea.

3.10.4 Areas of Traditional Importance

The term ATI is used in this EIS as a broad category encompassing places of traditional cultural importance to native, aboriginal, or local groups. These areas have either been identified through oral testimony or are associated with other cultural or natural components. Some ATI may be formally designated as historic properties. ATI at MMR and PTA may also include cultural landscapes (defined below), properties of traditional religious and cultural importance to a Native Hawaiian group, prehistoric and historic archaeological sites that may include *heiau* (temple complexes) and burial sites, traditional gathering places and traditional use sites, and sites used for subsistence and other cultural purposes. Other natural resources may have cultural significance, although they can be difficult to specify in terms of location and individual physical properties. Exceptions are where springs, ponds, caves, or other natural features are

incorporated into the physical structures of archaeological sites. Other ATI may be specific landforms, such as a mountain peak or large stones that are clearly mentioned in oral traditions.

Executive Order 13007 protects Indian and Native Alaskan sacred sites on federal lands, and the same protections have generally been extended by the Army in Hawai‘i to sites considered sacred by Native Hawaiian organizations. ATI may include sacred sites, although they may not necessarily be the same as properties of traditional religious and cultural importance (PTRCIs), which are defined in Section 3.10.5, and they may or may not be eligible for listing on the NRHP.

As shown in the legends cited above, some areas can derive traditional importance from oral histories that describe ancestral or mythical events, many of which explain how places or landscapes were named or created. These affiliations also illustrate how Native Hawaiian spirituality and religion is intertwined with the land, landforms, plants, water, ocean, sky (cosmology), mountains, and all things natural and supernatural. Native Hawaiian cultural landscapes, discussed below, share many of the same interconnected and difficult to explain qualities and intangible elements in nature and the environment that are significant and sacred to Native Hawaiians but that are generally not readily apparent or objectified by non-Native Hawaiians.

ATI may also be associated with flora and fauna. For example, Native Hawaiians feel a spiritual and even genetic connection to plants, specifically kalo or taro, because it plays a large role in their creation traditions (the Kumulipo). One version of this story describes how Wākea, the sky god, coupled with his daughter, resulting in a stillborn and misshapen male fetus that was buried in the earth on the east side of their house (Enos 1998). From out of the ground where the baby was buried the kalo grew, nourished by the tears of his mother. When Wākea’s daughter became pregnant again, she bore the first male human, named Hāloa. All future Hawaiians would be related to him, and consequently, related to the kalo, the plant that grew out of Hāloa’s stillborn brother.

With such direct links to plant life, much of Hawaiian religion and ceremony is centered around traditions regarding when to sow, fish, harvest, or process natural resources. This focus implies that the definition of “ancestor” to Native Hawaiians includes every water source, geological characteristic, plant, insect, and animal that exists in any given area. It also implies the belief that “Native Hawaiian” extends beyond the human form, encompassing the natural landscape and the physical forms of their gods held within earth, water, plants, and animals.

Given the above, ATI may therefore include more than specific areas where identifiable activities occurred. Because of the interconnected nature of Native Hawaiian beliefs, ATI may also represent links in a chain of places. MMR, for example, fits in the area between Pōkaʻī Bay and Kaʻena Point, which is all sacred land, or *wahi pana.*

Another example of ATI are LCAs, which are land parcels where families engaged in subsistence farming and other activities for a number of generations. Available records for LCAs are sometimes incomplete and may contain contradictory information. Land records indicate that LCAs were apportioned to a number of different families in Mākua and Kahanahāiki in the mid-1800s as *kuleana* claims. Table 3.10-1 lists recorded names of LCA claims in Mākua and Kahanahāiki. These LCA plots, in addition to other recorded parcels, are depicted in Figure 3.9-1.

Archaeological sites may be considered ATI and be evaluated as PTRCIs, especially when their locations coincide with LCAs, religious sites, or other places known from Hawaiian traditions. In this context, most archaeological sites in Mākua and Kahanahāiki may be considered ATI. These sites are listed in Table 3.10-5 at the end of this section and are depicted in Figure 3.10-3.

Native Hawaiian Cultural Landscapes

The Department of the Army has encouraged a cultural landscape approach in its cultural resources management planning strategy. This entails a holistic, integrated analysis of human cultural activity within an ecosystem and that takes into consideration the spatial and cultural relationships between all resources of cultural significance within a landscape.

Federal guidelines recognize four cultural landscape categories, two of which are most relevant for this discussion: historic vernacular landscapes that illustrate peoples' values and attitudes toward the land and reflect patterns of settlement, use, and development over time; and ethnographic landscapes associated with contemporary groups that are typically used or valued in traditional ways (Stoffle et al. 1997).

Table 3.10-1
Summary of LCAs in Mākua and Kahanahāiki

‘ahupua‘a	LCA #	Claimant	Location	Acres
Mākua	9750	Hoewaa	Haunouli	14.931
	(4)236-K	Kalama	Haunouli	3.136
	9709:1	Kuli	Haunouli	0.35
	9709:2	Kuli	Kaawa	14.62
	9054	Kaawa, for Manua	Kalena	18.06
	6123	Napuupaa	Kamakaakuholu	8.889
	9052:1	Kahueai	Koahai	10.26
	9052:2	Kahueai	Kaohai	0.41
	9706:1	Kauhi	Ko‘iahi	10.26
	9706:2	Kauhi	Kaolekea	0.694
	9706:3	Kauhi	Kihanau	0.38
	9707:1	Puiwa	Kihanau	ca. 6.13
	9707:2	Puiwa	Kihanau	ca. 0.2
	9053	Keolohua	Kulaelawa	12.92
Kahanahāiki	5556:1	Kalauli	Kapalai	ca. 3.3
	5556:2	Kalauli	Kapalai	ca. 0.3
	5565	Kamaka	Kahaniki	23.94
	5667:1	Kaheana	Keawioe	12.24
	5667:2	Kaheana	Keawioe	0.29
	9055:1	Kanae	Keawioe	ca. 9.94
	9055:2	Kanae	Keawioe	ca. 0.2
	6134:1	Nika, for Kalua	Kahaniki	ca. 1.87
	6134:2	Nika, for Kalua	Kahaniki	ca. 0.2
	6092:1	Moo	Kahaniki	6.832
	6092:2	Moo	Kahaniki	3.9

Source: Zulick and Cox 2001

National Park Service (NPS) Cultural Resource Management Guidelines describe cultural landscapes as complex resources that range from rural tracts to formal gardens, further defined by the way the land is organized and divided, settled, and used, including the types of structures that are built on it (Stoffle et al. 1997). Natural features, such as landforms, soils, and vegetation, provide the framework within which the cultural landscape evolves. In its broadest sense, a cultural landscape is a reflection of human adaptation to and use of natural resources (Stoffle et al. 1997).

It is difficult to define using the English language what cultural landscapes mean to Native Hawaiians, and it has become evident that labeling and evaluating geographic units that are usually loosely defined and based on interdependent and intermingled cultural traditions presents only a part of the overall picture. Although a number of different terms may be used to describe these cultural areas, the term “cultural landscape” is used here

because it is widely understood and has official standing in federal cultural resources compliance.

Native Hawaiian cultural landscapes may consist of culturally specific components reflecting Native Hawaiian spiritual, religious, and cultural values. In *Kalo Kanu o Ka ʻĀina*, a report on the cultural landscape for Keʻanae and Wailua Nui, five somewhat overlapping types of sites were identified (McGregor 1998). These categories (after McGregor 1998) necessarily reflect the importance of culturally significant natural resources, in addition to human-made archaeological sites, and are as follows:

- Areas of naturally occurring or cultivated resources used for food, shelter, or medicine;
- Areas that contain resources used for expression and perpetuation of Hawaiian culture, religion, and language;
- Places where known historical and contemporary religious beliefs or customs are practiced;
- Areas where natural or cultivated endangered terrestrial or marine flora and fauna used in Native Hawaiian ceremonies are located, or where materials for ceremonial art and crafts are found; and
- Areas that provide natural and cultural community resources for the perpetuation of language and culture, including place names and natural, cultural, and community resources for art, crafts, music, and dance.

Cultural landscapes have not been formally evaluated at MMR nor at PTA. Landscapes that are connected to Native Hawaiian culture as described above are considered ATI.

Traditional Place Names

Traditional Hawaiian place names are important culturally, not only for their sometimes poetic and philosophical description of the landscape but also for their reflection of historical events that took place at certain locations. The naming of the landscape in Mākua and Kahanahāiki and in the PTA vicinty is an example of traditional Hawaiian values and perceptions of the natural environment. Locations and areas that correspond to traditional place names may be considered ATI. Table 3.10-2 lists traditional place names in Mākua and Kahanahāiki. The 2004 SBCT EIS, Appendix J-2 contains a list of traditional place names associated with Pōhakuloa.

Table 3.10-2
Summary of Traditional Hawaiian Place Names in Mākua and Kahanahāiki

Place-Name	Comments	Source
Halemōhalu	A swimming spot at Mākua Beach	Walter Kanana in scoping comments 4/9/02
Haunouli or Haumoli	An ʻili in lower Mākua Valley; an area on Mākua shore between Punapōhaku Stream and Kaiahi Gulch	Tuggle 1997:20, 21
Kaʻaʻawa or Kaʻawa	An ʻili in lower Mākua Valley, just south of Kaiahi Gulch	Tuggle 1997:20, 21
Kaʻaukea	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kahanahāiki Stream	Now referred to as Punapōhaku Stream	Tuggle 1997:21
Kahapapa	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kahauaiki	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kalena	An ʻili in lower Mākua Valley, *mauka* of Farrington Highway and south of Kahanahāiki Stream	Tuggle 1997:20, 21; Kelly 1977:App. B
Kamakaʻakuholu	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kaohai	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kaolekea	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kapahu	A possible ʻili in lower Mākua Valley	Tuggle 1997:20
Kapalai	An ʻili in lower Mākua Valley	Tuggle 1997:20
Keaukea	Area on Mākua shore between Punapohaku and Kahanahāiki streams	Tuggle 1997:21
Keawaioe	An ʻili in lower Mākua Valley	Tuggle 1997:20
Kihanau	An ʻili in lower Mākua Valley between Kahanahāiki and Koʻiahi streams	Tuggle 1997:20, 21
Koʻiahi	Referred to in this EIS as Kaiahi Gulch. An ʻili in Mākua Valley, a gulch or small valley, a stream.	Pukui et al. 1974:115 Sterling and Summers 1978:84 Sterling and Summers 1978:84 Tuggle 1997:20, 21
Kōlealea, also Kolelea, Koleleʻa	The north end of Mākua Beach, fronting Kahanahāiki	Tuggle 1997:20; Clark 1977:97 Kelly 1977:interview (int) #2
Kuaiwa	A possible ʻili in lower Mākua Valley	Tuggle 1997:20
Kulaelawa	an ʻili in lower Mākua Valley, *mauka* of Farrington Highway and north of Kahanahāiki Stream	Tuggle 1997:20,21

Table 3.10-2
Summary of Traditional Hawaiian Place Names in Mākua and Kahanahāiki

Place-Name	Comments	Source
La‘ihau, also La‘iehau	• Coastal portion of Kahanahāiki • On the north side of Waihoe Stream • Where the Honolulu telephone company building used to be • May have been an ‘ili • There was lots of water at La‘ihau	• Kelly 1977:int#14 • ISD 1998:91 • Kelly 1977:int#3 • Tuggle 1997:20 • Kelly 1977:int#3
Lamaloa	A stream in Kahanahāiki by the site of the old McCandless house: “that’s the main stream where all the water comes into one.”	Kelly 1977: App. B, int#1
Mākua to Kawaihapai trail		Sterling and Summers 1978:84, 3
Manuhi	A possible ‘ili in lower Mākua Valley, *mauka* of Farrington Highway and south of Punapohaku Stream	Tuggle 1997:20, 21
Mo‘o Puna Wai	“It’s a hole in here, on the side of a little hill. You can’t see it unless you crawl in.”	ISD 1998:110
Nāmāhana	North end of Mākua Beach	Pukui et al. 1974 Tuggle 1997:20; Clark 1977:97 Kelly 1977:int#2
Pakalana	An ‘ili in lower Mākua Valley, just north of where Farrington Highway meets Ko‘iahi Stream	Tuggle 1997:20, 21
Papahānaumoku	A swimming spot at Mākua Beach	Walter Kanana in scoping comments 4/9/02
Papaloa	A reef off Mākua Beach, reputed to have a cave underneath it with air	Pukui et al. 1974, Clark 1977; Kelly 1977:int#2
Po‘ohūnā	Eastern point of Mākua Beach headland south of Mākua Beach	Clark 1977 Tuggle 1997:20
Po‘ohuna or Loko Pu‘uone	A dune pond	ISD 1998:110
Pōhaku-kū-la‘ila‘i (also Kūla‘ila‘i or Pōhaku Kūla‘ila‘i)	• Where the mo‘o lived in the stream • A big rock by the blowhole near Kāneana Cave, where the legendary mo‘o and the shark would meet. • This is on the beach now known as Pray for Sex Beach	• Kelly 1977:int#2 • Kelly 1977:int#4,2; Clark 2002:297
Pōhakuokūmaile	A possible ‘ili in lower Mākua Valley	Tuggle 1997:20

Table 3.10-2
Summary of Traditional Hawaiian Place Names in Mākua and Kahanahāiki

Place-Name	Comments	Source
Puʻu Paʻi (also Puʻupai, Hapu pai, Poʻopaʻi)	• A place inside Mākua Valley; a flat place, in the back of the valley, good for farming; "Kupuna lived way up there." There was a song written about this place, but the song wasn't finished. John Naiwi (a major Mākua Valley figure) lived there until sometime after his first child was born, when he moved down near the shore. "When you get to the cemetery, you look right into that valley that's Koʻiahi. That's Puʻupai on top, flat; where the helicopters land on top." You can see it from the beach. It was next to a stream. • It was once densely populated	• Kelly 1977: text p36 and interviews 1, 2, 4, 12, 15, • Clark 1977:96
Puna	• The white rock	• Kelly 1977:int#2
Pōhaku/Punapōhaku	• A place somewhat inland • An ʻili and stream in lower Mākua Valley	• Kelly 1977:App. B • Tuggle 1997:20,21
Puʻupai		Kelly 1977:App. B
Waikomo	Part of Mākua Beach. Meaning: entering water a point	Pukui et al. 1974:224
Pukano		Kelly 1977:int#2
Kāneana cave		Clark 1977:233 Pukui et al. 1974:84 Sterling and Summers 1978:82 Sterling and Summers 1978:81

3.10.5 Properties of Traditional Religious and Cultural Importance

The NHPA, Section 101(d)(6)(A), specifies that properties of traditional religious and cultural importance (PTRCI) to Native Hawaiian organizations may be determined eligible for inclusion in the NRHP and directs federal agencies to consult with Native Hawaiian organizations to identify and evaluate such properties. NPS Bulletin 38 provides nonbinding guidance on this statutory provision and created the term traditional cultural property (TCP) for these sites.

The NPS defines TCPs as properties that at a minimum are "eligible for their inclusion in the (NRHP) because of (their) association with cultural practices or beliefs of a living community that (a) are rooted in the community's history and (b) are important in maintaining the continuing cultural identity of the community" (Parker and King 1990:1).

Figure 3.10-2 shows archaeological resource features at MMR.

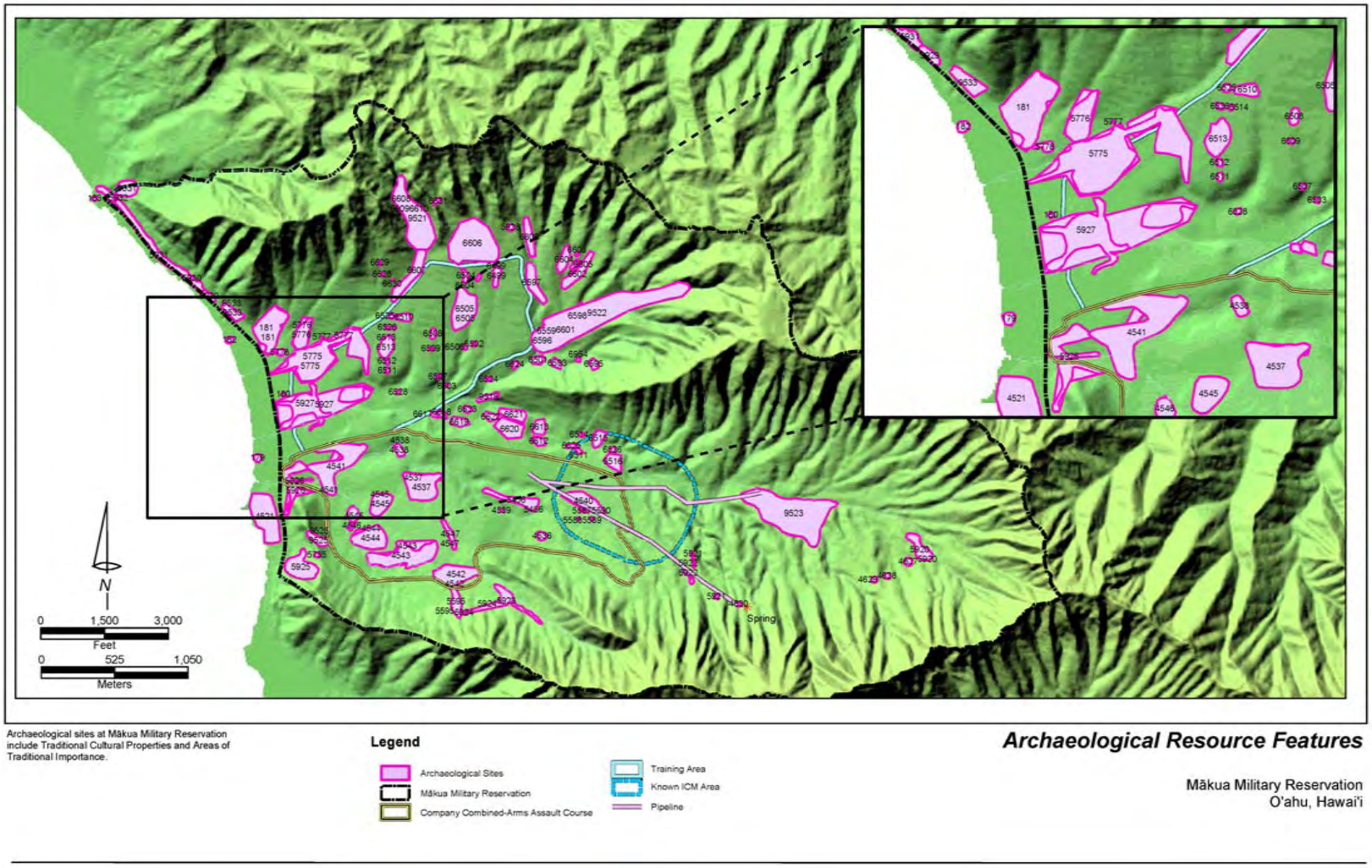

Figure 3.10-2 Archaeological Resource Features, MMR

Studies, including surface and subsurface surveys, archival research, and oral interviews, have identified a number of ATI, as discussed above, that may be eligible as PTRCIs. The process for determining if identified ATI are eligible as formal PTRCIs includes consultation among USARHAW, the SHPO, Native Hawaiian organizations, and other interested groups and individuals, including but not limited to those listed in the Ukanipo *Heiau* Programmatic Agreement. The Army treats all cultural resources as eligible for the NRHP until they have been formally assessed for eligibility. Some areas that cannot be surveyed due to unexploded ordnance or other safety concerns may contain cultural resources. The Army conducts additional archaeological investigations whenever possible. The areas that could be directly affected by the proposed training at MMR have been surveyed, and the identified sites are being protected. A large portion of the area outside of the CALFEX footprint but which is included within the ROI has been surveyed (see Figure 3.10-3 *(now B-68 in ICRMP)*).

3.10.6 Archaeological Surveys and Sites Mākua Military Reservation

Although several access roads, firebreak clearings, target constructions, and gun emplacements have been established at MMR during the period of US military use, the archaeological investigations conducted since the 1970s indicate that many of the archaeological sites, features, and deposits dating to the pre-Contact era have survived in good to excellent condition.

Table 3.10-3 lists the archaeological sites so far documented in Mākua and Kahanahāiki, and Figure 3.10-2 shows the locations of the sites. Table 3.10-2 also lists the reports and documents where the sites are described in more detail.

The first archaeological survey s for Mākua and Kahanahāiki concentrated on *heiau* and other prominent monuments (McAllister 1933; Thrum 1906, 1938). These initial studies recorded site locations, noted major salient characteristics, and made brief mention of known traditions pertaining to sites.

At the time of Thrum's survey, he described Ka'ahihi or Kahana'ike *Heiau* (Site 50-80-03-0180) in "ruins," Kumuakuopio or Kuopio *Heiau* (Site 50-80-03-0178) as mostly destroyed with "little now in evidence," and Kanaloa *Heiau* (site number unknown) as "now entirely destroyed" (1906:46). At the time of McAllister's survey, he described the fishing shrine of Site 50-80-03-0179 as partially destroyed (McAllister 1933). Ukanipō *Heiau* (Site 50-80-03-0181), a swimming pool (Site 50-80-03-

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
0177	Cave	Undetermined, Kāneana or Mākua Cave	Prehistoric	Not evaluated	McAllister (1933: 123)
0178	Surface architecture no longer exists,* but petroglyphs are present	Religious site, Kumuakuopio or Kuopio *Heiau*	Prehistoric	Not evaluated	McAllister (1933: 123); Rosendahl (1977: 2-22); Thrum (1906: 46; 1938: 136)
0179	Surface architecture no longer exists*	Fishing shrine	Prehistoric	Not evaluated	McAllister (1933: 123); Rosendahl (1977: 2-22); Tuggle (1997: 23-26)
0180	Most of the surface architecture no longer exists,* but some wall segments are present	Religious site, Ka‘ahihi or Kahana‘ike *Heiau*	Prehistoric	Not evaluated	McAllister (1933: 123); Rosendahl (1977: 2-22); Thrum (1906: 46; 1938: 135)
0181	multi-stepped terrace with several surrounding structures	Religious site, Ukanipō *Heiau*; also surrounding agricultural activities	Prehistoric	Listed 8/13/82	Cleghorn et al. (2002: 8-26, 62-65); Hommon (1980: 7-40) McAllister (1933: 124-125); Rosendahl (1977: 2-22); Thrum (1906: 46; 1938: 138)
0182	Pool of water with artificial modifications that have been altered by cattle ranching constructions*	Swimming pool	Prehistoric	Not evaluated	McAllister (1933: 124); Rosendahl (1977: 2-22)
0183	surface architecture no longer exists*	Fishing shrine, Pua‘akanoahoa Ko‘a	Prehistoric	Not evaluated	McAllister (1933: 124); Rosendahl (1977: 2-22)
0184	Cave, possibly in Keawa‘ula and not necessarily in Kahanahāiki	Undetermined, Poha Cave	Prehistoric	Not evaluated	McAllister (1933: 124); Rosendahl (1977: 2-23)
4536	terrace, wall, and well	Agricultural and livestock	Prehistoric and historic	D	Eblé et al. (1995: 7-1 to 7-5, 13-1 to 13-3)
4537	Terrace/wall, walls, and mounds	Agricultural	Prehistoric and historic	D	Eblé et al. (1995: 7-6 to 7-10, 13-1 to 13-3)
4538	enclosures and concrete pad	Military	Historic	D	Eblé et al. (1995: 7-10 to 7-11, 13-1 to 13-3): Zulick and Cox (2001: 38)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
4539	Wall	Undetermined	Undetermined	Not eligible	Eblé et al. (1995: 7-10 to 7-13, 13-1 to 13-3)
4540	Terraces, walls, enclosures, mounds, and one double-stepped platform	Habitation, probable agriculture, and ritual	Prehistoric and historic	a, c, d	Eblé et al. (1995: 7-13 to 7-22, 13-1 to 13-3); Williams and Patolo (2000: 47-63, 77-79)
4541	walls, enclosures	Habitation and agriculture	Historic	D	Eblé et al. (1995: 7-22 to 7-25, 13-1 to 13-3); Zulick and Cox (2001: 36-37)
4542	Terraces, enclosures, walls, mounds, cupboards, platform, and stacked stones	Habitation, agriculture, and ritual	Prehistoric and historic	D	Eblé et al. (1995: 7-26 to 7-38, 8-1 to 8-6, 13-1 to 13-3); Zulick and Cox (2001: 38-44)
4543	Enclosures, walls, mounds, terraces, and pits	Habitation and agriculture	Prehistoric and historic	D	Eblé et al. (1995: 7-39 to 7-47, 8-6 to 8-9, 13-1 to 13-3)
4544	Enclosures, alignments, terraces, mounds, and two petroglyphs	Habitation and agriculture	Prehistoric and historic	D	Eblé et al. (1995: 7-47 to 7-53, 8-9 to 8-11, 13-1 to 13-3); Zulick and Cox (2001: 45-48)
4545	Mounds and one wall	Habitation and agriculture	Prehistoric and historic	D	Eblé et al. (1995: 7-53 to 7-55)
4546	Enclosures, walls, and mound with upright stone	Religious site	Prehistoric	a, c, d	Eblé et al. (1995: 7-55 to 7-56, 13-1 to 13-3); Williams and Patolo (2000: 40-47, 77-79)
4547	Mounds and a wall	Agriculture	Prehistoric and historic	D	Eblé et al. (1995: 7-56, 13-1 to 13-3)
4627	Mounds, terraces, and one enclosure	Agriculture	Undetermined	D	Carlson et al. (1996: 15-17, 24)
4628	Mound with a cupboard	Undetermined	Undetermined	Not evaluated	Carlson et al. (1996: 15, 24)
4629	stone mounds	Undetermined	Undetermined	Not evaluated	Carlson et al. (1996: 15, 24)
4630	Terraces, wall, and alignment	Habitation	Historic	D	Carlson et al. (1996: 15-19, 24); Zulick and Cox (2001: 64-67)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
5456	Subsurface pits	Cooking and undetermined	Prehistoric	Not evaluated	Williams and Patolo (2000: 19-40, 79)
5587	Enclosures, terrace, and mound	Habitation	Undetermined	D	Williams and Patolo (2000: 63-65; 77-79)
5588	Terrace	Habitation	Undetermined	D	Williams and Patolo (2000: 65, 77-79)
5589	Terrace and platform	Habitation or workshop	Undetermined	D	Williams and Patolo (2000: 65-66, 77-80)
5590	Terrace, mound, and boulder with artificial markings	Habitation and ritual	Undetermined	a, c, d	Williams and Patolo (2000: 66-70, 77-80)
5595	Wall and enclosure	Livestock	Historic	Not evaluated	Zulick and Cox (2001: 74)
5734	Enclosure	Habitation	Undetermined	Not evaluated	Zulick and Cox (2001: 166-167)
5735	Scatter of basalt artifacts	Workshop	Prehistoric	Not evaluated	Zulick and Cox (2001: 166-167)
5775	Enclosures, terraces, walls, mounds, alignments, modified outcrop, platform, and one mound with a crypt and possibly burials	Habitation, agriculture, and ritual	Prehistoric	D	Cleghorn et al. (2002: 28-41, 62-65); Zulick and Cox (2001: 126-147)
5776	Walls, terraces, mounds, and enclosures	Habitation, agriculture, ritual, and livestock	Prehistoric and historic	D	Cleghorn et al. (2002: 41-58, 62-67)
5777	Mound	Religious site	Prehistoric	D	Cleghorn et al. (2002: 58, 62-67)
5778	Enclosures, mounds, terraces, wall, pit, and platform	Ritual	Prehistoric	D	Cleghorn et al. (2002: 26-27, 62-65)
5920	mounds, terraces	Agriculture and ritual	Undetermined	Not evaluated	Zulick and Cox (2001: 61-62, 154-156)
5921	Mounds, alignment, and terrace	Agriculture	Undetermined	Not evaluated	Zulick and Cox (2001: 67-70)
5922	Mound, modified outcrop, and alignments	Agriculture	Undetermined	Not evaluated	Zulick and Cox (2001: 71-73)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
5923	Walls, enclosures, platforms, mounds, alignments, terrace, modified boulder, upright boulder, and pit feature	Habitation and agriculture	Historic	Not evaluated	Zulick and Cox (2001: 74-75, 77-98)
5924	Alignments	Agriculture	Undetermined	Not evaluated	Zulick and Cox (2001: 92)
5925	Walls	Agriculture	Undetermined	Not evaluated	Zulick and Cox (2001: 99-101)
5926	Walls, well, alignment, upright slabs, and petroglyph	Habitation, agriculture, and ritual	Undetermined	Not evaluated	Zulick and Cox (2001:102-114)
5927	Walls, alignment, and enclosure	Agriculture	Historic	Not evaluated	Zulick and Cox (2001: 115-122)
5928	wall	Agriculture	Undetermined	Not evaluated	Zulick and Cox (2001: 151-152)
5929	Bunker, gun emplacement, Platforms, wall, path	Military	Historic	Not evaluated	Zulick and Cox (2001: 152-154)
5930	platforms	Habitation	Undetermined	Not evaluated	Zulick and Cox (2001: 155-158)
5931	Wall	Undetermined	Undetermined	Not evaluated	Zulick and Cox (2001: 159)
5932	Trail	Transportation	Undetermined	Not evaluated	Zulick and Cox (2001: 159-163)
9518	Trail	Transportation, Mākua Mountain Trail	Undetermined	Not evaluated	Rosendahl (1977: 2-23)
9519	Multiple features	Habitation, Keawa‘ula Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)
9520	Walls, enclosures	Habitation, Punapohaku Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)
9521	Terraces	Agriculture, Punapohaku Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)
9522	Terraces, walls	Habitation, Kahanahāiki Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)
9523	Multiple features	Habitation, Mākua Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
9524	Multiple features	Habitation, Koʻiahi Gulch Complex	Historic	Not evaluated	Rosendahl (1977: 2-23)
9525	Wall	Undetermined, Koʻiahi Gulch Wall	Historic	Not evaluated	Rosendahl (1977: 2-24)
9526	Multiple features	Habitation, Mākua Historic Occupation Complex	Historic	Not evaluated	Rosendahl (1977: 2-24)
9533	Terrace	Habitation, Kahanahāiki Platform	Historic	Not eligible	Hommon (1980: 41-46); Rosendahl (1977: 2-24)
6499	Terraces, mounds, and wall	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6500	Multiple features	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6501	Multiple features	Agriculture, ceremonial	Prehistoric	D	Roberts and Robins (2003)
6502	Mound	Agriculture, land clearing	Prehistoric	D	Roberts and Robins (2003)
6503	Terrace and wall	Possible habitation	Prehistoric	D	Roberts and Robins (2003)
6504	Walls and enclosures	Agriculture, military	Prehistoric and modern	D	Roberts and Robins (2003)
6505	Enclosures, mounds, terraces, platform, and petroglyph	Agriculture, habitation, possible burial, and military	Prehistoric and modern	D	Roberts and Robins (2003)
6506	Terraces and wall	Ceremonial	Prehistoric	D	Roberts and Robins (2003)
6507	Wall	Dam	Historic	D	Roberts and Robins (2003)
6508	Mound and terrace	Possible burial, ceremonial	Prehistoric	D	Roberts and Robins (2003)
6509	Enclosure and terrace	Habitation	Prehistoric	D	Roberts and Robins (2003)
6510	Enclosure and mound	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6511	Mounds and terrace	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6512	Terraces	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6513	Enclosures, terraces, and walls	Habitation, agriculture, and military	Prehistoric and modern	D	Roberts and Robins (2003)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
6514	Enclosure	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6525	Enclosure	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6526	Enclosure	Agriculture	Prehistoric	D	Roberts and Robins (2003)
6527	Enclosure	Possible habitation	Prehistoric	D	Roberts and Robins (2003)
6528	Mounds	Possible burial	Undetermined	D	Roberts and Robins (2003)
Sites Discovered Following the July 2003 Wildfire					
6593	Complex	Petroglyph/agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6594	Mound	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6595	Complex	Ceremonial; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6596	Complex	Habitation; petroglyph; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6597	Complex	Habitation; petroglyph; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6598	Complex	Habitation; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6599	C-shape	Habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6600	Complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6601	Enclosure	Habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6602	Complex	Habitation; ceremonial; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6603	Complex	Habitation; petroglyphs; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6604	Complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
6605	Complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6606	Complex	Habitation, possible burial, agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6607	Complex	Habitation; ceremonial; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6608	Enclosure	Possible imu	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6609	Wall	Cattle wall	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6610	Complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6611	Complex	Habitation; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6612	Complex	Habitation; agriculture; boundary	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6613	Complex	Habitation; petroglyph	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6614	Complex	Habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6615	Complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6616	Complex	Habitation; petroglyph; agriculture; boundary	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6617	Complex	Habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6618	Complex	Habitation; possible burials	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6619	Wall	Boundary	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6620	Complex	Boundary; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6621	Complex	Habitation; possible burial, animal pen, petroglyph, boundary	Pending evaluation	Pending evaluation	Roberts and Robins (2003)

Table 3.10-3
Summary of Identified Archaeological Sites in the Mākua and Kahanahāiki Valleys

Site # 50-80-03-xxxx	Description	Probable Function	Probable Age	NRHP Eligibility	Reference
6622	Mound	Possible burial	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6623	Complex	Habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6624	Mounds	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6625	Terraces	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6626	Mound complex	Agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6627	Concrete structure	Gun emplacement	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6628	Complex	Ceremonial; possible habitation	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6629	Complex	Ceremonial	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6630	Complex	Habitation; agriculture	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
6631	Wall	Cattle wall	Pending evaluation	Pending evaluation	Roberts and Robins (2003)
New Sites/Unrecorded Areas Discovered During the 2006 Subsurface Testing					
Area 2b West of Elk	Rock retained soil terraces and remnant mounds	Unknown	Pending evaluation	Pending evaluation	US Army 2007a
Area 2c North of Elk	Three mounds and other features	Unknown	Pending evaluation	Pending evaluation	US Army 2007a
Area 2d South of Elk	*Kiawe* fence post with wire fencing	Historic; ranching	Pending evaluation	Pending evaluation	US Army 2007a

*Where surface architecture no longer exists, the sites remain important for their possible sub-surface contents, and the locations also remain important for cultural value and scientific information.

NRHP Eligibility — The specific criterion used for recommendation for the National Register of Historic Places.

0182), and one fishing shrine (Site 50-80-03-0183) were presumably in fair to good condition, as were Kāneana or Mākua Cave (Site 50-80-03-0177) and Poha Cave (Site 50-80-03-0184) at the time of these initial surveys.

In 1977, the Army commissioned a survey to identify archaeological sites in all training ranges in O‘ahu. The resulting report (Rosendahl 1977) listed 19 archaeological sites at MMR. In addition to the previously identified archaeological sites, Rosendahl (1977) recorded the presence of a trail, systems of walls, habitation complexes, and agricultural complexes in the valleys of Mākua and Kahanahāiki. Most of the newly recorded sites appeared to include late pre-Contact or early post-Contact era components.

In 1980, an archaeological investigation resulted in detailed surface mapping of Ukanipō *Heiau* (Site 50-80-03-0181) and the Kahanahāiki Terrace Complex (Site 50-80-03-9533) (Hommon 1980). Based on the information from this work, Ukanipō *Heiau* (Site 50-80-03-0181) was listed on the NRHP in August 1982.

In 1985, consultation with the Hawai‘i SHPO concluded that the development of the CCAAC would have no significant effect on cultural resources. This conclusion was based on the findings of the Rosendahl (1977) survey.

In 1992, an archaeological reconnaissance survey was conducted for a portion of the proposed firebreak road in the upper valley area of MMR. This survey was limited to the firebreak road corridor, measuring approximately 17,754 feet (5,380 meters) long by 49.5 feet (15 meters) wide. The resulting report (Carlson et al. 1996) identified several habitation and dryland agricultural features that likely functioned in the past as parts of a larger system. Some areas were mapped in detail, but heavy vegetation and inaccessibility prevented complete recording in other areas.

Also in 1992, an archaeological reconnaissance survey was conducted in 477 acres (197 hectares) of the lower valley portion of MMR. The survey report (Eblé et al. 1995) recorded 153 features of 12 separate sites. The features included stone terraces and retaining walls, basalt cobble walls, stone mounds, enclosures, C-shaped enclosures, stone platforms, and fire pits. Limited subsurface testing was also conducted at a sample of the identified surface features. Based on the results of this work, training target fans have been adjusted to avoid potential direct fire damage near Site 50-80-03-4544.

This survey report (Eble' et al. 1995) included a surface survey of the entire area inside the south firebreak road, to include the portion later restricted because of ICM. This is reflected in Figure 3.10-1.

In 1994 and 1995, archaeological monitoring and surveys were conducted for the proposed CCAAC modifications. The resulting report (Williams and Patolo 2000) documented five previously unrecorded archaeological sites. The data from these sites suggest agriculture, habitation, and religious activities in the middle elevations of Mākua Valley. At Site 50-80-03-5456, archaeological excavation of seven of ten imu (earth ovens) confirmed a pre-Contact date for the past use of this area. Based on the results of this work, the Objective Elk mortar target was moved to avoid direct fire damage near Site 50-80-03-5456.

In 1998, a fire started off the reservation and subsequently burned 105 acres (42 hectares) in Kahanahāiki Valley. In 1998 and 1999, an archaeological survey was conducted in the burned area. The survey report (Cleghorn et al. 2002) provided detailed maps of four archaeological sites associated with the Ukanipō *Heiau* complex. The information from the survey was incorporated into a programmatic agreement (PA) for the cooperative management of Ukanipō *Heiau,* signed in October 2000.

In 2000, an archaeological survey of MMR was undertaken by the Environmental Division of the Army Directorate of Public Works. The survey report (Zulick and Cox 2001) verified the locations of previously recorded sites and also identified several previously unrecorded sites. The newly recorded sites included stone alignments, walls, platforms, mounds, enclosures, a trail, and a petroglyph. The resulting data have been incorporated in a geographic information system database.

Roberts and Robins (2003) completed three surveys: 1) conducted after the Kahanahāiki prescribed burn in October 2002, which yielded newly discovered sites; 2) following the July 2003 prescribed burn; and 3) subsurface survey of selected archaeological sites in the Mākua Valley in November and December 2003.

The Archaeological Subsurface Survey (US Army 2007a), found at Appendix G-9 of the EIS, shows areas that have been the subject of subsurface archaeological survey. The project's objective was to determine a presence or absence of cultural deposits where no surface features are discernible. The report was based on a plan for 350 sample probes and excavated 277. Figure 3 of the report shows the location of test probes. 73 probes could not be executed for various reasons (US

Army 2007a, section 2.3). Two hundred additional probes were executed along roads before the area in question was cleared in a controlled burn. The study found two probes that had the potential for intact cultural deposit. One had no cultural deposit and the other had two fire-affected mammal bones. The study also found several previously unrecorded surface features.

The survey looked at the entire area inside the south firebreak road of MMR, with limited exceptions. These were areas that already had archaeological sites and therefore had already been sampled; the improved conventional munitions area (which was too dangerous to sample); and a small area at the southeast edge of the firebreak area. These areas are shown in enclosure 2 of the 2007 published survey. The small area to the south of the ICM exclusion area has not been subject to subsurface archeological survey. This was for many reasons, but primarily because it was marked as off-limits due to the presence of ICMs. The ICM warning signs are posted on the roads to the south and west of the site. They were posted on the roads because signs posted at the actual boundary of the ICM area could be obscured by plant growth, and people could unsuspectingly walk by them into the dangerous area. The road serves as an easy-to-recognize boundary. In addition, this area is very steep and would be hard to survey other than visually. The area is heavily vegetated and includes trees that form a canopy over the firebreak road. This means that a controlled burn would not be likely to clear the area because of the increased natural moisture retention. It also means that it is possible any attempted burn could jump the firebreak road into the tree canopy and impact the nearby Okilolo Ridge area, where there are endangered plants.

There is also a dispute about the legitimacy of the Army's sampling methodology as shown in the letter from Dr. Thomas Dye. The Army responded to these comments and these responses are included immediately after the report. There were also questions about what should have been done when sampling units could not be excavated. Dr. Dye would have preferred that there had been surplus random numbers. Finally, there was a question about whether the road samples in one area identified by Dr. Dye were adequate. This question appears to be based on a misunderstanding, because the planned survey was completed in this area after a controlled burn allowed it to proceed. Despite these issues, the report met the requirements of the settlement agreement. Taken in conjunction with all of the previous archaeological studies, the report provides sufficient information about the affected environment to allow a decision-maker to make conclusions about the proposed action. The subject report, *Archeological Subsurface Survey Within The Company Combined Arms Assault Course (CCAAC) Circumscribed By The South*

Firebreak Road (USARHAW 2007a), is included as Appendix G-9 to this EIS. Revised comment responses are found as Appendix M.

The treatment of identified cultural resources inside MMR is discussed in Section 3.10.8 under Current Management Actions.

At present, significant evaluations to determine if the sites are NRHP eligible are continuing for the archaeological sites inside MMR.

As seen in the inset of Figure 3.10-2, the locations of LCAs at MMR, or *kuleana* plots, have a positive correlation with the locations of archaeological remains. This correlation suggests that at least a portion of the archaeological landscape reflects traditional Hawaiian patterns of land use in the 1800s. However, the continued use of sites over several generations would imply that the original dates of the sites are considerably older.

A review of historic maps reveals two branches of a water pipeline issuing from sources near the back of Mākua Valley at least as early as 1912 (see Figure 3.10-2). One source appears to be associated with historic archaeological site 9523. The other source is a spring associated with Site 4630 and also LCA 9706-2. This correlation emphasizes the importance of freshwater springs in the area. The pipeline appears to deliver to LCA 9708.1, also associated with LCA 6123.

Direct links between archaeological sites and specific ATI are often unclear, but a link is expected in some cases for the sites in Mākua and Kahanahāiki. Certainly, Ukanipō *Heiau* (Site 50-80-03-0181) is a good example of an archaeological site that is also identified as a traditional cultural property. Other identified archaeological sites also have important cultural values as locations where Hawaiian ancestors lived, worked, worshipped, or engaged in other activities.

Pōhakuloa Training Area Previous Surveys

The sections below discuss briefly the status of knowledge concerning cultural resources at PTA. This include areas where survey has occurred and known prehistoric and historic resources in addition to ATI. In the 1970s the Army commissioned a survey of cultural resources at PTA (Rosendahl 1977). Since the 1980s, many archaeological studies have been conducted at PTA, mostly for regulatory compliance (e.g., Cox 1983; Haun 1986; Hommon and Ahlo 1983). Other studies at PTA include Athens and Kaschko (1989), Reinman and Schilz (1993, 1994, 1999), and Streck (1985, 1986, 1990). Surveys in the northern section of PTA include those of Barrera (1987), Kalima and Rosendahl (1991), and Welch (1993),

among others. A biological inventory of cave and lava tube systems within PTA recorded cultural resources at the cave entrances and within the underground system (Pearthree, Stone, and Howard 1994). GANDA has completed additional survey work, including surveying potential SBCT project areas, training areas 1, 3, 4, 5, and 21, and potential Stryker maneuver areas north of the cantonment area (GANDA 2002a, 2003d).

There have been many archaeological investigations of the lands traversed by the PTA Trail corridor, including Barrera and Kelly (1974), Clark (1981), Hammatt and Shideler (1989), Hammatt et al. (1988), Langlas et al. (1997), Clark and Kirch (1983), Clark (1987), and Soehren (1980). Cox (1983) conducted a reconnaissance of the military vehicle trail between Kawaihae Harbor and PTA.

Most of the early archaeological surveys at PTA took place in the west and southwest portions of the training area along or off Bobcat Trail. In 1985, PHRI conducted a survey of the Bobcat Trail Habitation Cave Site and the surrounding kīpuka (Haun 1986), and, in 1987, Athens and Kaschko (1989) surveyed the heavily forested and (at the time) undeveloped region of the Multi-Purpose Range Complex (MPRC). In 1992, Ogden revisited the MPRC and conducted data recovery excavations of sites to be affected, as well as a survey of an additional 20,000 acres (8,094 hectares) (Reinman and Schilz 1999). This resulted in the discovery of 48 new sites.

On the east side of PTA, surveys were not initiated until 1993, when BioSystems Analysis conducted an aerial and pedestrian inventory survey of 6,700 acres (2,711 hectares) along both sides of Redleg Trail (Reinman and Pantaleo 1998b). Following this work, Ogden surveyed four areas east of Redleg Trail totaling about 970 acres (393 hectares) (Williams et al. 2002). Later, an additional area of 2,640 acres (1,068 hectares) to the east of the trail was surveyed and Phase II surface collection and testing conducted of sites in areas previously surveyed (Williams 2002 a & b). In an area with an expected low density of sites, 67 sites and over 1,800 excavated pits were recorded. Many of the sites identified in 2002 and 2003 fieldwork are now being formally evaluated. Cultural resources suverys at PTA from April 2004 to July 2007 are presented in Table 3.10-4. Figure 3.10-3 displays previously surveyed areas at PTA.

Table 3.10-4 Cultural resource surveys at PTA: April 2004 – July 2007
Since the 2004 Transformation EIS (USAG-HI 2004), cultural resource surveys were performed for many of the projects identified in the EIS. Information regarding projects, reports, and surveys reflects their status as of July

Project Location	Project Number	Project Name	Projected Fiscal Year Start	Contractor	Findings
PTA	57183	Anti-armor Live Fire & Tracking Range (AALFTR)	Not Funded	GANDA	8 sites in the AALFTR and 7 sites in the AALFTR extension
PTA	56994	Range Maintenance Facility	2013	GANDA	No Historic Properties
PTA	58165	Installation Information Infrastructure	2005		No Historic Properties
PTA		Fixed Tactical Internet (PTA FTI)	2005		No Historic Properties
PTA	57414	Tactical Vehicle Wash Facility (PTA FTI)	2006	GANDA	No Historic Properties
PTA	57417	Ammunition Storage	2012	GANDA	1 Archaeological Site
PTA	57197	Battle Area Complex (PTA BAX)	2007	GANDA	9 Archaeological Sites are recognized as potentially eligible for NRHP.
PTA	57408	Runway Upgrade & Extension, Bradshaw Army Air Field		GANDA	No Historic Properties

Table 3.10-4 Cultural resource surveys at PTA: April 2004 – July 2007
Since the 2004 Transformation EIS (USAG-HI 2004), cultural resource surveys were performed for many of the projects identified in the EIS. Information regarding projects, reports, and surveys reflects their status as of July

Project Location	Project Number	Project Name	Projected Fiscal Year Start	Contractor	Findings
PTA	57411	West PTA Maneuver Training Area Land Acquisition (Ke‘āmuku)	2005	GANDA	72 Archaeological Sites
PTA	58273	Land Easement & Tank Trail, Pōhakuloa to Kawaihae	2006		7 Archaeological Sites
PTA	57412	Construct Tank Trail, Pōhakuloa to Kawaihae	2013	GANDA	

Known Prehistoric and Historic Resources

In general, archaeological resources at PTA consist of modified natural features, such as lava tubes, lava shelters, and lava blisters. A 1998 review of previous archaeological studies concluded that lava tubes made up 70 percent of all recorded sites at PTA (Eidsness et al. 1998), and they remain one of the most common site types found in more recent surveys.

Other site types include cairn sites, trails, volcanic glass quarries, excavated pits, and lithic workshops. Within these sites, material remains include grinding tools, charred wooden torches, gourds, cordage and matting, woven ti leaf sandals, kukui nuts, ‘opihi shells, and other faunal remains. Surface features include stone-lined hearths, cupboards, rock-paved areas, low walls and platforms, rock-filled crevices, ramps, cairns, shrines, open-air shelters, and trails. The region has much value for archaeological research and has produced important information concerning bird hunting, trail systems, and short-term living conditions at higher elevations.

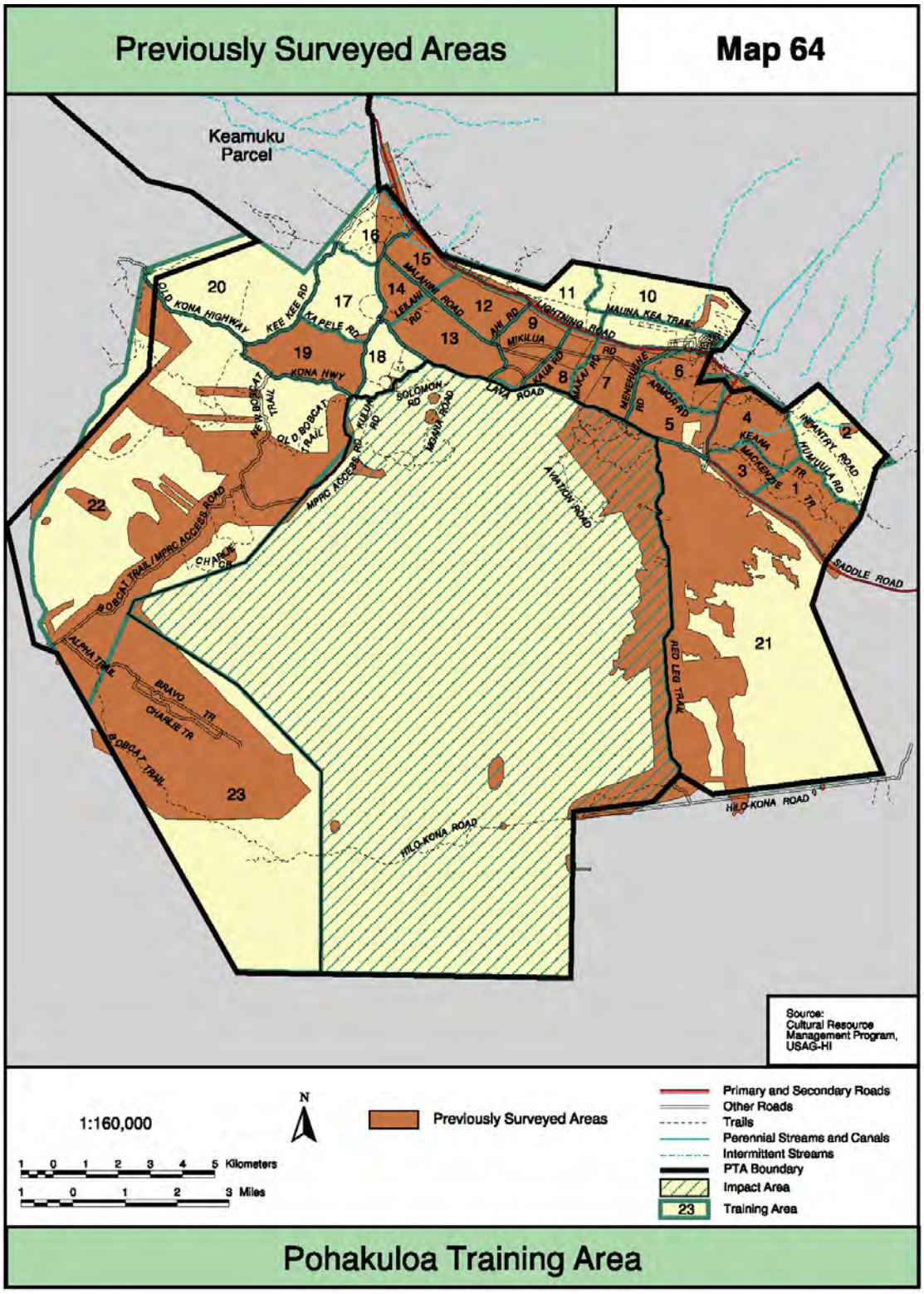

Figure 3.10-3 Previously Surveyed Areas, PTA

Reinman et al. (1998a) claim the cultural resources at PTA are important for addressing issues about Hawaiian prehistory and history in the uplands region, as well as the development of Native Hawaiian society.

The existence of approximately seven stone shrines attest to the likely ritual activity that went on at PTA. With prayers and ritual permeating traditional Hawaiian life, some of the structures at PTA may be occupational shrines (Buck 1957, 259, cited in McEldowney 1982, 1.10). Cairns (ahu) have been recorded at various terrains, either associated with trail systems or boundary markers, or as just isolated features. There appears to be no pattern to the distribution of cairns across the PTA landscape, and they have been quantified as representing between 10 and 15 percent of known sites. Cairns have also been constructed for military purposes, although the trained eye can usually differentiate military cairns from prehistoric ones. It is also possible that some cairns were constructed for rituals.

Archaeological Resources

PTA is rich with archaeological resources, with 350 reported archaeological sites, including both prehistoric and historic Native Hawaiian sites and historic military structures. Tables 8- 24 through 8-29 from the SBCT EIS (2004) detail the archeological resources identified for the SBCT projects. The only site listed on the NRHP is the Bobcat Trail Habitation Cave (Site 50- 10-30-5004). Figure 3.10-4 shows archaeological sensitivity areas at PTA.

Archaeological sites have been found during surveys conducted by BioSystems Analysis along Redleg Trail and areas to the east along the west side of Redleg Trail (Reinman and Pantaleo 1998b).

Sites identified to the east of Redleg Trail include Site 18671, a small lava tube containing cultural features and material; Site 21495, a complex of excavated pits; and Site 21671, a complex of scattered chill glass quarry locations (Williams 2002a, 2000b). Archaeological sites along the northern terminus of Red Leg Trail lie within the ROI in areas considered to have a high potential for fire spread.

Seventeen sites were found in the proposed area for the BAX during SBCT-related survey work, including excavated pit complexes, rock shelters, modified outcrops, rock mounds, a cairn, a lava tube, a lithic scatter, and an enclosure. One site, a complex of lava tubes, trails, enclosures, and a shrine was identified prior to archaeological survey for the Proposed SBCT Action (Reinman and Pantaleo 1998b). The GANDA survey of the entire BAX area revealed the presence of an additional 16 sites (Roberts et al.in GANDA 2003a). Except for the ahu or cairns, whose age is uncertain, all features seem to be prehistoric in age. Figure 3.10-5 shows recorded archaeological sites at PTA (including caves).

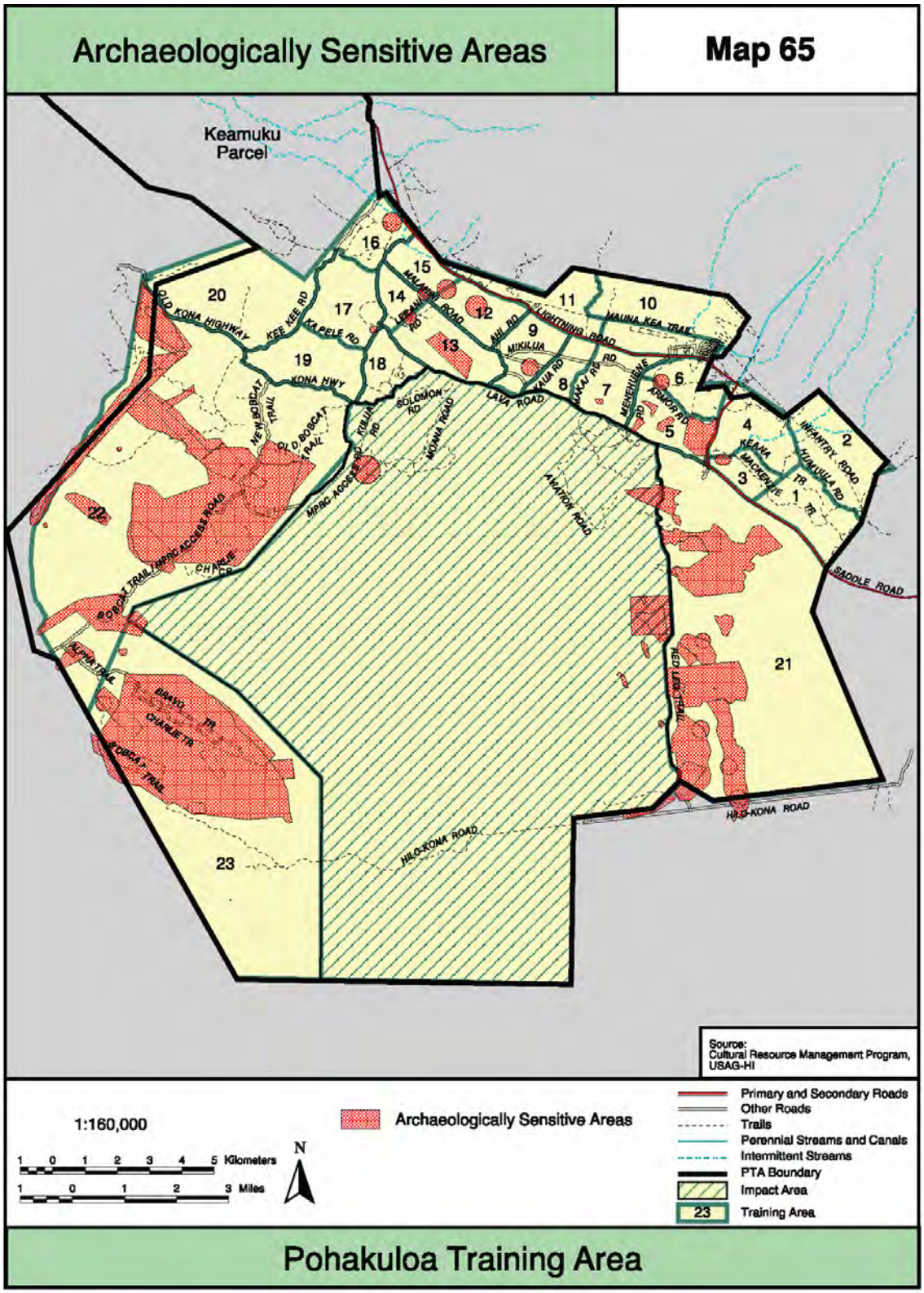

Figure 3.10-4 Archaeologically Sensitive Areas, PTA

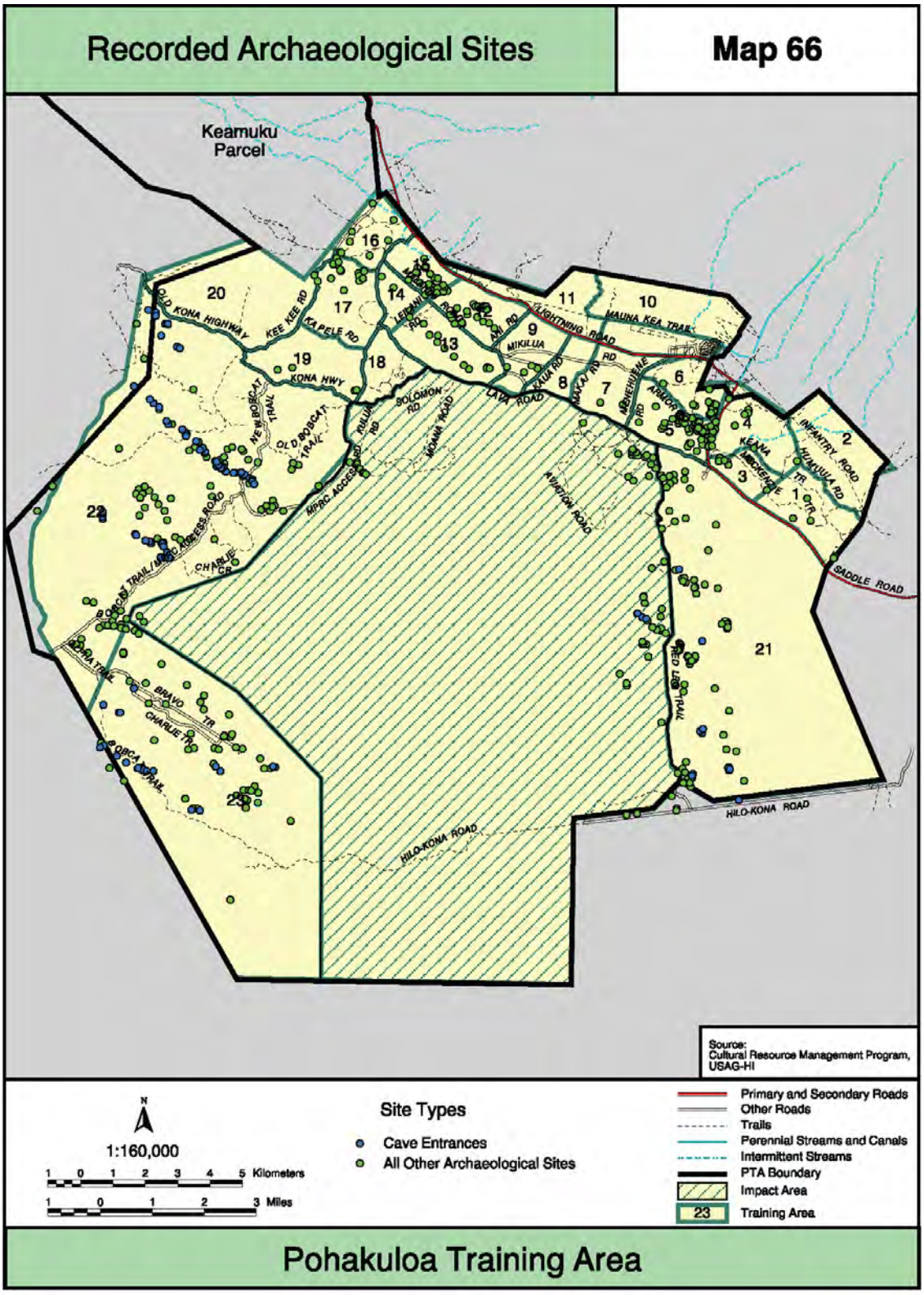

Figure 3.10-5 Recorded Archaeological Sites, PTA (including caves)

Areas of Traditional Importance Surveys

Maly (1997) conducted a series of interviews that considered not only Mauna Kea itself, but the landscape and view planes of the area. Many of the respondents had knowledge of several of the traditional practices described above. In the 1997 study, and in follow-up interviews, the researchers surmised that the Hawaiian people feel a "deep cultural attachment to the broad spectrum of natural and cultural resources" found in and around Mauna Kea (Maly 1999, 3). Maly recommended that the traditions, sites, practices, and continuing significance of Mauna Kea, both historically and today, make it "eligible for nomination as a traditional cultural property under federal law and policies" (Maly 1999, 3).

Known Areas of Traditional Importance

ATI may include previously identified archaeological sites. Almost all archeological sites at PTA are Native Hawaiian sites and reflect the traditional types of activities that Hawaiians conducted in this region. Activities included procurement of lithic (stone) resources, primary preparation of tools in workshops, hunting of birds, and collection of nestling birds. A few sites incorporate ritual aspects. Streck (1986b) interprets a basalt platform on a terraced mound within a lava tube as a shrine (Site 10269). Shapiro et al. (1995) identify a grouping of rock platforms and open-air sites with stone uprights near Puʻu Koli in the southeastern portion of PTA as a place where prehistoric Hawaiian religious activities took place (Reinman et al. 1998, 17). Ritual permeated traditional Hawaiian life, including everyday work activities, and some of the religious structures at PTA may be occupational shrines, where fowlers, quarry workers, and woodcutters recited formulas and made offerings connected with their work.

Pōhakuloa Training Area Trail

A new PTA Trail is scheduled to be constructed as a result of the SBCT use of PTA. The environmental impacts of the new PTA Trail are covered in the Stryker EIS and SEIS. The trail is expected to be operational no earlier than 2010. At that time, the PTA Trail will be the primary route for convoys traveling between the Kawaihae Harbor and PTA. The PTA Trail would replace a seldom used military vehicle trail that parallels Saddle Road. The current military vehicle trail passes through grazing lands and fields. The proposed road would consist of a 24-foot- (7-meter-) wide gravel road and a 3-foot- (1-meter-) wide shoulder on either side of the road. It would run approximately 27 miles (43 kilometers), connecting Kawaihae Harbor to PTA. Work would include grading, paving, improving drainage, installing culverts at stream crossings and guardrails at drop-offs, and building storm drainage structures. Road grades steeper than 10 percent would be paved with asphalt or concrete.

Table 3.10-5
PTA Trail Archaeological Sites

Site Number	Site Type	Probable Function	Probable Age
50-10-05-9012	Wall	Cattle boundary	Historic
50-10-05-23601	Retaining wall	Cart road	Historic
50-10-05-23602	Mound	Marker	Historic
50-10-05-23623	Wall network	Cattle boundary	Historic
50-10-05-23624	Terrace	Possible habitation	Possibly prehistoric
None	Lava blister	Possible burial	Possibly prehistoric
None	Mound	Undetermined	Undetermined

There have been many archaeological investigations of the lands traversed by the PTA Trail corridor, including Barrera and Kelly (1974), Clark (1981), Hammatt and Shideler (1989), Hammatt et al. (1988), Langlas et al. (1997), Clark and Kirch (1983), Clark (1987), and Soehren (1980). Cox (1983) conducted a reconnaissance of the military vehicle trail between Kawaihae Harbor and PTA. See Figure 8-39 from the 2004 SBCT EIS for a depiction of the archaeological sensitivity along the PTA trail.

GANDA surveyed a 98-foot- (30-meter-) wide corridor along the proposed trail, between Kawaihae Harbor and Māmalahoa Highway, and identified seven archaeological sites (Roberts et al in GANDA 2003b). Four sites are likely post-Contact or Historic in age. Two of these are segments of rock walls used as cattle enclosures or boundaries for Parker Ranch. One site is a stone mound possibly used as a trail marker. The fourth historic site, immediately inland from Kawaihae, consists of the remains of a .62-mile- (1–km-) long stretch of a cart road probably representing the main road built in the mid-1800s between Kawaihae and Waimea. Preserved features of the road include bridge foundations built of cobbles and boulders, milled lumber from the bridges with nails in place, stone retaining walls, and possible pāhoehoe barrow pits from which construction material was obtained.

Two possibly prehistoric sites include a lava blister, which might contain a burial, and a terrace that may have been used during the prehistoric period. No cultural materials were found in association with the prehistoric features during the survey. The seventh site recorded consists of a stone mound of undetermined age.

3.10.7 Paleontological Resources

No paleontological resources are expected to be present in Mākua, Kahanahāiki, or at PTA. No surveys have been conducted expressly to identify paleontological resources in these areas, although archaeological survey s so far have not encountered any sinkholes or caves containing paleontological resources. Caves and rockshelters might be present in unsurveyed portions of the backs of the valleys at MMR, but any such locations (if they exist) are not necessarily expected to contain paleontological resources due to the geologic characteristics of these areas.

3.10.8 Army Management of Cultural Resources

Regulatory Considerations

Government statutes, federal regulations and guidelines, executive orders, and presidential memoranda define the cultural resource management processes with which the Army must comply when planning and undertaking projects, tasks, and actions in areas under Army jurisdiction. Further, the Army at USAG-HI will follow the management procedures outlined in the draft ICRMP.

The cultural resources management program at USARHAW has a staff that includes a Cultural Resources Manager, two government Archeologists, an Architectural Historian and 14 contract Archeologists. The management of the resources includes maintaining a cultural site data base, as well as GIS mapping, field survey, site evaluation, location, verification, and monitoring before, during, and after training activities, site preservation, curation, document management, Native Hawaiian consultation and coordination with other regulatory agencies. The cultural resources team also coordinates and facilitates public outreach actions that include site visits and tours and public education. Cultural Advisory Committees were formed on the islands of Hawai‘i and O‘ahu. The cultural advisory committee on the island of Hawai‘i has continued to meet on a continual basis for the last seven years. The cultural advisory committee on the island of O‘ahu became the cultural monitors on the SBCT projects.

Army cultural resources staff members conduct regular outreach to Native Hawaiians to facilitate the Section 106 and 110 process and other consultation efforts to fulfill its obligations under the NHPA. This outreach includes offering tours and open houses, speaking to school groups and college students, and providing cultural access.

Mākua Military Reservation

Current Management Actions

Beginning in 1998, the Army undertook consultation consistent with Section 106 of the National Historic Preservation Act with Native Hawaiian organizations, interested parties, the State Historic Preservation Office, and the Advisory Council on Historic Preservation regarding the treatment measures the Army would implement for military training at MMR. After two years of consultation with these parties, a Programmatic Agreement (PA) that identified treatment measures for training was executed in September 2000. Since then, the Army has implemented these measures. This PA has expired, however, the Army reopened consultation under Section 106 of the NHPA. The new PA (Appendix L of this EIS) addresses current conditions and the effects of military training at MMR.

The PA was developed to resolve potential adverse effects by routine military training at MMR. The PA includes stipulations to:

1) Identify and evaluate cultural resources for National Register eligibility in consultation with Native Hawaiian Organizations (NHO) and the Hawai‘i State Historic Preservation Division (SHPD), when found as a result of post training monitoring, during discovery situations, or when funds are available to formally evaluate currently known "undetermined" sites.

2) Protect known historic properties from damage by denotations and vehicle and foot traffic, and develop protective measure for historic properties with the South Fire Break Road.

3) Consult with NHOs and SHPD when placing new targets or on projects that fall out site the scope of the PA, and when evaluating cultural resources for NRHP eligibility.

4) Update cultural awareness training programs for monitors, contractors and military personnel, in consultation with experts identified by the consulting parties. Training will occur for all new hires and on an annual basis.

5) Maintain a record of all artillery and mortar rounds that in the unlikely event they land outside the designated impact area.

6) Monitor historic properties by the Garrison within the South Fire Break Road. Monitoring outside the South Fire Break Road will take place only if the Safety Officer deems it safe to do so.

7) Provide annual reporting to consulting parties and the HI SHPD.

8) Identify certain activities at MMR that are exempt from further Section 106 consultation. and

9) Amend, terminate or resolve disputes pertaining to the PA.

In addition, there is a PA that deals with use and cultural access of the Ukanipō *Heiau* complex (referred to as the Ukanipō *Heiau* PA throughout this document). Signed in October 2000, the Ukanipō *Heiau* PA was developed in consultation with Native Hawaiian organizations and individuals and other regulatory agencies over two years.

Management of the Ukanipō *Heiau* complex at MMR is guided by the treatment measures developed through consultation for that PA. Other historic properties are addressed through compliance with regulations at 36 CFR, Part 800, under the NHPA. Additionally, the Army complies with all applicable laws and regulations set forth in AR 200-1. The Army employs two professional archaeologists whose duties are dedicated to cultural resource management and cultural resource access at MMR.

As part of routine management actions and consistent with the 2001 Settlement Agreement, the Army conducted a survey to identify traditional cultural places and it also conducted a cultural impact assessment. As part of these efforts, the Army undertook extensive consultation with Native Hawaiian organizations and individuals, documentation of oral history, and archival research.

Army management actions include the following:

The Army continues to seek, identify, and evaluate cultural resources at MMR, in accordance with Section 106 of the NHPA.

Further surveys may be conducted in areas that can be made accessible following wildland fires or prescribed burns. The presence of unexploded ordnance makes surveying hazardous. Detonation of ordnance outside the training area or close to existing sites is subject to consultation prior to any actions.

Annual status reports and/or survey reports are submitted to the Hawai‘i SHPO.

The Army continues to consult with Native Hawaiian organizations, groups, families, and individuals who may ascribe traditional religious and cultural importance to historic properties at MMR. The Office of Hawaiian Affairs and Hui Mālama I Nā Kūpuna ‘O Hawai‘i Nei, as well as other interested parties, are included in this consultation.

The Army continues to conduct expanded education of Army personnel in cultural resource awareness and protection and avoidance of cultural resources during training. Instruction includes field trips, classroom training, and printed literature. This information is also included in the cultural resource annex of the range standard operating procedure. Before each exercise, senior officers are briefed about cultural and natural resources. Soldiers are briefed at MMR prior to training activities.

The Army maintains a database incorporating all existing cultural resource data and continues to revise it as new information becomes available.

Geographic information system maps of cultural resource locations are distributed to the Hawai‘i SHPO, to Native Hawaiian organizations as requested, and to range and training officers to ensure site avoidance and protection during development of training plans. Cultural resources are protected from damage during training exercises. The Army has changed locations of training target objectives and has implemented other site protection measures to eliminate conflicts between locations of cultural resources and locations of training activities. No training is allowed to occur at archaeological sites, and barriers around sites serve as an extra protective measure.

Cultural resources are monitored by archaeologists to identify effects from training. Monitoring records and photographic documentation are included in the annual reports to the Hawai‘i SHPO.

The cultural resource manager continues to work with the Wildland Fire Manager to develop acceptable strategies for fire containment and control to suppress wildfires and also to protect cultural resources. This coordination will continue during site planning preparation and pre-season fire suppression operations.

Due to UXO, some portions of MMR cannot be surveyed for archaeological sites or ATI. These areas, such as in the improved conventional munition (ICM) area, are outside of the area the Army plans for training activities. Other unsurveyed areas are the steep slopes on the sides and backs of the valleys. No archaeological sites are expected on these steep slopes, with the possible exception of a reported Native

Hawaiian *holua* slide course. These portions of MMR are outside of the areas where the Army proposes to engage in training activities.

To increase Soldier and community awareness of cultural resources at MMR, the Army is developing an on-site visitor's center. This center will be used as an educational facility in conjunction with military training and with public access to MMR cultural resources, which is described below. It will contain a library and static and interactive displays concerning the cultural and natural resources of MMR.

Public Access and UXO Removal

MMR has been under restricted access since 1941. The lack of public access has likely contributed to a general loss of knowledge of sacred sites within MMR, and because of the restrictions, the area has not been used as much as other sacred sites that allow public visits. To address this situation, the Army has continued to allow access to ATI since 1998 when it began a program, in cooperation with members of the Wai'anae community, to open Ukanipō *Heiau* to Native Hawaiian religious practitioners under AIRFA. The Ukanipō *Heiau* PA signed in October 2000 was a result of the meetings and consultation with members of the Native Hawaiian community. In accordance with the PA, members of the community can access Ukanipō *Heiau* for appropriate uses, independent of training activities in MMR.

Before 2001, cultural access to MMR was provided on request, with considerable access provided to the area in and around the Ukanipō *Heiau* Complex, as provided for in the Ukanipō *Heiau* PA referenced above. In October 2001, under the Settlement Agreement, the Army agreed to provide cultural access at MMR twice a month and two overnight visits a year by December 2001. The Settlement Agreement did not specify a minimum number or location of sites that were to be made available for access, but was "…subject to limitations determined by defendants in consultion with native Hawaiian cultural practitioners, including those from Mālama Mākua, based on requirements for training, safety, national security, and compliance with applicable laws and regulations." Pursuant to the Settlement Agreement, the Army and Mālama Mākua developed a set of protocols for cultural access to MMR in July 2002. This guidance has been in effect since that time.

Immediately after the Settlement Agreement was signed, access was provided to 12 sites within the CCAAC in areas where all vegetation was removed, the grass was kept trimmed and EOD specialists had swept the surface.

In September 2004, the Department of Defense Explosives Board ("DDESB") conducted an inspection. In December 2004, the DDESB "restricted access to certain cultural sites by non-government personnel due to safety concerns relating to the presence of UXO at Mākua, as well as Department of Defense and Department of the Army regulations prohibiting public access to impact areas containing UXO." In January and February 2005, the United States Army Technical Center for Explosives Safety ("USATCES") conducted a risk assessment. USATCES then issued a report stating that, for members of the public to visit cultural sites at MMR, "there must be clearly defined and marked trails (footpaths) and cultural sites cleared subsurface to a depth of one foot." The Army told members of the public in February 2005 that they could not visit the 12 cultural sites at MMR that they previously were allowed to visit. A contractor hired by the Army to clear UXO from MMR, began clearing UXO on November 20, 2006, selectively clearing parts of sites 4536, 4537, 4538, 4541, 4542, 4543, 4544, 4547, 5456, and 5926. On January 11, 2007, the Army contacted the State Historic Preservation Division to explain what the Army intended to do to destroy the UXO found near sites 4546 and 5456, as well as other UXO. On March 16, 2007, the State Historic Preservation Division said it agreed with the Army that its intended means of destroying the UXO would not adversely affect those cultural sites. The UXO located near sites 4546 and 5456 was destroyed on March 26, 2007. On the morning of September 1, 2007, the Army allowed members of the public and the Office of Hawaiian Affairs to visit certain cultural sites at MMR. On February 9, 2008, members of Mālama Mākua were allowed to walk around sites 4537 and 4546.

The 2001 Settlement Agreement required the Army, no later than October 2002, to identify "high priority" cultural sites outside of the 1,000-meter area mauka (toward the mountain) of Farrington Highway for UXO clearance. Public meetings were held to identify additional high priority sites in September and December 2002. The October 2002 burn and the July 2003 burn were both conducted in part to provide additional access.

The identification process was the subject of a lengthy legal dispute. In early 2009, the federal district court resolved the dispute by requiring the Army to complete the compilation of the list of cultural sites for publication no later than February 26, 2009. The Army will conduct a second public comment period. No later than June 12, 2009, the Army will identify the high priority sites for UXO clearance.

Pōhakuloa Training Area

Current Management Actions

Current management actions at PTA mirror those employed at MMR, except for those that are installation specific. Such actions include but are not limited to fire control, Soldier and Army personnel education, consultation with Native Hawaiian organizations, groups, families, and individuals who may ascribe traditional religious and cultural importance to historic properties, the meeting of a Cultural Advisory Committee, site monitoring, and GIS use.

As with MMR, the area of potential effect will be surveyed and historic properties and ATI, if any, will be evaluated. Section 106 consultation will be conducted and any required mitigation measures for archaeological resources or ATI at PTA will be conducted. Further, NRHP eligibility will be evaluated and plans for avoidance, data recovery of eligible sites, or alternate mitigation for sites in areas that are a hazard to human health and safety will be developed. Impacts on ATI will be mitigated through avoidance. Mitigation will be developed in consultation with the SHPO and Native Hawaiians organizations.

For PTA, a preservation guidance plan (an Historic Preservation Plan or HPP) was developed in 1998, to recommend mitigation options for adverse effects due to routine training at PTA.

3.11 HAZARDOUS MATERIALS AND WASTE

3.11.1 Introduction/Region of Influence

The following section is an overview of the hazardous substances that may be used, stored, or encountered in the project ROI. Regulations that govern the use, transport, and disposal of these hazardous materials and wastes are discussed in Appendix A.

The project ROI for the MMR alternatives includes the boundaries of MMR and the trails (including buffer areas) that would be used for troop marches. Fences and mountain ranges cannot always confine or reduce impacts from hazardous materials and waste incidents; therefore, areas immediately adjacent to MMR and the trails also are considered part of the ROI.

The project ROI for the PTA alternative includes the boundaries of PTA and the areas immediately adjacent to PTA. It also includes the areas immediately adjacent to the main transportation routes from Kawaihae Harbor to the PTA Cantonment Area. This route is detailed in Section 2.4.3.

The public expressed concerns during the EIS scoping process regarding the impact of both existing and proposed military activities and training on the public and the environment. Specific issues include the following:

- Types, handling, and storage of ammunition;
- The presence of UXO;
- Potential contamination by various hazardous chemicals and materials, such as lead, depleted uranium (DU), pesticides, and polychlorinated biphenyls (PCBs);
- Radiation (radon); and
- Medical waste disposal procedures.

Lead-based paint (LBP) and asbestos are hazardous building materials that can create an impact on human health and safety if released to the environment. LBP and asbestos are often encountered when structures built prior to 1978 are remodeled or demolished. No structures containing LBP or asbestos would be remodeled or demolished on MMR or PTA as part of the proposed training, so there would be no effects related to LBP or asbestos.

Radon is a naturally occurring radionuclide found in the environment that affects air quality. If inhaled at large concentrations, radon is a carcinogen,

potentially producing a significant threat to human health and the environment. Radon, however, is found in low concentrations in Hawai‘i and is not considered a specific risk to this area. Additionally, no buildings would be built to potentially create radon-related effects.

A number of studies have been conducted to identify the types of materials that were used and disposed of at MMR, including materials that were burned in the OB/OD area. These findings are documented in the Hydrogeologic Investigation Report in Appendix G-1 of the EIS. No biomedical materials or infectious waste were discovered during these investigations (USACE 2006), and no such disposal or usage has been reported at MMR. Additionally, infectious waste has never been reported as being disposed of at MMR (Char 2003; Kim 2003). For these reasons, LBP, asbestos, radon, and biomedical waste are not included in the impact analysis.

In this section, contaminant concentrations are compared to EPA Region IX preliminary remediation goals (PRGs). The purpose of this comparison is to screen concentration values against conservative regulatory and health-based standards. PRGs are not promulgated cleanup standards, and higher or lower standards may be reasonably applied to sites based on site-specific risks and other conditions. The PRGs are goals and are designed to be protective of human health under a wide range of conditions. The guidelines for the use of PRGs allow users to adjust the exposure assumptions to better reflect site-specific conditions.

Because MMR is not an active or proposed remedial site, the Army is using the industrial soil PRGs and drinking water PRGs only as reference points for the concentrations of contaminants detected on the training ranges. However, these PRGs are based on exposure durations and assumptions that are substantially higher than those expected for military personnel using the MMR range areas. For example, industrial soil PRGs assume adult outdoor worker exposures for eight hours a day over 25 years. In fact, most military personnel use the training ranges for brief periods totaling days or weeks so that actual exposures are far lower than those assumed in the industrial PRGs.

3.11.2 Hazardous Materials Management

A hazardous material is defined as any material that, because of its concentration, physical, chemical, or infectious characteristics, can pose a substantial hazard to human health or safety or to the environment. Subcategories of hazardous materials include flammable, toxic, corrosive, and reactive materials. Typical hazardous materials used and stored on MMR and PTA include the following:

- Batteries and battery fluid;
- Aerosols;
- Petroleum, oils, and lubricants (POLs);
- Fuels (gasoline and diesel);
- Solvents;
- Fluorescent light bulbs;
- Paint products;
- Herbicides; and
- Munitions.

The Army follows strict SOPs for storing and using hazardous materials (MMR and PTA site-specific SOPs are kept at the respective range offices and are available upon request from the Army). All hazardous materials used by training units are stored at the Hazardous Materials Control Center (HMCC) on the Schofield Barracks East Range. When an Army unit requests a hazardous material, it is picked up from the HMCC and transferred by the unit to a temporary storage area for immediate use during training. No hazardous materials used by the troops are left on the range complex after completion of the training; materials are brought with the unit back for use in their respective motor pool or industrial facility.. Material safety data sheets are continually kept on-site and updated for all hazardous materials used and stored on-site. In accordance with Army and federal regulations, all hazardous materials are kept in approved storage containers, and contractors who temporarily store materials on-site must also follow these SOPs and regulations.

3.11.3 Hazardous Waste Management

Hazardous Waste

The Resource Conservation and Recovery Act (RCRA) defines a hazardous waste as a solid waste (or combination of wastes) that, due to its quantity, concentration, or physical, chemical, or infectious characteristics, can cause or significantly contribute to an increase in mortality. RCRA further defines a hazardous waste as one that can increase serious, irreversible, or incapacitating reversible illness or pose a hazard to human health or the environment when improperly treated, stored, disposed of, or otherwise managed. A solid waste is considered hazardous if it is not excluded from regulation as a hazardous waste or if it exhibits any ignitable, corrosive, reactive, or toxic characteristics (EPA 1999).

The Army follows strict regulations and site-specific SOPs for collecting, storing, and turning in hazardous waste and non-regulated waste for MMR and PTA. The Military Munitions Rule (62 FR 6621, 40 CFR 260, et seq.) identifies when military munitions become a hazardous waste under RCRA and guides safe storage and transport of such waste. This rule is discussed further below.

MMR is a conditionally exempt small quantity generator, in accordance with 40 CFR 261.5. Hazardous wastes generated on Army land are first collected at hazardous waste shop storage points (HWSSPs), which are designated areas at or near the point of waste generation. The only hazardous waste accumulated in the HWSSP on MMR is the burn pan residue, discussed in the ammunition section below. The MMR range office strictly follows MMR-specific SOPs for handling, storing, and disposing of hazardous waste. Once the HWSSP reaches full capacity (a 55-gallon limit), waste is sampled and profiled to determine the proper disposal method. Waste characterized as hazardous waste is picked up by a Defense Reutilization and Marketing Office, Hawaiʻi (DRMO-HI) contractor and transported to a treatment, storage, and disposal facility (TSDF) for ultimate disposal (Akasaki 2003). The DRMO-HI uses a contractor that is authorized and certified to transport hazardous waste from the MMR HWSSP with a EPA transporter identification number. Other wastes generated by contractors (for example, grass waste) are handled and disposed of by the contractor in accordance with federal, state, and Army regulations and MMR-specific SOPs.

PTA is a small quantity generator in accordance with 40 CFR 261.5. PTA operates its own transfer accumulation point, where it consolidates and stores hazardous waste. A contractor picks up the hazardous and non-hazardous wastes and transports it to the DRMO or it is shipped off-island for permanent disposal at a certified hazardous waste disposal site (US Army and USACE 2004).

Disposal of Ordnance Under RCRA

The disposal of ordnance, such as ammunition, is regulated under RCRA. Section 107 of the Federal Facilities Compliance Act of 1992 requires EPA, in consultation with DoD and the states, to issue a rule identifying when conventional and chemical military munitions become hazardous waste under RCRA and to provide for protective storage and transportation of that waste. This rule explains what is considered a solid waste and the rules for handling that waste (i.e., permitting, labeling, storing, transporting, and disposal). The final rule also amends regulations regarding emergency responses involving both military and nonmilitary munitions and explosives (EPA 2002c).

This rule establishes the regulatory definition of solid waste as it applies to the following three specific categories of military munitions:

- Unused munitions;
- Munitions being used for their intended purpose; and
- Used or fired munitions (which can then be termed either exploded ordnance [EXO] or UXO).

The rule conditionally exempts the following:

- From RCRA Manifest Requirements and Container Marking Requirements, nonchemical military munitions waste that is shipped from one military-owned or military-operated TSDF to another, in accordance with DoD military munitions shipping controls; and
- From RCRA Subtitle C storage regulations, nonchemical military munitions waste subject to the jurisdiction of the DoD Explosives Safety Board storage standards.

3.11.4 Specific Hazardous Materials and Wastes

The following sections address specific hazardous materials and wastes that may be used, stored, transported, or encountered within MMR or PTA. These hazardous substances could affect human health and the environment and often have specific regulations that govern their use, storage, and disposal. The hazardous materials and waste areas of interest for MMR are identified on Figure 3.11-1.

Ammunition and Training

MMR was first used for training from 1941 to 1949. Between 1949 and 1951, unexploded bombs and shells were cleared from the range. Approximately 11,000 rounds of artillery, mortars, and bombs, plus bulk explosives, were reportedly detonated, either in place or in the OB/OD area (USATHAMA 1984; Sox 1977). Range activities continued in the early 1950s to prepare for the Korean Conflict. Ordnance was again cleared in 1963. Ordnance was destroyed, and artillery, tanks, and infantry assault weapons were used regularly during the 1960s. The site was used extensively for training during the 1990s, until training was suspended in 1998. Limited training at MMR resumed in October 2001.

The PTA range location (Alternative 4) is located entirely in the existing impact area. The PTA training and impact areas were officially established in 1955 and have been in use ever since. The combined

impact area on PTA, including dudded areas, comprises 51,000 acres (20,640

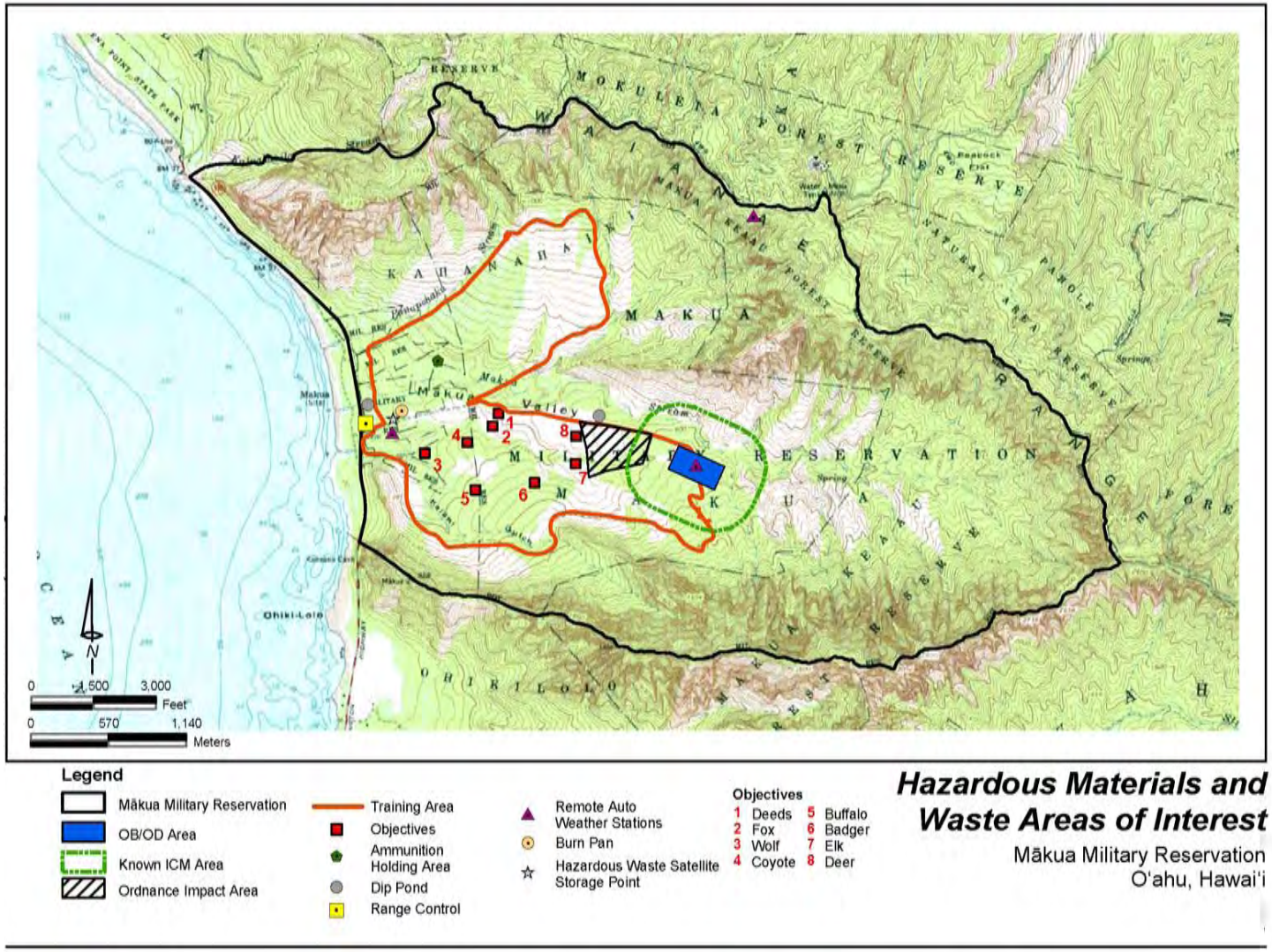

Figure 3.11-1 Hazardous Materials and Waste Areas of Interest, MMR

hectares). The impact area is off-limits to unauthorized personnel due to hazards from fired munitions. Since the range boundaries are located entirely in the existing impact area, UXO removal will have to take place prior to range construction.

The quantities of ammunition used depend on the training scenario being conducted. Table 2-3 summarizes the weapons and ammunition that are available for use during training at MMR and PTA. Table 2-6 presents the estimated quantities of munitions to be expended per year.

Ammunition to be used during each CALFEX is brought in by the user unit and is stored in a temporary ammunition holding area throughout the training exercise. At the completion of training, ammunition that was not used is returned to the ammunition supply point on WAAF used to store ordnance for all units of the USAG-HI or at the Navy magazines on Lualualei and West Loch.

Live-fire activities include artillery and mortar training. Bags filled with explosive propellant are required for artillery use, and similar explosive propellant charges are used for mortars. Propellant charges are explosive powders that propel the round of ammunition out of the gun barrel when ignited. Charges are transported to the firing point in the canisters they are received in. Each canister is transported with a maximum of three charges. If charges are removed from the originally packed canister prior to movement, the canister is resealed to prevent disturbance or damage from moisture or other influences.

The number of charges used generally determines how far an ammunition round travels. The exact number of bags of propellant required is not known prior to training because aligning a weapon toward its target requires adjustments to trajectory and distance (depending on the number of propellant bags). Accordingly, there is normally an excess of propellant as a result of the artillery and mortar training. Charges that are not used during training are burned in an approximately 50-square-foot (5-square-meter) metal burn pan with a 33-inch (84-centimeter) containment wall at the designated MMR burn site, shown in Figure 3.11-1. The burn sites for both MMR and PTA were selected and constructed in accordance with Section 17-5, Department of Army Pamphlet 385-64, Ammunition and Explosive Safety Standards. The burn sites are operated under the following restrictions:

- All burn sites have a means of collecting remnants produced by the burning operation;

- Propellants to be burned are unconfined and spread evenly over the burn pan. The depth of the propellant does not exceed 3 inches (8 centimeters); and
- The burn pan is used only once per 24-hour period.

The burnt propellant leaves an ash-like residue within the burn pan. The constituents of this residue change, but may contain chemicals such as lead, dinitrotoluene (DNT), benzene, and cyanide. After propellant burning is completed, a hazardous waste technician collects the residue. Management and disposal of burn pan residue is not required, but it is a best management practice (BMP) that is instituted to reduce the threat of uncontrolled wildland fires and minimize the potential for a release to the environment. The technician takes all hazardous waste precautions by wearing a protective Tyvek suit, gloves, and a respirator during collection. Propellants are burned separately according to artillery type. The residues created from burned propellant are temporarily stored at the range burn site in a designated HWSSP (see Figure 3.11-1). Each residue class is stored separately. Prior to disposal, the unit samples the residue and sends it out to be analyzed for chemical profiling and waste identification. When the HWSSP receptacle becomes full, it is properly disposed of by the DRMO-HI, or transported to a designated transfer and accumulation point (Husemann 2003d). Table 3.11-1 summarizes the specifications of the MMR and PTA burn sites and process.

Table 3.11-1
Burn Site Specifications

Burn Site	Est. Amount in Lbs./Burn	Est. Frequency of Burns/Week	Type of Propellants	Burn Pan Dimensions	Pan Quantity
MMR	5-10	0.5	M1, M8, M9, M10	5'9" by 8'10" by 33"	1 unit
PTA	10-50	2	M1, M8, M9, M10	5'9" by 8'10" by 33"	1 unit

Source: US Army 1999

During training, explosive munitions residues, fragments, or metal casings from munitions items, and projectiles (including lead-antimony alloy bullets) are deposited on the ranges. If they are left in place for long periods, the surfaces of metal fragments and projectiles may dissolve slowly and leach metals, including lead, antimony, iron, and nickel, into soil and water. Munitions contain a number of chemical constituents, depending on the types of munitions, including high explosives, propellants, fuse material, and other constituents. While most of the original chemicals are burned or vaporized when the munitions are fired or detonated, some of the material may not be fully destroyed, leaving residues that may be deposited in the soil. Greater discussion of munitions

residues sampled in soils at MMR is found in Chapter 3.8.5 Geology and Soils.

Historical Open Burn/Open Detonation Use

Shown in Figure 3.11-1, the OB/OD area at MMR is an inactive RCRA treatment facility in delayed closure status from the HDOH, Solid and Hazardous Waste Branch. The area is downslope of the access road. Army, Air Force, Navy, and Marine Corps personnel used this area from the 1960s into the 1990s. This site was reportedly the only safe disposal site in Hawai‘i for hazardous materials. Ammunition was doused with large amounts of fuel and waste oils in the bottom of a trench and ignited using incendiary grenades, blasting caps, or time bombs (Char 1977). Larger munitions (such as mines) were buried in specially designed trenches and detonated. Trenches were used only once, and each detonation consumed approximately one ton (908 kilograms) of waste. Detonations could be sequenced in 15-second intervals (USATHAMA 1984). After destruction of the munitions, the trenches were inspected to ensure complete destruction and were backfilled with soil. No nuclear, radiological, chemical, or biological agents were disposed of at the OB/OD area (Geotechnical and Structures Laboratory 2002).

The OB/OD area had three primary purposes, including the mass destruction of unserviceable ordnance; engineer training with large demolition and mine munitions, such as bangalores; and the burning of excess propellant (Char 2003). Quantities of ordnance disposed of in the OB/OD area varied from year to year, but approximate total quantities disposed of per year included 12 tons (11 metric tons) by the Army, 6 tons (5 metric tons) by the Air Force, and 60 to 70 tons (54 to 64 metric tons) by the Navy.

The last time ammunition was destroyed by open burning was in the OB/OD area in 1992. Unserviceable munitions are now shipped back to ammunition depots in the CONUS for final disposition (Akasaki 2003).

Unexploded Ordnance

Following training, the units remove target equipment, gather brass casings from spent rounds, remove litter, and otherwise make every effort to restore the facility to its condition prior to use. The only weapons used at the site that can produce UXO are grenades, mortars, and artillery; all other ammunition projectiles are inert. Following each training event, a group of 30 to 40 people, including explosive ordnance disposal (EOD) specialists and Soldiers, conduct two surface sweeps of the ordnance impact area to identify UXO (Husemann 2003d). EOD specialists destroy all identified UXO where it is found, whether it is a result of the training

just completed or from prior use of the range. No known unexploded rounds are left in place at the conclusion of a training exercise. These procedures ensure that training will not increase the amount of UXO on the site. There is one exception to these procedures: if UXO is found on or adjacent to a culturally sensitive site, it will be removed from the area prior to detonation, if possible. If it cannot be removed, the UXO will be shielded by plywood and sandbags in order to prevent damage to the cultural site.

During the week of October 28, 2002, the Army conducted a prescribed burn of Mākua Valley in the southern lobe to enable UXO clearance and to minimize the risk of fire outbreak by reducing the existing fuel load. This prescribed burn removed vegetation so that UXO could be cleared from suspect areas (US Army 2002a). An additional prescribed burn was conducted within the northern lobe on July 22, 2003, to reduce the vegetative fuel load and to locate UXO that could not be identified through ground clearance due to the terrain and heavy vegetation. EOD specialists detonated or removed surface UXO that did not discharge during the burn. A total of 172 pieces of UXO were identified and removed. Safe areas in the northern valley that were not culturally significant were identified for future troop marches, training, and maneuvers.

Improved conventional munitions (ICMs), also referred to as cluster bombs, are artillery munitions that contain multiple submunitions. Due to the extreme safety risk, ICMs are no longer used on Army training land, in accordance with HQDA Letter 385-01-1, Section 7a (HQDA 2001). Evidence of ICM detonation has been discovered at MMR extending beyond the radius of the former OB/OD area, and located near the CCAAC (shown on Figure 3.11-1). This area has been closed and is no longer accessible. There is also a 16,800-acre (6,800-hectare) ICM impact area within the larger impact area on PTA. This area is also closed and not accessible.

UXO has been identified within the northern valley of MMR, including a portion of the trail to be used by Soldiers marching between DMR and MMR (DEI 2002). While not conducted in the northern valley now, live-fire training may have been performed there in the past. EOD specialists have cleared the portion of the trail and valley used by troops, but UXO could be encountered in this region.

In 1950, a range clearance and dedudding operation was conducted from Mākua Beach to approximately 1,000 feet inland. This operation also covered a portion of the transferred land to the north of the northern MMR

boundary with a total coverage area of approximately 1,200 acres. Rockets, shells, shots, rifle grenades, bombs, and small arms ammunition were found and destroyed during this 4-month long operation. In 1963, a range clearance of the Mākua Valley impact area was conducted approximately 2,500 feet inland from Mākua Beach in the east-west direction and approximately 3,500 feet along Farrington Highway in the north-south direction. The items recovered were not disclosed, however, all of the ordnance found was destroyed.

In 2007, the Army conducted a Site Investigation (SI) under the Military Munitions Response Program at two sites: the former Mākua Training Area that was transferred to the state in 1990 (north of and separate from the current MMR) and the former Beach Assault Training Area. This area is on the makai side of Farrington Highway, adjacent to MMR. Neither of the sites are part of MMR and neither are involved in the proposed training. During the SI, a visual survey was conducted over approximately 38 line miles of the two sites as well as approximately 10 linear miles of geophysical survey. No munitions and explosives of concern (MEC) were found, however, munitions debris (MD) was found. The MD consisted of fragments from what appeared to be 155mm projectiles. Currently the Army is conducting a Remedial Investigation for MEC and their constituents at the two sites.

Soldiers are educated on identifying UXO and proper procedures for handling UXO. Soldiers are given a Skills Level 2 through 4 Manual, as well as a Field Manual 21-16, Unexploded Ordnance Procedures (HQDA 1994), detailing the types of UXO, safety guidelines, and handling procedures. Before they are deployed, Soldiers receive additional training in specific types of UXO in the deployment location. UXO classes are periodically given to Soldiers for further training on UXO management. Finally, Soldiers who are chosen to assist EOD specialists with UXO clearance are given special training prior to range sweeps (Dunn 2003).

Range Division Maintenance maintains MMR. Long-term scheduling is conducted on O‘ahu by the Directorate of Plans, Training, and Mobilization (DPTM) Range Division–Hawai‘i Scheduling Office, using the Range Facility Management Support System (RFMSS) database. Units can access the RFMSS to check the schedules of specific ranges. Additionally, the RFMSS keeps material safety data sheets of all chemicals stored on-site and records of ordnance use and management in the range scheduling office (Sato and Associates 1996).

Chemicals of Concern Used in Training

Energetic materials, such as nitroglycerine, tetryl, RDX, HMX, TNT, 2,4- and DNT, are used in a number of industries and, among many other uses, are used to produce explosives, ammunition, and dyes. These substances have been found at hazardous waste sites that contain buried ammunition wastes and have been known to affect the soil, surface water, groundwater, and air. Exposure to high levels may affect the nervous system and the blood (USDOHHS 1999). Because energetics are used in training, they are being analyzed as part of the ongoing air and hydrogeologic field investigations at MMR. The hydrogeologic investigation showed concentrations of energetics in soils at the following locations:

- OB/OD area;
- Within berms at Objective Deer;
- Weather station burn pan area;
- In streambed sediments of Mākua Stream;
- Demo pit; and
- Objectives Wolf, Deeds, and Badger.

None of the findings showed concentrations of energetics above PRG levels (see Appendix G).

Due to various studies documenting the use and disposal of Agent Orange on military bases within the US, public concern prompted research to confirm that this material was not stored, used, or disposed of in Hawai‘i. Various Air Force studies document that in 1971, chemical agents stored in Okinawa were transported to Johnston Island and stored at the Chemical Storage Facility there. Public Law 91-672, passed in 1972, prohibited the transport of chemical agents from Okinawa to any of the 50 states and authorized destruction of Agent Orange outside these areas. In 1972, the 1.4 million-gallon (5.3 million-liter) stockpile of Agent Orange amassed during the Vietnam War was transported directly to Johnston Island and placed in storage there. In 1977, Agent Orange stored at Johnston Island, as well as in Mississippi, prior to Public Law 91-672, was destroyed by high-temperature incineration at sea in the South Pacific (USARHAW and 25th ID(L) 2001a). There is no record of Agent Orange being used, stored, or disposed of on O‘ahu.

Depleted Uranium

In August 2005, while conducting range clearance activities to modernize ranges for the new Stryker Brigade, an Army contractor discovered 15 tail

assemblies from the M-101 spotting round body (SRB), a component of the Davy Crockett weapons system. The Davy Crockett was the name given to the M28 and M29 series of recoilless guns. This weapon system, which was produced from 1960 until 1968, was used in training until 1968. Although it could use several types of munitions, the munitions of interest were the M-101 SRB that contained DU. Unlike munitions that use DU in penetrators to defeat enemy armor, the DU in the M-101 was used to provide weight sufficient for the SRB to mirror the trajectory of the Davy Crockett's nuclear warhead. The M-101 was a small (about 1-inch [2.5-centimeter] diameter) low speed projectile that contained about 6.7 ounces (0.19 kilograms) of a DU-alloy.

When the Davy Crockett was used, it was a classified weapon system and information concerning its deployment to SBMR and associated training activities was closely guarded.

In 2006, a scoping survey confirmed the presence of DU fragments from the M-101 on a portion of the SBMR impact area. After confirming the presence of DU, the Army disclosed that information to the public.

As a result of archive searches conducted by the USACE regarding the potential for contamination resulting from the firing of spotter rounds for the Davy Crockett weapons system at SBMR, suspicion arose that this weapons system may have been used at other firing ranges in the Hawaiian Islands. The suspected ranges include MMR on O‘ahu, PTA on the Island of Hawai‘i, and the SBMR impact area on O‘ahu. For MMR and PTA, details of the archive searches were reported in "Archive Search Report On the Use of Cartridge, 20 mm Spotting M101 for Davy Crockett Light Weapon M28, Islands of O‘ahu and Hawai‘i" (Cabrera Services, 2008).

In August 2007, scoping surveys were performed at MMR and PTA. The surveys were performed to assess the presence of DU fragments that might have originated from past training activities involving Davy Crockett SRB. The results of these survey activities were used to develop the criteria and plans for a follow-on characterization survey of the potentially impacted areas.

The results of the MMR scoping survey were limited by accessibility issues. The aerial visual observations were obscured by vegetation and no radiological measurements were performed in the impact area. Entry to the impacted area was not allowed for safety reasons, and no samples of DU fragments were recovered or analyzed. The soil samples collected around the perimeter of the site did not identify any indications of DU (Cabrera Services, 2008).

The Army proceeded with a follow-on survey of MMR in December 2008 using a highly efficient technology alternative to conducting ground-based surveys where munitions and explosives of concern may be present, such as the impact area of MMR. The Army deployed this technology to more accurately enable the characterization of radiological data at MMR. The data was also compared to ground-based walkover data performed in some of the same areas in previous surveys. The results of this survey confirmed that no DU is found at MMR.

The fully detailed report indicating the results of these additional surveys at both MMR and PTA will be released in the near future to the public separately from the EIS.

The results of the PTA scoping survey confirmed several areas with launching pistons used to fire the Davy Crockett weapon system. Visual observations of these pistons, radiation measurements, and recovery of an intact Davy Crockett SRB all support that the Davy Crockett system was used at PTA. The soil samples collected around the perimeter of the site did not indicate the presence of DU, however, the Army will conduct a more thorough characterization survey and risk assessment in 2008 (Cabrera Services, 2008). The follow-on (December 2008) characterization surveys at PTA indicated that DU is not present at the twin Pu'u range site considered under Alternative 4 of this EIS.

AR 385-63, Range Safety, prohibits the use of DU ammunition for training worldwide. This policy has been in effect for more than 20 years. The Army does not have any plans to utilize DU at any range or other location in the state.

Lead from Ammunition

In addition to explosives residues deposited on the ranges at MMR and PTA during training, metals contained in various munitions may be deposited in the ranges. Among the metals present in some explosives are lead and mercury fulminate (an initiator for explosives). Lead is used in the manufacturing of ordnance/ammunition, such as those munitions used for small arms training listed in Table 2-3. Lead is used in the projectiles of small arms ammunition. Bullets are typically made up of an alloy of lead and antimony, which makes the bullet harder. Lead accumulating over the long term in backstops, range floors, and berms can leach into groundwater, be transported off-site by stormwater, be ingested by wildlife, or become airborne. Erosion can overload streams and rivers with sediments. The type and amount of ammunition used on the range along with its operational history greatly influences the risk of lead migration to groundwater. Different calibers of ammunition contain

varying amounts of lead; therefore, when looking at the risk of lead migration, both the total number and type of rounds fired must be taken into consideration. Contamination risk is substantially reduced if regular maintenance has been performed on the backstop and apron areas to remove rounds and fragments from soil (USAEC 1998). The Army implements general cleanup procedures following training events to remove shell casings and other munitions residue from the ranges. The permanent ammunition storage point located on WAAF requires that a certain percentage of weight of brass and links be returned to ensure the range area is returned to its original state to the extent possible.

The presence of lead can result in noncompliance with many environmental regulations, including the Clean Water Act, Safe Drinking Water Act, and Section 7003 of RCRA. Although these regulations and others can be applied to active small arms ranges, the law remains unresolved as to the extent to which federal and state agencies can directly regulate range activities. While the Army asserts that environmental authority does not reach active ranges, the Army's position is that prevention is the best course of action in an uncertain regulatory climate (USAEC 1998). The US Army Environmental Center (USAEC) Range XXI Team and the Army Training Support Center (ATSC) developed the guidance document, Prevention of Lead Migration and Erosion from Small Arms Ranges (USAEC 1998), to give range managers and military and environmental personnel management practices that minimize adverse impacts on human health and the environment from small arms range operations.

Preliminary results of the current hydrogeologic investigation show concentrations of lead above industrial PRG levels in soil samples taken at MMR's Objective Elk (see Appendix G of the EIS). Based on the limited detection of lead on the range and the isolated areas where it was found, lead is less of a contaminant than expected. As lead does not appear to be a migrating contaminant, no mitigation or maintenance is necessary until the range is closed.

Based on the results of a 2002 soil study at PTA, the highest lead concentrations, two of which exceeded the industrial soil PRG, were detected in samples from Ranges 9, 10, and 11. These concentrations are likely due to human activities. The resulting combined risk is above the one in one million cancer risk threshold (which mainly results from lead), but is within the range of what is considered acceptable under some circumstances (US Army and USACE 2004).

Records indicate that “green ammunition” may have been used at Mākua. Recent research indicates there may be a potential increase in the mobility of lead when it is found in conjunction with tungsten fired as part of the Army's "Green Ammunition" program. For a few years in the last decade, Green Bullets, also known as tungsten nylon bullets, were part of the Army's small arms portion of this program, an effort to provide Soldiers with ammunition that would be more environmentally sustainable than traditional munitions with lead cores. In this ammunition, tungsten metal and nylon were pressed together into the form of a bullet. This ammunition was used at MMR for a couple of years, ending in 2004.

Tungsten metal that was used for the manufacture of small caliber ammunition was originally thought to be inert and insoluble. However, it now appears that forms of tungsten (Tungstate) could potentially enter the groundwater. Tungsten in wet soils reacts with oxygen to form tungsten oxides, which dissolve in water as tungstate. This tungstate form has a greater potential to migrate into groundwater than previously thought. Additional research is underway through various Army agencies to determine potential health and ecological effects of tungstate. In the process of forming tungstate, soil pH is temporarily reduced and becomes more acidic. The lower pH may allow for easier transport of lead. The extent of this problem is not really known and continues to be studied by the Army. No remedial action has been determined to be required at this time. The tungstate reaction does not occur when water is no longer available, meaning that the reaction is limited in the dry environment of MMR.

The Army will continue to test for lead in the groundwater and surface water. At this point, there is no evidence that green ammunition has caused lead migration at MMR.

Pesticides

The EPA defines a pesticide as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (EPA 2002a). Pests can be insects, mice, and other animals, or unwanted plants (weeds), fungi, or microorganisms, such as bacteria and viruses. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, avicides (bird agents), rodenticides, and various other substances used to control pests. A pesticide is also defined as any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (EPA 2002a).

Pesticides can be applied only by someone who is certified to do so. There are three areas of pest management on MMR: herbicide treatment along the firebreak roads, alien weed species control, and building pests management. Herbicides are applied along the firebreak roads under contract every month or two, as needed. The DPW Environmental Division treats alien weed species. The DPW Pest Control Shop controls pests in the buildings. No pesticides are stored on MMR, as contractors are not allowed to store hazardous materials onsite. DPW personnel bring necessary materials to the site from SBMR. Pest management for MMR is covered under the USAG-HI Installation Pest Management Plan (USARHAW 2000), which conducts regular compliance inspections (Yamamoto 2002).

Hydrogeologic sampling being conducted by the Army includes testing for pesticides that may have been released to the environment through spills or disposal (Geotechnical and Structures Laboratory 2002). Preliminary results of the hydrogeologic studies found multiple areas within MMR that contain concentrations of pesticides below PRG levels. Heptachlor epoxide, a pesticide, was detected in MW-3C in the second round of sampling (but not in the first round) at a concentration of 0.039 μg/L, which is above the PRG of 0.007 μg/L but less than the MCL of 0.20 μg/L. On February 14, 2003, water samples were taken within MMR, and samples of water in both the Kaiahi Gulch and Punapōhaku streams contained concentrations of pesticides above PRG levels (see Appendix G-1 of the EIS).

There is one primary pesticide storage location on PTA, the DPW Natural Resources Department (Building T-93). This entity controls alien species and protects native threatened and endangered species with the use of herbicides and rodenticides on all training areas. Small volumes of pesticides are stored in plastic lockers, with closed plastic containers as secondary containment. Larger volumes are stored in plastic containers on secondary containment pallets. Pest management of the cantonment area is completed under contract. Contractors are not allowed to store hazardous materials, including pesticides, on site (US Army and USACE 2004).

According to site visits and interviews by outside consultants with PTA facility personnel during a 1997 hazardous waste inspection, a pesticide storage shed used to be located near the north side of Building T-31. In the 1980s, the pesticide storage shed was moved to the engineer's storage yard along the northwestern side of the cantonment area. The ground surface around the former pesticide storage area may be contaminated from inadvertent spills of pesticides during the formulation and mixing process; however, installation personnel identified no specific instances of

spillage (US Army and USACE 2004). Pesticide formulation and mixing was conducted at a potable water source equipped with a backflow-prevention device. Pesticide contaminated rinsates from the spray equipment and container rinsing were also reportedly disposed of by applying the rinsate to needed areas. Pesticides may also have spilled within the storage shed and seeped through a pervious wooden floor, contaminating the underlying soils. A gravel driveway now exists north of Building T-31, over the area that is believed to have been occupied by the pesticide storage shed. Later soil analysis in the area positively detected pesticide constituents in the soil, but average pesticide concentrations across the former pesticide storage area were well below the EPA Region IX PRG for pesticides of interest (PRC 1997, ES-3). As previously mentioned, pesticides are now stored in Building T-93 and are properly contained with an up-to-date spill plan (US Army and USACE 2004).

Field Investigations

The public has expressed concern about the impact on the environment of training operations throughout the Mākua Valley. Over the years, the area was used for military training with live ammunition. This resulted in a variety of ordnance and ammunition being distributed throughout Mākua Valley. Migration of compounds within and from MMR would likely be either through percolation into the deep groundwater or runoff and erosion of contaminated solid particles into surface water. Possible sources of groundwater contamination include metals, explosives, or explosives byproducts released into the environment. In addition to concerns about soil and water contamination, the public has expressed concerns about air pollution from military use of MMR. An overview of ongoing field investigations is discussed in the introduction to Chapter 3.

As mentioned previously, the MMR OB/OD area is a RCRA treatment facility and is undergoing delayed closure with the HDOH (Akasaki 2008). The quantities of ordnance detonated at the OB/OD area per year are discussed in the ammunition subsection in this report. There have been various studies conducted at MMR to evaluate the sources and the extent of contamination from military training. The potential for contamination from past training exercises and from the OB/OD area to migrate from the surface water to the groundwater pathway was considered in 1994 by Halliburton NUS. The monitoring well at the site, SP-7, was installed and sampled to investigate the possibility of surface water flow collecting contaminants then infiltrating through the streambed. Well SP-7 is shallow and adjacent to the streambed. Groundwater samples collected from this well were analyzed for energetics, semivolatile compounds, nitrates, nitrites, and total metals. None of the samples had detectable concentrations of energetics or semivolatile compounds. The nitrate and

nitrite concentrations in the samples were below risk-based health criteria and drinking water standards. Detectable levels of barium, chromium, lead, mercury, and nickel were also below risk-based health criteria and drinking water standards (Halliburton NUS Corporation 1994). The conclusion from the results was that the basal aquifer at MMR was not contaminated. Therefore, the potential for contaminants from past training activities to migrate from the surface water to groundwater pathway to the installation boundary was considered low.

In 1999, the EPA and the HDOH performed an investigation of sediment samples from the *muliwai* west of Farrington Highway (Baylor 1999). Samples were collected from the pond bottom sediments and were analyzed for metals. The investigation found that cadmium, chromium, and copper exceeded the NOAA Effects Range-Low levels and that nickel exceeded the NOAA Effects Range-Medium level in both the MMR and reference *muliwai* samples. The NOAA Effects Range is a measure of the risk to ecological receptors and designates chemical concentrations as low, medium, or high. Because concentrations of some metals are naturally elevated in Hawaiian soils, and because elevated concentrations of these metals were found in the reference (background) *muliwai* location, the investigators could not determine whether the elevated metals concentrations originated from human activities or were naturally occurring.

From May 19 through 21, 2003, the Army collected 50 sediment samples from the three *muliwai* along Mākua Beach and the two background locations. Twenty-two samples were collected from the north *muliwai*, 18 from the south *muliwai*, 4 from the dry *muliwai*, and 3 each from the north background location and the south background location. All of the samples were analyzed for metals and explosives. Ten of the samples and two of the duplicates were subjected to an extended suite of analyses that included benzene, toluene, ethylbenzene, and xylenes (BTEX); organochlorine pesticides; chlorinated herbicides; semivolatile organic compounds (SVOCs); dioxins and furans; nitrate/nitrite; total organic carbon; and particle size.

Based on the field observations and the analytical results of the *muliwai* sediment sampling program, the following conclusions were made:

- Concentrations of metals detected in the *muliwai* were within the ranges found in the background samples.
- Arsenic and chromium were detected at concentrations above EPA Region IX soil PRGs but were within background concentration ranges.

- Nearly all of the twelve samples that were analyzed for BTEX contained one or more of these compounds. All of the concentrations of the BTEX chemicals were far lower than EPA Region IX soil PRGs.
- Six of twelve sediment samples analyzed for the full suite of organic compounds contained one or more of the chemicals of concern (with the exception of BTEX, which was detected more frequently). One sample contained one of the explosive compounds, and one sample contained one pesticide compound. Three herbicides and three SVOCs were found in four samples. The detected concentrations were far below EPA soil PRGs.
- Trace concentrations of two dioxin isomers were detected in two of the twelve *muliwai* sediment samples analyzed for dioxins and furans. The 2,3,7,8-TCDD isomer was detected at a concentration above the EPA Region IX industrial soil PRG in one sample from the dry *muliwai*, collected at a depth of 2.5 feet. The toxicity equivalent of the octa-TCDD isomer found in the other sample, from the north *muliwai* did not exceed the Region IX industrial soil PRG.

The recent hydrogeologic sampling is discussed at the introduction of Chapter 3, and results are discussed for individual topic areas in Section 3.11.4.

Nearshore Underwater Survey

In December 2002, the Army's 7th Dive Detachment conducted and videotaped a 12-diver, 3-day-long, nearshore dive survey of Mākua Beach that included all locations where metal globules were suspected to be on the ocean floor. The planned dive followed a 4,921-foot (1,500-meter) transect that ran parallel to the beach at a distance of 492 feet (150 meters) offshore, and five 984-foot (300-meter) transects that were spaced equidistant along the 4,921-foot (1,500-meter) transect and were oriented perpendicular to Mākua Beach (see Figure 3.11-2).

No metal globules were found in the ocean, but one metal globule, similar to the specimen presented during a public scoping meeting, was found on Mākua Beach.

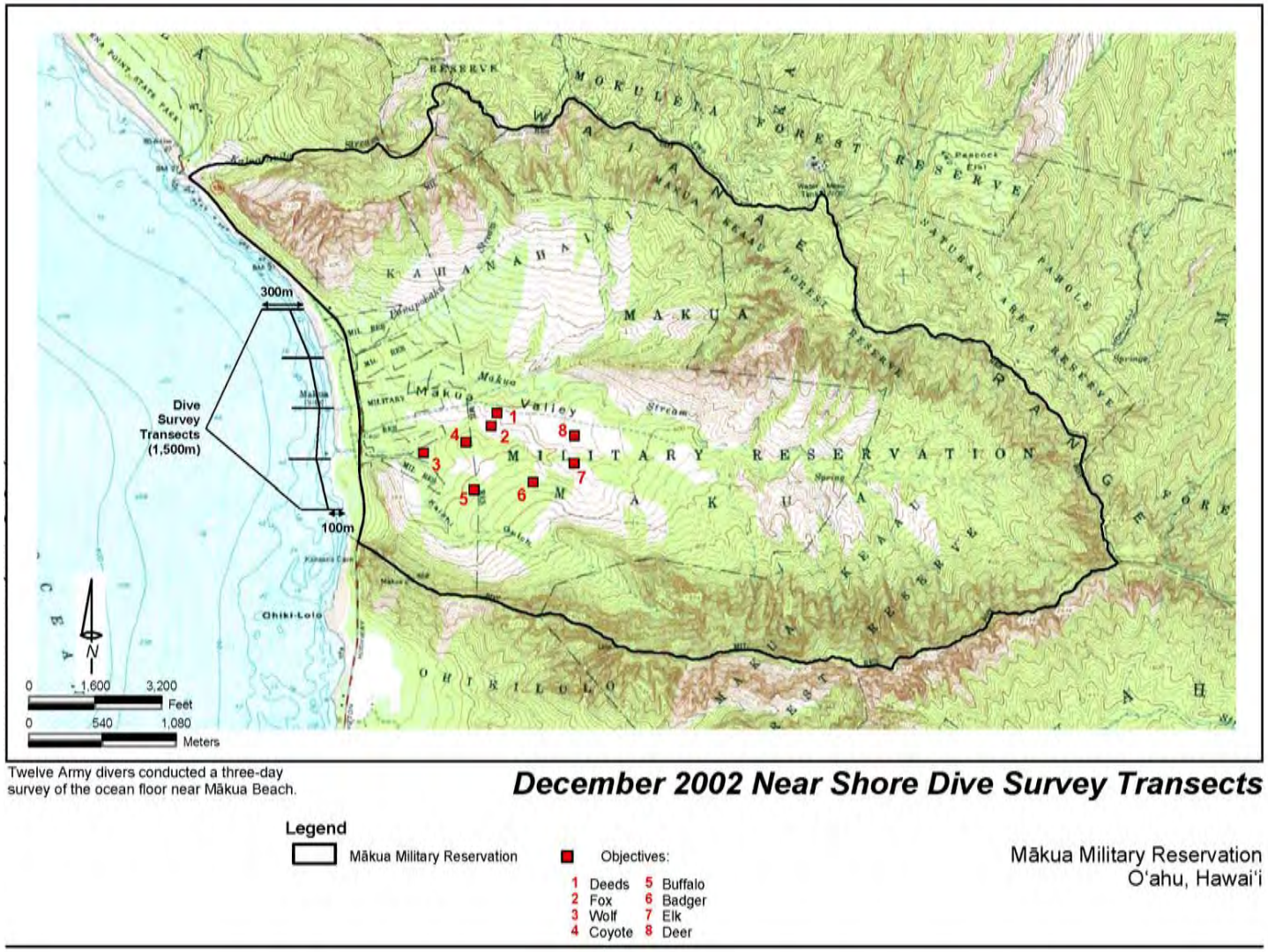

Figure 3.11-2 December 2002 Near Shore Dive Survey Transects, MMR

Analysis of the metal globule for 24 different metals (including mercury) found that greater than 99.4 percent of the sample was composed of the following four metals:

- Aluminum: 976,000 milligrams per kilogram (mg/kg) (approximately 97.6 percent);
- Magnesium: 12,100 mg/kg (approximately 1.2 percent);
- Iron: 3,750 mg/kg (approximately 0.4 percent); and
- Copper: 2,340 mg/kg (approximately 0.2 percent).

The balance of the sample (approximately 0.6 percent) was composed of various trace elements, including calcium, chromium, and zinc. Based on this analysis and the physical appearance of the sample, it was likely an irregular mass of melted down aluminum cans since the chemical composition of aluminum alloys used in beverage cans closely resembles the sample results noted above. According to the USAEC, the University of California Berkeley, and the Alcoa Corporation, magnesium is added to beverage can aluminum alloys for corrosion resistance, and iron, copper, and zinc are added for structural strength.

Polychlorinated Biphenyls

PCBs are mixtures of synthetic organic chemicals with the same basic chemical structure and similar physical properties, ranging from oily liquids to waxy solids. Due to their nonflammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications, including electrical, heat transfer, and hydraulic equipment (EPA 2002b). PCBs can be found in the cooling fluid of electrical equipment, including transformers and capacitors, particularly if such equipment was manufactured before the early 1970s. PCBs are also found in other manufactured items and as plasticizers and fire retardants in many solid materials (USCG 2002). No PCB-containing equipment or materials are located on MMR (Husemann 2003d).

Soil samples collected as part of the 1994 Halliburton NUS study contained PCBs in the soil above background concentrations. These contaminants were found in soils at the OB/OD area. The source of these chemicals is unknown; however, historic disposal of materials other than munitions in the OB/OD area was not uncommon. The concern was that these contaminants could be transported off-site by wind, surface water, or groundwater, as contaminants were found at depths ranging from between 6 inches (15 centimeters) below ground surface (bgs) to 12 feet (4 meters) bgs.

Because of the Halliburton NUS study results, historic site uses, historic records, and public concern regarding contaminants of interest (including PCBs), hydrogeologic investigations were initiated by the Army, including testing water and soil for a large number of different chemicals. PCBs are included to evaluate the potential disposal of transformer oils or other chlorinated oils. Results of the hydrogeologic investigation showed PCBs in two soil samples at the MMR OB/OD area. Concentrations were lower than industrial PRGs. PCBs were not detected in any other areas of MMR (see Appendix G-1).

PRC Environmental Management, Inc., conducted a preliminary assessment/site inspection of four potential contaminant sources (a former pesticide storage area, a fire training area, and two landfills) within the boundaries of PTA during March and April 1993. The analytical results for soil sampling in these areas indicated that PCB concentrations were all below the listed PRG. Devices that were found to contain regulated levels of PCB have been either removed and upgraded with non-PCB devices, or were retrofilled or removed, drained, packaged, and disposed of in accordance with 40CFR Part 761. No PCB-containing transformers remain at PTA.

Electromagnetic Fields

The production of weak electromagnetic fields (EMF) is associated with the generation, transmission, and use of electrical energy (NIEHS 2002). In 1992, Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act (NIEHS 2002). The EMF-RAPID Program was funded jointly by federal and matching private funds, with substantial financial support from the utility industry. Congress instructed the National Institute of Environmental Health Sciences (NIEHS) and the Department of Energy (DOE) to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to extremely low frequency-EMF (ELF-EMF). The NIEHS is one of 25 institutes and centers of the National Institutes of Health (NIH). The EMF-RAPID Program had the following three basic components:

- A research program focusing on health effects research;
- Information compilation and public outreach; and
- A health assessment for evaluating any potential hazards arising from exposure to ELF-EMF.

The NIEHS was directed to oversee the health effects research and evaluation (NIEHS 2002) and to provide a report outlining the possible

human health risks associated with exposure to ELF-EMF. The document that responds to this requirement is the NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields (NIEHS 2002).

In its report, the NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In the opinion of the NIEHS,

> "…this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS 2002)."

Based on the results of the NIEHS report discussed above, ELF-EMF are not addressed in this EIS as a potentially harmful issue of concern, but project activities involving EMF frequencies higher than ELF-EMF are addressed; this includes radio frequency EMF. Three remote automated weather stations (RAWS) are located on MMR (see Figure 3.11-1). These are typically set in remote wildland fire areas and are used to collect weather information to aid in determining the potential for wildfires (Shelley 2002). RAWS use radio frequencies to transmit weather data to a geostationary operational environmental satellite. The RAWS transmit information for approximately 15 seconds each hour. Exposure to any RAWS EMF is limited because they are typically located in remote locations, are unmanned, and transmit information for a short duration. These RAWS require personnel to be onsite only for maintenance and not for operations.

Equipment producing EMF that could pose a serious health risk is operated under strict constraints, in site-approved areas, and by qualified personnel per technical publications (Moreno 2002). Mobile radar equipment is owned by Division Artillery and consists of a radar set designed to detect incoming artillery and projectiles. It is operated and managed by the Forward Area Defense section.

<u>Petroleum, Oils, and Lubricants</u>

Mākua Military Reservation

The analytical results of the 1994 Halliburton NUS soil sampling showed that none of the soils used for past training exceeded the EPA's conservative public health criteria for volatile organic compounds (VOCs), which are constituents associated with petroleum products. VOCs are commonly found in solvents used to wash shell casings or to clean other ordnance as part of the demilitarization process. A commonly found VOC is trichloroethylene, which has been found in the soil and groundwater at other military training areas. Another VOC, benzene, is often associated with motor fuels and fuel leaks and spills. VOC contamination is an ongoing concern, however, as training continues, and VOCs could be transported off-site by wind, surface water, or groundwater.

The introduction of Chapter 3 includes a discussion of the hydrogeologic sampling and analysis of surface and subsurface soil, stream sediment, surface water, and groundwater; analysis of these materials includes VOCs. Sampling results are summarized in Sections 3.7 and 3.8.

There are no underground or aboveground storage tanks containing POLs or hazardous materials and no oil/water separators on MMR. All industrial fueling and maintenance is conducted from the "super station" and unit motor pools on SBMR. Tankers transport needed petroleum to the reservation and leave after fueling vehicles and equipment. Only necessary quantities of fuels and oils needed during training exercises are temporarily staged onsite (for example, gasoline needed for a generator would be stored in a canister next to the equipment). Unused fuels and oils are removed from the reservation by the unit.

Pōhakuloa Training Area

PRC Environmental Management, Inc. conducted a preliminary assessment and site inspection of PTA in March and April 1993 (PRC 1997). Soil samples were obtained across the installation and were analyzed for various constituents, including petroleum products. The results indicated that subsurface soils and bedrock at the fire training area and two landfill areas were contaminated with low concentrations of petroleum-based substances (likely used motor oil and fuel oil, such as kerosene). The former burn pit was in the vicinity of the fire training area and was constructed of rubber plates covered with dirt and surrounded by an earthen berm. Flammable liquids were poured into the burn pit during fire training exercises and may have seeped into the underlying soil and bedrock along the unsealed plate seams. The former burn pit was decommissioned after 1983, and a new fire training facility with a more suitable design was constructed in 1994 (US Army and USACE 2004).

Gross petroleum contamination was not apparent based on field observations and screening. Analytical results indicated that VOCs and SVOCs were below EPA Region IX PRGs. Site inspection data for soils in these areas indicate the presence of some contaminants of concern, but at concentrations that if left in place, would pose minimal, if any, threat to human health and the environment (PRC 1997) (US Army and USACE 2004).

The bulk storage facility, which was constructed in early 1982 at Building 343, has eight underground storage tanks (USTs). POL containers belonging to the bulk fuel facility are stored on a concrete pad with secondary containment.

One UST is included on the LUST list maintained by DPW. This tank was located at the dining facility in Building T-186 and was removed in May 1994. This site has been remediated, and the EPA issued a clean closure status in December 2001.

3.12 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

The socioeconomic indicators used to describe the affected environment for socioeconomic resources include population; economy, employment, and income; housing; and schools. The population data include the number of residents in the area and the recent changes in population growth. Data on employment, labor force, unemployment trends, income, and industrial earnings describe the economic health of a region. Income information is provided as an annual total by county and per capita. Housing availability and school enrollment and capacity are important considerations for assessing the effects of potential growth. The number and type of housing units, ownership, and vacancy rate are also indicators of the regional quality of life. Additional demographic data, including race and ethnicity, age, and poverty status, are presented to facilitate the evaluation of potential environmental justice and protection of children issues.

These socioeconomic indicators characterize the ROI.

The baseline year for socioeconomic data is 2000, which is the most recent year that data for most of the socioeconomic indicators are available. When available, more recent data are used to best characterize the current conditions of the socioeconomic ROI.

Comments from the public received during the EIS scoping process raised the following socioeconomic and environmental justice issues:

- Community treatment by the Army;
- Reduction of the Army training area and degree of Army training activity;
- Greater public participation and public opinion;
- Adverse health effects caused by toxic elements dispersed into the environment; and
- General project impact on cultural and natural resources.

3.12.1 Introduction/Region of Influence

A ROI is a geographic area selected as a basis on which the social and economic impacts of a project are analyzed. The ROI for socioeconomic impacts includes the counties in which the proposed facilities would be located. The ROI includes nearby trade and service centers related both

directly and indirectly to the economic activities of each installation, and takes into account the residency distribution of military and civilian personnel, and the schools their children attend.

The following criteria were used to determine the MMR and PTA ROIs:

- Geographic location;
- Residency distribution of the military and civilian personnel associated with MMR;
- Commuting distances and times;
- The location of businesses providing goods and services to the facility; and
- Facility personnel and their dependents.

The ROIs evaluated in this document are defined as counties in the State of Hawai‘i. One county covers each island. The City and County of Honolulu (hereafter also referred to as Honolulu County) covers the Island of O‘ahu, where MMR and SBMR are located. County of Hawai‘i or Hawai‘i County covers the Island of Hawai‘i, where PTA is located.

For the purpose of discussing socioeconomic characteristics, the islands can be further defined by the Census County Division (CCD) to more accurately depict the most affected areas adjacent to the reservation. A CCD represents a relatively permanent statistical area established cooperatively by the US Census Bureau and state and local government authorities that is used for presenting decennial Census statistics in those states that do not have well defined and stable minor civil divisions that serve as local governments (US DOC Census 2000). Honolulu County is divided into seven CCDs. Hawai‘i County has 12 CCDs.

Mākua Military Reservation

The MMR ROI for the social and economic environment is defined as Honolulu County. Although Honolulu County encompasses the entire Island of O‘ahu and contains several different distinct districts in terms of demographic makeup and level of development, most economic activities can be tracked only at the county level because of the way data are collected and compiled.

Where possible, this section describes the socioeconomic characteristics at the CCD level to more accurately depict the most affected areas adjacent to the reservation. Honolulu County is divided into seven CCDs, which include ‘Ewa, Honolulu, Ko‘olauloa, Ko‘olaupoko, Wahaiwa, Waialua,

and Waiʻanae. MMR is within the Waiʻanae CCD. SBMR is within the Wahiawā CCD.

Pōhakuloa Training Area

The PTA ROI is defined as Hawaiʻi County. The 12 CCDs within Hawaiʻi County are Hilo, Honokaʻa-Kukuihaele, Kau, Keaʻau-Mountain View, North Hilo, North Kohala, South Kohala, North Kona, South Kona, Pāʻauhau-Paʻauilo, Pāhoa-Kalapana, and Papaikou-Wailea. PTA occupies mainly Pāʻauhau-Paʻauilo CCD and small portions of the North Kona, South Kohala, and North Hilo CCDs.

3.12.2 Employment

Mākua Military Reservation

Table 3.12-1 presents the distribution of employment among the various industry sectors and the changes experienced in these sectors between 1990 and 2000 for Hawaiʻi, Hawaiʻi County, and Honolulu County. Note that Hawaiʻi's economy in general, and the Honolulu County ROI economy in particular, experienced very slow growth during the 1990s. Overall, the state economy performed poorly, compared to most regions in the continental US, where economic growth was quite robust through most of the 1990s.

The services, government, and retail trade sectors employed the greatest number of workers in the state and in both Hawaiʻi and Honolulu counties in 2000. Between 1990 and 2000 employment in the State of Hawaiʻi in the mining; farm services, forestry, and fishing sector; and services sector increased by the largest percentages (ranging from 20 to 41 percent). Of the major sectors shown in Table 3.12-1, construction, manufacturing, and farm employment experienced the greatest percentage decreases over the decade in the state (BEA 2002a).

Within the government sector, state and local government employed the majority of workers. The military experienced a 21.5 percent decline in employment between 1990 and 2000.

In Honolulu County, employment growth between 1990 and 2000 was similar to the state average, with the mining, farm services, forestry, and fishing, and services sectors experiencing the greatest percentage increases between 1990 and 2000. The construction, manufacturing, farming, and government sectors all experienced decreased employment over this period (ranging from -7 to -26 percent). The decline in employment in the government sector is attributed to decreases in federal civilian and military employment (-12.7 and -22.7 percent, respectively);

state and local employment increased in Honolulu County by 14.9 percent (BEA 2002a).

As of September 2001, SBMR employed approximately 12,000 personnel (HDBEDT 2003). About 10,100 were military personnel, 300 were civilian personnel, and the remaining 1,600 were other personnel. SBMR accounts for approximately 9 percent of all government jobs in Honolulu County. Employees at MMR are considered part of the SBMR work force.

Honolulu County's unemployment rate (3.8 percent) was below that of the state (4.3 percent) in 2000 (BLS, no date).

Pōhakuloa Training Area

The employment growth figures for Hawai‘i County contrast substantially with the state averages. In Hawai‘i County, on the Island of Hawai‘i, employment in the services, finance, insurance, and real estate, and government sectors increased by the greatest percentages between 1990 and 2000 (ranging from 20 to 33 percent). Within the government sector, both federal civilian and military employment increased over the decade, and farm employment and construction experienced the only employment declines. PTA employs approximately 170 military and civilian personnel.

Hawai‘i County had the highest unemployment rate in 2000 (6.7 percent), which exceeded the state average of 4.3 percent (BLS no date).

Table 3.12-1
Employment by Industry Sector

State of Hawai‘i Sector	1990	2000	Percent Change 1990-2000
Farm employment	14,610	12,890	-11.8
Farm services, forestry, fishing	7,572	9,423	24.4
Mining	374	528	41.2
Construction	40,228	32,083	-20.2
Manufacturing	24,041	20,785	-13.5
Transportation, public utilities	45,299	47,311	4.4
Wholesale trade	25,887	26,233	1.3
Retail trade	131,848	138,565	5.1
Finance, insurance, real estate	61,225	63,629	3.9
Services	207,861	249,499	20.0
Government	171,742	165,686	-3.5
Federal, civilian	33,717	30,083	-10.8
Military	67,225	52,776	-21.5
State and local	70,800	82,827	17.0
Total Employment	**730,687**	**766,632**	**4.9**

Table 3.12-1
Employment by Industry Sector

State of Hawai‘i Sector	1990	2000	Percent Change 1990-2000
Honolulu County Sector			
Farm employment	3,429	3,000	-12.2
Farm services, forestry, fishing	4,189	5,096	21.7
Mining	251	345	37.5
Construction	29,244	21,711	-25.8
Manufacturing	17,872	15,614	-12.6
Transportation, public utilities	36,967	37,085	0.3
Wholesale trade	21,096	20,796	-1.4
Retail trade	98,042	98,596	0.6
Finance, insurance, real estate	48,529	48,602	0.2
Services	153,043	175,426	14.6
Government	150,286	139,596	-7.1
Fedeeral, civilian	32,134	28,051	-12.7
Military	64,459	49,829	-22.7
State and local	53,693	61,716	14.9
Total Employment	**562,948**	**565,876**	**0.5**
Hawai‘i County Sector			
Farm employment	5,948	5,581	-6.2
Farm services, forestry, fishing	1,672	NA	NA
Mining	75	NA	NA
Construction	4,549	4,369	5.5
Manufacturing	2,666	NA	NA
Transportation, public utilities	2,681	3,191	4.0
Wholesale trade	2,384	NA	NA
Retail trade	12,460	14,154	17.8
Finance, insurance, real estate	4,608	5,684	7.1
Services	20,440	27,219	34.2
Government	10,130	12,182	15.3
Fedeeral, civilian	791	1,038	1.3
Military	1,212	1,277	1.6
State and local	8,127	9,867	12.4
Total Employment	**67,613**	**79,628**	**17.8**

Source: US DOC BEA 2002a

3.12.3 Income

Mākua Military Reservation and Pōhakuloa Training Area

Federal government expenditures in Hawai‘i totaled approximately $9 billion in 2000. Defense expenditures accounted for 39 percent of federal spending in 2000, down from approximately 54 percent in 1990. Nonetheless, defense spending in Hawai‘i increased 33 percent between 1990 and 2000 to $3.5 billion (Hawai‘i Department of Business, Economic Development, and Tourism [HDBEDT] 2001). In 2002, per capita defense spending in Hawai‘i reached $3,045, second only to that of Virginia in the 50 United States. The economic impacts of defense spending have a ripple effect throughout the Hawaiian economy due to additional spending by military residents for goods and services procured off-post and the increased demand for goods and services generated by vendors and contractors associated with the military installations.

The Honolulu County per capita personal income (PCPI) of $29,960 in 2000 exceeded the state and national PCPI level (Table 3.12-2). However, as shown in the Table, the State’s PCPI growth was considerably sluggish compared to the rest of the US economy, although the PCPI increased for Hawai‘i, Honolulu County, and Hawai‘i County between 1990 and 2000. Honolulu County experienced the greatest growth in PCPI in the time period. The Hawai‘i County PCPI was $20,399, with a PCPI increase between 1990 and 2000 of 22.9 percent (BEA 2002b).

Table 3.12-2
Per Capita Personal Income

Location	1990	2000	Percent Change
Honolulu County (ROI)	$23,758	$29,960	26.1
Hawai‘i County (ROI)	$16,599	$20,399	22.9
State of Hawai‘i	$22,375	$28,301	26.5
US	$19,572	$29,469	50.6

Source: US DOC BEA 2002b

3.12.4 Demographics

Mākua Military Reservation

Table 3.12-3 shows the population in the ROI in 1990 and 2000, with comparative data for the Waiʻanae CCD, Hawaiʻi, and the US. Honolulu County's population (ranked first in the State) comprised 72.3 percent of the state population (a 2.2 percent decline from the 1990 level) (US Census Bureau 1990, 2000). Hawaiʻi has a large military population, albeit one that has decreased from a high of 67,100 military personnel in 1984 to 40,800 in 2000. Because most of the population resides in or near Honolulu, the presence of military personnel and their dependents is most prominent on Oʻahu. No military or civilian personnel are permanently stationed at or reside at MMR.

Between 1990 and 2000, the ROI population increased by approximately 4.8 percent, or only about half the growth rate for the State of Hawaiʻi as a whole and just slightly more than a third of the growth rate for the United States. During the 1990s, approximately 100,000 residents emigrated from the State. This slow population growth rate reflected the stagnant growth in the overall regional economy during this period. Population in the Waiʻanae CCD, however, increased by 13 percent, about the same as the growth rate for the US.

Pōhakuloa Training Area

In 2000, Hawaiʻi County's population accounted for 12.3 percent of the state population (a slight increase from 1990) and ranked second in the State (which contains four counties). Between 1990 and 2000, the population increased in Hawaiʻi County by 23.6 percent, more than twice the percentage increase at the state level.

PTA mainly occupies the Pāʻauhau-Paʻauilo CCD and small portions of the North Kona, South Kohala and North Hilo CCDs. Within Hawaiʻi County, the South Kohala CCD experienced one of the greatest population growth percentages (43.7 percent). In 2000, the population of the North Kona CCD was one of the largest population centers on the Island of Hawaiʻi, with 19.2 percent of the population (US Census Bureau 1990, 2000). No military or civilian personnel are permanently stationed at or reside at PTA.

Table 3.12-3
Population Trends

	1990	2002	Percent Change 1990-2000
Waiʻanae CCD	37,411	42,259	13.0
Honolulu County (ROI)	836,231	876,156	4.8
Pāʻauhau-Paʻauilo CCD	1,864	2,213	18.7
North Kona CCD	22,284	28,543	28.1
South Kohala CCD	9,140	13,131	43.7
North Hilo CCD	1,541	1,720	11.6
Hawaiʻi County	120,317	148,677	23.6
State of Hawaiʻi	1,108,229	1,211,537	9.3
US	248,709,873	281,421,906	13.2

[1]Source: US DOC Census 1990
[2]Source: US DOC Census 2000

3.12.5 Housing

Mākua Military Reservation and Pōhakuloa Training Area

Soldiers training at MMR and PTA are stationed at SBMR, which has 3,356 family housing units, in addition to bachelor quarters and housing for visitors. There are no permanent housing facilities at MMR or PTA.

3.12.6 Other Quality of Life Issues

Because the Proposed Action and alternatives would have only limited impacts on employment or population levels, this EIS does not address medical care; primary, secondary, and post-secondary education; shops and services; family support; and homeless programs.

3.12.7 Environmental Justice

On February 11, 1994, President Clinton issued EO 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. The EO was designed to focus the attention of federal agencies on the human health and environmental conditions in minority and low-income communities. Environmental justice is analyzed to identify and address disproportionately high and adverse human health or environmental effects of federal agency programs, policies, and activities on minority and low-income populations and to identify alternatives that might mitigate these impacts. Data from the US Department of Commerce

2000 Census of Population and Housing were used for this environmental justice analysis.

Minority populations included in the census are identified as Black or African American; American Indian and Alaska Native; Asian; Native Hawaiian and other Pacific Islander; Hispanic; of two or more races; and other. The demographic profile of the State of Hawai‘i is unique and significantly differs from regions within the continental US in almost all respects. While many other regions in the US have large nonwhite populations, the majority of residents in the State of Hawai‘i are of Native Hawaiian, Asian, and other Pacific Islander descent. As seen in Table 3.12-4, these groups accounted for 51.0 percent of the total population of Hawai‘i.

Poverty status, used to define low-income status, is reported as the number of persons with income below the poverty level. The Census Bureau bases the poverty status of families and individuals on 48 threshold variables, including income, family size, number of family members under the age of 18 and over 65 years of age, and amount spent on food. The 2000 Census defines the poverty level as an annual income of $8,794 or less for an individual, and an annual income of $17,603 or less for a family of four. The 2000 Census estimates indicate that almost 11 percent of the population of the State of Hawai‘i, approximately 15 percent of Hawai‘i County, and almost 10 percent of Honolulu County were below the poverty level of families in 1999.

Mākua Military Reservation

The demographic profile of the socioeconomic ROI shows a majority of residents of Native Hawaiian, Asian, and other Pacific Islander descent. As seen in Table 3.12-4, these groups accounted for 54.9 percent of the total population of Honolulu County. When taken down to the CCD level of Wai‘anae, these groups accounted for a slightly lower percent of the total population (45.5 percent). Asian, Native Hawaiian, and other Pacific Islander account for less than five percent of the total US population. Persons describing themselves as Black or African American constituted only 2.4 percent of the ROI population and 1.1 percent of the Wai‘anae CCD population, compared to 12.3 percent of the total US population. Similarly, while White persons account for 75.1 percent of the US population, only 21.3 percent of the ROI population and 11.2 percent of the Wai‘anae CCD population fall into this category.

In 2000, approximately 9.9 percent of Honolulu County residents were classified as living in poverty, lower than State’s poverty rate and the

poverty rate for the US (Table 3.12-4). The poverty rate for the Wai‘anae CCD was 21.8 percent (US DOC Census 2000).

Because of the low-income status of the residents in the Wai‘anae CCD, that population qualifies for consideration under EO 12898 as a potential environmental justice population.

Table 3.12-4
Race, Ethnicity, and Poverty Status

	Wai‘anae CCD[1]	Honolulu County ROI[2]	Hawai‘i County ROI[2]	State of Hawai‘i[2]	US[2]
White	11.2%	21.3%	31.5%	24.3%	75.1%
Black or African American	1.1%	2.4%	0.5%	1.8%	12.3%
American Indian and Alaska Native	0.3%	0.2%	0.4%	0.3%	0.9%
Asian	16.8%	46.0%	26.7%	41.6%	3.6%
Native Hawaiian and Other Pacific Islander	28.7%	8.9%	11.3%	9.4%	0.1%
Other	1.1%	1.3%	1.1%	1.3%	5.5%
Two or More Races	40.7%	19.9%	28.5%	21.4%	2.4%
Hispanic or Latino[3]	13.9%	6.7%	9.5%	7.2%	12.5%
Living in Poverty[4]	21.9%	9.9%	15.1%	10.7%	13.3%

N/A = Not available
[1]Source: US DOC Census 2000
[2]Source: US DOC Census 2001
[3]Persons of Hispanic origin may be of any race.
[4]Percent of persons living below poverty is for 1999.

Pōhakuloa Training Area

As shown in Table 3.12-4, the dominant ethnic groups in the socioeconomic ROI are Asian and Native Hawaiian and other Pacific Islanders, comprising 38.0 percent of the population each. Within Hawai‘i County, the Hilo and Papaikou-Wailea CCDs had the highest minority populations; however, all CCDs were composed of greater than 50 percent minority populations. The North Hilo CCD had the highest percentage of minority populations (71.9 percent), and North Kohala had the lowest (52.9 percent) (US Census Bureau 1990, 2000).

Approximately 15 percent of Hawai‘i County residents were below the poverty line, higher than State’s poverty rate and the poverty rate for the US (Table 3.12-4).

3.12.8 Protection of Children

EO 13045, *Protection of Children from Environmental Health and Safety Risks*, requires federal agencies, to the extent permitted by law and mission, to identify and assess environmental health and safety risks that might disproportionately affect children and ensure that their policies, programs, activities, and standards address disproportionate risks to children that result from environmental health or safety risks. Environmental health and safety risks primarily entail risks that are attributable to products or substances that the child is likely to come into contact with or to ingest. In 2000, approximately 25.6 percent of the State's population was made up of children (under 18 years old), which is an increase of 10.9 percent from 1990.

Mākua Military Reservation

In 2000, 25.1 percent of the population in Honolulu County was under the age of 18. Within Honolulu County, the Waiʻanae, Koʻolauloa, and Wahiawā CCDs had the highest population percentages below the age of 18 (36.3, 32.3, and 31.0 percent, respectively), and the ʻEwa and Honolulu CCDs had the largest total populations of children (75,526 and 76,231, respectively) (US Census Bureau 1990, 2000).

MMR is fenced and closed to the public. The Army may restrict public use of MMR, post guards, and control traffic along Farrington Highway when necessary for training missions and for public safety.

During training at MMR, infantry companies and military vehicles travel from SBMR using public highways to reach MMR. These troop transport movements are scheduled to avoid school transit hours (see Section 2.5.3, Movement to the Site).

Pōhakuloa Training Area

In 2000, 27.4 percent of the population of Hawaiʻi County was under the age of 18. Within Hawaiʻi County, the Pāhoa-Kalapana, South Kohala, and Keaʻau-Mountain View CCDs had the highest population percentages below the age of 18 (30.1, 30.1, and 31.0 percent, respectively), and the Hilo, North Kona, and Keaʻau-Mountain View CCDs had the largest total populations of children (11,175, 7,281, and 7,040, respectively). PTA mainly occupies the Pāʻauhau-Paʻauilo CCD and small portions of the North Kona, South Kohala and North Hilo CCDs. The percentages of the populations of North Hilo, North Kona, Pāʻauhau-Paʻauilo, and South Kohala CCDs under the age of 18 were 25.8, 25.5, 28.7, and 30.1 percent, respectively (US Census Bureau 1990, 2000).

3.13 PUBLIC SERVICES AND UTILITIES

3.13.1 Introduction/Region of Influence

MMR uses federal and county police, fire, and emergency medical services. Utility services are obtained from the county and from contractors and include potable water, stormwater, wastewater, solid waste management, telephone, and electric power.

In addition to the project description in Chapter 2, the following was assumed: emergency care patients would be stabilized at Wai‘anae Coast Community Health Center (WCCHC). These patients ultimately would be transferred to Tripler Army Medical Center, rather than another area hospital, for continued care.

During the scoping process, public comments regarding public service and utility issues included concerns about land maintenance and the existence and location of a designated triage or medical care facility.

3.13.2 Police

Mākua Military Reservation

No on-site police force is maintained at MMR; the Army has jurisdiction and uses military police units as the primary law enforcement agency. While the Honolulu Police Department has no formal role in activities at MMR, it will respond to events at its discretion (Yamamoto 2003). The Army typically gives the Honolulu Police Department one to two weeks notice of upcoming training activities at MMR (Husemann 2003a). The Wai‘anae police station is approximately 8.3 miles (13 kilometers) from MMR.

Pōhakuloa Training Area

Army staff provide all police services on PTA. Units that come to PTA for training may bring military police of their own, depending on the size of the unit and other circumstances. The PTA police facility is located in the cantonment area and is open 24 hours per day, seven days per week. Saddle Road, a public highway, is patrolled by Hawai‘i County police, but PTA military police are available for support when necessary. Lands leased by the Army are not patrolled on a regular basis, but military police will respond to calls in coordination with county police. PTA military police coordinate extensively with county police on a regular basis (US Army and USACE 2004).

3.13.3 Fire

Mākua Military Reservation

Two 300,000-gallon (1.1-million-liter) reservoirs, one located in the valley at the final objective and the other between the staging area and administration building, provide water for helicopter dip buckets. A minimum depth of seven feet (2.1 meters) is provided at each reservoir before training begins. The lower reservoir is filled with water obtained from the on-site 33,000-gallon (125,000-liter) water storage tank, which is supplied by a county water service lateral pipe. The upper reservoir is filled with rainwater or augmented with water obtained from an off-site county fire hydrant and trucked to MMR. The Honolulu Fire Department will respond to fires outside of the facility or when requested to support the federal fire department (Husemann 2003a). The Waiʻanae fire station is approximately 7.8 miles (13 kilometers) from MMR. A federal fire fighting team is present during all military maneuvers. Fire fighting resources are discussed in greater detail in Section 3.14.

Pōhakuloa Training Area

Fire response services are provided by Army staff based at PTA. There is one fire station, located at BAAF, with a staff of six (including two emergency medical technicians sharing duty round the clock). Available equipment includes two brush trucks (wildland rigs), a tanker, a crash rig, and an ambulance.

3.13.4 Emergency Medical Services

Mākua Military Reservation

An emergency medical service facility does not exist at MMR. The nearest medical facility is the WCCHC approximately 9 miles (14 kilometers) from MMR. The health center provides 24-hour emergency room service and is capable of receiving patients by motor vehicle or helicopter. County ambulance transport is based at the Waiʻanae fire station. Staff at the health center can stabilize a patient for transport to Tripler Army Medical Center (Hefner 2003).

Pōhakuloa Training Area

Emergency medical services are provided by Army staff based at PTA. Serious medical emergencies rely on medical helicopter transport to Hilo, which is about 10 minutes away by air. PTA emergency staff respond to accidents on the roughly 25 miles (40.2 kilometers) of Saddle Road that pass through PTA, and at the border of the installation the injured are transferred to the care of the City and County of Hawaiʻi (US Army and USACE 2004).

3.13.5 Potable Water

Mākua Military Reservation

Freshwater is stored at MMR in a 33,000-gallon (125,000-liter), at-grade steel water tank east of the administration building. The tank is a source for on-site fire fighting systems, which include building sprinklers and dry standpipes (Husemann 2003a). Freshwater from the tank is processed through a filtration system to produce drinking water.The County Board of Water Supply provides water service to MMR through a 4-inch (10.2-centimeter) diameter underground line located in the state right-of-way. The sources for the Waiʻanae water sector include 11 wells, a tunnel, and a mountain spring. Additional sources of water are available from neighboring water sectors. For the fiscal year ending June 30, 2001, the average Waiʻanae water sector consumption was 9.2 mgd (34.8 mld) (BWS 2001). The sustainable yield for the Waiʻanae water district is 15.0 mgd (56.8 mld) (DLNR 2001).

Pōhakuloa Training Area

Water supply to PTA is now hauled by tanker trucks from the town of Waimea, where it is purchased (US Army and USACE 2004). Excess demand can be supplied by the City of Hilo. Each truck has a capacity of 5,000 gallons (18,927 liters), and up to 14 truckloads per day were required when the camp was at full capacity. Two pump stations transport the hauled water to two 670,000-gallon (2,553,226-liter) storage reservoirs, where it is treated with powdered chlorine and sent to three 10,000-gallon (37,854-liter) distribution reservoirs. Water from these reservoirs supplies PTA, BAAF, and fire reserves (C. H. Guernsey & Company 2001). Water consumption on PTA ranges from 10,000 gallons (37,854 liters) per day to 250,000 gallons (946,353 liters) per day, depending on camp occupancy; average consumption is 100,000 gallons (378,541 liters) per day (US Army and USACE 2004).

Hōkūpani Spring, Waihū Spring, and Liloe Spring previously supplied water to PTA. Spring water is captured by two 2-inch (5-centimeter) pipes running from the springs, through water catchments, and down to the base camp. The annual production of water supplied by the springs ranges from 20,000 gallons (75,708 liters) to 40,000 gallons (151,417 liters) per day. However, historically, the spring produces a range of 0 to 80,000 gallons (302,833 liters) per day. This water was stored in a 670,000-gallon (2,553,226-liter) tank and treated in a slow sand filter treatment plant installed in 1996. The treated water was then conveyed to the two storage reservoirs for chlorination. The slow sand filter ceased to function, and use of spring water was discontinued. The state ranger facility has the rights to the first 8,000 gallons (30283 liters) of water from the springs.

The Army has the rights to the next 6,000 gallons (22,712 liters), and the remainder of the water is divided equally between the two agencies (US Army and USACE 2004).

3.13.6 Stormwater

Runoff from MMR is either retained on-site or collected in a roadside swale along Farrington Highway. The swale discharges to two box culverts that cross beneath the highway and outlet to low areas between beach dunes and the highway (see Section 3.8, Geology and Soils, for further discussion).

3.13.7 Wastewater

Mākua Military Reservation

MMR maintains two permanent underground sewage holding tanks located east of the administration buildings. Sewage generated from the administration buildings is held in the two tanks. A licensed waste hauling contractor empties the tanks and disposes of sewage at the Schofield Wastewater Treatment Plant at Wheeler Army Air Field as needed. Between January 2002 and April 2003, the holding tanks were serviced on ten occasions, or every six weeks on average (Devera 2003). Eight portable toilets are on-site at all times for use by training units and are maintained by a contractor (Husemann 2003b). Six portable toilets are in the staging area, and two are east of the administration building.

Pōhakuloa Training Area

Wastewater flows at PTA derive from domestic wastewater generated by mess halls, latrines, and other administrative operations. Most of the flows from each of these facilities are disposed of in adjacent cesspools. Some facilities are grouped to one cesspool, and wastewater from grouped facilities is collected and transported through 4-inch (10-centimeter) sewer lines to a cesspool for disposal. Three latrine/shower facilities (T-87, T-290, and T-121) recycle water used in the showers and sinks for use in the latrines. The wastewater from the latrines is then discharged to a septic tank and is finally disposed of in a seepage pit or leach field.

3.13.8 Solid Waste Management

Mākua Military Reservation

Nonhazardous solid waste generated at MMR is collected in a 30-cubic-yard (23-cubic-meter) trash container and disposed of off-site by a licensed contractor as needed. Between January 2002 and April 2003, the container was emptied eight times, or every two months on average (Tamaru 2003).

Pōhakuloa Training Area

PTA generates an estimated 296 tons (269 metric tons) of industrial solid waste annually based on the waste and recycling streams generated during the third quarter of 2002 (USARHAW 2002a).

3.13.9 Telephone

Mākua Military Reservation

Verizon Hawai‘i provides telephone service at MMR using US government-owned underground cables. MMR is being converted to the Department of Defense Hawai‘i Information Transfer System (DoD HITS) operated by AT&T Government Solutions (Booker 2003). The HITS system upgrade will involve new underground fiber optic lines within existing government easements. Voice and data communications for MMR will be carried entirely on the DoD HITS system. The system upgrade is expected to be completed within two years (Grey 2003).

Pōhakuloa Training Area

Telecommunications from the area between Mauna Kea and Mauna Loa are transmitted to Hilo through the Humu‘ula microwave station. Overhead trunk lines extend from this station to PTA, and distribution lines are located in the base camp, cantonment area, and BAAF. The trunk and distribution lines are owned by GTE Hawaiian Telephone, Inc.

3.13.10 Electricity

Mākua Military Reservation

Two sources of electrical power are available at MMR. The Hawaiian Electric Company provides power from overhead power lines in the state right-of-way to the administration buildings. A standby diesel generator provides temporary emergency power in the event that permanent service is interrupted.

Pōhakuloa Training Area

HELCO supplies electric power to PTA through a single 12.47-kV delivery point from a HELCO-owned substation located outside the northeast fence of the cantonment area. The components of this system include metering equipment, 29 transformers, 20 miles (32.2 kilometers) of overhead lines, and 755 poles. Demand for electric power varies throughout the year, depending on troop population in the base camp. Usage varies from about 1,600 kilowatt hours per day (kWh/day) to 7,100

kWh/day; average consumption is approximately 4,553 kWh/day (US Army and USACE 2004).

3.14 WILDFIRES

3.14.1 Introduction/Region of Influence

This section presents information on the history of wildfires and improvements the Army has made in recent years regarding fire management. Additionally, it provides an overview of the IWFMP, which covers eight Army sites on O‘ahu and the Island of Hawai‘i (USARHAW and 25th ID[L] 2003). It contains a description of each fire management area and SOPs for MMR and PTA and is the primary tool for managing wildfires at MMR and PTA.

Wildfires on O‘ahu typically occur in undeveloped areas where vegetation (especially exotic species) supports ignition and spread of a fire. The ROI for assessing the ignition of wildfires is MMR and the lands immediately surrounding MMR.

PTA is a mosaic of dry habitats that can burn quickly when a fire is ignited. There is a risk that training activities or other unforeseen events (i.e., human error [an errant round or pyrotechnic], discarded cigarette, catalytic converter) could ignite a fire in the proposed PTA CALFAX training footprint or impact area and spread to areas outside of the impact area. In 1994, a fire destroyed 118 individuals of *Tetramolopium arenarium* ssp. *arenarium* eliminating approximately a third of the total population. Once a fire has occurred and the native habitat has been burned, there is the potential for subsequent invasion of non-native plant species (particularly fountain grass [*Pennisetum setaceum*]). These invasive plants increase competition with native plants and degrade the surrounding habitat (USFWS 2003c).

While impacts resulting from the Proposed Action may occur due to trampling, explosions, dust, and other activities, the side effect of training with the most substantial and furthest reaching impacts across PTA’s landscape is fire. For this reason, the potential rate of fire spread based on fuel type and weather conditions were the basis for determining the ROI for wildland fires, as well as the ROI for biological resources. The ROI encompasses the SDZ of the range footprint and extends into and throughout the areas designated as having moderate to high fire spread rates. The area that has the highest potential for impact by fire is the northwest portion of the installation (not including the Ke‘āmuku parcel) (USFWS 2003c). The Kīpuka Kālawamauna Habitat comprises a major portion of this area.

3.14.2 Wildfire History
Mākua Military Reservation

There is an increased threat of damage from fire at MMR for the following reasons:

- Fuels between the Mākua Valley floor and native habitats at higher elevations are highly flammable;
- The rugged terrain limits accessibility for fire suppression efforts;
- The area is susceptible to fires started by nonmilitary sources, such as arson and cigarettes, within or adjacent to MMR; and
- Military use of live ammunition, such as artillery and mortars, increases ignition sources at MMR.

Most of the fires that start on military training lands on O‘ahu are contained within the boundaries of the installation (USARHAW and 25th ID[L] 2001b). However, some fires have burned onto adjacent lands, especially those starting at MMR, which have burned onto the adjacent land of Albert Silva, the Kuaokalā Game Management Area, and the US Air Force Ka‘ena Point Satellite Tracking Station. Most of the training-related fires at MMR start in or escape from the CCAAC, which is where most of the training exercises take place (USARHAW and 25th ID[L] 2003).

Historical fire information obtained from the *Analysis of Fire Management Concerns at Mākua Military Reservation* states that a small number of fires cause a large part of the resource damage (Beavers et al. 1999). Between 1970 and 1998, 276 fires occurred at MMR, with approximately 20 fires (each burning over 100 acres [40 hectares]) causing most of the damage to natural resources. Most fires occurred during February (which is during the wet season), July, August, and September, and most occurred during the peak burning period of 12:00 PM to 4:00 PM. Between August 5, 1970, and September 17, 1998, 59 fires escaped the firebreak. Ten of these fires escaped the firebreak during September. Nine, eight, and seven fires escaped during November, July, and March, respectively.

The most common cause of wildfires on MMR has historically been the use of tracer ammunition (USARHAW and 25th ID[L] 2001b). In September 1998, the Army voluntarily discontinued the use of tracers at MMR. The following summarizes the percentages of historical fires at MMR by source (Beavers et al. 1999):

- Tracer ammunition, 49 percent;
- Anti-tank missiles, including the Dragon and inert TOW missiles, 12 percent;
- Demolition explosives and mines, 6 percent;
- Nonmilitary wildfire ignition sources (civilians or nonmilitary activities), 5 percent;
- Source of ignition is unknown or unrecorded, 6 to 12 percent. White phosphorus is one substance previously used during training that could be the source of an ignition in this category; it can be buried and then could ignite if uncovered; and
- Other ignition sources totaling 16 to 22 percent, each less than 5 percent. These sources include UXO detonation, indirect fire (including mortars and artillery), rockets, fire restart/escape, muzzle flash, and pyrotechnics.

Training was suspended in 1998 but was resumed in October 2001. Between October 2001 and October 2003, 21 CALFEXs were conducted, and one fire occurred during training in 2002, caused by an AT-4 anti-tank rocket and burned a 16-foot- (5-meter-) wide area next to Objective Deer. A commander used his boot to put out the fire (Husemann 2003c). Also, in June 2002, a small flare-up that was not a training-related fire ignited in the north firebreak road. It was not possible to determine how it started or extinguished itself; the flare-up was in a high hazard impact area, and ground visibility was limited due to heavy vegetation (Enriques 2004a). By the time forces arrived, there was no visible smoke or fire. The oxidation of white phosphorus was believed to have initiated the fire, and a lack of vegetation was the probable reason for the fire extinguishing itself.

In addition to fires accidentally started as a result of training, fires have also been intentionally started to perform prescribed burns. The most recent prescribed burn was conducted on July 22, 2003. Preparation and execution of the prescribed burn was performed according to the burn plan prepared by the Army (US Army, undated). The Army coordinated the prescribed burn with the USFWS; US Forest Service; HDOH, Clean Air Branch; State DNLR, Division of Forestry and Wildlife; Federal Fire Department; Honolulu Fire Department; Hickam Fire Department; and the National Weather Service. The prescribed burn was designed to burn between 800 and 900 acres (244 and 274 hectares) (Enriques 2003b). However, the prescribed burn area escaped the firebreak road due to a sudden 180 degree wind shift and an increase in wind speed from 9 miles (14.48 kilometers) per hour to 20 to 25 miles (32.2 to 40.2 kilometers) per

hour within five to ten minutes. As a result, the fire burned uncontrolled for three days and burned 2,100 acres (640 hectares).

The Installation Fire and Safety Office was responsible for the preparation and implementation of the prescribed burn plan for the July 2003 prescribed fire (Enriques 2003b). According to the Integrated Wildland Fire Program Manager, all of the precautionary steps (such as conducting a test burn, reviewing the go-no-go checklist, reviewing the weather forecast, stationing fire fighting resources on-site, and preparing an escape fire situation analysis), as outlined in the prescribed burn plan, were carried out prior to the prescribed burn. To further improve wildfire management for prescribed burns, the Integrated Wildland Fire Program Manager recommended the following actions (Enriques 2003b):

- Install fiber optics to improve local area network telecommunications. Better communications devices would have helped improve response times during the July 2003 prescribed burn.
- Increase staff to assist the Program Manager of the Wildfire Management Program. For example, a contracted or full-time 10-man strike team, whose members are wildland trained and possess red cards, could be used to respond to fires and assist daily in managing other fire prevention areas of the program; the red card is what qualifies a person to fight a fire with a federal agency or on federal land. This would include working at Pōhakuloa and O‘ahu training areas on the RAWS, fire fighting equipment and supply storage (cache), fire vehicle maintenance, wildland fire training, fire bucket repair and maintenance, fire trend analysis, and firebreak and fuelbreak maintenance.
- Consider leasing or procuring an S70A Fire Hawk helicopter that is dedicated to wildland fire standby and response to wildfires on military training lands. This would improve response time and provide dedicated contracted pilots that offer continuity and specialized training for wildland fire suppression.
- Provide IWFMP funding. The IWFMP is currently funded to some degree as an unfinanced requirement or unresourced requirement for fiscal year 2004 (Enriques 2004b). Funding for sustaining daily operations for the IWFMP is programmed in the next Program Objective Memorandum cycle from fiscal year 2005 to 2009. However, critical must-fund projects or contracts (such as for firebreak construction or dip pond/tank construction) are programmed in outgoing years and compete with other critical must-fund projects based on priority and available funds for that

year, and are subject to the approval of the Garrison Commander. Given limited funding, some of the Integrated Wildland Fire Program Manager's projects do not make the priority cutoff (based on other critical mission needs), requiring the manager to either wait for year-end funds or delay the project into the next fiscal year. The IWFMP is described below in Section 3.14.4, Wildfire Management.

- Ensure range use accountability. Range Division must enforce procedures and policies and take appropriate action when range safety procedures and policies are violated. Training units should be disciplined or admonished administratively when procedures and policies are not followed.

The Army is updating the IWFMP as a result of the recently completed Section 7 consultation. Revisions to the Standard Operating Procedures section in the IWFMP will outline the Fire Danger Rating System, revised weapons restrictions, new National Wildlife Coordinating Group (NWCG) qualifications standards and helicopter staffing requirements, fire equipment requirements, new firebreak and fuelbreak installation and maintenance standards, fire reporting responsibilities, and fire prevention, detection, and suppression standards, which will minimize the risk of resource damage due to training-related wildland fires at MMR.

To summarize, activities with highest risk of igniting fires outside the firebreak road are restricted to periods when the grass fuels within the valley are greener and burn more slowly. Weapons more likely to ignite wildland fires are further restricted to periods of the day when wind speeds are lower and relative humidity is higher, when the grass fuels are less likely to ignite, and when fires would be easier to suppress. New fuelbreaks and firebreaks and improved firefighter planning will provide for greater protection for the Kahanahāiki, Kaluakauila, and ʻŌhikilolo management units in the event of a large fire. A staffing guide has been developed to ensure that adequate fire suppression resources are assigned to each live-fire training exercise at MMR. Staffing requirements vary by time of year and weapon system in use in order to ensure that more suppression force is available during dry months or when the weapons being used are likely to ignite fires outside the firebreak road. Whenever a weapon or demolition is fired, MMR would be staffed, at minimum, by five NWCG-qualified, arduous-level, pack-tested, red-carded wildland fire personnel with two Type 6 engines and one water tender. Aerial fire suppression resources would be assigned to exercises in accordance with helicopter staffing guidelines, which depend on live herbaceous fuel moisture, forecasted wind speed and direction, and weapons system in use. More substantial fire suppression helicopter capability is assigned when

grass is more cured, when wind speeds are higher, and when weapons with a higher risk of igniting fires are in use. In the event of a fire at any location, training is stopped immediately and the unit takes all appropriate actions to put out the fire (USFWS 2007b).

Pōhakuloa Training Area

Historically, fire in the area of PTA was rare and of little significance limited to volcanically started fires and occasional lightning ignitions. There is a high risk of wildfire ignition from the use of aerial flares and similar pyrotechnics (US Army and USACE 2004). Fires caused by tracer ammunition is by far the largest cause of fires at PTA. This comes as no surprise since tracers easily start fires and are one of the most commonly used munitions (USARHAW and 25th ID[L] 2003). Based on fire records, the number of fires per month peaks from March to July (Beavers et al. 2002b). However, because PTA is dry throughout the entire year and the amount of precipitation received during the winter is probably not enough to change the probability of fire by any significant amount, an annual cycle in fire frequency was not expected. Therefore, the main cause of monthly variation in the data is probably the frequency and intensity of use by the military. Eighty percent of all recorded fires between 1987 and 1999 started between 9:00 AM and 5:00 PM (US Army and USACE 2004).

Although military use for live-fire exercises and target practice has increased ignition frequency dramatically and resulted in numerous small fires, a great deal of the threat to endangered species populations is a result of off post ignitions. Fires originating from non-military sources have caused the overwhelming majority of the acres burned at PTA (USARHAW and 25th ID[L] 2003). Since July 1990, over 8,000 acres (3,237 hectares) have been recorded as burned. Of these, over 7,700 acres (3,116 hectares) or 91 percent of all acres burned were burned by fires caused by lightning, arson, or carelessly discarded cigarettes, and the largest of these started off Army lands and later burned onto PTA. Highly flammable fuels and unique weather conditions also lead to high ignition rates. Fires may also originate from sources such as arson, cigarettes, and vehicles with catalytic converters within or adjacent to training areas (US Army and USACE 2004).

Based on fire history for PTA, the data show that the western and the northern sections of PTA potentially face the greatest threat of wildfire. The high risks inherent in military training activities, the existence of heavy loads of readily ignitable fuel, and the prevalent dry conditions of the area present significant fire management problems for the training area and adjoining lands (USARHAW and 25th ID[L] 2003).

3.14.3 Fire Fighting Resources
Mākua Military Reservation

Figure 3.14-1, Fire Management Facilities shows the location of fire management resources at MMR, which include equipment and materials storage, wheeled vehicles, helicopters, two 300,000-gallon (1,134,000-liter) dip ponds, and three RAWS to aid in determining weather conditions and the wildfire threat conditions (USARHAW and 25th ID[L] 2001b). Staffing requirements vary by time of year and by weapon system in use to ensure that adequate fire suppression force is assigned. During all training exercises when any weapon is being fired (including blanks) and during demolition exercises, MMR would be staffed, at minimum, by five NWCG-qualified, arduous-level, pack-tested, red-carded wildland fire personnel with two Type 6 engines and one water tender. Helicopters or other aircraft would be used for both fire suppression and fire detection at MMR. Fire containment with aircraft resources depends on the ability to perform at a pace in excess of the fire's rate of perimeter increase. Therefore, total combined continuous fireline productivity of on-site and total assigned helicopters would vary by season, forecasted fire weather, and scheduled training activities (USFWS 2007b).

According to the Integrated Wildland Fire Program Manager, the two dip ponds provide adequate water supply for the initial attack during wildland fire fighting activities at MMR, and there is no immediate need to add additional dip ponds (Enriques 2003a). In the event of an extended attack (one or more days) the capability to replenish water in the dip ponds may be compromised due to the high demand flow requirements to support fire bucket operations. The water distribution system is complicated by a restriction of the water flow due to the 1.5-inch (4-centimeter) pipe supplied from the meter to the 30,000-gallon (135,000-liter) water tank that is used to supply the domestic needs of the administration facilities and to refill the lower dip pond. The Army has plans to upgrade the water distribution system (Enriques 2005). The upper dip pond in the valley is filled via water hauling contracts once a year.

A small fire can be extinguished in as little as 30 minutes, whereas a large complex fire can last as long as three days. During a complex fire, helicopters scoop water throughout the daylight hours, refilling the bucket every two to five minutes. The aircraft has to stop approximately every two hours to get fuel (Fancher 2003b). A UH-60, Blackhawk uses a 660-gallon (2,498-liter) Bambi Bucket; a CH-47, Chinook uses a 2,000-gallon (7,570-liter) Bambi bucket, and a Hughes 500-D (Air One of Honolulu Fire Department) uses a 110-gallon (416-liter) Bambi fire bucket (Enriques 2003a).

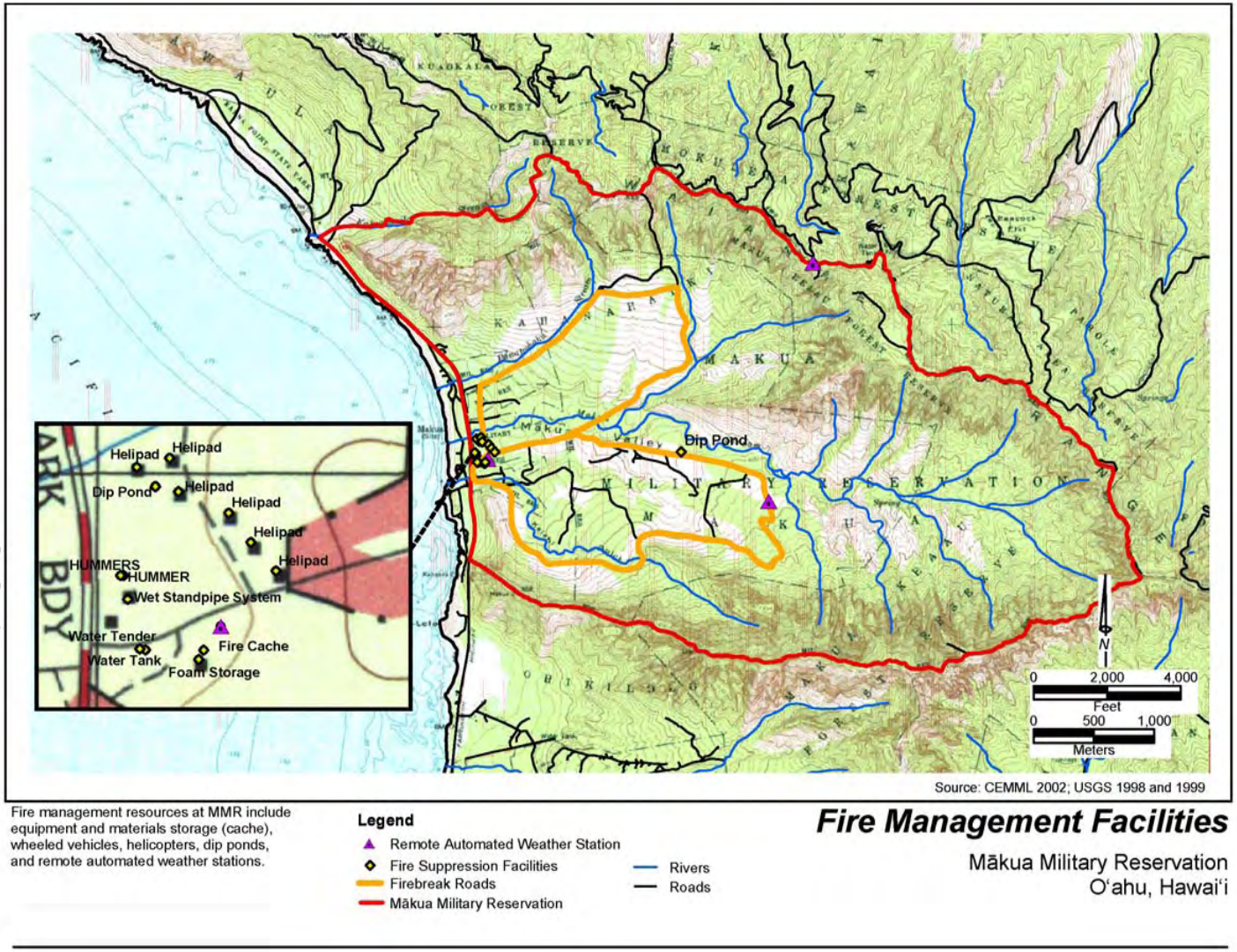

Figure 3.14-1 Fire Management Facilities, MMR

In the past, aviation units were capable of conducting nighttime fire suppression activities at MMR. Nighttime firefighting using helicopters is not currently authorized due to safety limitations, but these activities may be authorized in the future providing helicopter firefighting stipulations of the 2007 BO are met and approved by the USFWS.

Pōhakuloa Training Area

PTA ensures that wildland fire response requirements are in accordance with the IWFMP, Army Regulations (AR 420-90), and Department of Defense Instruction (DoDI) 6055.6, Fire Protection Program. (WFMP 2003). Four remote weather stations on PTA are used for fire indexing. An auxiliary wildland firefighting force provides an initial attack on a fire before the fire department arrives. The Hawaiʻi County Fire Department, HDLNR, and Hawaiʻi Volcanoes National Park assist with wildland fire suppression.

An additional position, PTA Wildland Fire Coordinator was added to the PTA Fire Department. The PTA Wildland Fire Coordinator works closely with the Wildland Fire Program Manager to facilitate pre-suppression actions on the Island of Hawaiʻi and assists in the fire fighting duties of the PTA Fire Department. (USARHAW and 25th ID[L] 2003).

The Directorate of Plans, Training and Mobilization (DPTM) ensures that PTA has a minimum of six fully qualified and trained fire fighting staff, to include a Humvee equipped to fight fire, available during live-fire training exercises, which includes a radio dispatcher (USARHAW and 25th ID[L] 2003 and USFWS 2003c). At a minimum, six trained fire fighting personnel are required during expected high fire danger rating days and any scheduled live-fire training operation. When deployed to PTA, military training units also provide, upon request, a platoon unit (minimum of 20 members) to assist the PTA Fire Department in fighting wildfires per the PTA IWFMP SOP.

In 1996, the Army constructed six above ground dip tanks (each 80,000-gallon [302.83-liter] capacity) at PTA to enhance its water supply resources and fire fighting capability (USARHAW and 25th ID[L] 2003). One of these dip tanks is located adjacent to the Kīpuka Kālawamauna Endangered Plant Habitat area by the Twin Pu'u range footprint. Another dip tank is located in the Kīpuka Kālawamauna area within the ROI. There are current plans for 3 more dip tanks at PTA (USARHAW and 25th ID[L] 2003). Two of these would be located along the western boundary of PTA proper, one near the MPRC Quarry and the other near the Old Kona Highway. The third dip tank would be located at the Keʻāmuku Parcel. In addition, there is a non-potable 60,000-gallon [227,124-liter]

water storage tank located at Bradshaw Army Airfield. It is equipped with a fire pump capable of providing rapid water resupply services to fire vehicles or water tenders in support of water shuttle delivery to and from the fire area (USARHAW and 25th ID[L] 2003).

Three GSA-leased 5,000-gallon [18,927-liter] water tankers are assigned at PTA. These water tankers are parked at designated spots and are used to shuttle water to refill the dip tanks or provide a water source for ground fire fighting crews. In addition, two HMMWV's or brush engines equipped with a 300-gallon [1,135-liters] slip-on pump unit (Class A foam capable) and one water tender (2,000-gallon [7,571-liter] capacity) or equivalent are assigned and available for initial attack response at PTA. A military helicopter with a certified and trained aircrew capable of performing fire bucket operations are on site at PTA during live-fire training operations. A UH-60, CH-46/7, or CH-53 are on site when Battalion or Brigade sized units deploy to PTA. In addition, a backup helicopter under contract services to the Army is available and able to arrive at PTA within 90 minutes after notification. PTA currently maintains three Bambi fire buckets: two (2) 660-gallon (2,498-liter) and one (1) 2,000-gallon (7,571-liter) for emergency backup use by military UH-60, CH-53, or CH-47 aircraft assigned to conduct fire bucket operations (USARHAW and 25th ID[L] 2003).

Cooperative agreements with other local fire cooperators (Hawai‘i County Fire Department, National Park Service, State Civil Defense, National Guard, and Division of Forestry and Wildlife) for mutual aid support have been established to provide for multiple agency response and cooperative assistance between agencies. The 25th ID(L) and USARHAW on O‘ahu will also provide additional fire fighting resources upon request.

3.14.4 Integrated Wildland Fire Management Plan

According to the Integrated Wildland Fire Program Manager, the development and enforcement of the Fire Danger Rating System (described below, under standing operating procedures), on-site dip ponds and other required fire fighting resources, and a comprehensive IWFMP have been the most important resources used to prevent the start and spread of wildfires (Enriques 2003a). The IWFMP for the O‘ahu and Pōhakuloa training areas was prepared in October 2003 and approved by the Installation Commander in December 2003 (USARHAW and 25th ID [L] 2003). It establishes specific guidance, procedures, and protocols for managing wildfires on Army training lands. In support of the most recent Section 7 consultation, the Army, with the assistance of the USFWS, has been updating its IWFMP to incorporate new and additional measures to

minimize the risk of resource damage due to training-related wildland fires.

The IWFMP acknowledges that most fire history files are incomplete; the files were retained primarily as manual records and after five years were destroyed, following the disposition of records in accordance with the Modern Army Recordkeeping System (USARHAW and 25th ID [L] 2003). Large gaps in information are frequent, and records prior to 1996 are incomplete (Beavers et al. 1999). Chapter 1 of the IWFMP is provided in Appendix J-1.

Mākua Military Reservation

The IWFMP addresses environmental conditions and fire effects in Hawai‘i, fire prevention, fire suppression, post-fire actions, and fire management areas. The MMR fire management area is described below. Fire prevention includes planning, managing fuels, using prescribed fire, planning water resources, and training firefighters. Fire suppression actions include the following issues:

- Identifying responsibilities, procedures, and strategies for fire suppression;
- Special considerations for suppression on USARHAW lands in order to minimize impacts on natural and cultural resources;
- Fire detection and reporting procedures;
- Initial and extended attack on fires;
- Communication devices used during fires;
- Air operation protocols;
- UXO concerns and safety during fire fighting; and
- Mutual aid support agreements with cooperating agencies.

Records and reports, reviews and formal investigations, and post-fire analysis make up post-fire actions.

The appendices to the IWFMP address standing operating procedures, which are described below (USARHAW and 25th ID[L] 2003). The appendices also provide additional details pertaining to interagency cooperative agreements and the wildland fire program budget.

<u>IWFMP Fire Management Area</u>
The IWFMP covers eight Army sites on O‘ahu and the Island of Hawai‘i (USARHAW and 25th ID[L] 2003). IWFMP discussion of the MMR fire

management area describes baseline site characteristics, wildland fire fuel types, previous fires, the protection of biological and cultural resources, and the firebreak system. MMR-relevant sections of the IWFMP are presented in Appendices J-2 and J-3, which include the MMR fire management area and standing operating procedures.

IWFMP Standard Operating Procedures

The SOPs provide specific requirements that delineate the responsibilities of Federal Fire Department, Range Control personnel, and military training units in the prevention and suppression of fires at MMR. In addition to addressing the environmental setting in the standing operating procedures, specific guidance is provided for fire prevention, fire suppression actions, and post-fire actions at MMR.

After 1998, the fuel model for MMR was changed from L (western perennial grass) to N (sawgrass) for Fire Danger Rating System burn index calculations, because N better represents the fuels at MMR (Beavers et al. 1999). This change provides burn indices that better represent fire behavior. The Fire Danger Rating System uses the following three colors to characterize fire threat conditions, as applicable to the proposed action:

- Green (indicating normal caution during training, burn index of 20 or lower). Weather conditions are favorable for use of most munitions, contingent on completion of conservation/management requirements of the 2007 BO, and smoking is permitted only in designated areas.
- Yellow (indicating caution because fires will start easily, with a burn index of 21 to 47). For this fire danger period, smoking is permitted only in designated areas, and use of certain munitions is permissible only after completion of conservation/management requirements of the 2007 BO. Under yellow conditions, a number of munitions/activities would not be allowed, such as tracers, live M79 and M203 grenade launchers, AT-4/M136 and SMAW, 2.75 rockets, Javelin, inert TOW missiles, and UXO demolition (outside the firebreak road or within 100 meters [328 feet] of the road).
- Red (indicating extreme caution because a fire would be difficult to control, with a burn index of 48 or higher). No smoking is permitted on the ranges and no munitions or pyrotechnics are allowed. In other words, no live-fire training is allowed and the ranges are closed. Only small arms blanks would be allowed following completion of certain conservation/management requirements and at fuel moisture of 50 percent or higher, per the 2007 BO.

This system is used to inform the Range Control Office and officers in charge about the fire hazard level at the ranges (Beavers et al. 1999; USARHAW and 25th ID[L] 2003).

Because the lowest burn indices are recorded during the morning, most recent training has been conducted during the morning and evening to minimize the ignition of wildfires. Also, training is permitted only under green and yellow fire danger rating conditions, and the Army voluntarily withdrew the use of tracers, inert TOW missiles, and incendiary munitions for recent training exercises. White phosphorus or aerial pyrotechnics are not authorized under any circumstances on MMR (USARHAW and 25th ID[L] 2003).

In the event of a wildfire, MMR range control personnel are required to maintain a log of actions during a fire on DA Form 1594, Daily Journal, or in the Duty Officer's Log. Fire incidences would be assigned a fire number and officially recorded on the standard Wildland Fire Incident Report form for all Army training lands (USARHAW and 25th ID[L] 2003). The fire incident report contains approximately 26 data input categories to be filled out and includes such information as date, fire location, and number of acres burned. Every fire, regardless of size, must be reported immediately to Range Control, and in turn, to the Federal Fire Department (Enriques 2003a). The Wildland Fire Program Manager maintains all wildfire records and submits quarterly reports to the DPW Environmental Division.

According to *Analysis of Fire Management Concerns at Mākua Military Reservation*, additional information should also be retained in the fire records (Beavers et al. 1999). It also states that one of the most frequently cited reasons for the decrease in fire prevention and suppression success in the 1990s has been the lack of a well-trained, devoted fire manager on-site at MMR, who could be relied on to implement the IWFMP (Beavers et al. 1999).

<u>Pōhakuloa Training Area</u>

The IWFMP was identified as a conservation measure in the BO for the PTA's ESA Section 7 formal consultation for the Stryker in 2003; therefore, the implementation of the plan is required under the terms of consultation. The PTA is required to address and implement the establishment and maintenance of fuel breaks, fire breaks, and fuel management corridors; dip tanks; suppression measures; and a Fire Danger Rating System (USFWS 2003c). The PTA Wildfire SOP establishes, amongst other things, procedures for fire prevention and suppression measures, as well as delineating responsibilities for

implementing these actions (USARHAW and 25th ID[L] 2003). As stated earlier in the document, to ensure the efficacy of the IWFMP, the Army has been updating the IWFMP with the assistance of the USFWS.

Impacts of project activities would all occur in locations covered by the IWFMP, and the existing conditions and management strategies are summarized below. Fire prevention includes planning, managing fuels, using prescribed fire, planning water resources, and conducting firefighter training. The actions below are components of the IWFMP and provide the overall framework to address wildfire management (US Army and USAEC 2008).

Planning. Planning activities include procedures, purchases, and budgeting to improve the Army's prevention of and response to wildfires. Procedures include, but are not limited to, implementing the National Fire Danger Rating System (NFDRS), fire reporting procedures, and keeping records on the maintenance of vegetation modifications and wildfire occurrences. Budgeting and purchases include additional funding to hire more firefighters and purchase firefighting equipment.

Fuel Management. Fuel management activities include fire access road and fuel management corridor construction, expansion, and/or maintenance; and fuels management including prescribed burning, construction of dip ponds, and firefighting actions. Fire access road and fuel management corridor expansion, construction, and/or maintenance are slated in one form or another for all Army training areas.

Fuels Modification. Fuels modification is defined as removing and/or modifying an area of flammable vegetation, thereby managing the fire hazard by changing the vegetation type. The goal is to maintain a fuel condition that makes fires easier to control. Mechanical treatments, chemical treatments, biological treatments, and prescribed burns are all implemented as part of the IWFMP.

Dip Ponds. One of the most important resources for firefighters is an ample water supply. Dip ponds are plastic-lined, earthen ponds that serve as a water storage resource and are available for aerial fire bucket operations, thereby enhancing firefighting capabilities.

Firefighting Actions. Firefighting actions may take place at any time and at any installation. This includes helicopter bucket drops of freshwater, retardant, foam, and in emergencies, saltwater. Firefighting activities may also involve cutting fire lines by hand or by bulldozer, burnout operations, and increased traffic in the form of firefighters on foot and in vehicles as

well as in the air. Because firefighting is considered an emergency operation, it is exempted from NEPA under 32 CFR 651.11. All reasonable efforts are made to protect natural and cultural resources from unnecessary harm during firefighting operations.

Fires originating on state land west of the installation are a major cause of fire on PTA affecting areas within and around the ROI. To reduce this threat, prescribed burns are proposed for the area lying between the two fire access roads located on and to the west of the installation boundary near Kīpuka Kālawamauna (IWFMP 2003). In addition, a fire break combined with a fuel break extends from the Keʻāmuku lava flow that goes south along the western boundary of PTA and separates the Kīpuka Kālawamauna Endangered Plant Habitat area from state lands. The fire break varies in width, but is not less than 29.5 feet (9 meters) across. The fuel break is 82 feet (25 meters) wide in grassy areas and 147.6 feet (45 meters) wide in shrub or forest areas. Fuels within the fuel break are maintained at less than 20 percent crown cover (USARHAW and 25th ID[L] 2003).

To the west of the Twin Puʻu area, there is currently an 11.5-foot (3.5-meter) fuel break along the MPRC access road. The fuel break is adjacent to the road, which is about 14.8 feet (4.5 meters) wide. The Endangered Plant Habitat is on the west side of the road (Schnell 2008, personal communication). The IWFMP calls for the fire break to be 14.8 feet (4.5 meters) in width and not to be combined with a fuel break, though fuels along the road would be managed via herbicide if populations of listed species are not present (USARHAW and 25th ID[L] 2003). The Draft Programmatic Environmental Assessment for the Implementation of the Integrated Wildland Fire Management Plan states that fire access roads would be established using existing roads and through new construction and would be constructed to be 20 feet (6.1 meters) wide with a buffer area of reduced vegetation extending 10 feet (3.1 meters) to the outside of the road and 30 feet (9.1 meters) inside.

IWFMP Fire Management Area

Five wildfire management areas have been designated, based on existing and planned fuel management corridors (USARHAW and 25th ID [L] 2003). The ordnance impact area is not considered because prevention activities there are not possible and resources at risk are largely unknown. Each area was assigned an ignition potential, fuels hazard, and habitat value, based on the best currently available information. Representatives of the USFWS and USAG-HI agreed on the ratings. The Kīpuka Kālawamauna, Mauna Kea, and Kīpuka Alala areas have a high wildfire prevention priority. The Keʻāmuku Parcel and southwestern PTA area

have a moderately high wildfire prevention priority (US Army and USACE 2004).

At PTA, the WFMP Fire Danger Rating System breaks up the large expanse of training lands into several smaller fire danger rating areas. The fuels and weather of each of these areas are more homogenous than PTA as a whole, thus making fire danger rating more accurate (USFWS 2003c). The six fire danger rating areas are Keʻāmuku, PTA West, PTA North, PTA East, impact area, and Kīpuka Alala (USARHAW and 25th ID[L] 2003).

IWFMP Standard Operating Procedures

A Fire Danger Rating System designed specifically for PTA has been developed by the US Forest Service and Colorado State University, based on analysis of PTA's fire history, fuels, fire behavior models, and weather (USARHAW and 25th ID[L] 2003, PTA-11 and PTA-29). National fire danger rating indices, as recommended by the US Forest Service and Colorado State University, are applied to the predominant fire carrying vegetation in each of six fire danger rating areas. The Fire Danger Rating System uses the following five colors to characterize fire conditions at PTA (US Army and USACE 2004, PTA Human Health and Safety Hazard):

- Blue (indicating low fire danger). No training restrictions;
- Yellow (indicating high fire danger). No tracers or white Green (indicating moderate fire danger). No training restrictions;
- Phosphorus are allowed;
- Red (indicating very high fire danger). No pyrotechnics, smoking, or cooking/warming fires are allowed; and
- Orange (indicating extreme fire danger). No live-fire, except ball and blank ammunitions, which are allowed only at fixed ranges. Maneuver training is limited to fixed ranges, TAs 7 to9, 12 to 16, and 21.

A supplemental system using wind speed criteria is in place for the restriction and use of pyrotechnics at PTA. Average wind speed (as measured over a 2 minute interval) and location are factors that govern pyrotechnic restrictions on the installation. The average wind speed (in knots) and fire risk factors are as follows:

- 0 to 10 knots (low fire risk)
- 11 to 15 knots (moderate fire risk)
- 16 to 20 knots (high fire risk)
- > 20 knots (very high risk)

All fires, regardless of size, are reported immediately to Range Control and in turn, to the PTA Fire Department. The PTA Deputy Fire Chief or the SFO serves as the Incident Commander (IC) for all wildfires on PTA. Fires started from outside the PTA boundary that have potential to carry into high value resource areas on PTA justify the fullest commitment to aggressive containment and control. The Army works with adjacent landowners to control fires before they escape or reach PTA.

The PTA Fire Department maintains a log of and assigns a number to all fires occurring on the installation. Every fire is officially recorded on the standard Wildland Fire Incident Report (WFIR) form for Army training lands. The Wildland Fire Program Manager and DPW Natural Resource Manager coordinate submission of semi-annual fire incident reports to USFWS NLT 10 July and 10 January of each calendar year (USARHAW and 25th ID[L] 2003).

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