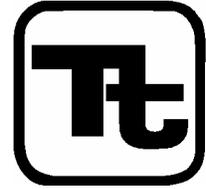
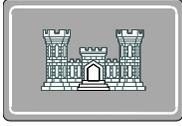

APPENDIX G-6

AIR SAMPLING REPORT



TC K838-0403

AIR SAMPLING AND ANALYSIS INVESTIGATION REPORT

SUPPORTING THE ENVIRONMENTAL IMPACT STATEMENT ON MILITARY TRAINING ACTIVITIES

MAKUA MILITARY RESERVATION O`AHU, HAWAI`I

Contract No. GS-10F-0268K
Delivery Order No. DACA 83-02-F-002

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Full Phrase
ACGIH	American Conference of Governmental Industrial Hygienists
agl	above ground level
APPL	Agriculture & Priority Pollutants Laboratories, Inc.
ASTM	American Society for Testing and Materials
CALFEX	combined arms live fire exercises
CFR	Code of Federal Regulations
EIS	environmental impact statement
GC/MS	gas chromatography/mass spectrometry
GC/ECD	gas chromatography/electron capture detection
GC/SCD	gas chromatography/sulfur chemiluminescence detection
GPS	global positioning system
HAR	Hawai'i Administrative Rules
HED	Honolulu Engineer District
HPLC	high performance liquid chromatography
HxCDD	1,2,3,4,7,8-hexachlorodibenzo-p-dioxin
ICP	inductively coupled plasma (spectrometry)
ISE	ion specific electrode
μl	microliter
μg	microgram
m ³	cubic meter
MCE	mixed cellulose ester
ml	milliliter
mm	millimeter
MMR	Mākuā Military Reservation
NIOSH	National Institute for Occupational Safety and Health
OB/OD	open burn/open detonation
OBJ	objective
OCDD	octochlorodibenzo-p-dioxin
OE	ordnance and explosives
PAH	polycyclic aromatic hydrocarbon
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PCE	tetrachloroethene
PEL	permissible exposure limit
PEM	personal environmental monitor
pg	picogram
PM _{2.5}	particulate matter less than 2.5 microns
PM ₁₀	particulate matter less than 10 microns
ppbV	parts per billion by volume
ppmV	parts per million by volume
PUF	polyurethane foam

LIST OF ACRONYMS AND ABBREVIATIONS *(continued)*

Acronym/Abbreviation	Full Phrase
QA/QC	quality assurance/quality control
REL	recommended exposure limit
RPD	relative percent difference
SAP	sampling and analysis plan
SSHP	site safety and health plan
STEL	short-term exposure limit
SVOC	semivolatile organic compound
TCE	trichloroethene
TLV	threshold limit value
TWA	time-weighted average
µg	microgram
µg/m ³	micrograms per cubic meter
USACE	United States Army Corps of Engineers
USDHHS	United States Department of Health and Human Services
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

SECTION 1

INTRODUCTION

This air sampling and analysis investigation report presents the objectives, technical approach, methodology, and analytical results of the ambient air sampling and monitoring conducted to support data needs of the 2002-2003 environmental impact statement (EIS) for resumption of military training activities at the Mākua Military Reservation (MMR) (site), located in O`ahu, Hawai`i. Tetra Tech, Inc., is preparing the EIS under contract no. GS-10F-0268K (delivery order No. DACA83-02-F-0002) for the United States Army Corps of Engineers (USACE), Honolulu Engineer District (HED); the applicable scope of work was issued in March 2002 (USACE HED 2002).

1.1 SITE DESCRIPTION

MMR is approximately 38 miles northwest of Honolulu, on the western shore of O`ahu, near Kaena Point, and is in the adjoining Mākua and Kahanahaiki valleys (see Figure 1). The military reservation is bordered to the west by the Pacific Ocean and is surrounded by the Wai`anae Mountains to the north, east, and south. MMR borders Farrington Highway and extends west from the Wai`anae Mountains ridgeline to the Pacific Ocean; Makaha, 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 high, precipitous valley walls surrounding the installation reach heights of 2,100 to 2,900 feet. The broad range in rainfall and topography results in a diversity of vegetation types within the valley. Of the total acreage at MMR, the US Army owns 170 acres in fee simple, holds 1.64 acres by license, leases 782.35 acres from the state of Hawai`i, and has the use of 3,236.48 acres of ceded lands.



Source: Rand McNally 2002

Site Location Map

Makua Military Reservation
Oahu, Hawai'i

1.2 OBJECTIVES AND SCOPE OF WORK

1.2.1 Objectives

The primary objectives of the air sampling and monitoring program at MMR included the following:

- 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);
- To conduct additional air sampling at the reservation during nonactive periods to characterize representative “background” conditions in the valley;
- To 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;
- To evaluate any detected airborne pollutants relative to applicable regulatory standards, including federal and state air quality goals, as well as to relevant industrial hygiene guidelines;
- To estimate the impacts of controlled burn operations and the resumption of military training activities on human health and the environment; and,
- To provide data and information necessary to comply with the terms of the settlement agreement and to support preparation of the EIS.

1.2.2 Scope of Work

The proposed scope of work designed to meet the objectives of the investigation and included the following elements:

- ***Preliminary Activities.*** Tetra Tech reviewed findings of previous air studies and assessments available for MMR and related military training sites. Tetra Tech obtained basic information (e.g., maps, soil data, meteorological conditions, munitions compositions, and historic site activities) and obtained permission to enter MMR and adjacent or off-range properties.
- ***Sampling and Analysis Plan.*** Tetra Tech assessed detectable air quality impacts during both controlled burn operations and CALFEXs at MMR in accordance with a USACE-approved sampling and analysis plan (SAP) (Tetra Tech 2002a); this SAP also incorporated general public and third-party technical expert review comments.
- ***Site Safety and Health Plan.*** Tetra Tech followed the site safety and health Plan (SSHP) during all air sampling activities (Tetra Tech 2002b). The SSHP was implemented in compliance with 29 Code of Federal Regulations (CFR) 1910.120 and applicable USACE guidance documents (EM 385-1-1) to address the potential for hazardous materials or conditions being encountered during field work at MMR.

- **Site Visits.** Tetra Tech visited the reservation and surrounding areas multiple times, accompanied by MMR and USACE personnel, to assist in locating and mapping appropriate air sampling locations for the investigation.
- **Sample collection and analysis.** Tetra Tech collected air samples during background conditions and during several site events, in accordance with quality control (QC) requirements of the SAP, and arranged for delivery of the samples under chain-of-custody to certified contract laboratories for analysis within the required analytical holding times (where possible).
- **Air Sampling Report.** Tetra Tech prepared an air sampling investigation report (i.e., this document), based on an evaluation of site conditions and on the results of laboratory analyses. This report describes the methods and procedures used to collect and analyze the samples; the results and observations of the sampling and analysis; and discusses the significance of these results. This report also provides a comparison of results with established human health-based air quality standards and guidelines.

SECTION 2

APPROACH AND METHODOLOGY

2.1 POLLUTANTS OF INTEREST

There is limited chemical-specific information available on air emissions during ordnance and explosives (OE) firing and detonation. However, material safety data sheets and previous air media studies on air emissions from ordnance detonation at other military installations (USEPA 1996, Harding ESE 2000, and Harding ESE 2001) indicate that aromatic volatile organic compounds (VOCs) and explosives-related semivolatile organic compounds (SVOCs) may be produced. Therefore, VOCs, SVOCs, and explosives/energetics were considered as primary pollutants of interest for this investigation. Breakdown products of these explosives materials potentially may be present and were likewise included as pollutants of interest for the investigation.

Particulate metals associated with common OE additives and structural components, 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 associated with OE items scheduled for use during daytime MMR training exercises, these compounds were added to the suite of monitored pollutants.

The US Environmental Protection Agency's AP-42 document (USEPA 1996) further identifies particulate matter less than 10 microns (PM_{10}) as a major air emission during OE firing and detonation. These PM_{10} emissions include "various organic compounds with low vapor pressures, metals associated with shell casings, possibly some metals associated with propellants or explosives, and soil particles suspended by detonations and ballistic impact of nonexplosive ordnance." Consequently, PM_{10} ("coarse" or "inhalable" particulate matter), as well as particulate matter less than 2.5 microns ($PM_{2.5}$) ("fine" or "respirable" particulate matter), were both added to the pollutant regimen as monitored parameters.

Lastly, incidental wildland fires resulting from planned OE detonation activities represent an extremely complex source of air emissions and are therefore difficult to quantitate. The diversity in the type and quantity of combustion products emitted during wildland fires is due to many factors, including fuel (biomass) type and quantity, moisture content, and the diversity of combustion processes which occur simultaneously within a fire. Estimations of emissions from biomass burning include combustion gases (carbon monoxide and dioxide, nitrogen oxides, non-methane hydrocarbons, various non-halogenated VOCs, and both PM_{2.5} and PM₁₀). Air emissions of metals from the heat of burning vegetation acting on structural components is, however, considered to be unlikely (Harding ESE 2001).

The specific pollutants of interest designated for monitoring at MMR and related adjacent or off-range properties, based on the above-noted data and studies and on public and third-party technical expert review comments, are summarized in Table 1 below.

Table 1
Pollutants of Interest
Air Sampling - Mākua Military Reservation

Pollutant Category	Analytical Method¹	Representative Target Chemical(s)
VOCs	USEPA TO-15	Includes full suite of VOCs, including aromatic VOCs (e.g., BTEX) and halogenated VOCs (e.g., TCE and PCE).
SVOCs	USEPA TO-13	Includes full suite of SVOCs, including polycyclic aromatic hydrocarbons (PAHs) and phenolic compounds.
Explosives and energetic compounds ²	USEPA 8330mod	Includes nitroaromatic and nitramine explosive compounds stable in air (e.g., RDX and HMX), as well as relevant breakdown compounds (e.g., nitrotoluene and dinitrotoluene isomers).
Chlorinated herbicides	USEPA 8151Amod	Includes 10 chlorinated herbicides, including phenoxy-acid herbicides (e.g., 2,4-D and 2,4,5-T) and phenolic herbicides.
Dioxins/furans	USEPA TO-9A	Includes 17 isomers and congeners of tetra through octa chlorine-substituted dioxins and furans (i.e., PCDDs and PCDFs).
Particulate metals	NIOSH 7300	Includes 10 metals associated with common OE additives and structural components: aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, magnesium, nickel, and zinc.
Sulfur gases	ASTM D-5504mod	Includes 20 sulfur gases, including thiophenes, hydrogen sulfide, carbon disulfide, mercaptans, and other sulfides.
Cyanide	NIOSH 7904	Includes hydrogen cyanide.
Particulate matter - 2.5 microns	USEPA IP-10A	“Fine” or “Respirable” particulate matter, including PM _{2.5} .
Particulate matter - 10.0 microns	USEPA IP-10A	“Coarse” or “Inhalable” particulate matter, including PM ₁₀ .
Nitrogen-based emission gases	(field monitored)	Nitric oxide and nitrogen dioxide as NO _x .

Notes:

¹Referenced analytical methodology is defined and discussed in Section 2.2.

²Nitroglycerin added to suite of explosives/energetics for CALFEX #1 and CALFEX #2 air sampling per USACE request.

2.2 FIELD SAMPLING AND LABORATORY ANALYTICAL REQUIREMENTS

All air samples were collected at MMR and adjacent or off-range areas using standardized collection procedures appropriate to the respective pollutant of interest and as discussed below; contract laboratories providing the air testing services are summarized in Section 2.3. The staggered intervals of the CALFEX training exercises and the short-term episodic nature of the air sampling investigation precluded the type of monitoring instruments and procedures used at fixed ambient air quality sampling stations. Consequently, air sampling procedures and laboratory analysis methodologies resembled those employed for short-term industrial hygiene and hazardous air pollutant monitoring rather than those used for long-term criteria pollutant monitoring.

Pollutants of interest were sampled for at the designated air sampling locations described in Section 2.4. Sampling was initiated just prior to the controlled burn and CALFEX onsets and was performed concurrently at each of the respective locations during these events. Air sampling was continuous and integrative for the entire duration of the events; active sampling periods were measured to be approximately five to seven hours in duration, depending on the respective length of the event. Pumps situated at off-range locations were allowed to operate for an additional one-half hour following active phases of the controlled burn and CALFEX sampling events to account for any differentials in the transfer of potential airborne pollutants. All pumps were battery operated; no gasoline or fuel-powered equipment was utilized in the field. A photograph of a representative air sampling station assembled at MMR is provided in Appendix A.

USEPA Methods 8330 and 8151A are designed for characterizing both water and solid matrices since they were developed for RCRA applications. Respective field sampling methods are discussed in Sections 2.2.3 and 2.2.4 of the report. However, because filters (e.g., XAD-glass fiber and PUF filters) were used as the collection media, the noted methods were modified in the laboratory as follows:

8330mod

The XAD-glass fiber filters were extracted with acetonitrile consistent with USEPA Method 8151A. However, the laboratory used a Carbosorb reverse phase column as the quantitation column and a Zorbax SB-CN column as the confirmation column for instrument analysis; all other chromatographic conditions were consistent with the method.

8151Amod

The PUF filters and their containers were triple-rinsed with methylene chloride (DCM), with wringing of the filter performed between rinses. The DCM extracts were then run through sodium sulfate, rotoevaporated, and quantitatively transferred to ethyl ether. Derivatization steps and chromatographic conditions were subsequently followed consistent with USEPA Method 8151A.

2.2.1 VOCs

Air samples for VOCs were collected in evacuated six-liter Summa canisters at approximately five-feet above ground level (agl); this height simulates the oral-nasal level

of a typical human receptor. Each canister was equipped with a pre-set flow controller to provide regulated sample collection over the expected duration of the burn or CALFEX event. To provide a means of verifying sample integrity, the flow rate was set to fill about 80 percent (4.8 liters) of the six-liter volume. This left a small vacuum in each canister which was verified by the contract laboratory upon receipt of the canisters for analysis. Air samples collected in these canisters were analyzed for the full target list of VOCs in accordance with USEPA Method TO-15 (Determination of VOCs in Ambient Air using Specially Prepared Canisters with subsequent Analysis by Gas Chromatography/Mass Spectrometry [GC/MS]). Typical analytical detection limits for the investigation using USEPA Method TO-15 were approximately 0.5 to 5.0 parts per billion by volume (ppbV).

2.2.2 SVOCs

Air samples for SVOCs, including PAHs and phenolic compounds, were collected using glass-sleeved PUF-XAD filter cartridges. Calibrated low-volume pumps (set at 3 liters/minute) were used to draw air into the sampling media for all SVOC cartridges to ensure a sufficient sample mass for analysis. Samples were collected at approximately five-feet agl and sent to the contract laboratory for the full target list of SVOCs using USEPA Method TO-13 (Determination of SVOCs in Ambient Air by GC/MS). Typical analytical detection limits for the investigation using USEPA Method TO-13 were approximately 1.0 to 20 micrograms (μg) per filter.

2.2.3 Explosives and Energetic Compounds

Air samples for explosives and energetic compounds were collected using glass-sleeved XAD-glass fiber filter cartridges provided by the contract laboratory. Calibrated low-volume pumps (set at 3 liters/minute) were used to draw air into the sampling media for all explosives/energetic cartridges to ensure a sufficient sample mass for analysis. Samples were collected at approximately five-feet agl and sent to the contract laboratory for the target list of compounds following USEPA Method 8330mod (Determination of Nitroaromatic and Nitramine Explosives, modified) using high performance liquid chromatography (HPLC) with ultra-violet detection. Confirmation of any detected analyte concentrations would be achieved using a second (i.e., dissimilar phase) HPLC column. Nitroglycerin, requiring a separate HPLC analysis of each filter, was also requested by the USACE for the two CALFEX sampling events. Typical analytical detection limits for the investigation using USEPA Method 8330mod were approximately 0.5 μg per filter.

2.2.4 Chlorinated Herbicides

Air samples for chlorinated herbicides, including phenoxy acid compounds like 2,4-D and 2,4,5-T, were collected using glass-sleeved PUF filter cartridges. Calibrated low-volume pumps (set at 3 liters/minute) were used to draw air into the sampling media for all chlorinated herbicide cartridges to ensure a sufficient sample mass for analysis. Samples were collected at approximately five-feet agl and sent to the contract laboratory for chlorinated herbicide analyses following USEPA Method 8151Amod (Determination of Chlorinated Herbicides, modified) using gas chromatography with electron capture detection (GC/ECD). Typical analytical detection limits for the

investigation using USEPA Method 8151Amod were approximately 0.2 to 200 µg per filter.

2.2.5 Dioxins and Furans

Air samples for dioxins and furans, including the seventeen 2,3,7,8-substituted polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) isomers and congeners, were collected using glass-sleeved PUF filter cartridges provided by the contract laboratory. Calibrated low-volume pumps (set at 3 liters/minute) were used to draw air into the sampling media for all dioxin/furan cartridges to ensure a sufficient sample mass for analysis. Samples were collected at approximately five-feet agl and sent to the contract laboratory for the target list of compounds following USEPA Method TO-9A (Determination of Polychlorinated Dibenzop-Dioxins and Dibenzofurans in Ambient Air); this method employs high resolution GC/MS. Typical analytical detection limits for the investigation using USEPA Method TO-9A were approximately 1.0 to 10 picograms (pg) per filter.

2.2.6 Particulate Metals

Air samples for particulate metals (aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, magnesium, nickel, and zinc) were collected using 37-millimeter (37-mm) mixed cellulose ester (MCE) filter cassettes provided by the contract laboratory. Calibrated low-volume pumps (set at 3 liters/minute) were used to draw air into the sampling media for all metals cassettes to ensure a sufficient sample mass for analysis. The 37-mm MCE filters were removed from the cassettes by the contract laboratory and digested and analyzed for the target list of particulate metals following National Institute for Occupational Safety and Health (NIOSH) Method 7300 (Determination of Elements by ICP) using inductively coupled plasma (ICP) emission spectrometry for simultaneous multielemental analysis. Typical analytical detection limits for the investigation using NIOSH Method 7300 were approximately 0.002 to 0.4 µg per filter.

2.2.7 Sulfur Gases

Air samples for sulfur gases, including hydrogen sulfide, carbon disulfide, and other sulfur-based compounds, such as alkylated mercaptans, were collected using five-liter and ten-liter Tedlar bags that were protected from sunlight during sampling and prior to analysis. Similar to the VOC sampling described above, sample inlets were positioned five-feet agl. However, each Tedlar bag was equipped with a vacuum chamber and calibrated low-volume pumps (set at 0.02 liters/minute) to provide regulated sample collection over the expected duration of the sampling event. The Tedlar bags were analyzed by the contract laboratory for the target list of sulfur-based compounds following American Society for Testing and Materials (ASTM) Method D-5504mod (Standard Test Method for Determination of Sulfur Compounds, modified) using gas chromatography with sulfur chemiluminescence detection (GC/SCD). Typical analytical detection limits for the investigation using ASTM Method D-5504mod were approximately 4.0 ppbV.

2.2.8 Cyanide

Air samples for cyanide (measured as hydrogen cyanide) were collected using midjet impinger trains consisting of two primary impinger tubes and one backup tube. The two primary impinger tubes, with an approximate 15 to 20 milliliter (ml) capacity, were loaded with 0.1N potassium hydroxide solution for cyanide collection. Calibrated low-volume pumps (set at 1 liter/minute) were used to draw air through the impinger tubes during the sampling durations; samples were collected at approximately five-feet agl. Impinger solutions were submitted to the contract laboratory in sterile vials for analysis using NIOSH Method 7904 (Ambient Air Sampling for Hydrogen Cyanide). Impinger solutions were analyzed by the contract laboratory using either an ion specific electrode (ISE) for cyanide, or by using a spectrophotometer. Typical analytical detection limits for the investigation using NIOSH Method 7904 were approximately 0.15 µg per sample (spectrophotometric) to 3.6 µg per sample (ISE).

2.2.9 Particulate Matter

Air samples for particulate matter of 2.5 microns or less in aerodynamic diameter (PM_{2.5}) and for particulate matter of 10 microns or less in aerodynamic diameter (PM₁₀) were collected using pre-weighed 37-mm Teflon filters (with polyolefin rings) and size-specific personal environmental monitors (PEMs), consisting of an inlet-nozzle section, impactor plate, and exit section. Calibrated low-volume pumps (set at 4 liters/minute) were used to draw air through the PEMs during the sampling durations; all samples were collected with the inlet nozzle situated at approximately five-feet agl. Following sampling, Teflon filters were sent to the contract laboratory in sterile petri dishes to be analyzed gravimetrically for particle mass following USEPA Method IP-10A (Determination of Respirable Particulate Matter in Indoor Air Using Size-Specific Impaction). Typical analytical detection limits for the investigation using USEPA Method IP-10A were approximately 0.1 µg per filter.

2.2.10 Nitrogen-based Emission Gases

Nitrogen-based emission gases, such as nitric oxide and nitrogen dioxide, were measured in the field directly using colorimetric detector tubes (Sensidyne). These tubes were operated by drawing a specified amount of air (with a hand operated pump) through a glass tube that was packed with a powder specifically designed to chemically react with nitric oxide and/or nitrogen dioxide. The color of the powder changes when it reacts with the air contaminant passing through the tube and the length of the color change is proportional to the concentration of the contaminant in the atmosphere that is being sampled. Typical analytical detection limits for the investigation using colorimetric detector tubes were approximately 0.04 to 20 parts per million by volume (ppmV).

2.3 CONTRACT LABORATORIES

Six environmental air testing facilities were designated as contract laboratories for the project, based on their respective fields of chemical expertise (see Table 2 below). A quality assurance management plan was obtained from each contract laboratory and reviewed by appropriate Tetra Tech and USACE HED personnel prior to the

Table 2
Summary of Contract Laboratories
Air Sampling - Mākua Military Reservation

Contract Laboratory	Contact Information	Project Testing Services
Air Toxics, Ltd.	180-B Blue Ravine Road Folsom, CA 95630 916-985-1000 (phone) 916-985-1020 (facsimile)	VOCs, SVOCs, sulfur gases
ALTA Analytical Laboratory	5070 Robert J. Matthews Parkway El Dorado Hills, CA 95762 916-933-1640 (phone) 916-933-0940 (facsimile)	Dioxins/furans
Agriculture & Priority Pollutants Laboratories, Inc. (APPL)	4203 West Swift Avenue Fresno, CA 93722 559-275-2175 (phone) 559-275-4422 (facsimile)	Chlorinated herbicides
Chester LabNet	12242 SW Garden Place Tigard, OR 97223 503-624-2183 (phone) 503-624-2653 (facsimile)	Particulate metals, PM _{2.5} , PM ₁₀
Southwest Laboratory of Oklahoma, Inc. (SWL)	1700 West Albany Broken Arrow, OK 74012 918-251-2858 (phone) 918-251-1889 (facsimile)	Explosives and energetic compounds
Environmental Analytical Service, Inc. (EAS Lab)	173 Cross Street San Luis Obispo, CA 93401 805-781-3585 (phone) 805-541-4550 (facsimile)	Cyanide

investigation onset. All contract laboratories providing air testing services held current certification under the National Environmental Laboratory Accreditation Program, where applicable, had demonstrated proficiency in each of the required methods, and had recently generated method detection limit data available for review.

2.4 AIR SAMPLING EVENTS AND LOCATIONS

Air sampling activities were conducted at MMR during four discrete events. These events and their respective dates of occurrence are summarized as follows (*note: the events are discussed in relative order rather than chronological order*):

- Background Air Sampling Event (April 8, 2003);
- CALFEX #1 Air Sampling Event (January 31, 2003);
- CALFEX #2 Air Sampling Event (April 10, 2003); and,

- Open Burn Air Sampling Event (October 30, 2002).

Based on range firing records, interviews with key MMR personnel and technical experts, and site visits during previous CALFEX events, multiple air emissions sources were identified at MMR. The basis and relative positions of these emission sources are discussed in the investigation SAP (Tetra Tech 2002a). In consideration of these various CALFEX air emissions sources, and based on local climatological and topographical features, as well as general public and third-party technical expert review comments, eight representative air sampling locations, and one field duplicate location, were designated for sampling during background and CALFEX events at MMR. In addition, because of the logistical inability to locate many of the air sampling stations on-reservation during the open burn, three air sampling locations were designated during this event.

2.4.1 Background and CALFEX Air Sampling Events

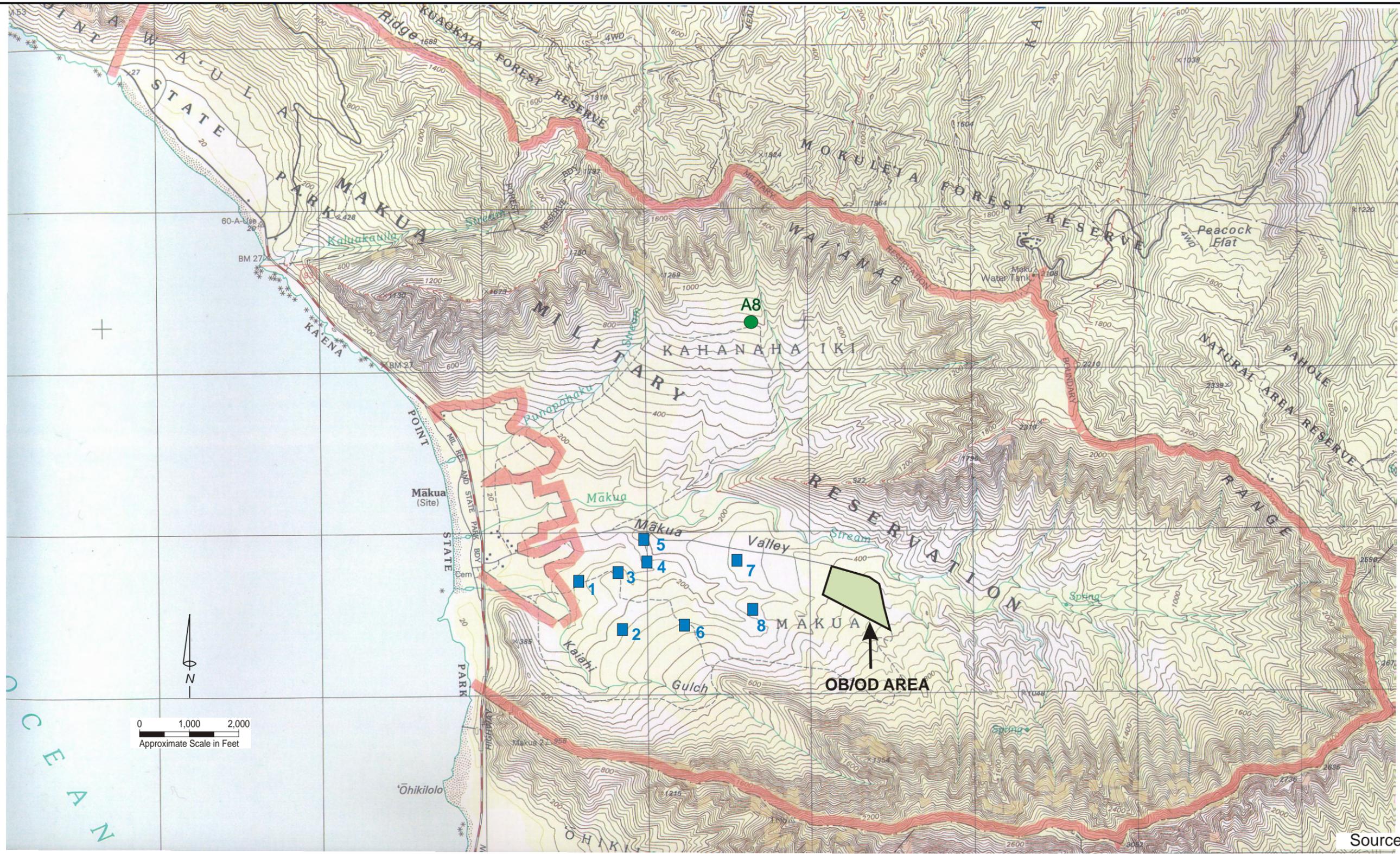
The eight representative air sampling locations, and one field duplicate location, used for sampling during background and CALFEX events at MMR are discussed below (see Figures 2 through 4). Approximate elevations and geographical coordinates, recorded using a handheld global positioning system (GPS) unit, are presented in Table 3.

Table 3
GPS Coordinates of Air Sampling Locations
Air Sampling - Mākua Military Reservation

Air Sampling Location	Applicable Sampling Events	Elevation (feet above mean sea level)	GPS Coordinates ¹	
			Latitude	Longitude
A1	CALFEX #1	284	North 21° 31.754	West 158° 12.896
A1	CALFEX #2	<i>(not determined)</i>	North 21° 31.916	West 158° 12.733
A2	CALFEX #1, CALFEX #2	400	North 21° 31.710	West 158° 12.564
A3	CALFEX #1, CALFEX #2	85	North 21° 31.746	West 158° 13.519
A4	CALFEX #1, CALFEX #2	10	North 21° 31.690	West 158° 13.722
A5	CALFEX #1, CALFEX #2	<i>(not determined)</i>	<i>(not determined)</i>	<i>(not determined)</i>
A6	CALFEX #1, CALFEX #2	294	North 21° 31.774	West 158° 12.870
A7	CALFEX #1	320	North 21° 31.683	West 158° 12.834
A7	CALFEX #2	<i>(not determined)</i>	North 21° 31.735	West 158° 12.719
A8	CALFEX #1, Background	846	North 21° 32.485	West 158° 12.666
A9	CALFEX #1, CALFEX #2	85	North 21° 31.746	West 158° 13.519

¹Approximate coordinates (latitude, longitude) recorded using a handheld global positioning system (GPS) unit.

r:\new\K838106\Figure-2_Air_Sample_Locations.cdr -06/19/03 - CT



Source: USGS 1998

Legend

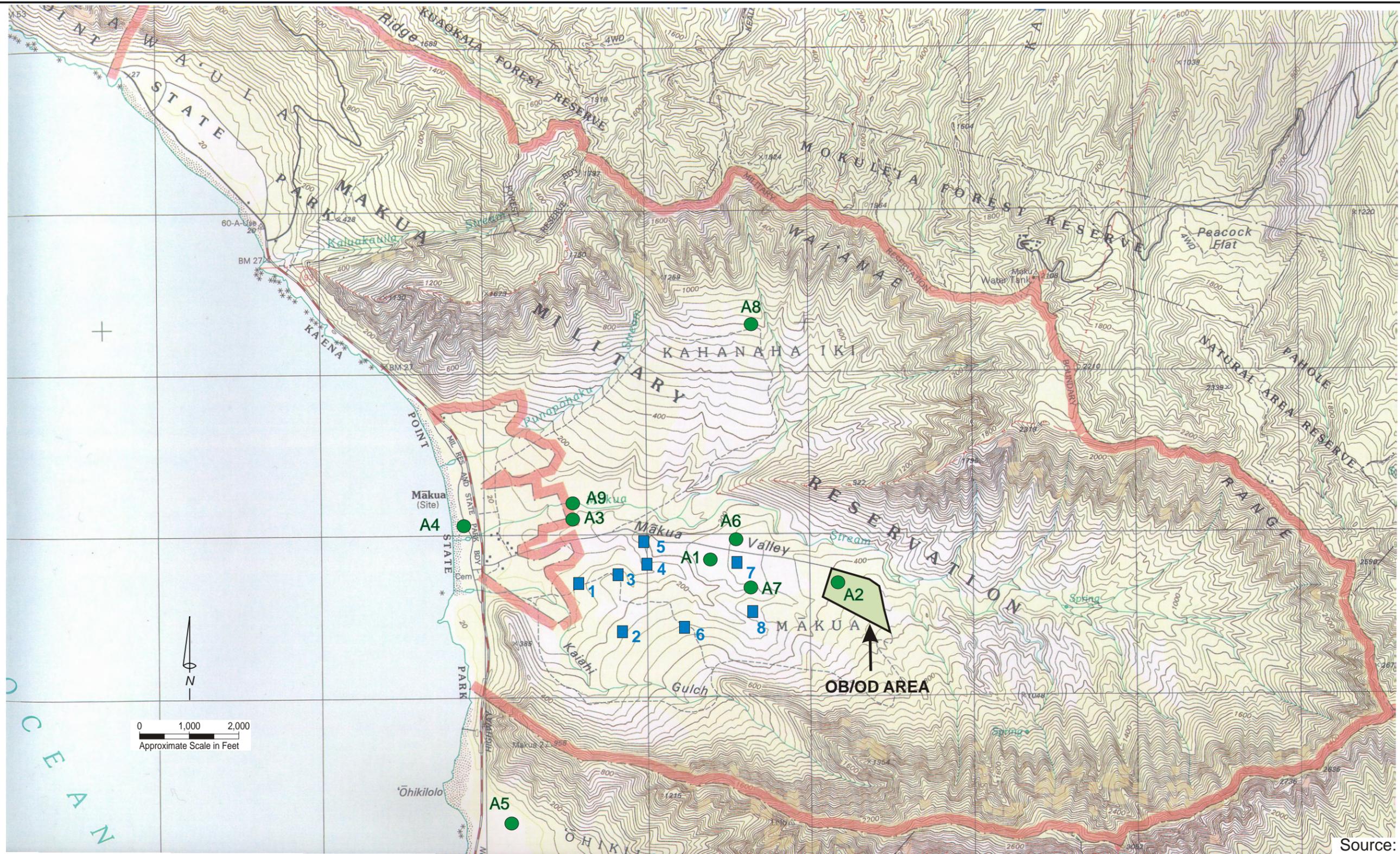
- 1. Wolf
- 2. Buffalo
- 3. Coyote
- 4. Fox
- 5. Deeds
- 6. Badger
- 7. Deer
- 8. Elk

- A1 Air Sampling Location
- 2 Objective Location

“Background” Air Sampling Location (April 8, 2003)

Mākua Military Reservation
O’ahu, Hawai’i

r:\new\K838106\Figure-3_Air_Sample_Locations.cdr -06/19/03 - CT



Source: USGS 1998

Legend

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

- A1 Air Sampling Location
- 2 Objective Location

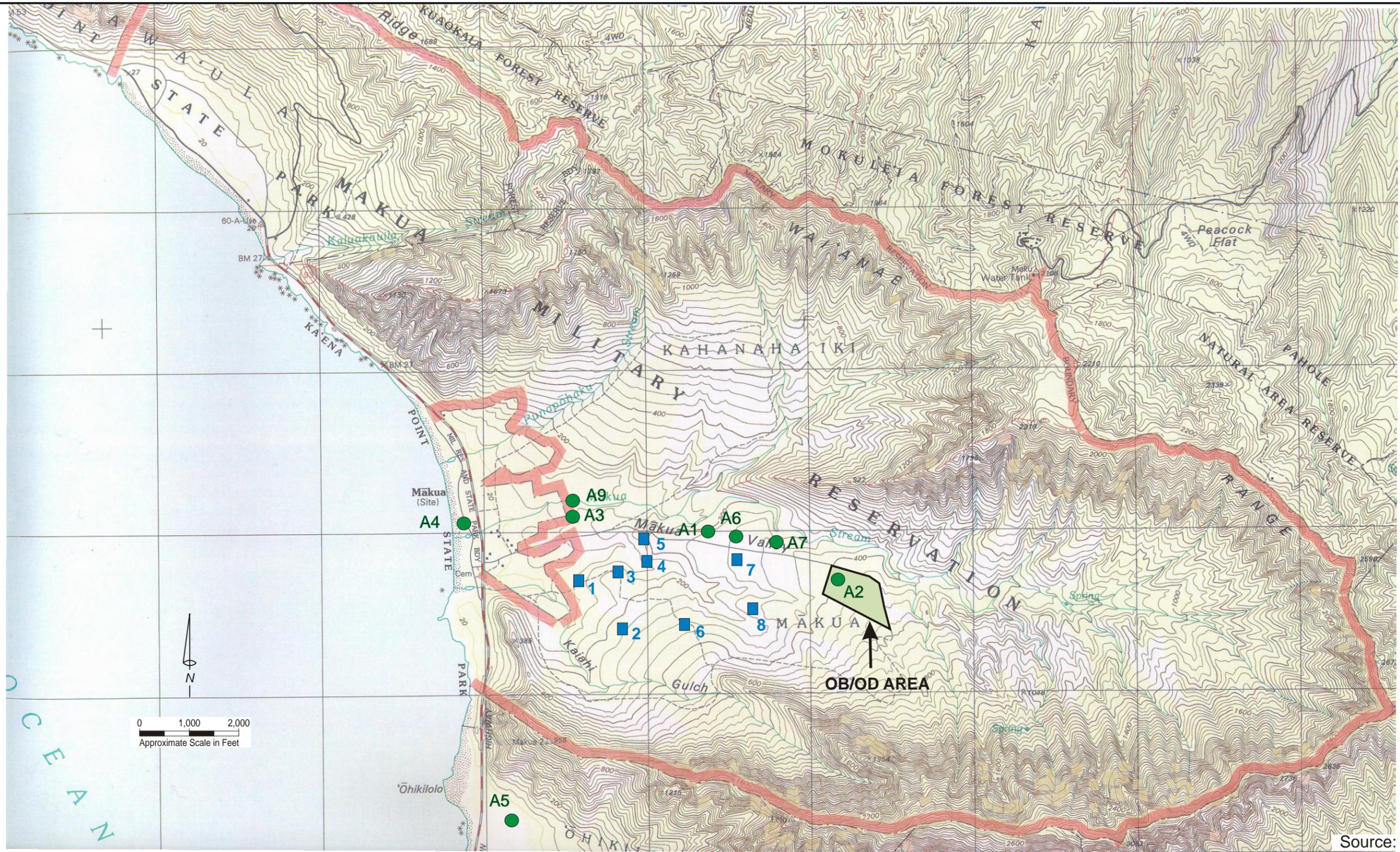
"CALFEX #1" Air Sampling Locations (January 31, 2003)

Makua Military Reservation
O'ahu, Hawai'i



Figure 3

r:\new\K838106\Figure-4_Air_Sample_Locations.cdr -06/19/03 - CT



Source: USGS 1998

Legend

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

- A1 Air Sampling Location
- 2 Objective Location

“CALFEX #2” Air Sampling Locations (April 10, 2003)

Mākua Military Reservation
O’ahu, Hawai’i

- **Air Location 1 (A1)**—This air sampling location was selected primarily to assess the potential for air pollutants to be generated at firing/detonation points near Objective (OBJ) Deer, including grenades, Brashier/Bangalor torpedoes, smoke canisters, Claymore mines, and rifle fire. The location was also intended to assess the prevailing downwind migration of air emissions during early-morning to mid-afternoon hours. This location was sampled during both CALFEX events #1 and #2; however, the location was moved slightly north to accommodate troop activities during CALFEX event #2.
- **Air Location 2 (A2)**—This air sampling location was selected to assess the potential for on-range, prevailing upwind migration of air pollutants adsorbed onto airborne dusts or particulates emitted from the primary detonation area west of the Open Burn/Open Detonation (OB/OD) area. This location was sampled during both CALFEX events #1 and #2.
- **Air Location 3 (A3)**—This air sampling location was selected to assess the potential for air pollutants near the downwind boundary of MMR, based on expected (prevailing) wind directions. The location was approximately 500 feet downwind of the OBJ Deeds objective, near the administration area, and was expected to be downwind of most of the potential air emissions-generating activities. This location was sampled during both CALFEX events #1 and #2.
- **Air Location 4 (A4)**—This air sampling location was selected to assess the potential for prevailing downwind and off-range migration of air emissions. This location was also selected to determine potential affects to air quality at Mākua Beach, a public access point and recreational area for local residents. This location was sampled during both CALFEX events #1 and #2.
- **Air Location 5 (A5)**—This southern-most air sampling location was selected as a background sample point and to assess the potential for off-range migration of air pollutants and impact to the nearest residents to MMR at the Silva Ranch. This location was sampled during both CALFEX events #1 and #2.
- **Air Location 6 (A6)**—This location was situated northwest of OBJ Deer, OBJ Elk, and the OB/OD Area. The sample location was selected to assess the potential for crosswinds to transport emissions and dusts and to account for other possible changes in wind direction. This location was sampled during both CALFEX events #1 and #2.
- **Air Location 7 (A7)**—This location was situated southeast of OBJ Deer, north of OBJ Elk, and west of the OB/OD Area. As with Air Location 6, this sample location was selected to assess the potential for crosswinds to transport emissions and dusts and to account for other possible changes in wind direction. This location was sampled during both CALFEX events

#1 and #2; however, the location was moved slightly north to accommodate troop activities during CALFEX event #2.

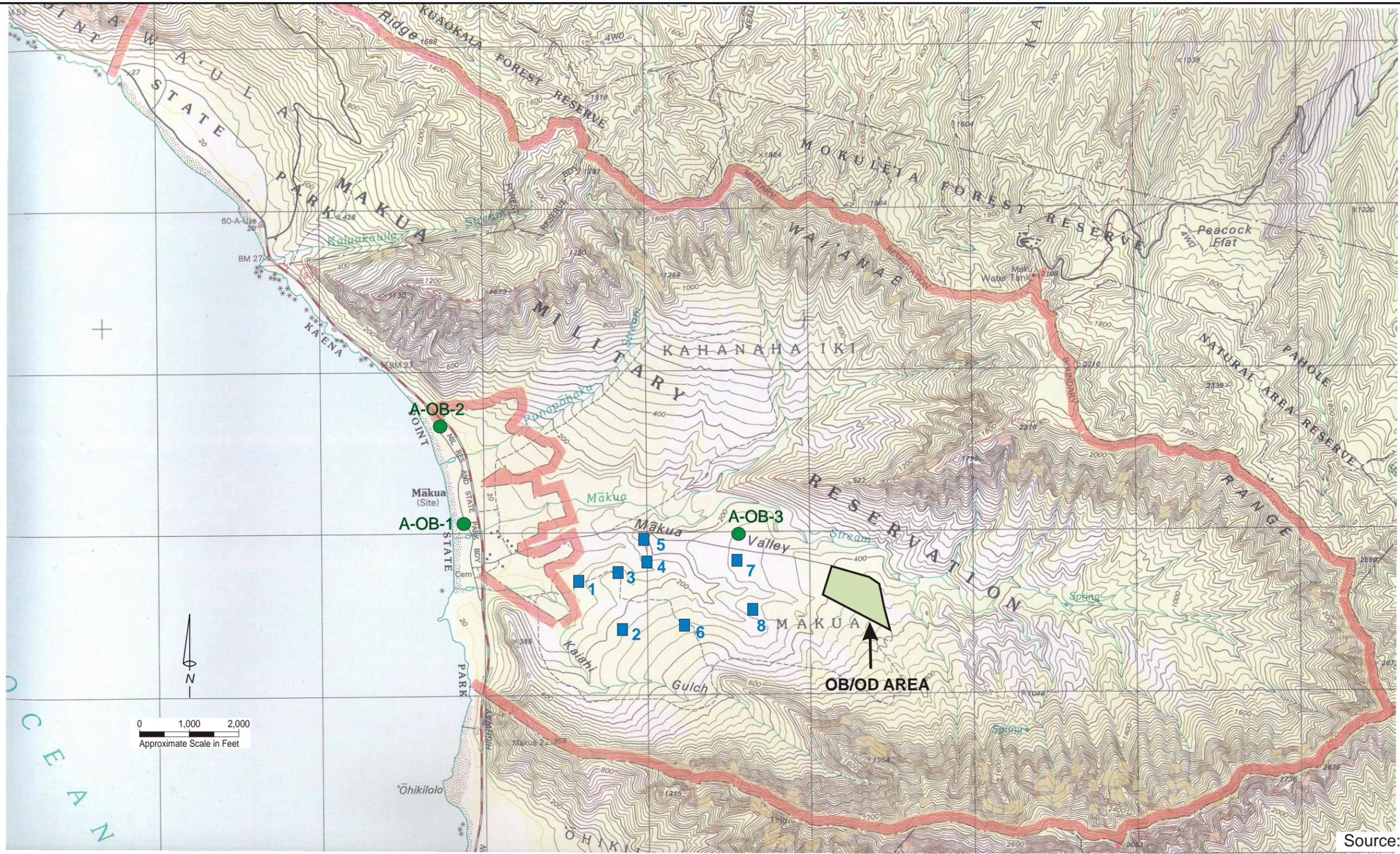
- **Air Location 8 (A8)**—This location was situated on the north side of the Kahanahaiki Valley Fire Break Road to serve as a background sample location. The location was selected because there was anticipated to be no influence from MMR emission sources at this background location, thus providing representative ambient air characteristics for the pollutants of interest. This location was sampled during CALFEX event #1 and during a non-CALFEX date with no troop activities at MMR (i.e., “background event”).
- **Air Location 9 (A9)**—This air sampling location was selected as the field duplicate location (collocated with Air Location 3) to assess the potential for air pollutants near the downwind boundary of MMR, based on expected wind directions. As with Air Location 3, the location was approximately 500 feet downwind of the OBJ Deeds and was expected to be downwind of most of the potential air emissions-generating activities. This location was also sampled during both CALFEX events #1 and #2.

2.4.2 Open Burn Sampling Event

The three representative air sampling locations used for sampling during the open burn event at MMR are discussed below. These sampling locations included one up-valley, on-range station and two other off-range “sensitive receptor” sites along the beach (see Figure 5). Elevations and geographical coordinates were not recorded during this sampling event; however, estimates have been provided based on similar sampling locations staged during respective CALFEX events (see Section 2.4.1).

- **Open Burn Air Location 1 (A-OB-1)**—This off-range sampling location was selected to assess the potential for prevailing downwind and off-range migration of air emissions. This location was chosen to determine potential effects to air quality at south end of Mākua Beach (“South Beach”), a public access point and recreational area for local residents. The elevation and geographical coordinates of this location are expected to be very similar to those of CALFEX Air Location 4 (see Table 3).
- **Open Burn Air Location 2 (A-OB-2)**—This off-range sampling location was situated at the north end of Mākua Beach (“North Beach”), also a public access point and recreational area for local residents. Similar to the South Beach sampling station noted above, this location was likewise selected to assess the potential for prevailing downwind and off-range migration of air emissions during an open burn event.

r:\new\K838061\Figure-5_Air_Sample_Locations.cdr -06/19/03 - CT



Source: USGS 1998

Legend

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

- A1 Air Sampling Location
- 2 Objective Location

"Open Burn" Air Sampling Locations (October 30, 2002)

Makua Military Reservation
O'ahu, Hawai'i



Tetra Tech, Inc.

Figure 5

- **Open Burn Air Location 3 (A-OB-3)**—This on-range sampling location was situated northwest of OBJ Deer, OBJ Elk, and the OB/OD Area. This location was selected to assess the emissions and dusts experienced on-range and in the valley during the open burn event. The elevation and geographical coordinates of this location are expected to be very similar to those of CALFEX Air Location 6 (see Table 3).

2.5 EVALUATION OF BACKGROUND CONDITIONS

The interpretation of air sampling data from MMR recognizes that many contract laboratory analyses are for chemical constituents and pollutants of interest that are not unique to OE use at military training exercises. However, the proposed air sampling network (see Section 2.4) included one sampling location (Air Location 8) that was specifically situated to serve as a background monitoring station. As noted above, this sampling location was monitored both during both a CALFEX event and during a non-CALFEX event (i.e., no troop activities on-range). Therefore, sampling data from Air Location 8 provide information on background air conditions in two different event scenarios. In addition, the monitoring location at the Albert Silva Ranch (Air Location 5) can also provide background monitoring data, since it is situated off-range and approximately one-half mile south of MMR.

2.6 COMPARISON TO AIR QUALITY STANDARDS

The comparison of measured pollutant concentrations to human health effects criteria used state and federal ambient air quality standards where applicable, and supplemental criteria (such as hazardous air pollutant exposure criteria and industrial hygiene criteria) for other chemicals of concerns. These criteria included the following:

- American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs) for chemical substances (ACGIH 2003);
- Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) and National Institute for Occupational Safety and Health (NIOSH) recommended exposure limits (RELs) for airborne chemical hazards (USDDHS 1997);
- Hawai'i Administrative Rules (HAR) ambient exposure guidelines for hazardous air pollutants (HAR Title 11, Chapter 60.1, Section 179); and,
- Federal ambient air quality standards (“National Primary and Secondary Standards for Particulate Matter”) (40 CFR 50.7)

The comparison to human health effects air quality criteria took into account the respective duration of air sampling during the open burn and CALFEX events for each pollutant parameter. Actual sampling durations were compared to the time frame of applicable standards and evaluation criteria, and converted to respective time-weighted averages (TWAs). For comparison to TLV guidelines and HAR criteria (which are concentrations equal to 1% of the corresponding OSHA PEL), 8-hour TWAs were calculated for each detected pollutant. For comparison to federal ambient air quality standards for particulate matter parameters (PM_{2.5} and PM₁₀), normalization of the

measured particulate concentrations to 24-hour TWAs was accomplished using respective background concentrations for the balance of the 24-hour period not directly measured (see Appendix B).

SECTION 3

RESULTS

3.1 BACKGROUND AIR SAMPLING EVENTS

Results of the monitoring conducted at MMR on April 8, 2003 during the background air sampling event are summarized below. Detected pollutants of interest are also discussed relative to applicable human health effects air quality criteria (where established). Complete results of the background air sampling event are presented in Table B-1 of Appendix B.

- **VOCs**—Chloromethane (1.3 ppbV) was the only VOC detected during the background sampling event. According to the sampling duration, the 8-hour TWA for chloromethane was calculated at 0.9 ppbV, significantly below both its ACGIH TLV (50,000 ppbV) and HAR guideline (1,000 ppbV) based on the respective OSHA PEL (1,000,000 ppbV).
- **SVOCs**—There were no SVOCs detected above analytical detection limits during the background sampling event.
- **Explosives and Energetic Compounds**—There were no explosives/energetic compounds detected above analytical detection limits during the background sampling event.
- **Chlorinated Herbicides**—There were no chlorinated herbicides detected above analytical detection limits during the background sampling event.
- **Dioxins and Furans**—Octochlorodibenzo-p-dioxin (OCDD) was reported by the contract laboratory in the air sample collected during the background sampling event at a concentration of 25.3 pg; however, this compound was also detected in the associated method blank at a comparable level of 27.4 pg. Consistent with USEPA organic data validation guidelines (USEPA 1999), the OCDD observed in the background air sample is regarded as laboratory-introduced contamination and is therefore considered to be a nondetected value.

- **Particulate Metals**—Six of the ten metals were detected during the background sampling event: barium, chromium, magnesium, nickel, lead, and zinc (*note: aluminum, arsenic, beryllium and cadmium were not detected above respective analytical detection limits*). Concentrations of these detected metals ranged from 0.03 $\mu\text{g}/\text{m}^3$ (barium) to 0.71 $\mu\text{g}/\text{m}^3$ (chromium), with a corresponding 8-hour TWA range of 0.02 $\mu\text{g}/\text{m}^3$ (barium) to 0.56 $\mu\text{g}/\text{m}^3$ (chromium). As shown in Table B-1 (Appendix B), 8-hour TWAs for all detected metals were below both ACGIH TLVs and HAR guidelines based on respective OSHA PELs.
- **Sulfur Gases**—There were no sulfur gases detected above analytical detection limits during the background sampling event.
- **Cyanide**—Hydrogen cyanide was not detected above the analytical detection limit during the background sampling event.
- **PM_{2.5}**—This “fine” particulate parameter was detected during the background sampling event at a concentration of 12.9 $\mu\text{g}/\text{m}^3$, with a corresponding 8-hour TWA value of 8.3 $\mu\text{g}/\text{m}^3$ and a normalized 24-hour TWA value of 12.9 $\mu\text{g}/\text{m}^3$. As shown in Table B-1 (Appendix B), the 8-hour TWA for PM_{2.5} was below its ACGIH TLV (3,000 $\mu\text{g}/\text{m}^3$) and the 24-hour TWA was below the respective federal ambient air quality standard (65 $\mu\text{g}/\text{m}^3$).
- **PM₁₀**—This “coarse” particulate parameter was detected during the background sampling event at a concentration of 14.5 $\mu\text{g}/\text{m}^3$, with a corresponding 8-hour TWA value of 9.3 $\mu\text{g}/\text{m}^3$ and a normalized 24-hour TWA value of 14.5 $\mu\text{g}/\text{m}^3$. As shown in Table B-1 (Appendix B), the 8-hour TWA for PM₁₀ was below its ACGIH TLV (10,000 $\mu\text{g}/\text{m}^3$) and the 24-hour TWA for PM₁₀ was below the respective federal ambient air quality standard (150 $\mu\text{g}/\text{m}^3$).
- **Nitrogen-based Emission Gases**—Monitoring for nitrogen-based emission gases was not performed during the background sampling event; therefore, no data are available.

3.2 CALFEX AIR SAMPLING EVENTS

Results of the monitoring conducted at MMR on January 31, 2003 and April 10, 2003 during the CALFEX air sampling events are summarized below. Detected pollutants of interest are also discussed relative to applicable human health effects air quality criteria (where established). Complete results of the CALFEX air sampling events are presented in Table B-2 (CALFEX event #1) and Table B-3 (CALFEX event #2) of Appendix B.

- **VOCs**—Fifteen different VOCs were detected during the two CALFEX sampling events (acetone, benzene, carbon disulfide, dichloromethane, 1,4-dioxane, ethanol, ethylbenzene, Freon-112, PCE, 2-propanol, TCE, toluene, 1,2,4-trimethylbenzene, m,p-xylenes, and o-xylene). Of these 15 VOCs, acetone, DCM, and toluene were the most frequently detected compounds at the nine field sampling locations. During CALFEX event #1, eight gasoline-related VOCs were detected at Air Location 5 (off-range, Silva Ranch), an area adjacent to Farrington Highway. During CALFEX event #2,

however, only one VOC was detected at this air sampling location. While there were definite qualitative differences among VOC detections between the two sampling events, all detected compounds were observed at relatively low-level concentrations ranging from 0.9 to 21 ppbV. Consequently, all 8-hour TWAs for detected VOCs were significantly below corresponding ACGIH TLVs and, to a lesser extent, also below their respective HAR guidelines.

- **SVOCs**—There were no SVOCs detected above analytical detection limits during either of the CALFEX sampling events.
- **Explosives and Energetic Compounds**—There were no explosives/energetic compounds detected above analytical detection limits during either of the CALFEX sampling events.
- **Chlorinated Herbicides**—There were no chlorinated herbicides detected above analytical detection limits during either of the CALFEX sampling events.
- **Dioxins and Furans**—There were no PCDDs/PCDFs detected above analytical detection limits during the CALFEX event #1 sampling, although OCDD was reported by the contract laboratory in several samples (including the quality assurance/quality control [QA/QC] trip blank sample) from CALFEX event #2 at concentrations ranging from 17.7 to 62.6 pg per filter. However, this compound was also detected in the associated method blank at a comparable level of 27.4 pg. Consistent with USEPA organic data validation guidelines (USEPA 1999), all OCDDs observed in associated air samples are regarded as laboratory-introduced contamination and are therefore considered to be nondetected values.
- **Particulate Metals**—Seven of the ten metals were detected during the two CALFEX sampling events: aluminum, barium, chromium, magnesium, nickel, lead, and zinc (*note: arsenic, beryllium and cadmium were not detected above respective analytical detection limits*). Aluminum was detected only at Air Location 1 (on-range, near OBJ Deer), while the other six metals were observed to varying degrees at all nine field sampling locations. With the exception of the magnesium result obtained at Air Location 5 (off-range, Silva Ranch) during CALFEX event #1, all other metals results from both live fire exercises were less than five times the amount found in associated QA/QC trip blanks (see Section 3.4.2). Data for the detected metals showed no significant quantitative differences among the field locations, either on-range or off-range. For instance, the following range of concentrations were obtained: aluminum (0.63 to 0.65 $\mu\text{g}/\text{m}^3$), barium (0.02 to 0.03 $\mu\text{g}/\text{m}^3$), chromium (0.19 to 0.80 $\mu\text{g}/\text{m}^3$), magnesium (0.36 to 2.26 $\mu\text{g}/\text{m}^3$), nickel (0.07 to 0.17 $\mu\text{g}/\text{m}^3$), lead (0.19 to 0.30 $\mu\text{g}/\text{m}^3$), and zinc (0.09 to 0.21 $\mu\text{g}/\text{m}^3$). As shown in Tables B-2 and B-3 (Appendix B), 8-hour TWAs for all detected metals were below both ACGIH TLVs and HAR guidelines based on respective OSHA PELs.
- **Sulfur Gases**—Carbonyl sulfide was the only sulfur gas observed during the two CALFEX sampling events. This compound was detected at several of the nine field sampling locations, including Air Location 8 (background location),

at a relatively low concentration range of 4.6 to 15 ppbV. Eight-hour TWAs for carbonyl sulfide were subsequently calculated at a range of 3.4 to 11.1 ppbV. There is no ACGIH TLV or OSHA PEL established for this compound. Moreover, Dr. Steven Hoyt (EAS Lab Director and an expert on air media analytical methodologies) indicated that “low-level carbonyl sulfide detections have been seen many times before” in his laboratory and are generally regarded as “an artifact of the Tedlar bag sampling process, possibly due to out-gassing” (Hoyt 2003). There were no other sulfur gases detected above analytical detection limits during the CALFEX sampling events.

- **Cyanide**—Hydrogen cyanide was not detected above the analytical detection limit during either of the CALFEX sampling events.
- **PM_{2.5}**—This “fine” particulate parameter was detected during CALFEX event #1 at a concentration range of 4.3 to 13.1 $\mu\text{g}/\text{m}^3$ and during CALFEX event #2 at the somewhat higher concentration range of 10.6 to 19.1 $\mu\text{g}/\text{m}^3$. However, there was no consistent relationship between PM_{2.5} levels measured on-range versus those recorded off-range during these firing exercises. For instance, the highest observed PM_{2.5} reading was at Air Location 8 (background location) during CALFEX event #1, while the lowest reading was at Air Location 2 (on-range, near OB/OD area). During CALFEX event #2, alternatively, the highest observed PM_{2.5} reading was at Air Location 7 (on-range, near OBJ Deer), while the lowest reading was at Air Location 4 (off-range, Mākua Beach). For both events, all 8-hour TWAs for PM_{2.5} were significantly below the ACGIH TLV (3,000 $\mu\text{g}/\text{m}^3$) and all normalized 24-hour TWAs for PM_{2.5} were below the corresponding federal ambient air quality standard (65 $\mu\text{g}/\text{m}^3$).
- **PM₁₀**—This “coarse” particulate parameter was detected during CALFEX event #1 at a concentration range of 9.0 to 50.6 $\mu\text{g}/\text{m}^3$ and during CALFEX event #2 at a concentration range of 16.1 to 34.0 $\mu\text{g}/\text{m}^3$. During both firing exercises, the highest recorded PM₁₀ values were measured off-range at Air Location 5 (Silva Ranch), an area adjacent to Farrington Highway. Similar to the observations noted above for PM_{2.5} data, there was no consistent relationship between PM₁₀ levels measured on-range versus those recorded off-range during the two firing exercises. Excluding this Air Location 5 data, the highest observed PM₁₀ reading was at Air Location 7 (on-range, near OBJ Deer) during CALFEX event #1, while the lowest reading was at Air Location 4 (off-range, Mākua Beach). During CALFEX event #2, alternatively, the highest observed PM₁₀ reading was at Air Location 9 (on-range, near administration area), while the lowest reading was at Air Location 1 (on-range, crosswind of OBJ Deer). For both events, all 8-hour TWAs for PM₁₀ were significantly below the ACGIH TLV (10,000 $\mu\text{g}/\text{m}^3$) and all normalized 24-hour TWAs for PM₁₀ were below the corresponding federal ambient air quality standard (150 $\mu\text{g}/\text{m}^3$).
- **Nitrogen-based Emission Gases**—There were no nitrogen-based emission gases detected above analytical detection limits during either of the CALFEX

sampling events (*note: several air sampling locations were not monitored for this parameter due to logistical constraints during the live firing events; see Tables B-2 and B-3 in Appendix B*).

3.3 OPEN BURN AIR SAMPLING EVENT

Results of the monitoring conducted at MMR on October 30, 2002 during the open burn air sampling event are summarized below. Detected pollutants of interest are also discussed relative to applicable human health effects air quality criteria (where established). Complete results of the open burn air sampling event are presented in Table B-4 of Appendix B.

- **VOCs**—Four VOCs (acetone, chloromethane, dichloromethane, and toluene) was detected at both Air Locations A-OB-1 (off-range, South Beach) and A-OB-3 (on-range) during the open burn sampling event; benzene, however, was observed only at Air Location A-OB-1 but not at Air Location A-OB-3. In contrast, there were no VOCs detected above analytical detection limits at Air Location A-OB-2 (off-range, North Beach) during this event. With the exception of dichloromethane, the highest concentrations of detected VOCs were measured at off-range Air Location A-OB-1. Concentrations of detected VOCs at Air Location A-OB-1 ranged from 1.0 $\mu\text{g}/\text{m}^3$ (dichloromethane) to 9.2 $\mu\text{g}/\text{m}^3$ (acetone), with a corresponding 8-hour TWA range of 0.7 $\mu\text{g}/\text{m}^3$ (dichloromethane) to 6.3 $\mu\text{g}/\text{m}^3$ (acetone). For these detected VOCs, 8-hour TWAs at all air locations were below both ACGIH TLVs and respective HAR guidelines during the open burn sampling event.
- **SVOCs**—There were no SVOCs detected above analytical detection limits during the open burn sampling event.
- **Explosives and Energetic Compounds**—There were no explosives/energetic compounds detected above analytical detection limits during the open burn sampling event.
- **Chlorinated Herbicides**—There were no chlorinated herbicides detected above analytical detection limits during the open burn sampling event.
- **Dioxins and Furans**—1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD) was reported by the contract laboratory in the sample collected at Air Location A-OB-1 (South Beach) during the open burn sampling event at a concentration of 0.71 pg; however, this compound was also detected in the associated method blank at a comparable level of 0.65 pg. Consistent with USEPA organic data validation guidelines (USEPA 1999), the HxCDD observed in the open burn air sample is regarded as laboratory-introduced contamination and is therefore considered to be a nondetected value.
- **Particulate Metals**—Similar to results obtained during the CALFEX sampling events, the same seven metals were detected during the open burn sampling event: aluminum, barium, chromium, magnesium, nickel, lead, and zinc (*note: arsenic, beryllium and cadmium were not detected above respective analytical detection limits*). Lead was detected only at Air Locations A-OB-2 (North Beach) and A-OB-3

(on-range), while the other six metals were observed to varying degrees at all three field sampling locations. Data for detected metals other than lead showed no significant quantitative differences among the field locations, either on-range or off-range, and all metals results were all less than five times the amount found in associated QA/QC trip blanks (see Section 3.4.2). As shown in Table B-4 (Appendix B), 8-hour TWAs for all metals detected during the open burn event were below both ACGIH TLVs and HAR guidelines based on respective OSHA PELs.

- **Sulfur Gases**—Monitoring for sulfur gases was not performed during the open burn sampling event; therefore, no data are available.
- **Cyanide**—Hydrogen cyanide was detected at all three sampling locations during the open burn event at a concentration range of 1.8 to 5.4 $\mu\text{g}/\text{m}^3$; the highest level was observed on-range at Air Location A-OB-3 while the lowest level was observed at Air Location A-OB-1 (South Beach). For all stations, however, the 8-hour TWAs for hydrogen cyanide were significantly below both the ACGIH short-term exposure limit (STEL) (5,000 $\mu\text{g}/\text{m}^3$) and the respective HAR guideline (110 $\mu\text{g}/\text{m}^3$) during the open burn sampling event.
- **PM_{2.5}**—This “fine” particulate parameter was detected during the open burn event at concentrations ranging from 26.4 $\mu\text{g}/\text{m}^3$ (Air Location A-OB-2, North Beach) to 212.4 $\mu\text{g}/\text{m}^3$ (Air Location A-OB-1, South Beach), with a corresponding 8-hour TWA range of 18.2 $\mu\text{g}/\text{m}^3$ to 150.0 $\mu\text{g}/\text{m}^3$. The range of normalized 24-hour TWA values was 16.2 $\mu\text{g}/\text{m}^3$ to 60.1 $\mu\text{g}/\text{m}^3$. As noted, the highest PM_{2.5} readings were observed at the southern end of Mākua Beach, with lowest readings measured at the northern end of the beach, most likely due to the prevailing wind direction. The highest PM_{2.5} levels were approximately an order of magnitude greater during the open burn event than during any of the two CALFEX events. As shown in Table B-4 (Appendix B), however, both the 8-hour TWAs and the normalized 24-hour TWAs for PM_{2.5} were below respective air quality criteria at all sampling locations.
- **PM₁₀**—This “coarse” particulate parameter was detected during the open burn event at concentrations ranging from 42.3 $\mu\text{g}/\text{m}^3$ (Air Location A-OB-2, North Beach) to 231.2 $\mu\text{g}/\text{m}^3$ (Air Location A-OB-1, South Beach), with a corresponding 8-hour TWA range of 23.4 $\mu\text{g}/\text{m}^3$ to 128.1 $\mu\text{g}/\text{m}^3$. The range of normalized 24-hour TWA values was 25.1 $\mu\text{g}/\text{m}^3$ to 60.0 $\mu\text{g}/\text{m}^3$. Similar to PM_{2.5} results obtained during the open burn event, the highest PM₁₀ readings were observed at the southern end of Mākua Beach, with lowest readings measured at the northern end of the beach. As shown in Table B-4 (Appendix B), however, both the 8-hour TWAs and the normalized 24-hour TWAs for PM₁₀ were below respective air quality criteria at all sampling locations.
- **Nitrogen-based Emission Gases**—Monitoring for nitrogen-based emission gases was not performed during the open burn sampling event; therefore, no data are available.

3.4 QA/QC SAMPLES

For the air sampling performed during CALFEX events #1 and #2, one field duplicate location was included along with the eight discrete air sampling locations (see Section 2.4.1). This field duplicate location (Air Location 9) was collocated with Air Location 3, a station situated near the downwind boundary of MMR. As such, QA/QC field duplicate air samples were collected and analyzed for the same parameters as the corresponding primary air samples to assist in assessing both field and laboratory precision. In addition, one QA/QC trip blank sample was included with both CALFEX events #1 and #2 for relevant contract laboratory parameters; these trip blank samples (e.g., canisters and filters) were transported to and from MMR along with the field media used for air sampling but remained unopened in the field to prevent contamination. Complete results for the QA/QC samples are presented in Tables B-2 (CALFEX event #1) and B-3 (CALFEX event #2) of Appendix B.

3.4.1 Field Duplicates

Field duplicate results from the two CALFEX sampling events showed acceptable qualitative and quantitative precision for detected target parameters; relative percent differences (RPDs) were within 50% for all analyte/particulate values greater than five times their respective analytical detection limit. Several analytes were observed above their analytical detection limit in only one sample of the field duplicate pair. These low-level detections included two VOCs (dichloromethane and PCE) and one metal (lead) during CALFEX event #1 and two VOCs (acetone and carbon disulfide) and one metal (lead) during CALFEX event #2. Because of the relatively low concentrations measured during the events (i.e., ppb-level), however, such field duplicate variation is not unexpected since analytical precision decreases markedly as reported values approach their limit of detection.

3.4.2 Trip Blanks

The five metals with the highest frequency of detection in field samples collected during CALFEX event #1 (barium, chromium, magnesium, nickel, and zinc) were also observed in the associated QA/QC trip blank sample. In addition, the five above-noted metals, along with lead, were observed in the QA/QC trip blank sample associated with CALFEX event #2 sampling. According to USEPA inorganic data validation guidelines (USEPA 1994), sample results greater than the analytical detection limit but less than five times the amount found in “any blank” should be considered to be nondetected values. With the exception of the magnesium result obtained at Air Location 5 (off-range, Silva Ranch) during CALFEX event #1 sampling, all other metals results were less than five times the amount found in their associated trip blank. Although 8-hour TWAs for all detected metals were below both ACGIH TLVs and HAR guidelines based on respective OSHA PELs, all metals data from both CALFEX sampling events should be viewed with caution based on USEPA data validation guidelines.

SECTION 4

CONCLUSIONS

For both the open burn and CALFEX sampling events, wind direction and speed were monitored using eight wind sock stations and three permanent meteorological stations located throughout the Makua Valley and adjacent residence. There were no chemical parameters or pollutants of interest detected above ACGIH TLVs (ACGIH 2003) or State of Hawai'i Administrative Rules ambient exposure guidelines for hazardous air pollutants (HAR Title 11, Chapter 60.1, Section 179). Moreover, all PM_{2.5} and PM₁₀ results were below both ACGIH respirable/inhalable TWAs and federal 24-hour ambient air quality standards (40 CFR 50.7).

Based on field observations and analytical results of the MMR air sampling investigation, the following additional conclusions were made:

- Sixteen different VOCs were detected during the CALFEX, open burn, and background sampling events. Of these 16 VOCs, acetone, DCM, and toluene were the most frequently detected compounds. During CALFEX event #1, eight gasoline-related VOCs were detected at Silva Ranch, an off-range area located adjacent to Farrington Highway. During CALFEX event #2, however, only one VOC was detected at this sampling location. Moreover, just four VOCs were detected during the open burn sampling event. While there were definite qualitative differences among VOC detections between the different sampling events, all detected compounds were observed at relatively low-level concentrations at or below 21 ppbV. Consequently, all 8-hour TWAs for detected VOCs were significantly below corresponding ACGIH TLVs and, to a lesser extent, also below their respective HAR guidelines.
- Seven of the ten metals were detected during the CALFEX, open burn, and background sampling events. During the CALFEX events, aluminum was detected only at on-range locations, while the other six metals were observed to varying degrees at all nine sampling locations. In general, data for detected metals showed no significant quantitative differences among field locations, either on-range or off-range. During the open burn sampling event, lead was

detected at two of three air locations, while the other six metals (including aluminum) were observed at all three locations. With the exception of a single magnesium result obtained during CALFEX #1, all metals results from all sampling events were less than five-times the amount found in associated QA/QC trip blanks. According to USEPA data validation guidelines, these low concentration results should be considered to be nondetected values. Moreover, 8-hour TWAs for all metals detected during the sampling events were below both ACGIH TLVs and their respective HAR guidelines.

- PM_{2.5} was detected during the background sampling event at a concentration of 12.9 µg/m³, during the CALFEX events at a concentration range of 4.3 to 19.1 µg/m³, and during the open burn event at a range of 26.4 µg/m³ to 212.4 µg/m³. The highest observed PM_{2.5} levels were therefore associated with the open burn event (i.e., approximately an order of magnitude greater during the open burn event than during any of the two CALFEX events), while background concentrations were shown to not vary significantly from those observed either on-range or off-range during the CALFEX events. The highest overall PM_{2.5} reading (212.4 µg/m³) was observed off-range during the open burn at the southern end of Mākua Beach, most likely due to the prevailing wind direction. For each of the sampling events, however, all 8-hour TWAs for PM_{2.5} were below the ACGIH TLV and all normalized 24-hour TWAs for PM_{2.5} were below the corresponding federal ambient air quality standard.
- PM₁₀ was detected during the background sampling event at a concentration of 14.5 µg/m³, during the CALFEX events at a concentration range of 9.0 to 50.6 µg/m³, and during the open burn event at a range of 42.3 µg/m³ to 231.2 µg/m³. Similar to the PM_{2.5} results discussed above, the highest observed PM₁₀ levels were associated with the open burn event, although background concentrations for PM₁₀ were shown to be at the lower end of the range of readings obtained during CALFEX events. The highest overall PM₁₀ reading (231.2 µg/m³) was also observed off-range during the open burn at the southern end of Mākua Beach, most likely due to the prevailing wind direction. For each of the sampling events, however, all 8-hour TWAs and all normalized 24-hour TWAs for PM₁₀ were below respective air quality criteria at all sampling locations.
- Hydrogen cyanide was detected during the open burn sampling event at relatively low concentrations ranging from 1.8 to 5.4 µg/m³, but was not observed during either CALFEX sampling event. During the open burn, the highest level of hydrogen cyanide was observed on-range while the lowest level was observed off-range at the southern end of Mākua Beach. However, all 8-hour TWAs for hydrogen cyanide were significantly below both the ACGIH STEL and the respective HAR guideline.
- Carbonyl sulfide was the only sulfur gas observed during the two CALFEX sampling events; this compound was detected at the relatively low concentration range of 4.6 to 15 ppbV (*note: there is no ACGIH TLV, OSHA PEL, or HAR guideline established for this compound*). However, the contract

laboratory providing the sulfur gas testing indicated that low-level carbonyl sulfide detections using ASTM D-5504 methodology are generally regarded as “an artifact of the Tedlar bag sampling process” and are not considered representative of actual field conditions sampled.

- Several PCDD/PCDF isomers were detected above analytical detection limits during the CALFEX #1, open burn, and background sampling events. However, all of these detections were associated with laboratory method blank contamination. Consistent with USEPA data validation guidelines, all PCDD/PCDF isomers observed in collected air samples were attributed to laboratory-introduced contamination and were therefore considered to be nondetected values.
- 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 events.

SECTION 5

REFERENCES

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APPENDIX A

**PHOTOGRAPH OF REPRESENTATIVE
AIR SAMPLING STATION
(MMR AIR SAMPLING EVENTS 2002-2003)**



APPENDIX B

**DATA SUMMARY TABLES
(MMR AIR SAMPLING EVENTS 2002-2003)**

DATA SUMMARY TABLE B-1
MAKUA AMBIENT AIR SAMPLING
“BACKGROUND SAMPLING EVENT” (8 APRIL 2003)
(Page 1 of 1)

POI Category	Analytical Method (Laboratory; Instrument)	Field Results Background Sampling Event		Health-Based Guidance & State Regulatory 8-Hour TWAs	
		Individual POI Concentrations	Corresponding POI Results Expressed as 8-Hour TWA	ACGIH Health-Based Exposure Guidelines	State of Hawai'i "Hazardous Air Pollutants" Guidelines
VOCs	USEPA TO-15 (AIR TOXICS; GC/MS)	Chloromethane: 1.3 ppbV	Chloromethane: 0.9 ppbV (TWA)	Chloromethane: 50,000 ppbV	Chloromethane: 1,000 ppbV
SVOCs	USEPA TO-13 (AIR TOXICS; GC/MS)	<i>(no detected SVOCs)</i>	<i>(no detected SVOCs)</i>	<i>(no detected SVOCs)</i>	<i>(no detected SVOCs)</i>
Energetic Compounds	USEPA 8330mod (SWL Lab; HPLC)	<i>(no detected energetics)</i>	<i>(no detected energetics)</i>	<i>(no detected energetics)</i>	<i>(no detected energetics)</i>
Chlorinated Herbicides	USEPA 8151Amod (APPL; GC/ECD)	<i>(no detected herbicides)</i>	<i>(no detected herbicides)</i>	<i>(no detected herbicides)</i>	<i>(no detected herbicides)</i>
PCDDs/PCDFs	USEPA TO-9A (ALTA; HR-GC/MS)	OCDD: 27.2 pg/m ³ <i>(NOTE: compound also detected in associated laboratory Method Blank at a higher level)</i>	<i>(NOTE: OCDD was detected in the associated Method Blank at a higher level than the background field sample and is considered to be a laboratory contaminant; therefore, TWA calculations are not applicable.)</i>	<i>(no detected PCDDs/PCDFs)</i>	<i>(no detected PCDDs/PCDFs)</i>
Particulate Metals	NIOSH 7300 (CHESTER; ICP)	Barium: 0.03 µg/m ³ Chromium: 0.71 µg/m ³ Magnesium: 0.54 µg/m ³ Nickel: 0.11 µg/m ³ Lead: 0.27 µg/m ³ Zinc: 0.12 µg/m ³	Barium: 0.02 µg/m ³ (TWA) Chromium: 0.46 µg/m ³ (TWA) Magnesium: 0.35 µg/m ³ (TWA) Nickel: 0.07 µg/m ³ (TWA) Lead: 0.18 µg/m ³ (TWA) Zinc: 0.08 µg/m ³ (TWA)	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³
Cyanides	NIOSH 7904 (EAS; ISE)	<i>(no detected hydrogen cyanide)</i>	<i>(no detected hydrogen cyanide)</i>	<i>(no detected hydrogen cyanide)</i>	<i>(no detected hydrogen cyanide)</i>
Sulfur Gases	ASTM D-5504 (AIR TOXICS; GC/SCD)	<i>(no detected sulfur gases)</i>	<i>(no detected sulfur gases)</i>	<i>(no detected sulfur gases)</i>	<i>(no detected sulfur gases)</i>
Particulate Matter – 2.5 microns	USEPA IP-10A (CHESTER; gravimetric)	PM-2.5: 12.9 µg/m ³	PM-2.5: 8.3 µg/m ³ (TWA) PM-2.5: 12.9 µg/m ³ (24-hr)	PM-2.5: 3,000 µg/m ³ (TWA - respirable) PM-2.5: 65 µg/m ³ (24-hr Federal Air Quality Standard)	<i>(not established)</i>
Particulate Matter – 10.0 microns	USEPA IP-10A (CHESTER; gravimetric)	PM-10: 14.5 µg/m ³	PM-10: 9.3 µg/m ³ (TWA) PM-10: 14.5 µg/m ³ (24-hr)	PM-10: 10,000 µg/m ³ (TWA - inhalable) PM-10: 150 µg/m ³ (24-hr Federal Air Quality Standard.)	<i>(not established)</i>

Notes:

- Background sampling location: Kahanahaiki Valley, northern side of MMR.
- Background sampling conditions: non-CALFEX date (i.e., no troop or helicopter activities at MMR during sample collection).
- TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
- 24-hour PM-2.5 and PM-10 background values equivalent to the recorded particulate concentrations for the respective background monitoring duration.
- ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
- State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
- Acronyms and abbreviations used in this table:

µg/m³: micrograms of substance per cubic meter of air
ACGIH: American Conference of Governmental Industrial Hygienists
AIR TOXICS: Air Toxics, Ltd. (Folsom, CA)
ALTA: Alta Analytical Laboratory, Inc. (El Dorado Hills, CA)
APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)
GC/ECD: gas chromatography/electron capture detection
GC/MS: gas chromatography/mass spectrometry
GC/SCD: gas chromatography/sulfur chemiluminescence detection

HAR: Hawai'i Administrative Rules
HPLC: high performance liquid chromatography
hr: hour
HR: high resolution (GC/MS)
ICP: inductively coupled plasma (atomic emission spectroscopy)
ISE: ion specific electrode
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OCDD: octachlorodibenzodioxin
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin

PCDF: polychlorinated dibenzofuran
pg/m³: picograms of substance per cubic meter of air
PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
POI: pollutant of interest
ppbV: parts per billion by volume
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TLV: threshold limit value (ACGIH)
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

DATA SUMMARY TABLE B-2
MAKUA AMBIENT AIR SAMPLING
“CALFEX #1 SAMPLING EVENT” (31 JANUARY 2003)
(Page 1 of 3)

AIR SAMPLING STATION (LOCATION)	VOCs (USEPA TO-13; AIR TOXICS)				SVOCs (USEPA TO-13; AIR TOXICS)	ENERGETICS (USEPA 8330mod; SWL Lab)	CHLOR. HERBICIDES (USEPA 8151Amod; APPL)	PCDDs/PCDFs (USEPA TO-9A; ALTA)
	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD RESULT	FIELD RESULT	FIELD RESULT
STATION 1 (On-site; just west of OBJ Deer, downwind air station)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	1,4-Dioxane: 3.7 ppbV	1,4-Dioxane: 3.0 ppbV	1,4-Dioxane: 20,000 ppbV	1,4-Dioxane: 1,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	Acetone: 3.5 ppbV	Acetone: 3.3 ppbV	Acetone: 500,000 ppbV	Acetone: 10,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	DCM: 1.5 ppbV Benzene: 5.2 ppbV Toluene: 9.6 ppbV Ethylbenzene: 1.4 ppbV m,p-Xylenes: 3.2 ppbV o-Xylene: 1.4 ppbV 1,2,4-TMB: 1.0 ppbV Ethanol: 5.7 ppbV	DCM: 1.1 ppbV Benzene: 3.9 ppbV Toluene: 7.1 ppbV Ethylbenzene: 1.0 ppbV m,p-Xylenes: 2.4 ppbV o-Xylene: 1.0 ppbV 1,2,4-TMB: 0.7 ppbV Ethanol: 4.2 ppbV	DCM: 50,000 ppbV Benzene: 500 ppbV Toluene: 50,000 ppbV Ethylbenzene: 100,000 ppbV m,p-Xylenes: 100,000 ppbV o-Xylene: 100,000 ppbV 1,2,4-TMB: 25,000 ppbV Ethanol: 1,000,000 ppbV	DCM: 250 ppbV Benzene: 10 ppbV Toluene: 2,000 ppbV Ethylbenzene: 1,000 ppbV m,p-Xylenes: 1,000 ppbV o-Xylene: 1,000 ppbV 1,2,4-TMB: (not established) Ethanol: 10,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	DCM: 1.2 ppbV Acetone: 4.8 ppbV	DCM: 1.0 ppbV Acetone: 4.0 ppbV	DCM: 50,000 ppbV Acetone: 500,000 ppbV	DCM: 250 ppbV Acetone: 1,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 7 (On-site; just south of OBJ Deer, crosswind air station)	Acetone: 5.1 ppbV	Acetone: 4.2 ppbV	Acetone: 500,000 ppbV	Acetone: 1,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 8 (Background air station in Kahana-haiki Valley; northern side of MMR)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	DCM: 2.2 ppbV PCE: 2.4 ppbV	DCM: 1.5 ppbV PCE: 1.6 ppbV	DCM: 50,000 ppbV PCE: 25,000 ppbV	DCM: 250 ppbV PCE: 1,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)
STATION 10 (Trip blank; QA/QC sample)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)

Notes:

1. TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
2. 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 2.2 µg/m³ for PM-2.5 and 4.5 µg/m³ for PM-10).
3. ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
4. State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
5. Acronyms and abbreviations used in this table:

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ALTA: Alta Analytical Laboratory, Inc. (El Dorado Hills, CA)
APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)

EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)
HAR: Hawai'i Administrative Rules
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin
PCDF: polychlorinated dibenzofuran
PCE: tetrachloroethene

PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
ppbV: parts per billion by volume
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TMB: trimethylbenzene
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

DATA SUMMARY TABLE B-2
MAKUA AMBIENT AIR SAMPLING
“CALFEX #1 SAMPLING EVENT” (31 JANUARY 2003)
(Page 2 of 3)

AIR SAMPLING STATION (LOCATION)	PARTICULATE METALS (NIOSH 7300; CHESTER)				CYANIDES (NIOSH 7904; EAS LAB)	SULFUR GASES (ASTM D-5504; AIR TOXICS)			
	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA
STATION 1 (On-site; just west of OBJ Deer, downwind air station)	Aluminum: 0.65 µg/m ³ Barium: 0.02 µg/m ³ Chromium: 0.69 µg/m ³ Magnesium: 0.50 µg/m ³ Nickel: 0.13 µg/m ³ Zinc: 0.16 µg/m ³	Aluminum: 0.54 µg/m ³ Barium: 0.02 µg/m ³ Chromium: 0.56 µg/m ³ Magnesium: 0.41 µg/m ³ Nickel: 0.10 µg/m ³ Zinc: 0.13 µg/m ³	Aluminum: 10,000 µg/m ³ Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Aluminum: 150 µg/m ³ Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 10 ppbV	Carbonyl sulfide: 8.2 ppbV	(not established)	(not established)
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	Barium: 0.02 µg/m ³ Chromium: 0.62 µg/m ³ Magnesium: 0.36 µg/m ³ Nickel: 0.13 µg/m ³ Zinc: 0.10 µg/m ³	Barium: 0.01 µg/m ³ Chromium: 0.52 µg/m ³ Magnesium: 0.31 µg/m ³ Nickel: 0.11 µg/m ³ Zinc: 0.09 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 11 ppbV	Carbonyl sulfide: 9.5 ppbV	(not established)	(not established)
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	Barium: 0.02 µg/m ³ Chromium: 0.80 µg/m ³ Magnesium: 0.49 µg/m ³ Nickel: 0.10 µg/m ³ Lead: 0.28 µg/m ³ Zinc: 0.15 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.53 µg/m ³ Magnesium: 0.32 µg/m ³ Nickel: 0.07 µg/m ³ Lead: 0.18 µg/m ³ Zinc: 0.10 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 11 ppbV	Carbonyl sulfide: 7.2 ppbV	(not established)	(not established)
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	Barium: 0.02 µg/m ³ Chromium: 0.55 µg/m ³ Magnesium: 0.44 µg/m ³ Nickel: 0.09 µg/m ³ Lead: 0.19 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.51 µg/m ³ Magnesium: 0.41 µg/m ³ Nickel: 0.08 µg/m ³ Lead: 0.18 µg/m ³ Zinc: 0.10 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	Barium: 0.02 µg/m ³ Chromium: 0.33 µg/m ³ Magnesium: 2.26 µg/m ³ Nickel: 0.13 µg/m ³ Zinc: 0.12 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.24 µg/m ³ Magnesium: 1.65 µg/m ³ Nickel: 0.10 µg/m ³ Zinc: 0.09 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 15 ppbV	Carbonyl sulfide: 11.1 ppbV	(not established)	(not established)
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	Barium: 0.02 µg/m ³ Chromium: 0.73 µg/m ³ Magnesium: 0.43 µg/m ³ Nickel: 0.14 µg/m ³ Zinc: 0.21 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.61 µg/m ³ Magnesium: 0.36 µg/m ³ Nickel: 0.11 µg/m ³ Zinc: 0.18 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 10 ppbV	Carbonyl sulfide: 8.4 ppbV	(not established)	(not established)
STATION 7 (On-site; just south of OBJ Deer, crosswind air station)	Barium: 0.02 µg/m ³ Chromium: 0.73 µg/m ³ Magnesium: 0.41 µg/m ³ Nickel: 0.16 µg/m ³ Lead: 0.23 µg/m ³ Zinc: 0.17 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.61 µg/m ³ Magnesium: 0.34 µg/m ³ Nickel: 0.13 µg/m ³ Lead: 0.19 µg/m ³ Zinc: 0.14 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 9.6 ppbV	Carbonyl sulfide: 8.0 ppbV	(not established)	(not established)
STATION 8 (Background air station in Kahana-haiki Valley; northern side of MMR)	Barium: 0.02 µg/m ³ Chromium: 0.43 µg/m ³ Magnesium: 0.52 µg/m ³ Nickel: 0.13 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.34 µg/m ³ Magnesium: 0.41 µg/m ³ Nickel: 0.10 µg/m ³ Zinc: 0.08 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 14 ppbV	Carbonyl sulfide: 9.4 ppbV	(not established)	(not established)
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	Barium: 0.02 µg/m ³ Chromium: 0.46 µg/m ³ Magnesium: 0.52 µg/m ³ Nickel: 0.17 µg/m ³ Zinc: 0.16 µg/m ³	Barium: 0.01 µg/m ³ Chromium: 0.30 µg/m ³ Magnesium: 0.35 µg/m ³ Nickel: 0.11 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 10 (Trip blank; QA/QC sample)	Barium: 0.03 µg/filter Chromium: 0.81 µg/filter Magnesium: 0.29 µg/filter Nickel: 0.15 µg/filter Zinc: 0.13 µg/filter	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Zinc: (not applicable)	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Zinc: (not applicable)	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Zinc: (not applicable)	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)

Notes:

1. TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
2. 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 2.2 µg/m³ for PM-2.5 and 4.5 µg/m³ for PM-10).
3. ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
4. State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
5. Acronyms and abbreviations used in this table:

µg/m³: micrograms of substance per cubic meter of air

ACGIH: American Conference of Governmental Industrial Hygienists

AIR TOXICS: Air Toxics, Ltd. (Folsom, CA)

ALTA: Alta Analytical Laboratory, Inc. (El Dorado Hills, CA)

APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)

ASTM: American Society for Testing and Materials

CHESTER: Chester LabNet, Inc. (Tigard, OR)

DCM: dichloromethane (methylene chloride)

EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)

HAR: Hawai'i Administrative Rules

MMR: Makua Military Reservation

NIOSH: National Institute for Occupational Safety and Health

OSHA: Occupational Health & Safety Administration

PCDD: polychlorinated dibenzodioxin

PCDF: polychlorinated dibenzofuran

PCE: tetrachloroethene

PM-2.5: particulate matter – 2.5 microns

PM-10: particulate matter – 10 microns

ppbV: parts per billion by volume

SVOC: semivolatle organic compound

SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)

TMB: trimethylbenzene

TWA: time-weighted average (8-hour)

VOC: volatile organic compound

DATA SUMMARY TABLE B-2
MAKUA AMBIENT AIR SAMPLING
“CALFEX #1 SAMPLING EVENT” (31 JANUARY 2003)
(Page 3 of 3)

AIR SAMPLING STATION (LOCATION)	NITROGEN GASES (IN-FIELD; DRAEGER TUBES)	PARTICULATES: PM – 2.5 (USEPA IP-10A; CHESTER)				PARTICULATES: PM – 10 (USEPA IP-10A; CHESTER)			
	FIELD RESULT	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA
STATION 1 (On-site; just west of OBJ Deer, downwind air station)	<i>(station not sampled)</i>	8.9 µg/m ³	7.3 µg/m ³ (8-hr TWA) 4.0 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	12.1 µg/m ³	9.9 µg/m ³ (8-hr TWA) 6.6 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	<i>(station not sampled)</i>	4.3 µg/m ³	3.7 µg/m ³ (8-hr TWA) 2.8 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	12.9 µg/m ³	19.9 µg/m ³ (8-hr TWA) 6.9 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	<i>(no detected nitrogen oxides)</i>	4.8 µg/m ³	3.1 µg/m ³ (8-hr TWA) 2.7 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	14.3 µg/m ³	9.4 µg/m ³ (8-hr TWA) 6.6 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	<i>(no detected nitrogen oxides)</i>	8.5 µg/m ³	7.8 µg/m ³ (8-hr TWA) 4.1 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	9.0 µg/m ³	8.3 µg/m ³ (8-hr TWA) 5.9 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	<i>(no detected nitrogen oxides)</i>	7.1 µg/m ³	5.2 µg/m ³ (8-hr TWA) 3.4 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	50.6 µg/m ³	37.0 µg/m ³ (8-hr TWA) 15.7 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	<i>(no detected nitrogen oxides)</i>	6.3 µg/m ³	5.2 µg/m ³ (8-hr TWA) 3.3 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	14.5 µg/m ³	12.0 µg/m ³ (8-hr TWA) 7.3 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 7 (On-site; just south of OBJ Deer, crosswind air station)	<i>(station not sampled)</i>	11.5 µg/m ³	9.4 µg/m ³ (8-hr TWA) 4.7 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	28.6 µg/m ³	23.5 µg/m ³ (8-hr TWA) 11.1 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 8 (Background air station in Kahana-haiki Valley; northern side of MMR)	<i>(no detected nitrogen oxides)</i>	13.1 µg/m ³	10.4 µg/m ³ (8-hr TWA) 5.1 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	10.5 µg/m ³	8.3 µg/m ³ (8-hr TWA) 6.1 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	<i>(no detected nitrogen oxides)</i>	6.3 µg/m ³	4.2 µg/m ³ (8-hr TWA) 3.1 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	11.7 µg/m ³	7.8 µg/m ³ (8-hr TWA) 6.1 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 10 (Trip blank; QA/QC sample)	<i>(not applicable)</i>	5 µg/filter	<i>(not applicable)</i>	<i>(not applicable)</i>	<i>(not established)</i>	4 µg/filter	<i>(not applicable)</i>	<i>(not applicable)</i>	<i>(not established)</i>

Notes:

1. TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
2. 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 2.2 µg/m³ for PM-2.5 and 4.5 µg/m³ for PM-10).
3. ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
4. State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
5. Acronyms and abbreviations used in this table:

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APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)

EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)
HAR: Hawai'i Administrative Rules
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin
PCDF: polychlorinated dibenzofuran
PCE: tetrachloroethene

PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
ppbV: parts per billion by volume
SVOC: semivolatle organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TMB: trimethylbenzene
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

**DATA SUMMARY TABLE B-3
MAKUA AMBIENT AIR SAMPLING
“CALFEX #2 SAMPLING EVENT” (10 APRIL 2003)
(Page 1 of 3)**

AIR SAMPLING STATION (LOCATION)	VOCs (USEPA TO-13; (AIR TOXICS))				SVOCs (USEPA TO-13; AIR TOXICS)	ENERGETICS (USEPA 8330mod; SWL Lab)	CHLOR. HERBICIDES (USEPA 8151Amod; APPL)	PCDDs/PCDFs (USEPA TO-9A; ALTA)	
	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD RESULT	FIELD RESULT	FIELD RESULT	FIELD TWA
STATION 1 (On-site; just northwest of OBJ Deer, crosswind air station)	Toluene: 1.6 ppbV	Toluene: 1.1 ppbV	Toluene: 50,000 ppbV	Toluene: 2,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 30.9 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	TCE: 1.2 ppbV Toluene: 1.2 ppbV	TCE: 0.9 ppbV Toluene: 0.9 ppbV	TCE: 50,000 ppbV Toluene: 50,000 ppbV	TCE: 1,000 ppbV Toluene: 2,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 21.8 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	Toluene: 1.2 ppbV	Toluene: 0.9 ppbV	Toluene: 50,000 ppbV	Toluene: 2,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 25.9 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	Freon-12: 0.9 ppbV Toluene: 1.5 ppbV Acetone: 8.0 ppbV 2-Propanol: 2.8 ppbV Ethanol: 3.4 ppbV	Freon-12: 0.8 ppbV Toluene: 1.3 ppbV Acetone: 7.1 ppbV 2-Propanol: 2.5 ppbV Ethanol: 3.0 ppbV	Freon-12: 1,000,000 ppbV Toluene: 50,000 ppbV Acetone: 500,000 ppbV 2-Propanol: 200,000 ppbV Ethanol: 1,000,000 ppbV	Freon-12: 10,000 ppbV Toluene: 2,000 ppbV Acetone: 10,000 ppbV 2-Propanol: 4,000 ppbV Ethanol: 10,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 18.9 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	Ethanol: 8.9 ppbV	Ethanol: 7.0 ppbV	Ethanol: 1,000,000 ppbV	Ethanol: 10,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 20.6 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	DCM: 1.1 ppbV Toluene: 1.7 ppbV Acetone: 5.5 ppbV Ethanol: 4.7 ppbV	DCM: 0.7 ppbV Toluene: 1.1 ppbV Acetone: 3.6 ppbV Ethanol: 3.1 ppbV	DCM: 50,000 ppbV Toluene: 50,000 ppbV Acetone: 500,000 ppbV Ethanol: 1,000,000 ppbV	DCM: 250 ppbV Toluene: 2,000 ppbV Acetone: 1,000 ppbV Ethanol: 10,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 65.9 pg/m ³ OCDF: 6.9 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 7 (On-site; just northeast of OBJ Deer, crosswind air station)	Acetone: 21 ppbV	Acetone: 15 ppbV	Acetone: 500,000 ppbV	Acetone: 1,000 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	(no detected PCDDs/PCDFs)	(no detected PCDDs/PCDFs)
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	Toluene: 1.3 ppbV Acetone: 6.4 ppbV Carbon disulfide: 7.6 ppbV	Toluene: 1.0 ppbV Acetone: 4.7 ppbV Carbon disulfide: 5.5 ppbV	Toluene: 50,000 ppbV Acetone: 500,000 ppbV Carbon disulfide: 10,000 ppbV	Toluene: 2,000 ppbV Acetone: 1,000 ppbV Carbon disulfide: 200 ppbV	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 16.9 pg/m ³ (NOTE: OCDD also detected in associated laboratory Method Blank and field Trip Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)
STATION 10 (Trip blank; QA/QC sample)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected VOCs)	(no detected SVOCs)	(no detected energetics)	(no detected herbicides)	OCDD: 17.8 pg/sample (NOTE: OCDD also detected in associated laboratory Method Blank at a comparable level.)	(NOTE: both OCDD/OCDF are considered to be laboratory contaminants; therefore, TWA calculations are not applicable.)

Notes:

- TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
- 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 5.3 µg/m³ for PM-2.5 and 8.1 µg/m³ for PM-10).
- ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
- State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
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APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)
EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)

HAR: Hawai'i Administrative Rules
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OCDD: octachlorodibenzodioxin
OCDF: octachlorodibenzofuran
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin
PCDF: polychlorinated dibenzofuran
pg/m³: picograms of substance per cubic meter of air

PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
ppbV: parts per billion by volume
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TCE: trichloroethene
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

DATA SUMMARY TABLE B-3
MAKUA AMBIENT AIR SAMPLING
“CALFEX #2 SAMPLING EVENT” (10 APRIL 2003)
(Page 2 of 3)

AIR SAMPLING STATION (LOCATION)	PARTICULATE METALS (NIOSH 7300; CHESTER)				CYANIDES (NIOSH 7904; EAS LAB)	SULFUR GASES (ASTM D-5504; AIR TOXICS)			
	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA
STATION 1 (On-site; just northwest of OBJ Deer, crosswind air station)	Aluminum: 0.63 µg/m ³ Barium: 0.03 µg/m ³ Chromium: 0.61 µg/m ³ Magnesium: 0.49 µg/m ³ Nickel: 0.12 µg/m ³ Lead: 0.30 µg/m ³ Zinc: 0.12 µg/m ³	Aluminum: 0.45 µg/m ³ Barium: 0.02 µg/m ³ Chromium: 0.43 µg/m ³ Magnesium: 0.35 µg/m ³ Nickel: 0.08 µg/m ³ Lead: 0.21 µg/m ³ Zinc: 0.08 µg/m ³	Aluminum: 10,000 µg/m ³ Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Aluminum: 150 µg/m ³ Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	Barium: 0.03 µg/m ³ Chromium: 0.78 µg/m ³ Magnesium: 0.44 µg/m ³ Nickel: 0.08 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.58 µg/m ³ Magnesium: 0.32 µg/m ³ Nickel: 0.06 µg/m ³ Zinc: 0.08 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 4.6 ppbV	Carbonyl sulfide: 3.4 ppbV	(not established)	(not established)
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	Barium: 0.03 µg/m ³ Chromium: 0.19 µg/m ³ Magnesium: 0.46 µg/m ³ Nickel: 0.08 µg/m ³ Zinc: 0.09 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.14 µg/m ³ Magnesium: 0.33 µg/m ³ Nickel: 0.06 µg/m ³ Zinc: 0.07 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 5.1 ppbV	Carbonyl sulfide: 3.7 ppbV	(not established)	(not established)
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	Barium: 0.02 µg/m ³ Chromium: 0.36 µg/m ³ Magnesium: 0.74 µg/m ³ Nickel: 0.07 µg/m ³ Zinc: 0.12 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.32 µg/m ³ Magnesium: 0.66 µg/m ³ Nickel: 0.06 µg/m ³ Zinc: 0.10 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 4.9 ppbV	Carbonyl sulfide: 4.3 ppbV	(not established)	(not established)
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	Barium: 0.02 µg/m ³ Chromium: 0.46 µg/m ³ Magnesium: 1.08 µg/m ³ Nickel: 0.10 µg/m ³ Lead: 0.23 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.36 µg/m ³ Magnesium: 0.85 µg/m ³ Nickel: 0.08 µg/m ³ Lead: 0.18 µg/m ³ Zinc: 0.09 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	Barium: 0.03 µg/m ³ Chromium: 0.77 µg/m ³ Magnesium: 0.52 µg/m ³ Nickel: 0.11 µg/m ³ Lead: 0.29 µg/m ³ Zinc: 0.14 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.51 µg/m ³ Magnesium: 0.34 µg/m ³ Nickel: 0.07 µg/m ³ Lead: 0.19 µg/m ³ Zinc: 0.09 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 7 (On-site; just northeast of OBJ Deer, crosswind air station)	Barium: 0.03 µg/m ³ Chromium: 0.59 µg/m ³ Magnesium: 0.46 µg/m ³ Nickel: 0.11 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.42 µg/m ³ Magnesium: 0.33 µg/m ³ Nickel: 0.08 µg/m ³ Zinc: 0.07 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	Barium: 0.03 µg/m ³ Chromium: 0.80 µg/m ³ Magnesium: 0.52 µg/m ³ Nickel: 0.08 µg/m ³ Lead: 0.24 µg/m ³ Zinc: 0.11 µg/m ³	Barium: 0.02 µg/m ³ Chromium: 0.58 µg/m ³ Magnesium: 0.38 µg/m ³ Nickel: 0.06 µg/m ³ Lead: 0.17 µg/m ³ Zinc: 0.08 µg/m ³	Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³	(no detected hydrogen cyanide)	Carbonyl sulfide: 4.6 ppbV	Carbonyl sulfide: 3.3 ppbV	(not established)	(not established)
STATION 10 (Trip blank; QA/QC sample)	Barium: 0.02 µg/filter Chromium: 0.81 µg/filter Magnesium: 0.31 µg/filter Nickel: 0.10 µg/filter Lead: 0.27 µg/filter Zinc: 0.13 µg/filter	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Lead: (not applicable) Zinc: (not applicable)	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Lead: (not applicable) Zinc: (not applicable)	Barium: (not applicable) Chromium: (not applicable) Magnesium: (not applicable) Nickel: (not applicable) Lead: (not applicable) Zinc: (not applicable)	(no detected hydrogen cyanide)	(station not sampled)	(station not sampled)	(station not sampled)	(station not sampled)

Notes:

1. TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
2. 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 5.3 µg/m³ for PM-2.5 and 8.1 µg/m³ for PM-10).
3. ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
4. State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
5. Acronyms and abbreviations used in this table:

µg/m³: micrograms of substance per cubic meter of air
ACGIH: American Conference of Governmental Industrial Hygienists
AIR TOXICS: Air Toxics, Ltd. (Folsom, CA)
ALTA: Alta Analytical Laboratory, Inc. (El Dorado Hills, CA)
APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)
EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)

HAR: Hawai'i Administrative Rules
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OCDD: octachlorodibenzodioxin
OCDF: octachlorodibenzofuran
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin
PCDF: polychlorinated dibenzofuran
pg/m³: picograms of substance per cubic meter of air

PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
ppbV: parts per billion by volume
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TCE: trichloroethene
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

DATA SUMMARY TABLE B-3
MAKUA AMBIENT AIR SAMPLING
“CALFEX #2 SAMPLING EVENT” (10 APRIL 2003)
(Page 3 of 3)

AIR SAMPLING STATION (LOCATION)	NITROGEN GASES (IN-FIELD; DRAEGER TUBES)	PARTICULATES: PM – 2.5 (USEPA IP-10A; CHESTER)				PARTICULATES: PM – 10 (USEPA IP-10A; CHESTER)			
	FIELD RESULT	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA	FIELD RESULT	FIELD TWA	ACGIH TWA	HAWAII TWA
STATION 1 (On-site; just northwest of OBJ Deer, crosswind air station)	<i>(station not sampled)</i>	12.5 µg/m ³	8.9 µg/m ³ (8-hr TWA) 7.0 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	16.1 µg/m ³	11.5 µg/m ³ (8-hr TWA) 10.0 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 2 (On-site; in OB/OD area, eastern-most air station, upwind)	<i>(no detected nitrogen oxides)</i>	12.0 µg/m ³	8.9 µg/m ³ (8-hr TWA) 6.9 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	17.7 µg/m ³	13.0 µg/m ³ (8-hr TWA) 10.4 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 3 (On-site; near administration/helipad area and MMR's west-end, downwind)	<i>(no detected nitrogen oxides)</i>	12.1 µg/m ³	8.9 µg/m ³ (8-hr TWA) 7.0 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	25.0 µg/m ³	18.2 µg/m ³ (8-hr TWA) 12.2 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 4 (Off-site; at Makua Beach, recreational area, western-most air station)	<i>(no detected nitrogen oxides)</i>	10.6 µg/m ³	9.4 µg/m ³ (8-hr TWA) 6.9 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	18.3 µg/m ³	16.2 µg/m ³ (8-hr TWA) 11.1 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 5 (Off-site; at Silva Ranch, residential area, southern-most air station)	<i>(station not sampled)</i>	11.3 µg/m ³	8.9 µg/m ³ (8-hr TWA) 6.9 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	34.0 µg/m ³	26.6 µg/m ³ (8-hr TWA) 14.8 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 6 (On-site; just north of OBJ Deer, crosswind air station)	<i>(station not sampled)</i>	17.4 µg/m ³	11.5 µg/m ³ (8-hr TWA) 8.0 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	18.2 µg/m ³	12.0 µg/m ³ (8-hr TWA) 10.3 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 7 (On-site; just northeast of OBJ Deer, crosswind air station)	<i>(no detected nitrogen oxides)</i>	19.1 µg/m ³	13.5 µg/m ³ (8-hr TWA) 8.6 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	16.9 µg/m ³	12.0 µg/m ³ (8-hr TWA) 10.2 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 9 <FIELD DUPLICATE OF STATION 3> (On-site; near administration area at MMR's west-end, downwind)	<i>(no detected nitrogen oxides)</i>	15.8 µg/m ³	11.5 µg/m ³ (8-hr TWA) 7.8 µg/m ³ (24-hr extrapolation)	3,000 µg/m ³ (8-hr TWA; respirable) 65 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>	26.5 µg/m ³	19.3 µg/m ³ (8-hr TWA) 12.5 µg/m ³ (24-hr extrapolation)	10,000 µg/m ³ (8-hr TWA; inhalable) 150 µg/m ³ (24-hr Fed. Air Quality Std.)	<i>(not established)</i>
STATION 10 (Trip blank; QA/QC sample)	<i>(not applicable)</i>	18 µg/filter	<i>(not applicable)</i>	<i>(not applicable)</i>	<i>(not established)</i>	15 µg/filter	<i>(not applicable)</i>	<i>(not applicable)</i>	<i>(not established)</i>

Notes:

1. TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
2. 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 5.3 µg/m³ for PM-2.5 and 8.1 µg/m³ for PM-10).
3. ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
4. State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
5. Acronyms and abbreviations used in this table:

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APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
ASTM: American Society for Testing and Materials
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)
EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)

HAR: Hawai'i Administrative Rules
MMR: Makua Military Reservation
NIOSH: National Institute for Occupational Safety and Health
OCDD: octachlorodibenzodioxin
OCDF: octachlorodibenzofuran
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin
PCDF: polychlorinated dibenzofuran
pg/m³: picograms of substance per cubic meter of air

PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
ppbV: parts per billion by volume
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TCE: trichloroethene
TWA: time-weighted average (8-hour)
VOC: volatile organic compound

DATA SUMMARY TABLE B-4
MAKUA AMBIENT AIR SAMPLING
“OPEN BURN SAMPLING EVENT” (30 OCTOBER 2002)
(Page 1 of 1)

POI Category	Analytical Method (Laboratory; Instrument)	Individual POI Concentrations			Corresponding POI Results Expressed as 8-Hour TWA			Health-Based Guidance & State Regulatory 8-Hour TWAs	
		Station 1 South Beach	Station 2 North Beach	Station 3 On-Range	Station 1 South Beach	Station 2 North Beach	Station 3 On-Range	ACGIH Health-Based Exposure Guidelines	State of Hawai'i "Hazardous Air Pollutants" Guidelines
VOCs	USEPA TO-15 (AIR TOXICS; GC/MS)	Chloromethane: 1.9 ppbV DCM: 1.0 ppbV Benzene: 2.4 ppbV Toluene: 2.0 ppbV Acetone: 9.2 ppbV	(no detected VOCs)	Chloromethane: 1.7 ppbV DCM: 3.5 ppbV Benzene: ND Toluene: 1.3 ppbV Acetone: 5.6 ppbV	Chloromethane: 1.3 ppbV (TWA) DCM: 0.7 ppbV (TWA) Benzene: 1.6 ppbV (TWA) Toluene: 1.4 ppbV (TWA) Acetone: 6.3 ppbV (TWA)	(no detected VOCs)	Chloromethane: 1.0 ppbV (TWA) DCM: 2.0 ppbV (TWA) Benzene: ND (TWA) Toluene: 0.8 ppbV (TWA) Acetone: 3.2 ppbV (TWA)	Chloromethane: 50,000 ppbV DCM: 50,000 ppbV Benzene: 500 ppbV Toluene: 50,000 ppbV Acetone: 500,000 ppbV	Chloromethane: 1,000 ppbV DCM: 250 ppbV Benzene: 10 ppbV Toluene: 2,000 ppbV Acetone: 10,000 ppbV
SVOCs	USEPA TO-13 (AIR TOXICS; GC/MS)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)	(no detected SVOCs)
Energetic Compounds	USEPA 8330mod (SWL Lab; HPLC)	(no detected energetics)	(no detected energetics)	(no detected energetics)	(no detected energetics)	(no detected energetics)	(no detected energetics)	(no detected energetics)	(no detected energetics)
Chlorinated Herbicides	USEPA 8151Amod (APPL; GC/ECD)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)	(no detected herbicides)
PCDDs/PCDFs	USEPA TO-9A (ALTA; HR-GC/MS)	1,2,3,4,7,8-HxCDF: 0.66 pg/m ³ (NOTE: isomer also detected in associated laboratory Method Blank at a higher level)	(no detected PCDDs/PCDFs)	(no detected PCDDs/PCDFs)	(NOTE: 1,2,3,4,7,8-HxCDF was detected in the associated Method Blank at a higher level than the South Beach field sample; therefore, no TWA calculation is applicable)	(no detected PCDDs/PCDFs)	(no detected PCDDs/PCDFs)	(no detected PCDDs/PCDFs)	(no detected PCDDs/PCDFs)
Particulate Metals	NIOSH 7300 (CHESTER; ICP)	Aluminum: 0.76 µg/m ³ Barium: 0.04 µg/m ³ Chromium: 0.59 µg/m ³ Magnesium: 1.32 µg/m ³ Nickel: 0.08 µg/m ³ Lead: ND Zinc: 0.24 µg/m ³	Aluminum: 0.51 µg/m ³ Barium: 0.03 µg/m ³ Chromium: 0.62 µg/m ³ Magnesium: 0.63 µg/m ³ Nickel: 0.15 µg/m ³ Lead: 0.29 µg/m ³ Zinc: 0.22 µg/m ³	Aluminum: 0.61 µg/m ³ Barium: 0.35 µg/m ³ Chromium: 0.51 µg/m ³ Magnesium: 0.42 µg/m ³ Nickel: 0.08 µg/m ³ Lead: 0.19 µg/m ³ Zinc: 0.20 µg/m ³	Aluminum: 0.44 µg/m ³ (TWA) Barium: 0.02 µg/m ³ (TWA) Chromium: 0.34 µg/m ³ (TWA) Magnesium: 0.76 µg/m ³ (TWA) Nickel: 0.05 µg/m ³ (TWA) Lead: ND (TWA) Zinc: 0.14 µg/m ³ (TWA)	Aluminum: 0.29 µg/m ³ (TWA) Barium: 0.02 µg/m ³ (TWA) Chromium: 0.36 µg/m ³ (TWA) Magnesium: 0.37 µg/m ³ (TWA) Nickel: 0.09 µg/m ³ (TWA) Lead: 0.17 µg/m ³ (TWA) Zinc: 0.13 µg/m ³ (TWA)	Aluminum: 0.35 µg/m ³ (TWA) Barium: 0.02 µg/m ³ (TWA) Chromium: 0.29 µg/m ³ (TWA) Magnesium: 0.24 µg/m ³ (TWA) Nickel: 0.05 µg/m ³ (TWA) Lead: 0.11 µg/m ³ (TWA) Zinc: 0.11 µg/m ³ (TWA)	Aluminum: 10,000 µg/m ³ Barium: 500 µg/m ³ Chromium: 500 µg/m ³ Magnesium: 10,000 µg/m ³ Nickel: 1,500 µg/m ³ Lead: 50 µg/m ³ Zinc: 10,000 µg/m ³	Aluminum: 150 µg/m ³ Barium: 5 µg/m ³ Chromium: 10 µg/m ³ Magnesium: 150 µg/m ³ Nickel: 10 µg/m ³ Lead: 1 µg/m ³ Zinc: 150 µg/m ³
Cyanides	NIOSH 7904 (EAS; Spectrophotometry)	HCN: 1.8 µg/m ³	HCN: 2.2 µg/m ³	HCN: 5.4 µg/m ³	HCN: 1.3 µg/m ³ (TWA)	HCN: 1.2 µg/m ³ (TWA)	HCN: 3.1 µg/m ³ (TWA)	HCN: 5,000 µg/m ³ (STEL)	HCN: 110 µg/m ³ (STEL)
Particulate Matter – 2.5 microns	USEPA IP-10A (CHESTER; gravimetric)	PM-2.5: 212.4 µg/m ³	PM-2.5: 26.4 µg/m ³	PM-2.5: 138.8 µg/m ³	PM-2.5: 150.0 µg/m ³ (TWA) PM-2.5: 60.1 µg/m ³ (24-hr)	PM-2.5: 18.2 µg/m ³ (TWA) PM-2.5: 16.2 µg/m ³ (24-hr)	PM-2.5: 94.3 µg/m ³ (TWA) PM-2.5: 41.6 µg/m ³ (24-hr)	PM-2.5: 3,000 µg/m ³ (respirable) PM-2.5: 65 µg/m ³ (24-hr Federal Air Quality Standard)	(not established)
Particulate Matter – 10.0 microns	USEPA IP-10A (CHESTER; gravimetric)	PM-10: 231.2 µg/m ³	PM-10: 42.3 µg/m ³	PM-10: 114.1 µg/m ³	PM-10: 128.1 µg/m ³ (TWA) PM-10: 60.0 µg/m ³ (24-hr)	PM-10: 23.4 µg/m ³ (TWA) PM-10: 25.1 µg/m ³ (24-hr)	PM-10: 51.6 µg/m ³ (TWA) PM-10: 35.2 µg/m ³ (24-hr)	PM-10: 10,000 µg/m ³ (inhalable) PM-10: 150 µg/m ³ (24-hr Federal Air Quality Standard.)	(not established)

Notes:

- Station locations: South Beach (off-range, south end of Makua Beach); North Beach (off-range, north end of Makua Beach); On-Range (on-site location at MMR, near Objective Dear).
- TWA calculations: (sample concentration) x [(sampling time in minutes) / (480 minutes)].
- 24-hour extrapolations of PM-2.5 and PM-10 used one-half of lowest recorded particulate concentrations for respective background values (i.e., 13.2 µg/m³ for PM-2.5 and 21.2 µg/m³ for PM-10).
- ACGIH health-based exposure guidelines refer to Threshold Limit Values (ACGIH 2002); Federal 24-hour air quality standards are also cited for PM-2.5 and PM-10 parameters.
- State of Hawai'i "Hazardous Air Pollutants" 8-hour ambient concentration guidelines refer to Hawai'i Administrative Rules (Title 11, Chapter 60.1, Section 179); these are 8-hour average concentrations equal to 1% of the corresponding Permissible Exposure Limits adopted by OSHA.
- Acronyms and abbreviations used in this table:

µg/m³: micrograms of substance per cubic meter of air
ACGIH: American Conference of Governmental Industrial Hygienists
AIR TOXICS: Air Toxics, Ltd. (Folsom, CA)
ALTA: Alta Analytical Laboratory, Inc. (El Dorado Hills, CA)
APPL: Agricultural & Priority Pollutants Laboratory, Inc. (Fresno, CA)
CHESTER: Chester LabNet, Inc. (Tigard, OR)
DCM: dichloromethane (methylene chloride)
EAS: Environmental Analytical Services, Inc. (San Luis Obispo, CA)
GC/ECD: gas chromatography/electron capture detection
GC/MS: gas chromatography/mass spectrometry
HAR: Hawai'i Administrative Rules

HCN: hydrogen cyanide
HPLC: high performance liquid chromatography
hr: hour
HR: high resolution (GC/MS)
HxCDF: hexachlorinated dibenzofuran
ICP: inductively coupled plasma (atomic emission spectroscopy)
MMR: Makua Military Reservation
ND: non-detected
NIOSH: National Institute for Occupational Safety and Health
OSHA: Occupational Health & Safety Administration
PCDD: polychlorinated dibenzodioxin

PCDF: polychlorinated dibenzofuran
PM-2.5: particulate matter – 2.5 microns
PM-10: particulate matter – 10 microns
POI: pollutant of interest
ppbV: parts per billion by volume
STEL: short-term exposure limit
SVOC: semivolatile organic compound
SWL: Southwest Laboratory of Oklahoma, Inc. (Broken Arrow, OK)
TLV: threshold limit value (ACGIH)
TWA: time-weighted average (8-hour)
VOC: volatile organic compound