SECTION 1
INTRODUCTION

The objectives of this marine resources study were defined by the 2007 partial Settlement Agreement (SA) entered into by the Army and Malama Mākua and were as follows:

- To evaluate whether fish, shellfish, limu (marine algae), 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 training at Mākua;
- To evaluate if activities at MMR have contributed to or will contribute to contamination detected in the fish, shellfish, and limu; and
- To evaluate whether the proposed training activities pose a health risk to area residents who rely on marine resources for subsistence.

The scope of work and methods for the field sampling and risk assessments were previously presented in the *Marine Resources Study Sampling and Analysis Plan, Mākua Military Reservation, O'ahu, Hawai'i* (the sampling and analysis plan [SAP])(Tetra Tech 2007). Here we report the results of the Marine Resources Study. This report is organized into the following sections:

- **Section 1: Introduction—**A site description, project history and project description, and outlines the objectives and scope of work for this study;
- **Section 2: Methods—**A description of the fish, shellfish, and limu sampling activities performed as part of this marine resources study and a description of the methods used to perform these activities;
- **Section 3: Results and Discussion—**A summary of the results of fish, shellfish, and limu field sampling activities, the potential natural and anthropogenic (man-made) sources of the chemicals of concern, and laboratory analyses ;
- **Section 4: Human Health Risk Assessment—**The human health risk assessment conducted to evaluate the potential risk from consuming fish, shellfish, and limu collected in the muliwai and nearshore area at Mākua, and compares these results to

the potential risk from consuming fish and shellfish collected in background locations on O‘ahu;

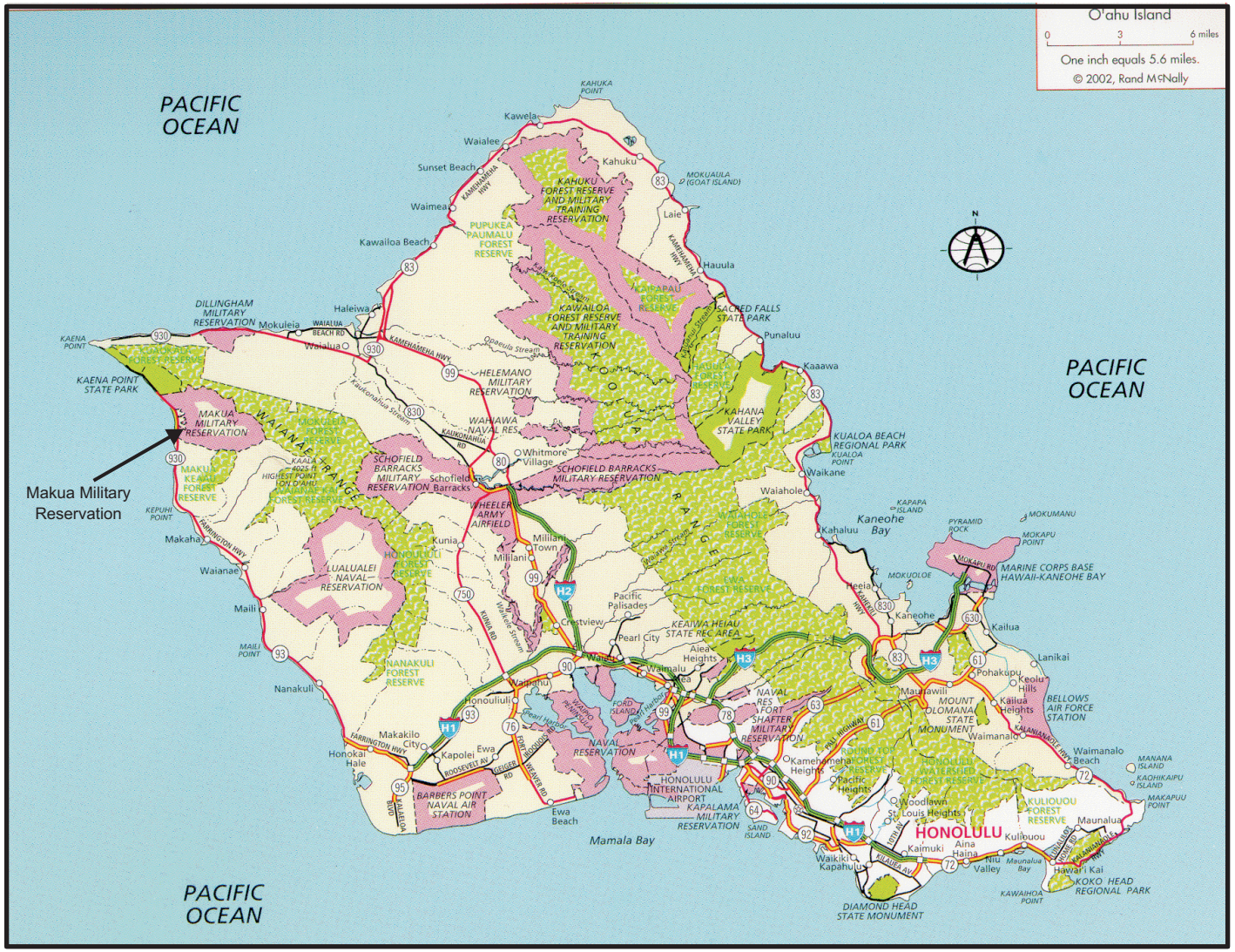
- **Section 5: Screening Level Ecological Risk Assessment—**The screening level ecological risk assessment conducted to evaluate the potential risk to marine organisms from contaminants present in the muliwai and nearshore area at Mākua, and compares these results to the potential risk to marine organisms from contaminants present in background locations on O‘ahu;
- **Section 6: Conclusions—**Conclusions regarding the results of the marine resources study; and
- **Section 7: References**.

1.1 SITE DESCRIPTION

MMR is approximately 38 miles northwest of Honolulu, on the western shore of O‘ahu, near Ka‘ena Point, and is in the adjoining Mākua and Kahanahāiki Valleys (Figure 1-1). MMR is bordered on the west by the Pacific Ocean and is surrounded by the Wai‘anae Mountains on the north, east, and south. MMR borders Farrington Highway and extends west from the Wai‘anae Mountains ridgeline to the Pacific Ocean; Mākaha, the nearest township, is approximately three miles south. The installation encompasses almost 4,190 acres and is arid, with annual rainfall ranging from about 50 inches toward the head of the valley, to less than 15 inches at the mouth of the valley. The precipitous valley walls surrounding the installation reach heights of 2,100 to 2,900 feet. The broad range in rainfall and topography results in diverse vegetation types within the valley.

There are no isolated wetlands at the MMR, but there are four streams and associated riparian and estuarine wetlands in the Mākua Valley. Mākua Stream and its tributaries, which originate on the western slope of the Waianae Range, drain most of the Mākua Valley. The Mākua Stream system is intermittent and flows only about five percent of the year, rarely flowing for two consecutive days. This is a typical characteristic of streams in arid regions. Three other intermittent streams at Mākua also drain the eastern higher elevations west to the Pacific: 1) Kaluakaula Stream borders the northern boundary of Mākua, 2) Punopahaku Stream is north-central, and 3) the Kaiahi Gulch is found in the southern portion of Mākua.

Muliwai are located at the outlets of Mākua Stream, Punopahaku Stream, and the Kaiahi Gulch, although the muliwai at the mouth of Punopahaku Stream is usually dry. The muliwai are transition zones between the streams and the Pacific Ocean, with water flowing from Mākua Valley or from incoming high tides collecting in the muliwai. The water levels and salinity of the muliwai vary daily, and typically muliwai in the Hawaiian Islands, are completely flushed each year by heavy rainfall; however, muliwai on the leeward sides of all islands, including the Mākua Valley muliwai, are flushed much less frequently. The muliwai in the vicinity of the Mākua Beach that were sampled for this task include the muliwai at the outlet of Mākua Stream (north muliwai) and Kaiahi Gulch (south muliwai).



Source: Rand McNally 2002

Site Location Map

Mākua Military Reservation
O´ahu, Hawai´i

Tetra Tech, Inc.

Figure 1-1

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1.2 PREVIOUS INVESTIGATIONS

A number of field investigations at MMR have been performed, including the Halliburton NUS study, the Mākua Supplemental Environmental Assessment (SEA), the muliwai sampling conducted by the US Environmental Protection Agency during 1999 (Tetra Tech 2005a), and the muliwai sampling conducted by Tetra Tech in 2003 (Tetra Tech 2005b). In addition, a few studies have been performed along the leeward coast that include or apply to Mākua Valley, including US Geological Survey Professional Paper 1412B and Hydrologic Investigation HA-358.

The Halliburton NUS study evaluated the potential for chemicals associated with past training activities at MMR and with the open burn/open detonation area to migrate from surface water to groundwater beneath the MMR. This study concluded that groundwater samples did not have detectable concentrations of explosive or semivolatile organic compounds (SVOCs), and contained levels of nitrate, nitrite and several metals at concentrations that were below risk-based health criteria and drinking water standards. The study concluded that the basal aquifer at MMR was not impacted by contaminants (Tetra Tech 2005a).

The USEPA sampled the muliwai at Mākua Valley and an adjacent dry streambed for background data in 1999. They concluded that "further investigation does not appear warranted at this time because the overall concentrations of the metals of concern are relatively low, and do not tend to indicate a significant adverse impact on ecoreceptors" (Tetra Tech 2005a).

US Army Corps of Engineers and their contractors performed a hydrogeologic investigation at MMR between 2002 and 2004, as part of the Environmental Impact Statement (EIS) for resumption of live-fire training at MMR (Tetra Tech 2005c). Soil, sediment from streambeds, surface water and groundwater were sampled as part of this investigation. Eighteen areas of concern that were associated with training areas and several background locations were targeted for sampling. Samples were analyzed for a wide variety of chemicals, including explosives and their byproducts, metals, cyanide, dioxins/furans, polychlorinated biphenyls, SVOCs, VOCs and chlorinated herbicides. A summary of the results from this study follow.

Analytical results of 123 shallow soil samples from the areas of concern were compared to USEPA Region IX industrial preliminary remediation goals (PRGs). This comparison indicated the only chemicals detected at concentrations exceeding the PRG were iron (approximately 30 samples), lead (1 sample), dibenzanthracene (2 samples) and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), a dioxin (3 samples). Iron is a naturally occurring byproduct of weathered basalt, which is prevalent on O'ahu, and is likely present due to these natural conditions. Iron also exceeded the PRG in one of the five soil samples collected from the background areas at MMR. Dibenzanthracene was detected in laboratory blanks analyzed with the samples that exceeded the PRGs, suggesting dibenzanthracene may not have been present in the soil samples.

Analytical results of 11 streambed sediment samples were compared to the Region IX PRGs, with all of the sample results below the PRGs. No dioxins/furans, PCBs, chlorinated

pesticides or cyanide were detected in the samples and 1,3-dinitrobenzene was the only explosive compound detected in the samples (1 sample). Several volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) were detected in the samples, although dibenzanthracene was not detected. Aldrin, alpha-BHC and gamma-BHC (lindane) were the only pesticides detected in the samples. Many of these sample results were "J-qualified," indicating the detected concentrations were low enough that the laboratory could not accurately quantify the concentration.

A total of 81 surface water samples were collected during three different sampling events from all four of the intermittent streams present in Mākua Valley (Mākua Stream, Kaluakaula Stream Punopahaku Stream and Kaiahi Gulch). Perchlorate (1 sample) and 2,4-dinitrotoluene (2 samples) were the only explosives chemicals detected in the samples. Trace levels of dioxins/furans and trace levels of gasoline-related chemicals were also detected in the surface water samples.

Tetra Tech sampled the sediment from the muliwai at Mākua Valley and in several background muliwai in 2003 (Tetra Tech 2005b). The primary objectives of the sampling program were to evaluate if various chemicals, primarily explosives and metals, were present in the muliwai sediments, and to evaluate if chemicals from the open burn/open detonation area or the range complex at MMR had migrated off-site. Concentrations of metals detected in the muliwai were within the ranges found in the background samples, although arsenic and chromium were detected at concentrations above USEPA Region IX soil preliminary remediation goals (PRGs). Several organic compounds were detected in the sediment samples, but all of the detected concentrations were well below USEPA Region IX residential soil PRGs. Trace concentrations of two dioxin congeners were detected in two of the twelve muliwai sediment samples analyzed for dioxins/furans, with the 2,3,7,8-TCDD congener being the only congener detected at a concentration above the USEPA Region IX industrial soil PRG.

Furthermore, the US Army Corps of Engineers and its contractors performed an air quality investigation at MMR in October 2002, as part of the Environmental Impact Statement (EIS) for resumption of live-fire training at MMR. Some of the objectives of the investigation were to survey the reservation for air quality effects that occur during both a controlled (i.e., prescribed) burn operation and typical combined arms live-fire exercises (CALFEXs) and to gather background data and identify the presence or absence of airborne pollutants of interest at representative potential on-range and off-range exposure locations, including upwind and downwind locations, during the noted events.

VOCs, SVOCs, and explosives/energetics were considered to be primary pollutants of interest for this investigation. Breakdown products of these explosives materials likewise were included as pollutants of interest for the investigation. Particulate metals from additives and structural components of, common ordnance and explosives, nitrogen and sulfur-based emission gases, and airborne cyanide were also designated as pollutants of interest. Moreover, chlorinated herbicides were included as pollutants of interest due to concerns with previous herbicide and agricultural defoliant use at the reservation. Although data on dioxins and furans suggest these airborne contaminants would not be from ordnance and

explosives scheduled for use during daytime MMR training, these compounds were added to the suite of monitored pollutants. The investigation results indicated that there were no SVOCs, chlorinated herbicides, explosives/energetic compounds, or nitrogen-based emission gases detected above analytical detection limits at any air sampling location during either the open burn or CALFEX sampling.

Seven metals were detected during the sampling: aluminum, barium, chromium, magnesium, nickel, lead, and zinc (*note: arsenic, beryllium, and cadmium were not detected above analytical detection limits*). Data for detected metals showed no significant quantitative differences among the field locations, either on-range or off-range. Magnesium and lead were detected at an off-site location. Barium, chromium, magnesium, nickel, lead, and zinc were detected during background sampling (*note: aluminum, arsenic, beryllium, and cadmium were not detected above analytical detection limits*).

1.3 OBJECTIVES AND SCOPE OF WORK

1.3.1 Objectives

The objectives of this marine resources study are to evaluate whether fish, shellfish, limu (marine algae), 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 training at Mākua; to evaluate if activities at MMR have contributed to or will contribute to contamination detected in the fish, shellfish, and limu; and to evaluate whether the proposed training activities pose a health risk to area residents who rely on marine resources for subsistence.

The primary military activity at MMR has been live fire training. Chemicals associated with proposed training activities include explosive compounds and byproducts of explosives and metals that may be released to the environment from the munitions. In response to public comments on the SAP, samples in this marine resources study were analyzed for these chemicals as well as a large number of additional chemicals, including dioxins/furans, organochlorine pesticides, and volatile and semivolatile organic compounds (VOCs and SVOCs). The additional chemicals included in the investigation provide little evidence that chemicals have migrated beyond the boundaries of MMR because they have a wide range of natural and anthropogenic sources. Natural and anthropogenic sources (civilian and military) of these compounds are reviewed in Section 2.

1.3.2 Scope of Work

The draft SAP was issued in December 2005, and proposed that fish, shellfish, and limu samples be analyzed only for explosive and energetic compounds, using USEPA Method 8330. These are chemicals that are associated with the proposed training activities at MMR, although there are sources other than military training activities. Based upon comments from the public to the draft SAP, the SAP was modified to include analysis of fish, shellfish, and limu samples for a wide variety of analytes, including 1) explosives, 2) dioxins/furans, 3) metals, 4) organochlorine pesticides, 5) selected VOCs, and 6) selected SVOCs. The final SAP was published in January 2007.

The scope of work for the marine resources study and risk assessments included the following elements:

- ***Sample Collection and Analysis.*** Tetra Tech collected samples of target species in accordance with the SAP, including samples from "background" locations. Samples were analyzed by certified contract laboratories for the analytes specified in the SAP. These analytes are also listed in Section 2 of this report;
- ***Human Health Risk Assessment and Screening Level Ecological Risk Assessment.*** Tetra Tech performed a human health risk assessment for consumption of seafood from both the muliwai and nearshore waters at Mākua and a background site. Ecological risks to fish and shellfish were estimated using sediment data collected during earlier studies, along with tissue data collected as part of the present study; and
- ***Marine Resources Sampling Report.*** Tetra Tech prepared this report, including a description of the methods and procedures used to collect and analyze the samples, a presentation of the results of sample collection and laboratory analyses, the results of the risk assessments, and a discussion of the interpretation and significance of the results.

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