TETRA TECH

Remedial Investigation Report

Hickam Communities Remedial Action Site
Joint Base Pearl Harbor-Hickam
Oʻahu, Hawaiʻi

June 7, 2012

complex world | CLEAR SOLUTIONS™

99873

Remedial Investigation Report

Hickam Communities Remedial Action Site
Joint Base Pearl Harbor-Hickam
Oʻahu, Hawaiʻi

Prepared for:

Hickam Communities, LLC

211 Mercury Street
Honolulu, HI 96818

Prepared by:

Tetra Tech

737 Bishop Street, Suite 3020
Honolulu, HI 96813
(808) 533-3366
Fax (808) 533-3306
Tetra Tech Project No. T26535

June 7, 2012

DCN: 2653505.0001.F02

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

AL	Alternative Action Level
APRA	Analysis of Potential Removal Alternatives
°C	Celsius
COC	chain-of-custody
COPCs	chemicals of potential concern
CY	cubic yard
D/B	design/build
DDD	dichlorodiphenyldichloroethane (also 4,4'-DDD)
DDE	dichlorodiphenyldichloroethylene (also 4,4'-DDE)
DDT	dichlorodiphenyltrichloroethane (also 4,4'-DDTor p,p'-DDT)
DU	decision unit
EAL	Environmental Action Level
ECR	excess carcinogenic risk
EHE	Environmental Health Evaluation
EPA	US Environmental Protection Agency
°F	Fahrenheit
HAR	Hawaiʻi Administrative Rules
HASP	health and safety plan
HC	Hickam Communities LLC (formerly Hickam Community Housing LLC)
HDOH	Hawaiʻi Department of Health
HEER	hazard evaluation and emergency response
HHRA	Human Health Risk Assessment
HHRE	human health risk evaluation
HHRE WP	*Human Health Risk Evaluation Work Plan for Hickam Communities*
HI	hazard index (cumulative non-cancer risk number)
HQ	hazard quotient (non-cancer risk number for an individual compound)
IRP	Installation Restoration Program
JBPHH	Joint Base Pearl Harbor-Hickam
LCS	laboratory control spike
Lend Lease	Lend Lease Americas LLC (formerly Actus Lend Lease LLC)
LUCID	Land Use Control Inventory Document
mg/kg	milligram per kilogram
MDL	method detection limit
MFH	military family housing
MHPI	Military Housing Privatization Initiative
MI	multi-incremental
MS/MSD	matrix spike/matrix spike duplicate
OC	organochlorine

ACRONYMS AND ABBREVIATIONS (continued)

PI	pesticide-impacted
PQL	practical quantitation limit
PM_{10}	fine particulate matter equal to or less than 10 microns
POC	point-of-contact
PPE	personal protective equipment
PRG	Preliminary Remediation Goals
QA/QC	quality assurance/quality control
RAR	removal action report
REC	recognized environmental condition
RO	removal action
RPD	relative percentage difference
RSD/%RSD	relative standard deviation/percent relative standard deviation (also known as coefficient of variance)
SAP	sampling and analysis plan
TGM	Technical Guidance Manual

GLOSSARY

Borrow pit. A borrow pit is used as a source of clean fill material. Once the clean fill material is removed it can be converted into a burial pit.

Burial pit. A burial pit is designed for permanent management of pesticide-impacted soil.

Capehart Housing Area. The military family housing area located in the northwest corner of JBPHH that is now called Hale Na Koa. This area included the first stage of demolition and new construction undertaken under the MPHI at JBPHH.

Common Area. Common areas are portions of the ground lease that are accessible to and intended for use by all residents and guests. For purposes of the Remedial Investigation sampling plan, common areas are distinguished from areas with more focused use, such as playgrounds (intended for use of children), and the back yards and front yards of residential buildings (where the main users are the families living in those buildings).

Engineering controls. Engineering controls are the methods implemented under institutional controls to manage PI soil, such as soil capping, stockpiling, dust control, and placement of PI soil in burial pits or soil berms.

Environmental Action Level (EAL). The lowest concentration of a chemical in a given medium such as soil or water, at which further action must be taken. EALs are based on assumptions regarding the exposure scenarios associated with the medium and location in which the chemical is present. Tier 1 EALs are designed to be protective in a broad range of contexts. Further action may include further evaluation of the site-specific context to determine if the assumptions associated with default EALs are appropriate. Different EALs apply to residential and occupational exposure scenarios, to adult and child exposure scenarios, and to soils located near or far from ground water or surface water bodies. HDOH periodically reviews and updates the Tier 1 EALs. The HDOH Tier 1 EALs and supporting information are published online (HDOH 2011a, 2011b, 2011c).

Ground Lease. A lease covering certain real property occupied by military family housing and related improvements, entered into by Hickam Communities for a period of 50 years, with an option to renew the lease at the end of the initial lease period. Also refers to the geographic area within the boundaries of the ground lease.

Hickam Communities LLC. The project company, affiliated with under Lend Lease Americas LLC (Lend Lease), which leases property at JBPHH from the USAF through the contract of a 50-year ground lease. The HC Project Company has certain responsibilities under the lease (development, property management and maintenance), and has overall responsibility for the PI soil management program.

Hickam Communities Military Family Housing Privatization Program Area. All family housing neighborhoods at Joint Base Pearl Harbor-Hickam (JBPHH) included within the ground lease managed by Hickam Communities. The HCMFHPP Area includes Hale Na Koa, Onizuka Village, Earhart Village, Earhart Village Park and the Historic District.

Hickam Field. Hickam Field was established in 1934 on what was formerly agricultural land prior to 1930. Hickam field became Hickam Air Force Base in 1948, which merged with Naval Base Pearl Harbor in 2010 to form Joint Base Pearl Harbor-Hickam (JBPHH).

GLOSSARY (continued)

Institutional controls. Institutional controls are administrative measures created to permanently manage PI soil and to prevent exposure to PI soil by HC workers, residents, and guests. These controls provide guidance for HC residents and guests and define standard operating procedures for HC workers.

Lend Lease Americas LLC. Lend Lease Americas LLC (formerly Actus Lend Lease LLC) was selected as part of the Department of Defense Military Family Housing Privatization Initiative to develop, design, and construct 1,182 new homes and to renovate 1,260 homes at JBPHH.

Military Housing Privatization Initiative (MHPI). The Military Housing Privatization Initiative is a public/private program whereby private sector developers may own, operate, maintain, improve and assume responsibility for military family housing, where doing so is economically advantageous and national security is not adversely affected. The MHPI was enacted on February 10, 1996 as part of the National Defense Authorization Act for fiscal year 1996.

Open area. Open areas around buildings not covered by hardscapes, including common areas.

Phase I/Phase II ESA. A Phase I Environmental Site Assessment (ESA) is an investigation, typically conducted prior to a property transaction, to identify Recognized Environmental Conditions (RECs) associated with current or past uses of a property. The focus of a Phase I ESA is on public records and other documents, interviews, and visual inspections of a site, and does not include collection and analysis of samples or other intrusive investigations. A Phase II ESA is typically conducted as a follow up to a Phase I ESA, and involves intrusive investigative activities such as sampling of environmental media.

Phase/Stages of Construction. The military family housing privatization project at JBPHH was developed in two phases. Phase I included the Hale Na Koa (formerly Capehart) and Earhart housing areas. Phase II included Onizuka Village, Earhart Village Park, and the Historic District. New construction within the Earhart and Onizuka housing areas was implemented sequentially, in “stages.” The first construction stage of the first phase of development occurred in the Hale Na Koa neighborhood, referred to as Hale Na Koa I-1 (Phase I, Stage 1). The Earhart housing area was developed from east to west, starting with Earhart I-2, then Earhart I-3, and then Earhart I-4. The Onizuka Village housing area was developed from south to north, beginning with Onizuka II-1, then Onizuka II-2, and then Onizuka II-3.

Post-construction. After structures have been completed or pavement has been restored.

Pre-construction. Prior to construction of any infrastructure (including excavation or grading), may be post-demolition if the area was previously developed.

Pre-demolition. Prior to demolition of buildings, foundation, concrete slabs, or any other improvements.

GLOSSARY (continued)

Pesticide Impacted Soil Management Program Area (Program Area). The Program Area includes all areas within the Ground Lease managed by HC at JBPHH.

Recognized Environmental Condition (REC). With respect to a Phase I ESA, a REC is "…the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release..."

Remedial Investigation Study Area (Study Area). The Remedial Investigation Study Area includes Earhart I-2, Earhart I-3, and Onizuka II-1. Results from the investigation of the Study Area are presented for the first time in the Remedial Investigation Report.

Removal Action. Action taken in advance of selection of the overall remedy for a site to achieve specific short-term objectives, such as to stabilize a release or otherwise achieve an immediate reduction in risk to human health or the environment.

Hickam Communities Remedial Action Site (Site). The Site includes all areas within the Program that warrant a response under HRS 128D and HAR 11-451. Hickam Communities Remedial Action Site, comprising the four neighborhoods that had been completed and occupied by residents at the time the Remedial Investigation was initiated in August 2010: Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-1. The Site includes the Study Area (defined above), plus Hale Na Koa I-1.

Standard Operating Procedure. General project-specific methodology to be used as additional guidance for HC workers to ensure that work is conducted safely and that quality assurance practices are followed. Each standard operating procedure defines the scope, application, necessary equipment, and procedure/method to be used for various types of field work at HC property.

Technical Chlordane. A pesticide product produced from the 1940s until the mid-1980s, when most authorized uses were discontinued, consisting of a mixture of organochlorine compounds. The principal constituents of technical chlordane are alpha-chlordane, gamma-chlordane, nanochlor, and heptachlor, but the mixture included many additional compounds. Actual percentages of each constituents varied by manufacturer and batch. It was widely used in Hawai'i and elsewhere in the U.S., as a termiticide, (a pesticide used to treat termites).

Voluntary Agreement. Agreement between HDOH and HC, specifying certain actions to be undertaken by HC under two programs: a Remedial Action Program, and to characterize, manage, or reduce human health and environmental risks associated with pesticide-impacted (PI) soil at the HC Remedial Action Site.

This page intentionally left blank

1.0 INTRODUCTION AND PURPOSE

This report has been prepared on behalf of Hickam Communities LLC (HC) to present the results the Site investigation of the magnitude and extent of organochlorine pesticides in shallow soil within the HC Remedial Action Site at Joint Base Pearl Harbor-Hickam (JBPHH), Oʻahu, Hawaiʻi; formerly Hickam Air Force Base. The Remedial Action Site at JBPHH consists the neighborhoods are Earhart I-2, Earhart I-3, Onizuka II-1 and Hale Na Koa I-1 (hereinafter the "Site"; Figure 1-1). The Site Investigation was conducted as part of the Remedial Action implemented under the *Voluntary Agreement for Environmental Response Actions* (*Voluntary Agreement*) between the Hawaiʻi Department of Health (HDOH) and HC.[1]

As part of the Department of Defense Military Housing Privatization Initiative (MHPI), Lend Lease Americas, LLC (Lend Lease) (formerly Actus Lend Lease, LLC), was selected by the US Air Force (USAF) to develop, design, and construct 1,182 new homes and to renovate 1,260 existing homes at JBPHH. The HC project company is an affiliate of Lend Lease and leases property at JBPHH from the USAF through the contract of a 50-year ground lease. The HC Project Company has certain responsibilities under the lease (development, property management and maintenance). HC has overall responsibility for the pesticide-impacted (PI) soil program. The USAF, as lessor, maintains a review and coordination role for all activities conducted at HC project sites. The dates of the ground lease are February 1, 2005 through July 31, 2057 for the first housing development phase (Phase I) and August 1, 2007 through July 31, 2057 for the second housing development phase (Phase II).[2]

As indicated in Table 1-1, Phase I of the MFHPI program at JBPHH included the Hale Na Koa (formerly Capehart) housing area and the Earhart housing area. Phase II included the Onizuka housing area, the Historical Housing District, and housing at Bellows Air Force Station (not shown).

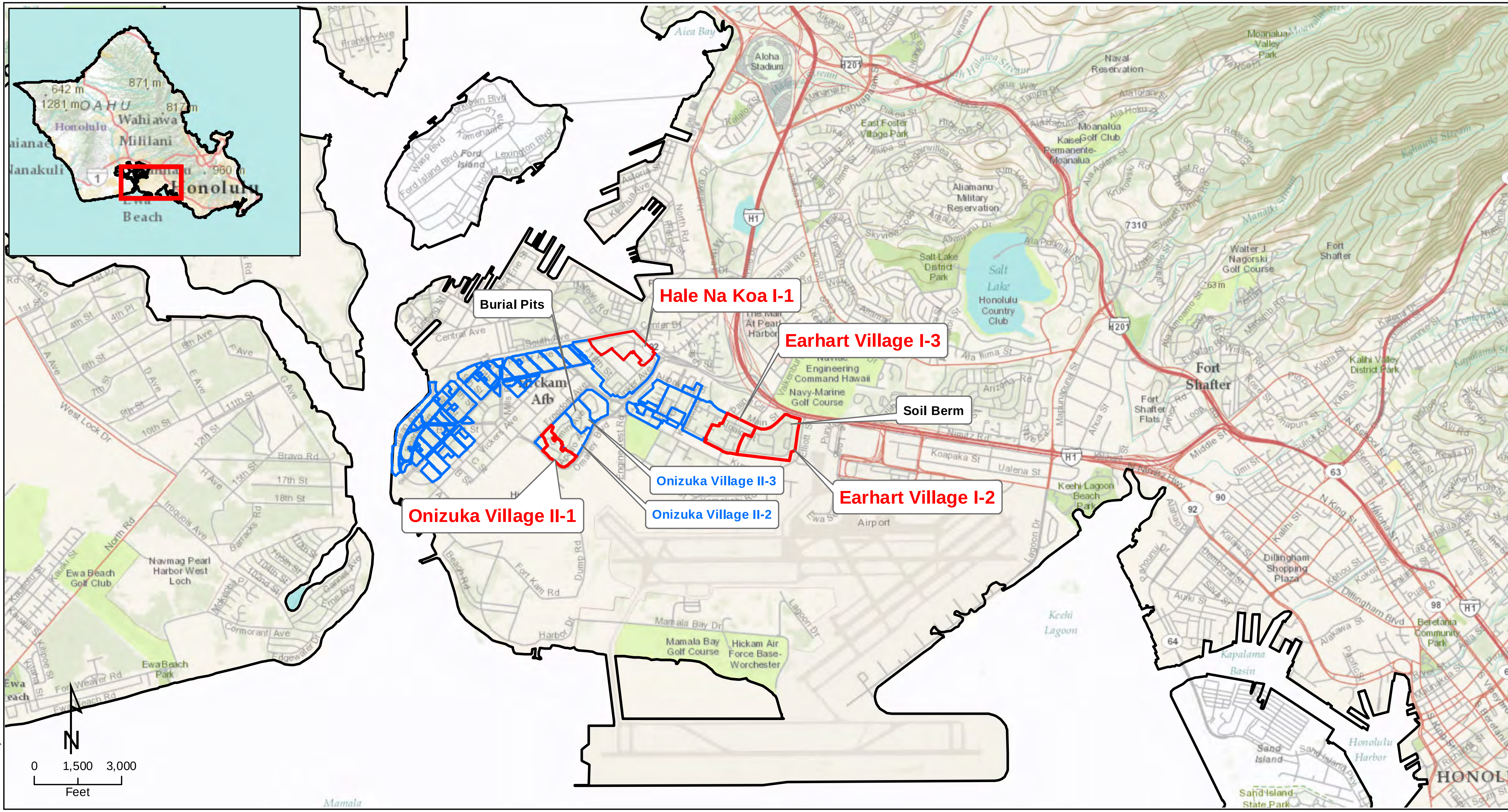
Table 1-1. Hickam Communities Construction and Renovation Schedule

Neighborhood (Construction Stage)		Demolition[1]	New Construction[1]	Minor Renovations[1]	Start	End
Development Phase I	Hale Na Koa I-1	194	170	354	Apr 2005	Apr 2007
	Earhart I-1	0	24	186	Apr 2005	Apr 2009
	Earhart I-2	222	252	0	Jun 2006	Jun 2008
	Earhart I-3	214	222	0	Jun 2007	Jun 2009
	Earhart I-4	186	156	0	Aug 2008	Aug 2010
Development Phase II	Historic District	0	0	438	May 2008	July 2013
	Earhart Village Park	0	60	0	May 2008	May 2009
	Onizuka II-1	142	104	0	Aug 2007	Aug 2009
	Onizuka II-2	142	102	0	Mar 2009	Mar 2011
	Onizuka II-3	108	98	0	Sep 2010	Jan 2012
	Challenger Loop	0	0	96	July 2009	Dec 2011
TOTAL		***1208***	***1188***	***1074***		

[1] Numbers of family housing units are shown, rather than number of structures. Many structures are multi-family.

[1] HC 2011a
[2] HC 2011b

This page intentionally left blank



R:\NEW\29064\Layouts\Site Location.mxd 03/15/12 - YE

Site Boundary

Hickam Communities Project Boundary

TETRA TECH

Site Location

Hickam Communities Neighborhoods-March 2012

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

Figure 1-1

[Note: throughout this report, the use of Roman numerals I and II, as in the terms Phase I and Phase II, refer to the two major segments of development of privatized military family housing at JBPHH.]

Prior to the award of these projects, the USAF prepared reports documenting known or potential environmental issues affecting the property to be transferred or leased. In addition, as part of its due diligence process, Lend Lease Americas assessed known or potential environmental issues.

Construction and renovation in each of the two major development phases have been implemented in stages. These construction stages are presented in Table 1-1. [Note: throughout this report, the two development phases (Phase I and Phase II) are designated with Roman numerals, while the *construction stages* within these phases are designated by Arabic numerals, as in *Hale Na Koa I-1*, indicating Phase I, Stage 1. The term "neighborhood" generally corresponds to the areas of the construction stages, as in the "Earhart I-2 Neighborhood."].

Earhart I-2, (second stage of construction in the Earhart housing area, under development Phase I), is at the eastern end of the Earhart housing area. Forty-six substandard housing structures were demolished and were replaced with 69 multifamily structures between June 2006 and June 2008. Earhart I-3, which was the third stage of construction in the Earhart housing area, is adjacent to and west of the Earhart I-2 neighborhood. The Earhart I-3 construction project involved the demolition of 40 housing structures and construction of 61 multifamily structures between June 2007 and June 2009.

Construction of new housing on vacant land in Earhart Village Park represents the final piece in the buildout of the former Earhart housing area, and was conducted as part of the second development phase (Phase II). Construction in the Historic District involves renovation to upgrade the buildings consistent with their historic character. Most soil disturbance in the Historic District has been as a result of removal of historically inconsistent building additions and lanais and replacement or realignment of underground utilities. This work is being implemented in blocks.

Development Phase II was also constructed in stages, and hence demolition of housing and construction of new housing in the Onizuka housing area began with Onizuka II-1, at the southern end of the Onizuka housing area, and proceeded northward to Onizuka II-2 and Onizuka II-3. (The northernmost part of the Onizuka housing area, the Challenger Loop neighborhood, is of more recent construction than the rest of Onizuka and will be renovated rather than replaced.) Eighteen structures were demolished in the Onizuka II-1 area and 27 new multifamily structures were constructed at the Site, along with two administrative buildings for the housing management offices, between August 2007 and August 2009.

In August 2009, pesticide concentrations significantly above the action levels that had been established for the Program Area[3] were discovered in surface soil within open areas at the nearly-completed Earhart I-4 neighborhood.[4] The concentrations of pesticides in surface soil indicated improper implementation of PI Soil Management Program.

[3] Tetra Tech 2009a
[4] Tetra Tech 2009c, 2009d.

HC's response at Earhart I-4 itself has been addressed separately and is not covered in this Remedial Investigation Report;[5] however, the improper management of PI soil during construction at Earhart I-4 raised concerns that previously-completed neighborhoods such as Hale Na Koa, Earhart I-2, Earhart I-3, and Onizuka II-1, could have similar conditions. Unlike at Earhart I-4, residents had already moved into the new housing in these neighborhoods. At the time of the discovery of the problem at Earhart I-4, Hale Na Koa had been occupied for more than two years, Earhart I-2 for about 13 months, Earhart I-3 for about two months, and Onizuka II-1 had just begun to be occupied.

In a preliminary investigation in June 2010, HC found evidence of pesticide concentrations at concentrations significantly above the screening levels established for the Program Area in surface soils in the Earhart I-2, Earhart I-3, and concentrations slightly above the screening levels in parts of the Onizuka II-1 neighborhood.[6] Confirmation soil sampling was also conducted by HC in the Hale Na Koa neighborhood in June 2010.[7] The results of that investigation indicated concentrations generally below the screening levels. The results of these investigations are summarized more fully in Section 2.0.

HDOH considered the observed pesticide levels in the Earhart I-2 and Earhart I-3 neighborhoods to be a significant potential human health risk, and directed HC to conduct a thorough and detailed Remedial Investigation to collect information for reliable cleanup action decision-making at all three of the newly-occupied neighborhoods: Earhart I-2, Earhart I-3, and Onizuka II-1 (together, the *Remedial Investigation Study Area* or "Study Area"). HC conducted the field portion of the Remedial Investigation in August-October 2010.[8]

This report presents the results of the field investigation that was conducted in response to these concerns, and the results of the earlier investigation at the Hale Na Koa I-1 neighborhood, and presents a detailed interpretation of the results. It describes *Removal Actions* that were conducted by HC in the Earhart I-2 and Earhart I-3 Neighborhoods to remove immediate threats posed by pesticides in exposed shallow soils,[9] and includes an assessment of the human health and environmental risks (Environmental Hazard Evaluation) presented by pesticides at the Study Area before and after the Removal Actions were implemented. Finally, the report discusses the conditions remaining in the Study Area, and throughout the Program Area, under reasonably anticipated future conditions.

[5] Tetra Tech 2010b, 2010d, 2010h, 2010k.
[6] Tetra Tech 2010e, 2010f, 2010c
[7] Tetra Tech 2010p, 2010q
[8] Tetra Tech 2010i, 2010j.
[9] Tetra Tech 2012c

2.0 BACKGROUND

This chapter describes the environmental setting of the Site and past and current land uses.

2.1 Site Description

Joint Base Pearl Harbor-Hickam is situated on approximately 2,700 acres of the Pearl Harbor coastal plain on the southern coast of Oʻahu. The topographic relief of the area is generally flat, with elevations ranging from 0 to 20 feet above mean sea level. [10]

As indicated in Chapter 1.0 and shown on Figure 1-1, the Site comprises portions of the two ground leases managed by HC, including the replacement housing area within Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-1. The Hale Na Koa I-1 neighborhood covers approximately 85 acres. The Site includes the approximately 25-acre northern portion of the Hale Na Koa I-1 neighborhood, in which 65 buildings constructed in 1959 were replaced with 45 buildings. The demolition and new construction were completed from April 2005 to April 2007. The housing on the remaining 60 acres of the Hale Na Koa I-1 neighborhood received minor renovations, involving little or no soil disturbance.

The Earhart I-2 and Earhart I-3 neighborhoods occupy most of the eastern half of the Earhart Village housing area, which encompasses approximately 130 acres. Earhart I-3 is adjacent to Earhart I-4, which is not included within the Site, but is part of the Phase I ground lease. The Earhart I-2 neighborhood comprises approximately 47 acres, and the Earhart I-3 neighborhood comprises approximately 32 acres.

The Onizuka Village housing area covers approximately 74 acres. Approximately 16.5 acres at the southern end of Onizuka Village comprise the Onizuka II-1 neighborhood, with another approximately 2.8 acres at the west side of Onizuka II-1 containing the Housing Office and Maintenance Facility (HOMF). The HOMF contains two office buildings and a large parking area that were constructed at the same time as the Onizuka II-1 housing. [11]

2.1.1 Climate

The climate in the Honolulu area is mild to very warm, with dry to moderate humidity and northeasterly trade winds approximately 90 percent of the summer and 50 percent of the winter. There is very little diurnal or seasonal variation in temperature on Oʻahu because of its tropical latitude, marine influence, and the prevailing northeasterly trade winds. The average daytime temperatures range between 22 and 27 degrees Celsius (°C), approximately 72 to 81 degrees Fahrenheit (°F), and humidity varies between 58 and 90 percent.[12]

The average annual precipitation at JBPHH is approximately 56 centimeters (22 inches). December is typically the wettest month of the year, and June is the driest.[13]

[10] (USAF 2002).
[11] (Waller 2005)
[12] (USACE 1997)
[13] (HAFB 2006)

2.1.2 Soils/Geology

Joint Base Pearl Harbor-Hickam lies on the coastal plain on the leeward side of the Koʻolau Range, immediately east of Pearl Harbor. The Pearl Harbor coastal plain is underlain by a succession of terrestrial alluvial and marine sedimentary layers. As Oʻahu subsided over thousands of years, alluvial sediments interspersed with volcanic flows and volcanic ash were deposited on the margin of the island, building a reef platform. During periods of lower sea levels, the reef was exposed. This so-called caprock (because it caps the underlying volcanic rock, which contains the basal aquifer) contains strata of alluvium, lagoonal mud, beach sands, volcanic tuff, and corals. At depth, these strata overlay volcanic bedrock of the Honolulu volcanic series.

Most of JBPHH soils are mapped as fill, composed of material dredged from the ocean or hauled in from elsewhere. Placement of the fill changed the topography of JBPHH from an uneven series of low lying coastal ridges and swales to a nearly level plateau. In addition to the fill, there are five naturally occurring soil types—Māmala stony silt clay loam, Makalapa clay, Keaʻau stony clay, Jaucus sand, and coral outcrop—that are associated with the coastal plain and coral reef substratum over which JBPHH lies. The fill and naturally occurring soil types are considered poor for vegetation growth, and landscaping areas usually contain topsoil fill from off-base sources. The erosion potential for the JBPHH soils is generally slight to moderate, with the exception of Jaucus sand, which is highly erodible. [14]

2.1.3 Surface Water

There are no natural lakes, rivers, or streams on the Hale Na Koa or Earhart Village housing areas; however, Manuwai Canal, which provides storm drainage for the eastern third of JBPHH, flows adjacent to the southern boundary of the Earhart Village housing area. The Manuwai Canal empties into Māmala Bay to the south. The housing areas are not within a potential flood inundation zone.

No wetlands are present on the Hale Na Koa or Earhart Village housing areas properties. The Manuwai Canal, which flows adjacent to the southern boundary of the Earhart Village area, has been classified by the National Wetland Inventory as an estuarine, open water, subtidal inundation, excavated wetland. [15]

2.1.4 Groundwater

Most of JBPHH is underlain at shallow depth by brackish aquifers that are not suitable for commercial, residential, or recreational use. General groundwater flow in the area is toward the Pacific Ocean to the south. At greater depth, a small portion of JBPHH is underlain by a protected freshwater aquifer and has stringent requirements for water quality protection. Potable water is supplied to JBPHH from off-site US Navy storage tanks.[16]

The Site is in the lower portion of the Southern Oʻahu Groundwater Flow System, which extends from the Koʻolau Range and the dike-impounded central highlands, to Pearl Harbor and the Pacific Ocean. In the low-elevation areas surrounding Pearl Harbor, high quality

[14] (USAF 2002)
[15] (USAF 2002)
[16] (USAF 1998)

groundwater occurs mainly in the basal aquifer, where it is confined by 1,000 feet or more of sedimentary caprock, consisting largely of interbedded ancient reefs and volcanic deposits.[17]

The Earhart Village housing area overlies the Moanalua Aquifer System of the greater Honolulu Aquifer Sector, with aquifer codes 30104116 and 30104121. The upper, basal aquifer (aquifer code 30104116) is comprised of fresh water in contact with salt water, and it is unconfined and occurs in sedimentary (non-volcanic) deposits. This upper, basal aquifer is described as having potential for use, without specific utility, moderately saline (1,000 to 5,000 milligrams per liter chloride), replaceable, and highly vulnerable to contamination. The lower basal aquifer (aquifer code 30103121) is comprised of freshwater not in contact with salt water, confined (under caprock) and located in flank lithology (horizontally extensive lavas).

Onizuka Village, Hale Na Koa, and the Historic District, to the west of Hale Na Koa, lie within the Waimalu system of the Pearl Harbor Sector, with aquifer codes 30201116 (upper basal aquifer), and 30201121 (lower basal aquifer). The hydrologic characteristics of these two units are similar to the adjacent units that underlie the Earhart Village housing area.[18]

2.2 Historic Land Use

Hickam Field was established in 1934 (HAFB 2006). Hickam Field became Hickam Air Force Base in 1948, which merged with Naval Base Pearl Harbor in 2010 to form JBPHH. Prior to 1930, the area was used for agriculture and fish ponds (KJC 1991). The entire Military Family Housing (MFH) area overlays what was once part of the airfield (USAF 1946).

The Hale Na Koa housing area was formerly known as “Capehart Village” through the Capehart Act, which appropriated funds and authorized use of private developers to address the demand for military housing during the Cold War era. Construction of Capehart Village housing was completed in 1959. Appendix A includes a map from the Phase I Environmental Site Assessment (ESA)[19] showing the former building locations in the Capehart housing area. The official name of Capehart Village was changed to Hale Na Koa Village in honor of Hawaiian culture in 2007, after completion of the housing replacement and renovation project.

Earhart Village housing was constructed in the 1960s and 1970s. The housing area contained 168 residential buildings, 46 of which were within the boundaries of the Earhart I-2 area and 43 were within the Earhart I-3 area. Thirty-two buildings were in the Earhart I-4 area, 33 additional residential buildings were located in a housing area west of Earhart I-4, and 14 buildings were located in another area south of Earhart Village Park.

Onizuka Village consisted of two-story multifamily dwellings that were constructed in 1975.

Very little information is available about past use of termiticides at JBPHH. Installation Restoration Program documents report past pesticide use at the base, and detection of pesticides during some hazardous waste site investigations, but no information relating to pesticide use or detection in the MFH areas is reported. The Environmental Baseline Study (EBS) for the Phase II development area[20] indicates that pesticides were applied as intended for pest control at the base, and further reports that chlordane was applied for termite control at

[17] (Nichols et al. 1996)
[18] (Mink and Lau 1990)
[19] (Tetra Tech 2004)
[20] (Waller 2005)

housing units at Fort Kamehameha, south of JBPHH. The EBS reports the results from analysis of composite samples collected from within the driplines of ten housing structures at Fort Kamehameha where chlordane concentrations ranged from below the detection limit (less than 0.025 milligrams per kilogram [mg/kg]) to 240 mg/kg.[21]

No similar data are provided for the Site until Phase II ESAs were conducted by Tetra Tech, in 2004 and 2006, respectively. The results of these Phase II ESAs demonstrated that termiticides had been applied to subfoundation soils in both the Phase I and Phase II housing areas. In both the Hale Na Koa and Onizuka housing areas, the principal termiticide detected in driplines adjacent to buildings was chlordane. In the Earhart Village housing area, the principal termiticides detected were aldrin and dieldrin. These initial observations were subsequently further confirmed by direct sampling within the footprints of the building foundations. Sampling of the open areas beyond building foundations indicated concentrations of termiticides below HDOH Tier 1 Environmental Action Levels (EALs). Further discussion of previous investigations is presented in Section 8.1.

Aldrin and dieldrin are chemically similar compounds that were probably both present in the technical grade pesticide historically applied to treat termites under and around foundations in the Earhart Housing Area. Peak use of aldrin and dieldrin in the United States was in 1966, when 19 million pounds of aldrin and one million pounds of dieldrin were reportedly used. The much higher use of aldrin suggests that aldrin might have been the main termiticide product applied to the Earhart Housing Area and that the concentrations of dieldrin may be primarily due to chemical degradation of aldrin to dieldrin.

Domestic production of aldrin and dieldrin halted in 1972, when the US Environmental Protection Agency (EPA) cancelled all but three uses (one of which was treatment of subterranean termites). Manufacture of aldrin, dieldrin and chlordane were discontinued in 1987.[22]

2.3 Current Land Use

The Site is developed for military family housing and it being managed by Hickam Communities LLC under a 50-year lease. The ground lease covering the Phase I development was executed February 1, 2005 and extends through July 31, 2057. The ground lease covering the Phase II development was executed August 1, 2007 and extends through July 31, 2057.

Phase I of the MHP contract was awarded to Lend Lease in 2004 and construction and renovation was completed in August 2010. The Phase II MHP contract was awarded in 2007 and all construction and renovation is scheduled for completion by the summer of 2013.

There are currently 47 newly-constructed family housing structures in the Hale Na Koa I-1 neighborhood; 69 newly constructed multifamily housing structures in the Earhart I-2 area; 61 multifamily structures in the Earhart I-3 area; and 27 multifamily structures in the Onizuka II-1 area. A 2.8-acre parcel in the western corner of the Onizuka II-1 area contains HC's housing management offices and associated parking, and is therefore considered non-residential.

[21] (Waller 2005)
[22] (US EPA 2003)

The residential buildings are designed with paved driveways in the front yards and concrete lanais in the backyards. Most of the backyards open directly onto common areas, but residents can request that fences be installed to enclose the backyards to a specified distance from the rear walls of the buildings. It is estimated that currently about 20 percent of the units have backyard fences.

Landscaping and landscaping maintenance is provided by the property manager, Hickam Communities LLC. As a condition of their leases, and in accordance with the Resident Guide, residents are prohibited from digging, excavating, or gardening without permission from HC.[23] Most of the common areas of the Site are covered by Bermuda grass, which is irrigated automatically. There are narrow landscaping strips around the perimeters of the buildings. The residential areas of the Study Area include children's playgrounds and walking and biking paths. The terrain is nearly level, with gentle slopes to allow infiltration of runoff. Excess surface drainage flows to local drainage swales, which drain to the major storm drainage channels.

2.4 Pesticide-Impacted (PI) Soil Management at Hickam Communities

From the 1940s to the 1980s, organochlorine pesticides were used as termiticides, i.e., to treat for subterranean termites under and around the foundations of buildings. The termiticides used for this purpose at JBPHH were aldrin, chlordane,[24] and dieldrin. Because of their toxicity and persistence in the environment, these chemicals were gradually taken out of production, and licensing for most uses was discontinued in the mid-1980s, as alternative treatments were developed. However, because of their persistence and the fact that the termiticides had been applied to soil beneath building foundation slabs, which helped to preserve them from weathering and degradation, termiticides were still present in soil under the building foundation slabs when the buildings in the Site were demolished.

As part of the construction program, a series of management practices were implemented at HC since any PI soil detected at a HC project site would require management during demolition, renovation, and/or construction of military housing. The first plan developed for HC was the *Management Plan for Pesticide-Impacted Soils* (*MPPIS*) which was implemented at HC in 2006.[25] To capture changes in the HC redevelopment and construction processes, the *MPPIS* was updated and renamed the *Pesticide-Impacted Soils Investigation and Management Program Manual (Program Manual)* in 2009.[26] Under the most recent version of the HC *Program Manual* dated August 31, 2011[27], the procedures call for excavation of PI soil to a depth of at least one foot below final grade in areas that would not be covered by hardscapes after new construction is completed. The excavated areas are then capped by at least one foot of acceptable soil to bring the HC project site to final grade. Any PI soil under hardscapes (e.g. roads, building foundations, sidewalks, driveways, and parking lots), would not need to be removed because the hardscapes provide a long-term barrier to exposure. Placement of excavated PI soil under new hardscapes is also used as a method to permanently manage PI soil and prevent the exposure pathways of direct contact, inhalation, and ingestion that may be associated with exposed soil. Programmatic documents either developed directly for PI soil management at HC, or including PI soil awareness for HC property are presented in Table 2-1.

[23] HC 2010
[24] In this report, the term *chlordane* refers to *technical chlordane*. The product used as a termiticide. Technical chlordane is a mixture of many compounds, including alpha- and gamma-chlordane, heptachlor, heptachlor epoxide, nanochlor, and others. See Section 8.1 for additional details.
[25] (Tetra Tech 2006e)
[26] (Tetra Tech 2009a)
[27] (Tetra Tech 2011g)

Table 2-1. Hickam Communities Programmatic Documents

Plan Title	Date	Purpose and Description	Target Audience
***Management Plan for Pesticide-Impacted Soils (MPPIS;* Tetra Tech 2006e)**	October 16, 2006	Initial programmatic plan developed in 2006 to provide PI soil management procedures during construction. Presented the initial risk criteria and procedures used a HC at this time.	construction workers, subcontractors, third party consultants
***Pesticide Impacted Soils Investigation and Management Program Manual (Program Manual;* Tetra Tech 2009a).**	May 2009	The MPPIS for PI soil management procedures during construction was superseded by revised and renamed the Program Manual in 2009. The 2009 revision included updated risk criteria and new soil management procedures.	construction workers, subcontractors, third party consultants
***Pesticide Impacted Soils Investigation and Management Program Manual (Program Manual;* Tetra Tech 2011).**	August 31, 2011	The 2009 Program Manual for PI soil management procedures during construction was superseded by the revised 2011 revision of the Program Manual. This revision presented updated for risk criteria and soil management procedures.	construction workers, subcontractors, third party consultants
Land Use Controls Inventory Document (LUCID; Tetra Tech 2012b).	January 11, 2012	Long-term PI soil management following construction. Procedures for locating and planning work in PI soil areas. Includes emergency response.	maintenance workers, emergency responders, third party consultants
Hickam Communities Resident Guide and Community Standards Handbook (Resident Guide; HC 2010).	January 1, 2010	The Resident Guide is Attachment A to the Tenant Lease, and provides digging requirements at HC, and clearly specifies that tenants may not dig into the ground for any reason without first obtaining approval to do so from HC.	residents and guests

The *Land Use Controls Inventory Document (LUCID)*[28] identifies all known PI soil in the area covered by the ground lease and contains protocols for conducting soil disturbing work in areas where PI soil is known or assumed to be present on HC property. The *LUCID* is targeted at HC maintenance workers and subcontractors, and is intended to be updated and applied over the 50-year ground lease at HC.

Beginning in 2007, with the lease of housing units in Hale Na Koa, tenants were notified of the potential presence of pesticides in soils in back yards, front yards, and common areas, and were warned not to disturb soils within 5 feet of houses. Tenants have also been provided a copy of the *Hickam Communities Resident Guide and Community Standards Handbook* (*Resident Guide)* as Attachment A to the tenant lease.[29]

[28] Tetra Tech 2012b)
[29] Section 5.13 of the *Resident Guide* (HC 2010) specifies that tenants may not dig into the ground for any reason without first obtaining approval to do so from HC. Following HC approval of any digging requests, tenants must then obtain a WCR form (647th CES, JBPPH: Form 103) from the CES office at JBPHH.

3.0 SUMMARY OF INVESTIGATION HISTORY

3.1 Basewide Investigations

Sources of contaminants from past operations at JBPHH have been identified under the Department of Defense Installation Restoration Program (IRP). A number of contaminant source sites have been identified in the vicinity of the Site and have been investigated and remediated. Data from the IRP site investigations provide an important source of information about the environmental conditions in the Site. However, until due diligence activities were conducted in anticipation of initiation of Phase I and Phase II of the Military Housing Privatization Initiative (MHPI) program at JBPHH, only anecdotal evidence was available regarding past use of termiticides at the base. While some of the IRP site investigations describe pesticides detected in connection with past waste disposal, or releases, none of the information suggests that pesticides were disposed or were present at elevated concentrations within the housing areas. Instead, most of the IRP investigations associated with the Site involved characterization and cleanup of petroleum products; mainly jet fuel.

As described in the Phase I ESA for the first development phase (Phase I) of the Military Housing Privatization Initiative program at Hickam AFB[30], a search of previous records[31] identified eleven sites that involved fuel leaks from underground fuel distribution lines in or near the project area, which were subsequently investigated in a Phase II, Stage 1 Confirmation/Quantification study under the IRP[32]. [Note: *Phase I and Phase II ESAs* are investigations usually conducted as part of due diligence activities preceding a property transaction. The terms *Phase I* and *Phase II* in this context have nothing to do with the development phases of the MHPI program at JBPHH. See the glossary for further information.]

Additional investigations identified other potential contamination release sites. By 1996, 37 of 41 identified source sites had been evaluated, and an additional 72 areas of concern were identified.[33]

A management action plan prepared in May 2007 summarized the status of the IRP sites.[34] In addition to the SS-01 site, which underlies most of the Hale Na Koa neighborhood west of Onizuka Village, IRP sites adjacent to and south of Earhart Village included site MY158 (a former motor pool with petroleum hydrocarbons, solvents and metals) and SS-25 (the Hickam Village Shoppette site, with petroleum hydrocarbons). Both of these sites have been investigated, and records of decision have been signed identifying no further action as the remedy for both sites.

3.2 Investigations of the Site

HC has conducted numerous investigations of the Site, beginning with the Phase II ESAs conducted prior to entering into the MHPI ground leases. Table 3-1 presents a summary of the investigation history of the Site, which is described in more detail below.

30 (Tetra Tech 2004a, 2005)
31 (for example, USAF 1991)
32 (Dames and Moore, 1986)
33 (Tetra Tech 2007a)
34 (HAFB 2007)

Table 3-1. Site Investigation History

Activity	Location	Date(s)	Citation
Phase I ESA	Phase I development area	March 2004	Tetra Tech 2004a
Phase II ESA	Phase I development area	March 2004	Tetra Tech 2004b
Phase I ESA (Update)	Phase I development area	January 2005	Tetra Tech 2005a
Pesticide Management Plan	Programmatic	January 2005	Tetra Tech 2005b
Soil Investigation	Hale Na Koa	Feb-April 2006	Tetra Tech 2006a
Soil Investigation	Earhart I-2, I-3, I-4	August 2006	Tetra Tech 2006b
Risk Evaluation Memo (2006 HHRA)	Hale Na Koa and Earhart	June 2006	Tetra Tech 2006c
Management Plan for PI Soil (MPPIS)	Programmatic	October 2006	Tetra Tech 2006d
Phase I ESA	Phase II development area	July 2007	Tetra Tech 2007a
Phase II ESA	Phase II development area	July 2007	Tetra Tech 2007b
Subfoundation Sampling at 8 Buildings	Earhart I-2, I-3, I-4	April 2007	Tetra Tech 2007c
Sampling at 8 Buildings	Onizuka Village	August 2008	Tetra Tech 2008
Post-Construction Sampling of 4 DUs	Earhart I-4	August 2009	Tetra Tech 2009a
Follow up Post-Construction Sampling	Earhart I-4	Sept-Oct 2009	Tetra Tech 2009c
Post-Construction Sampling 5 DUs	Onizuka II-1	May 25, 2010	Tetra Tech 2010c
Post-Construction Sampling 10 DUs	Earhart I-2	June 1-3, 2010	Tetra Tech 2010e
Post-Construction Sampling 7 DUs	Earhart I-3	June 8-9, 2010	Tetra Tech 2010f
Confirmation Sampling 11 DUs	Hale Na Koa	June 2010	Tetra Tech 2010q
Remedial Investigation Sampling Plan	Earhart I-2/ Earhart I-3	August 6, 2010	Tetra Tech 2010i
Remedial Investigation Sampling Plan	Onizuka II-1	August 6, 2010	Tetra Tech 2010j

HHRA: Human Health Risk Assessment

3.2.1 Previous Investigations of Hale Na Koa

Due Diligence. In 2004, as part of due diligence activities prior to HC entering into the ground lease for the Phase I development areas, Tetra Tech prepared a Phase I ESA to identify recognized environmental conditions (RECs) in the Hale Na Koa I-1 housing area and the Earhart Village Housing Area.[35] The Phase I ESA identified pesticides (particularly chlordane) used for treatment of subterranean termites as a potential Recognized Environmental Condition throughout Hale Na Koa, but no definitive historical data were obtained to indicate the nature or extent of past use of pesticides, and therefore the Phase I ESA recommended sampling to evaluate the soils surrounding and under the buildings.

A Phase II investigation was conducted shortly after completion of the Phase I ESA, which included discrete surface soil sampling at sixteen locations in the proposed housing demolition

[35] (Tetra Tech 2004a)

and new construction portion of the Hale Na Koa housing area, including locations next to the foundations of buildings to evaluate the presence of pesticides such as chlordane.[36]

The results were compared to EPA residential Preliminary Remediation Goals (PRGs), which were equivalent to the HDOH Tier 1 EALs. Dieldrin was detected at low concentrations, although it was above the PRG of 0.03 mg/kg in three samples. Aldrin, which is associated with dieldrin in other housing areas at Hickam AFB, was not detected. Chlordane was detected in three samples at concentrations above the PRG of 1.6 mg/kg, and in one sample, from the dripline of a building, at a concentration of 65 mg/kg. Based on these results, Tetra Tech recommended developing a management plan to address pesticides that might be encountered during construction at the Site.[37]

PI Soil Management Planning. Following confirmation of the presence of elevated concentrations of termiticides in the driplines of the old housing units in the Phase II ESA, a pesticide management plan was prepared, based on the assumption that soil beneath all of the buildings in the Hale Na Koa housing area had been treated with chlordane and therefore contained concentrations above the applicable screening level for the Site.[38] This initial plan identified tasks and responsibilities, including recommending preparation of a detailed plan for management of pesticide impacted soil.

Based on data from sampling at Hale Na Koa and at Earhart Village, and because termiticides were encountered at other military family housing project sites in Hawaii, risk-based site-specific (Tier 2) screening levels were developed for use at JBPHH.[39] The development of risk-based standards is discussed in detail in Chapter 11. For purposes of this discussion, it is sufficient to note that the site-specific standard (herein called the 2006 Human Health Risk Assessment [HHRA] standard), was based on a cumulative excess cancer risk threshold of 1 x 10^{-5} and a hazard index (HI) of 1. The individual site-specific risk-based EALs of the three principal termiticides were: 23.4 mg/kg for chlordane; 0.45 mg/kg for dieldrin; and 0.42 mg/kg for aldrin. The use of these site-specific screening levels was contingent on the concurrent, continuing application of specific land use controls, which included stringent residential activity prohibitions, such as prohibitions on excavation, as well as the assumption of continued use of the housing by military families, which is the basis for the less than lifetime exposure duration assumed in the EALs.

Prior to demolition of structures at Hale Na Koa I-1, a comprehensive MPPIS was developed that called for segregation and management of all soils under building foundations (including a five-foot buffer around the building footprint) to a depth of at least one foot below the final subgrade elevation of the Site, temporary stockpiling of the excavated soil, and long-term management (and documentation) of the excavated soil beneath new building foundations or other hardscapes, or under at least one foot of acceptable fill soil, or in burial pits, or in utility trenches.

[40]***Pre-Construction Soil Investigation.*** A comprehensive investigation of shallow soils in the Hale Na Koa replacement housing area was conducted from February 20, 2006, through April 5, 2006 and included multi-increment sampling of soil for chlordane, dieldrin, and aldrin.[41] At the

36 (Tetra Tech 2004b)
37 (Tetra Tech 2004b)
38 (Tetra Tech 2005)
39 (Tetra Tech 2006c)
40 (Tetra Tech 2006e)
41 (Tetra Tech 2006b)

time this sampling occurred, the former buildings and foundations had been removed, the Site had been graded, and the new buildings had been constructed. New parking areas had not yet been paved, so these areas were sampled. The Site was not yet at final grade, but was at minus four inches, awaiting import of topsoil for landscaping. Therefore, the soil that was sampled would subsequently be 4 to 10 inches below final grade.

The results indicated that aldrin and dieldrin were either not detected or were detected at concentrations well below the respective Tier 2 EALs. Chlordane was detected in all samples, at concentrations ranging from less than 1.0 mg/kg to 36.70 mg/kg. Samples from twelve decision units (DUs) exceeded the Tier 2 screening level for chlordane of 23.4 mg/kg. Additional risk contributed by dieldrin and aldrin caused an additional eight DUs to exceed the cumulative carcinogenic risk threshold of 1 x 10-5, based on the EALs in effect at the time. No geographic trends were apparent in the distribution of the concentrations, and it appeared that the concentrations represented a relatively random redistribution that may have resulted from earth moving operations (filling and grading) during construction.

Post-Construction/Pre-Occupation Sampling. Between November 2006 and February 2007, after the buildings were constructed, the portions of the DUs identified from the previous sampling as containing soils associated with cumulative carcinogenic risks in excess of the goal of 1 x 10-5, that were not covered by hardscapes, were excavated an additional eight inches to a depth of 12 inches below final grade. (The excavated soil was transported to Earhart I-2, where it was reportedly placed as backfill in utility trenches.) Confirmation sampling of the soils exposed on the floors of the excavated areas was performed between November 2006 and February 2007. Although some of the confirmation samples contained chlordane concentrations above the Tier 2 screening levels, these soils were subsequently covered with at least one foot of fill, as required under the MPPIS.[42] The soil used to fill the excavations included soil from previously-tested stockpiles left from initial rough-grading of the Study Area. The testing showed that these soils contained chlordane concentrations of 11 to 13 mg/kg, and no detectable aldrin or dieldrin, and were thus suitable for use as fill.

Post-Occupation Verification Sampling. On June 3 and 4, 2010 HC conducted an investigation of the Hale Na Koa I-1 neighborhood to confirm that the exposed soils were within the cumulative risk goal for the program. The neighborhood was divided into eleven DUs, which were sampled on June 3 and 4, 2010. Each multi-incremental sample consisted of 50 increments. The sampling design involved DUs of various sizes, but the boundaries of the DUs were designed to correspond to combinations of the same DUs that had been sampled during the investigations of February through April 2006. Five of the DUs matched the boundaries of DUs that had previously exceeded the Tier 2 criteria and had been excavated to one foot below final grade. These DUs were sampled at depths of 0- to 6-inches, and at 6- to 12-inches. The remaining six DUs represented larger groupings of the previous DUs, and were sampled at 0- to 6-inches only.[43] It should be noted here that in their review of the results from this investigation, HDOH questioned the design of the sampling program, because some DUs were much larger than the one-half-acre size typically appropriate for representing a residential exposure area. However, analysis of the results of the investigation suggest that it would be highly improbably for soils in any contiguous one-half-acre area, within the DUs actually sampled, to exceed the screening levels applicable at the time. Based on the risk discussion in Chapter 11, it is even less likely that any of the shallow soils within Hale Na Koa exceed the current risk-based standard.

[42] (Tetra Tech 2006e)
[43] (Tetra Tech 2010q)

The concentrations in all of the samples were below the EALs in effect at the time. Aldrin was not detected. Dieldrin was detected at low concentrations (up to 0.06 mg/kg) in all of the samples. Chlordane was detected at concentrations ranging from 1.8 to 17 mg/kg. The higher concentration is consistent with the concentration in the stockpile soil used as fill. Concentrations in the 6 to 12 inch samples were generally higher than in the 0 to 6 inch samples, likely due to the effect of placing four inches of clean topsoil containing mulch over the area. The risks presented by the residual concentrations indicated by the results of the June 2010 are further discussed in Chapter 11, and in Appendix E of this report.

3.2.2 Previous Investigations of Earhart Village

Due Diligence. As discussed above, the 2004 Phase I ESA for the Phase I development area, identified past termiticide use as a potential REC and recommended sampling to evaluate pesticide concentrations in soils throughout the Phase I development area.

The Phase II ESA that followed included sampling at three locations next to building foundations and 16 locations abutting transformers, where discrete shallow soil samples were collected before building demolition for analysis of metals, PCBs, pesticides, and herbicides. Dieldrin was detected in three samples, at concentrations slightly above the HDOH Tier 1 Environmental Action Level of 0.03 mg/kg.[44] Tetra Tech recommended additional sampling beneath and next to building foundations to further characterize the pesticides and recommended developing a management plan to protect workers and future residents.

Pre-Demolition Open Area Sampling. In April 2006 Tetra Tech performed shallow soil sampling to characterize pesticide occurrence in the Earhart housing area. [45] The results were reported in a combined report that included the results from Hale Na Koa described in Section 3.2.1. Discrete soil samples were collected from selected points to the west of the Earhart I-4 area and multi-incremental (MI) samples were collected from common areas in the Earhart I-2, I-3, and I-4 areas.

The results of the MI sampling of the common areas in Earhart I-2, I-3 and I-4 were very similar. Aldrin, dieldrin, and chlordane were not detected in the MI samples from Earhart I-3 and I-4; dieldrin was detected at the HDOH Tier I EAL (0.03 mg/kg) in the MI sample from Earhart I-2, which was only slightly above the analytical detection limit. Moreover, the results of these three samples were similar to the results of the 15 discrete and MI samples collected in the other parts of the Earhart Village Housing Area. Aldrin and chlordane were not detected in those samples, and dieldrin was detected at concentrations ranging from about 0.01 to 0.16 mg/kg. These results provide an indication of the baseline conditions within the common areas of the Earhart Village Housing Area prior to building demolition and construction.

In order to characterize the distribution of pesticides in the target areas of the Study Area, where construction was to be located, the Earhart I-2, I-3, and I-4 areas were divided into 59 approximately 1.5-acre DUs containing an average of one to two residential buildings. (A figure showing the locations and identification numbers assigned to the DUs is presented in Appendix A). MI samples consisting of a minimum of 40 sample increments were collected from each of the DUs.

[44] (HDOH 2011b)
[45] (Tetra Tech 2006a)

The results of this investigation were summarized in a memorandum dated September 1, 2006 that is included for reference in Appendix A.[46] The results were generally consistent with the previous sampling of the common areas. Concentrations of all of the pesticides were low, and dieldrin and aldrin concentrations were nearly all below the method detection limit (MDL) or the practical quantitation limit (PQL). Chlordane concentrations were generally below the HDOH Tier 1 EAL of 1.6 mg/kg. Duplicate sample DU I-2-2D contained a concentration greater than the 2006 HHRA EAL, but the concentration of dieldrin in the normal sample from that DU was lower than the HDOH Tier I EAL by a factor of 10.

Pre-Demolition Sub-Foundation Sampling. In February 2007, as some of the buildings were vacated for demolition, Tetra Tech sampled beneath the slabs of eight of the buildings in the Earhart I-2 area and one building in the Earhart I-3 area. The investigation confirmed the presence of pesticides at elevated concentrations relative to the 2006 HHRA EALs beneath some of the slabs. Appendix A includes a figure showing the locations of the buildings in which subfoundation core samples were collected. The samples consisted of composite samples from five points in each building. Each of the sample locations was accessed by drilling a hole through the foundation slab, hand augering to a depth of 18 inches, and collecting six-inch core samples representing the depth intervals from 0 to 6 inches, 6 to 12 inches, and 12 to 18 inches. All of the six-inch cores from the same depth in a building were combined to form a five-point composite sample representing that depth interval.

The results showed a high degree of heterogeneity, with concentrations ranging from below the 2006 HHRA EALs to many times higher than the 2006 HHRA EALs. (It should be noted that this heterogeneity could have been the result of the small number of composite sample points, which were far fewer than the 30 to 50 increments normally included in a multi-increment sample). The primary constituents encountered were dieldrin and aldrin. Pesticides were either not detected or were detected at or below the PQL in the samples from Buildings 7186 and 7403, which are south of Ohana Nui Circle, at the southern edge of Earhart I-2 and Earhart I-3. The subslab soil concentrations at these two buildings were consistent with those found in the common areas. These buildings were of different construction than the buildings north of Ohana Nui Circle and may not have been treated with pesticides in the same way or to the same extent as other residential buildings in the Earhart Village neighborhood.

In April 2007, in order to further investigate the depth of pesticide occurrence beneath the foundation slabs, Tetra Tech collected additional core samples from depths of 18 to 24 inches and 24 to 30 inches in three of the buildings previously sampled. The results were consistent with the results from the shallower samples, suggesting that pesticides were present beneath the foundation slabs to depths of more than 30 inches. Based on these results, Tetra Tech concluded that soil beneath the foundation slabs would contain pesticides to any depth and would be managed as such, unless sampling results confirmed otherwise. No further soil investigations were conducted in Earhart Village until post-construction sampling was conducted at the Earhart I-4 neighborhood in 2009, as described in Section 3.2.4, below.[47]

3.2.3 Previous Investigations of Onizuka Village

Due Diligence. Onizuka Village was included in development Phase II of the MHPI program at JBPHH. In 2007 a Phase I ESA for the development Phase II properties was conducted, and

[46] (Tetra Tech 2006d)
[47] (Tetra Tech 2007c)

the Onizuka Village area was included as one of the subject properties.[48] No RECs were identified in connection with past uses of the Onizuka Village area, although pesticides in soil were identified as a potential concern.

During the Phase II ESA surface and subsurface investigation,[49] conducted multi-incremental soil sampling of the Onizuka Village area in May of 2007. Samples were collected to test driplines of buildings and common areas for the presence of organochlorine pesticides in soil. One common area DU, eight dripline DUs, and eight foundation pad DUs were sampled within the Onizuka Village housing area. Common area and dripline MI sample locations are shown in the 2007 report, provided in Appendix A.

Pre-Demolition Open Area Sampling. Tetra Tech collected three common area MI samples (including one triplicate sample) within Onizuka Village MFH Common Area 1 on May 10, 2007. It was anticipated that common area soil would be disturbed during the new home construction within Onizuka Village during renovation. Lead, methoxychlor, dichlorodiphenyltrichloroethane (DDT), and dichlorodiphenyldichloroethylene (DDE), were detected at concentrations above the laboratory PQL but below the 2006 HHRA EALs. Alpha-chlordane, a constituent of technical chlordane, was detected, but technical chlordane was not. No other organochlorine pesticides were detected within the common area, nor was asbestos detected.

On May 16 and 17, 2007, the driplines of eight buildings were sampled, including one triplicate sample at building 2346. Endosulfan II, DDT, DDE, endrin, endosulfan sulfate, methoxychlor, technical chlordane, and lead were all detected, but at concentrations below the 2006 HHRA EALs.

Eight foundation pad DUs in Onizuka Village were sampled between May 25 and 30, 2007 at buildings scheduled for demolition. Boreholes were drilled around the exterior of the homes approximately 1 to 3 feet from the outer edge of the building foundations. Technical chlordane, dieldrin, and other organochlorine pesticides were detected, but concentrations of chlordane and dieldrin were below 2006 HHRA EALs.[50]

Pre-Demolition Sub-Foundation Sampling. Tetra Tech collected multi-incremental samples of soil beneath concrete foundations from Buildings 2310, 2376 and 2390 at the Onizuka Village Neighborhood Stage 1 construction area between March 5 and March 10, 2008, as part of a predemolition investigation.[51] In addition, predemolition subfoundation sampling was conducted at three of the buildings in the south Onizuka Village area (Appendix A) by coring through the foundation slabs. These predemolition samples were composited from nine core locations, with increments collected at 0.5-foot depth increments (0-0.5, 0.5-1.0, 1.0-1.5, and 1.5-2.0 feet).

The samples were analyzed by Torrent Laboratory in Milpitas, California, and one set of split samples was analyzed by Test America Honolulu, ʻAiea, Oʻahu. All samples from the 1.0- to 1.5-foot interval were put on hold and were not analyzed, pending evaluation of the results from the other samples. Results for chlordane, aldrin, and dieldrin are listed in Appendix A. Only chlordane concentrations exceeded the site-specific 2006 HHRA EALs.

48 (Tetra Tech 2007a)
49 (Tetra Tech 2007b)
50 (Tetra Tech 2007b)
51 (Tetra Tech 2008)

Chlordane was detected in the subfoundation soil at concentrations ranging from 0.638 mg/kg to 45.8 mg/kg in the south Onizuka Village area. Concentrations above the 2006 HHRA EAL of 23.4 mg/kg were detected in the three soil samples collected at the 0-0.5-foot depth. The results suggested that below 0.5 feet, chlordane concentrations were below the 2006 HHRA EALs. The average chlordane concentration in samples collected from a depth of 0-0.5 foot was 32 mg/kg, while the average concentration in the samples collected from 0.5-1.0-foot depth was 5.5 mg/kg, and the average concentration in the 1.5-2.0-foot depth samples was 3.2 mg/kg. Dieldrin and aldrin were not detected.

The results of samples of soil from within the foundation footprints of selected buildings in the Onizuka Village area suggested that the soil had been treated with chlordane rather than aldrin and dieldrin. Based on the observed concentration profile with depth, it was hypothesized that the soil had been treated with moderate applications of chlordane by spraying the soil prior to pouring the foundations and that concentrations above the 2006 HHRA EAL for chlordane might be limited to the upper six inches of soil beneath the foundations.

The consistently low concentrations of organochlorine pesticides in the soil samples below 0.5 foot suggested that if the upper 0.5 foot of soil were removed after the foundation slabs were removed, the remaining soil left in place might not need long-term management and could be used without restriction. Additional sampling was recommended to confirm this.

Post-Demolition Subfoundation Sampling. Tetra Tech performed sampling at the Onizuka Village Neighborhood Stage 1 construction area on August 1, 2008. Multi-incremental confirmation soil samples were collected within the footprints of former Buildings 2391, 2392, 2393, 2394, 2390, 2389, 2387, and 2385, where the concrete slabs and the initial six inches of soil from under the slabs had been removed. Incremental subsurface samples were collected at thirty points distributed beneath the area of each former building at a depth of 0 to 0.5 foot.

Chlordane was detected at concentrations ranging from 11.6 mg/kg to 62.6 mg/kg in the confirmation soil samples. Three of the samples had concentrations (61.8 mg/kg, 62.6 mg/kg, and 40.7 mg/kg) above the site-specific 2006 HHRA EAL of 23.4 mg/kg. Chlordane concentrations in the remaining soil samples ranged from 12 to 22 mg/kg. The arithmetic mean concentration for the eight samples is 31.5 mg/kg. Again, the results supported the conclusion that technical chlordane was the primary termiticide applied in the Onizuka Village area. On the basis of these sample results, it was assumed, for construction purposes, that all of the subfoundation soil in the Onizuka II-1 area were pesticide-impacted (PI) soil and would require long-term management in accordance with the PI Soil Management Plan.[52]

3.2.4 Post-Construction Discovery of PI Soil in Open Areas of the Site

Post-Construction Verification Sampling of Earhart I-4. On August 31, 2009, surface soil samples were collected from four DUs delineated in the Earhart I-4 neighborhood in areas where new construction was nearing completion. At this time, all PI soil should have been covered by at least one foot of acceptable fill soil, or by hardscapes. The samples were intended to check the quality of post-demolition PI soil management. The analytical results indicated that the soil in all four DUs contained dieldrin and aldrin concentrations exceeding the 2006 HHRA environmental action levels (EALs) established for the HC project.[53] Based on the results of this investigation, the Earhart I-4 neighborhood was subdivided into smaller DUs in

[52] (Tetra Tech 2008)
[53] (Tetra Tech 2009a)

order to further delineate areas of PI soil and sampling of these DUs was conducted in September and October 2009.[54] Additional sampling was conducted on December 3, 2009, and the results were presented in a report entitled *Letter Report on Results of Additional Open Area Verification Sampling at the Earhart 1-4 Neighborhood, Hickam Air Force Base, O'ahu, Hawai'i*.[55]

Since the concentrations of pesticides in the soil throughout the Earhart I-4 neighborhood exceeded the site-specific criteria established for soil exposed at the ground surface, HC reported the results to HDOH and developed a corrective action plan to remove and replace the exposed PI soil in the upper one foot throughout the Earhart I-4 neighborhood. The plan called for excavation of a borrow pit in the Onizuka II-3 neighborhood where uncontaminated soil was obtained for use as replacement fill at Earhart I-4. The borrow pit was then converted into a burial pit to receive PI soil removed from the Earhart I-4 neighborhood for long term management (see Figure 1-1 and Figure 3-1). The plan for this action was approved by HDOH in January 2010. The soil replacement action was completed in April 2010. The progress of the replacement action was documented with daily observation logs, and its completeness and effectiveness was documented by confirmation soil sampling conducted at the conclusion of each phase of the replacement action.[56]

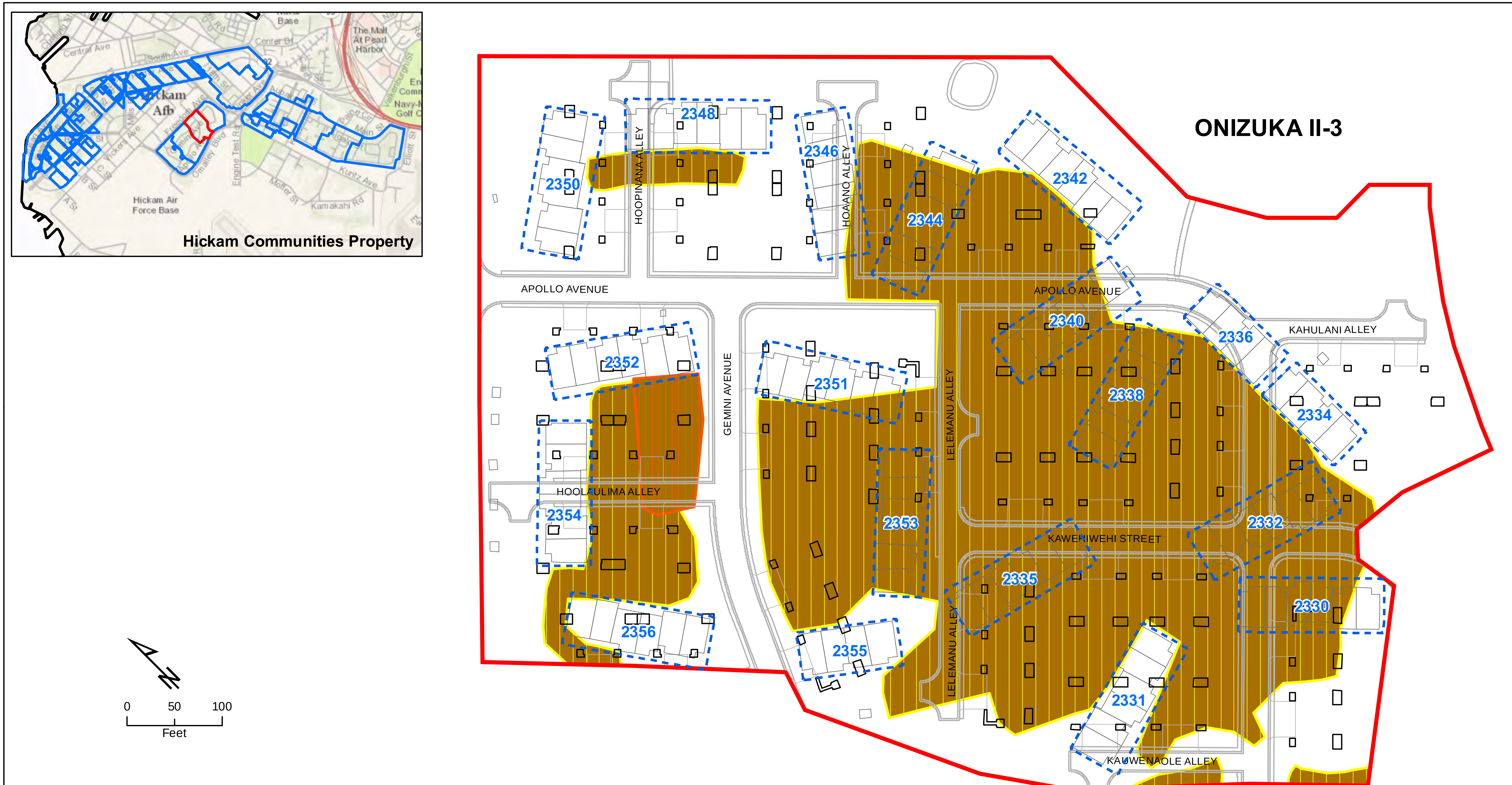
The observation of PI soil (soil that exceeded the site-specific risk-based standard established for the HC project area) in the Earhart I-4 area raised concern that PI soil might be present in the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods, where preconstruction PI soil management had been conducted according to similar procedures. Unlike the Earhart I-4 neighborhood, which was not yet occupied by residents at the time of discovery of the PI soil at the surface in open areas, these three neighborhoods had already been occupied.

Post-Construction Verification Sampling of Onizuka II-1. On May 25, 2010, an investigation of the Onizuka II-1 neighborhood was conducted to evaluate the effectiveness of PI soil management at the Study Area.[57] The neighborhood was divided into five large DUs, and MI samples were collected from depth intervals of 0 to 6-inches and 6 to 12-inches from each DU. Samples from two of the DUs contained concentrations above the site-specific 2006 HHRA standard established for the project area. One of the DUs in which the standard was exceeded corresponded to the northwest corner of the property in which the Housing Office and Maintenance Facility is located. This area is not intended for residential use. Only the 6- to 12-inch sample from this area exceeded the PI soil standard. The combined concentrations of the pesticides detected in the MI samples from DU-3, located on the east side of the neighborhood, slightly exceeded the cumulative excess carcinogenic risk (ECR) threshold of 10^{-5} based on the risk assumptions assumed at the time.

Post-Construction Verification Sampling of Earhart I-2. In order to evaluate soil in the Earhart I-2 neighborhood, the neighborhood was divided into 10 large DUs, and MI samples were collected between June 1 and 3, 2010, from each DU at depths of 0 to 6-inches and 6 to 12-inches. Comparison of the results to the site-specific 2006 HHRA standard established for the project area indicated that the standard was exceeded in all of the 0-6-inch DUs and in all but one of the 6-12-inch DUs.[58]

[54] (Tetra Tech 2009c)
[55] (Tetra Tech 2009d)
[56] (Tetra Tech 2010a, 2010b, 2010d, 2010h, 2010L, and 2010m)
[57] (Tetra Tech 2010c)
[58] (Tetra Tech 2010e)

This page intentionally left blank



This is a draft map. The final topographic map for the burial pits is still outstanding.

Onizuka II-3 Boundary

New Building Footprints

Roads

Burial Pits

Old Building Footprints

Burial Pit #6b

Notes:

- **Inset map shows Hickam Communities Property Boundary Line.**
- **Within the burial pits, PI soil is expected under building foundations and in utility trenches**
- **An orange geotextile marker layer has been installed between the clean soil cap and the PI soil**
- **Within burial pits, all soil removed from deeper than 1 foot has to be assumed pesticide-impacted unless tested**
- **Within burial pits, PI soil has been placed up to an elevation of 5 feet amsl**

TETRA TECH

Onizuka II-3 Burial Pits

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

Figure 3-1

R:\NEW\29064\Layouts\Onizuka II-3 Burial Pits.mxd 04/26/12 - YE

Post-Construction Verification Sampling of Earhart I-3 A similar investigation was conducted in the Earhart I-3 neighborhood between June 8 and 9, 2010. The neighborhood was divided into seven large DUs, and MI samples were collected from the 0-6-inch and 6-12-inch

3.2.5 Remedial Investigation Planning

After discovery of pesticide concentrations that exceeded the 2006 HHRA EALs, HC worked with HDOH to develop a strategy for characterizing the Study Area and the nature of the threats it posed to human health and the environment, and to identify appropriate actions to address those threats. It was agreed that multi-increment sampling would be an appropriate methodology to use to characterize the Study Area. It was further agreed, based on the initial verification sampling results described in Section 3.2.4, that Earhart I-2 and Earhart I-3 presented the greatest threats, and that each should be sampled in their entirety. The results of verification sampling of Onizuka II-1 suggested that soils there probably presented a lower level of threat, and could be sampled more selectively to assess the nature of the threat in phases, if appropriate, with the first phase focusing on the portions of the neighborhood where the verification sampling had indicated concentrations above the 2006 HHRA EALs. The existing evidence from the verification samples suggested that it might be necessary to conduct expedited removal actions to reduce some of the highest risks posed by the Site, and due to the size of the area involved, one of the objectives of planning the Remedial Investigation was to prioritize the responses so that the highest risks could be addressed first.

Field Split Multi-Increment Sample Collection. To demonstrate that the standard MI sampling procedures used in the Remedial Investigation would be acceptable to HDOH, a test of the procedure was performed under controlled conditions. From June 21 to June 23 one DU in the southeast corner of the Earhart I-2 neighborhood was sampled by HDOH and triplicate MI soil samples were collected from the upper one foot of soil. (The DU sampled in this investigation was later given the designation of DU-63a.) In addition, one discrete sample was collected from a depth of 12 to 24 inches. “Split samples” were provided to HC, and these samples were analyzed by Torrent Laboratory in Milpitas, California. The results from this investigation indicated concentrations of pesticides exceeding the 2006 HHRA EALs. Reports describing the investigation and results are included in Appendix B.[59]

Remedial Investigation Sampling Plan. In response to HDOH direction, HC prepared sampling and analysis plans for a comprehensive investigation of the Earhart I-2, Earhart I-3 and Onizuka II-1 neighborhoods[60], which were subsequently approved by HDOH. As described in detail in Chapter 4.0, the areas to be sampled were divided into approximately 5,500 square foot or smaller exposure areas corresponding to back yards, front yards, children’s playgrounds, and common areas.

The investigations were conducted from August through October 2010, and the results of the investigation are described in detail in the remainder of this report.

[59] (Tetra Tech 2010g; ETC 2010)
[60] (Tetra Tech 2010i and 2010j)

This page intentionally left blank

4.0 SUMMARY OF DATA QUALITY OBJECTIVES

4.1 Problem Statement

Based on initial sampling of several large areas of the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods, concentrations of organochlorine pesticides including aldrin, dieldrin, and chlordane, were observed at concentrations above the 2006 HHRA Screening Levels established for the Site. These compounds were found in surface soil in areas where residents could be exposed to the soil, contrary to the Management Plan for Pesticide-Impacted Soil developed to address this soil.

After these results were reported to HDOH, a decision was made to undertake a Remedial Investigation, followed by implementation of appropriate remedial actions consistent with requirements of the State Contingency Plan in the Hawaiʻi Administrative Rules (HAR) Title 11, Chapter 451 and the HDOH hazard evaluation and emergency response (HEER) Technical Guidance Manual (TGM).

The primary objective of the Remedial Investigation is to identify and address risks to residents and the environment associated with residual pesticide concentrations in shallow soil (the upper one foot of soil across the Study Area), including prioritizing the order of addressing these risks so that any risks perceived to justify immediate action would be addressed in a timely fashion by implementing removal actions. A further objective of the Remedial Investigation is to assess the future long-term risks posed by the pesticides in soils throughout the Site and at any depth, under reasonably-anticipated future exposure scenarios.

4.2 Conceptual Site Model

The conceptual model for the Site includes several components:

- A conceptual model of the pre-construction (pre-disturbance) distribution of pesticides;
- A conceptual model of the post-construction distribution of pesticides;
- A conceptual model of the environmental fate and mobility of the contaminants; and
- A conceptual model of the exposure pathways related to the pesticides.

Each of these components informed the development of the Remedial Investigation of the Site and are briefly discussed here as the basis for the investigation design. The Remedial Investigation was used to test the conceptual model. Further discussion of the final conceptual model for the Site is presented in Chapter 13.

Pre-Construction Distribution of Pesticides. For purposes of this discussion, pre-construction refers to the conditions that were present before construction activities (grading, demolition, excavation) resulted in disturbance of soils at the Site. Based on information from investigations conducted to date, organochlorine pesticides were applied in the past to treat the soil beneath and adjacent to the foundations of the former residential buildings at the Site. Chlordane was the principal pesticide applied to soil in the Onizuka Village neighborhood, while dieldrin and aldrin were the principal pesticides used in the Earhart Village neighborhood.

Pre-demolition sampling of the common areas between buildings indicated very low pesticide concentrations in those soils, consistent with the assumption that pesticide treatments were confined to the immediate footprints or perimeters of the building foundations.

No record of other buildings, beside those present at the outset of development of the Phase I and Phase II projects, was discovered.

Preconstruction sampling of soil beneath selected building foundations revealed elevated concentrations of organochlorine pesticides within the depths sampled. Most of the subfoundation soil sampling has been limited to shallow depths within two feet below the foundation slabs. At the few locations where samples were collected from depths of three feet or more, elevated pesticide concentrations were also found; therefore, pesticides are assumed to be present in soil within the former footprints of the residential buildings at the Site to a depth of at least four feet.

Post-Construction Distribution of Pesticides. By "post-construction" is meant after the Site was substantially built out to its final configuration, and no further soil-disturbing activities (other than for maintenance, or other minor or discrete activities) would occur. During Site preparation, in accordance with the soil management procedures in effect at the time, PI soil was to be excavated from building footprints to a depth of one foot below the final grade. The excavated soil was to be staged on the Site pending final disposition of the soil. During construction, the soil was to be placed beneath new hardscapes, including roads, parking lots, sidewalks, and buildings. In addition, PI soil was used to backfill utility trenches. In all open areas, at least one foot of clean soil was to be placed over the PI soil as a barrier to prevent exposure. PI soil is presumed to be present within the footprints of the former buildings, beneath hardscapes, and in utility trenches, unless otherwise documented. At HDOH's direction, use of PI soil to fill utility trenches was discontinued in 2010. (An exception to this rule would be in specific areas where the trenches traversed PI soil, such as through burial pits or former building footprints, and PI soil would have been replaced in the trenches.)

Based on sampling conducted at the adjacent Earhart I-4 neighborhood after construction was nearly completed, preliminary investigations of the Earhart I-2, Earhart I-3, and Onizuka II-1, and Hale Na Koa areas were undertaken to determine whether inadvertent cross-contamination by PI soil had occurred. The preliminary investigation revealed that pesticide concentrations exceeded the 2006 HHRA goals in common areas of the Earhart I-2 and Earhart I-3 areas. The results for soil in common areas of the Onizuka II-1 neighborhood indicated that pesticide concentrations were generally below the 2006 HHRA levels, except in two subareas of the Site where the concentrations were slightly above 2006 HHRA levels. The results of the investigation of Hale Na Koa indicated that PI soil was not exposed at the surface in open areas. The results of these investigations are described in Section 3.2.

Following the initial investigations, a more detailed investigation was designed to evaluate the distribution of pesticides within the Site and the risk posed to residents and the environment. That investigation is described in Chapters 4 through 10 of this report.

Environmental Fate and Mobility of the Organochlorine Pesticides. The organochlorine pesticides that have been identified as the principal chemicals of concern at the Site are relatively immobile in the environment. They adsorb strongly to soil particulate matter and especially to the natural organic matter present in soil. Leachability studies using soil samples from the Site indicate low leaching potential.[61] Further discussion of the fate and mobility of these chemicals is presented in Chapter 11.

Exposure Pathways. The primary human health risk posed by these chemicals is through ingestion, inhalation of particulates, and direct contact/dermal absorption. The Site action levels took into consideration specific conditions associated with conditions at a military base, such as the number of years that military families would likely occupy the housing units, and the degree of assurance that residents would not encounter PI soil in the subsurface due to controls on gardening and digging enforced at the Site. Further discussion of exposure pathways is presented in Chapter 11.

4.3 Decision Unit Design

Based on the conceptual model of the sources, distribution, and primary routes of exposure to pesticides at the Site, a detailed investigation of the Study Area was designed, using the multi-increment sampling approach to identify the average concentrations of organochlorine pesticides in DUs. In order to evaluate all of the soil within open areas of the Site, the Earhart I-2 and Earhart I-3 areas were subdivided into DUs based on four classes of exposure: playground areas intended for use by children; front yard areas, extending from the front edges of the buildings to the street and including unpaved areas adjacent to driveways; backyards, extending at least 30 feet to the rear of the buildings and including side yards between buildings; and common areas, consisting of all other unpaved land. The maximum size of the DUs was set to 5,500 square feet of open areas, determined on the basis of available as-built GIS maps of the Study Area. The 5,500-square-foot constraint was based on EPA guidance that suggests residential exposure areas should be limited to approximately 5,000 square feet. Since the EPA guidance is based on a typical single-family residential lot, and because all of the residences in the Study Area are multifamily buildings, the criterion was interpreted as accurate to one significant figure to allow for site-specific conditions.

In the Onizuka II-1 Area, a slightly different approach was taken. Since the preliminary investigation of the Onizuka II-1 Area indicated that PI soil (soil with concentrations above the 2006 HHRA screening levels) were limited to the northeast corner of the Study Area (previously identified as DU-5), and because the highest concentrations observed in DU-5 were significantly lower than concentrations observed in the Earhart areas, detailed sampling of the Onizuka II-1 area focused on the area encompassed by DU-5. Therefore, in addition to identifying the magnitude of risk presented by pesticides above the 2006 HHRA screening levels within this subarea of Onizuka II-1, a second objective was to evaluate whether the results of the detailed sampling were consistent with the previous results at the scale of the smaller exposure areas and to assess whether further fine-scale investigation of the Onizuka II-1 area would be needed.

Underlying the design of the DUs is the assumption that the upper one foot of soil consists of one of the following:

- Relatively undisturbed soil that was not previously impacted by pesticides applied for termite control;

[61] (Tetra Tech 2009b)

- Soil placed, in accordance with the pesticide-impacted soil management plan, to provide one foot of “clean” (not PI) cover over undisturbed soil within the footprints of former buildings or to cover PI soil placed in utility trenches; or
- PI soil that originated from excavating footprints of former building that were improperly placed or graded into open areas.

As discussed in Chapter 7, some of the DU boundaries were modified in the field due to conditions that were not known at the time the DUs were defined. Tables 4-1 through 4-3 and Figures 4-1 through 4-3 present the DUs and their boundaries.

4.4 Decision Rules

4.4.1 Introduction

Table 4-1 lists the decision rules used in the Remedial Action. The derivations of the standards are discussed in detail in Chapter 10 (Removal Actions), and Chapter 11 (Environmental Hazard Evaluation).

Decision criteria are context-specific; that is, specific actions apply to specific land uses or environments, and different criteria may be appropriate if those uses or environments are limited to a specific range.

In each DU, multi-increment samples were collected, consisting of 30 to 50 increments collected from throughout the DUs. Increments were collected from two depth intervals (0 to 6-inches and 6 to 12-inches) at each of the sampling points, as described further in Chapter 7. Each multi-increment sample is considered to be representative of the average concentration in the depth interval sampled. Since soil within the upper one foot may have been disturbed and mixed to various degrees by grading, collection of samples from two depths can also provide a measure of the homogeneity of the pesticide concentrations within the upper one foot.

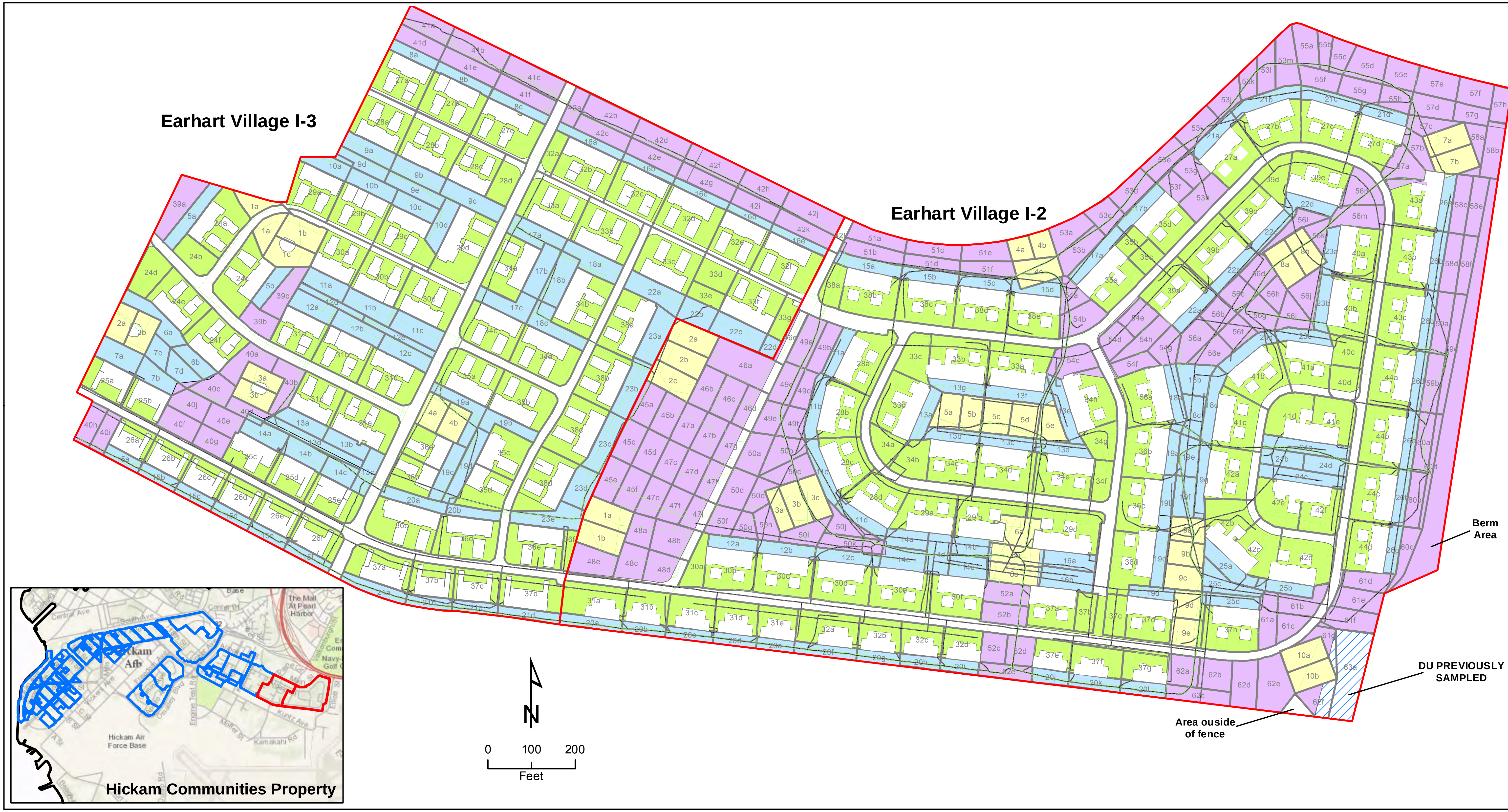
The investigation was designed under the assumption that the decision for each DU would be made independently of the other DUs, based on the cumulative risk represented by the combined concentrations of pesticides present in the soil in each DU and depth interval.

The HDOH Tier 1 EALs represent default standards that apply anywhere that the underlying exposure assumptions on which the standards are based are met. Therefore, soil that meets the HDOH Tier I EALs are not restricted to on-site use.

HC Human Health Risk Assessment (HHRA) standards were developed for the housing properties in 2006 using site-specific assumptions about exposure duration and the acceptable level of risk.[62] At the beginning of the Remedial Investigation, the 2006 HHRA standard was used in developing the Removal Actions conducted at the Site.

The Analysis of Potential Remedial Alternatives (APRA) standards were interim site-specific standards developed in consultation with HDOH to address concentrations exceeding the 2006 HHRA standards that were observed in samples from the Earhart I-2 and Earhart I-3 housing areas during the preparation of a detailed health evaluation.[63]

[62] (Tetra Tech 2006c)
[63] (Tetra Tech 2010n)



Earhart Village I-2/I-3	10b Decision Unit Number
Hardscapes	
Backfill Utilities	
Utilities	

Areas

- Playground Areas
- Common Areas
- Front Yard
- Backyard

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Decision Unit at Earhart I-2 and I-3

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 4-1

Onizuka Village II-1

10 b Decision Unit Number

Hardscapes

Backfill Utilities

Utilities

Areas

Playground Areas

Common Areas

Front Yard

TETRA TECH

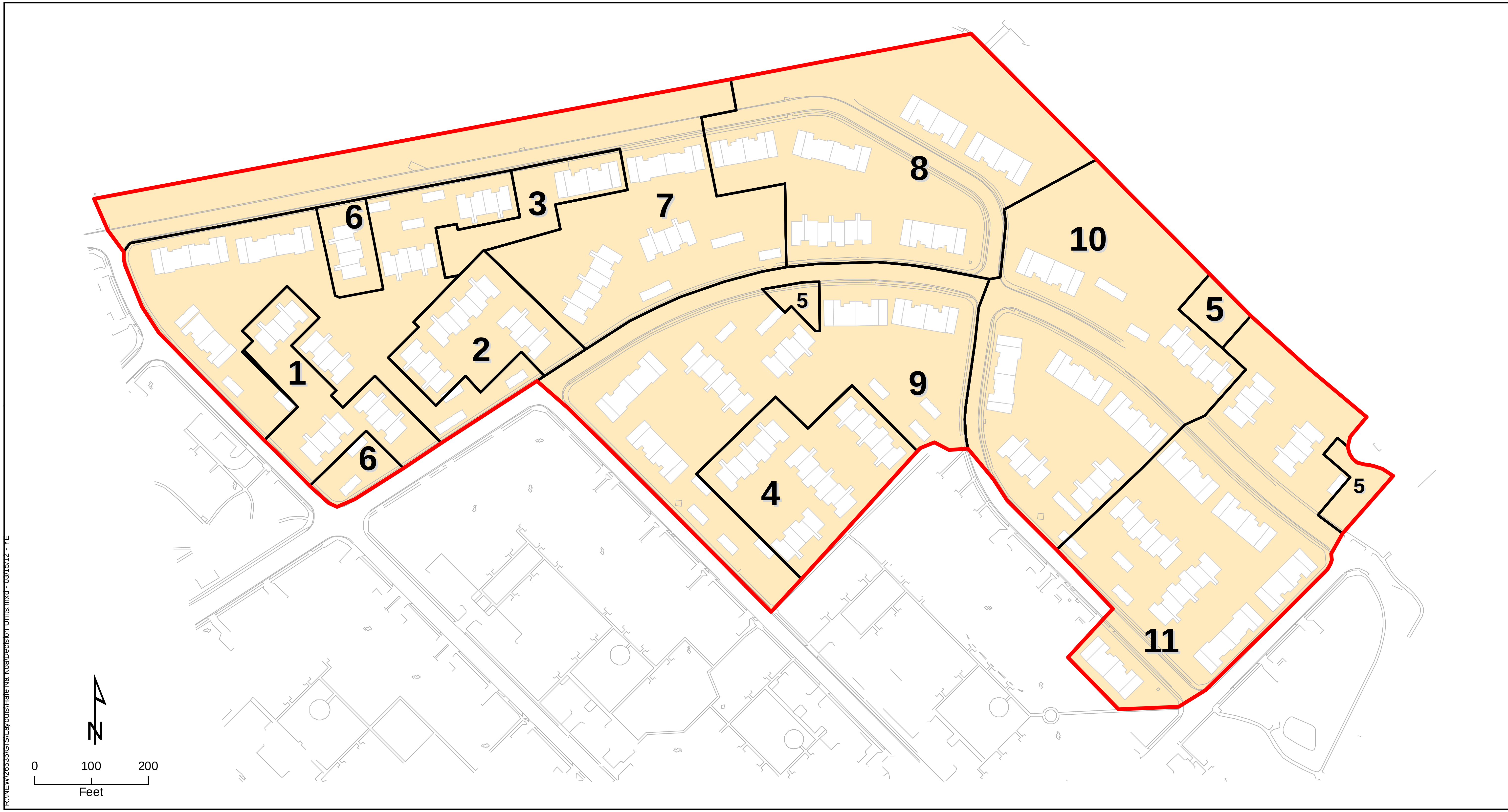
Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Decision Units at Onizuka II-1

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 4-2



Hardscapes

Hale Na Koa I-1

1 Decision Unit Number

Decision Units at Hale Na Koa
Hickam Communities

Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

TETRA TECH

Figure 4-3

Table 4-1. Decision Rules Used in the Remedial Investigation

Applies to	Standard	Action to be taken if standard is exceeded	Removal Action[64]
All Soils, any depth	• HDOH Tier 1 EALs	Restricted use within HC ground lease if meets 2011 HHRE Standard	NA
Upper one foot, in open areas	• 2011 HHRE Standard[65]	Replace top 6 inches of soil	**RO-3**
Below one foot or under hardscapes	• 2011 HHRE Standard	Evaluate alternatives to address future reasonably anticipated exposure scenarios	NA
Bare soil areas	• APRA 1 (2011 APRA Standard with HI >1)[66]	Inspect and reseed grass cover in bare soil areas	**RO-2C**
Landscaping strips with plants to be retained	• APRA 2 (2011 APRA Standard with HI >1)	Remove low ground cover vegetation, place geotextile and gravel around remaining plants	**RO-2B2**
Landscaping strips with replaceable vegetation	• APRA 2 (2011 APRA Standard with HI >1)	Remove all vegetation, place geotextile beneath gravel bed	**RO-2B1**
0 to 12-inch depth	• APRA 3 (2011 APRA Standard with HI >1)	Replace top 12 inches of soil	**RO-2A**
0 to 6-inch depth	• HHRA 3 (2006 HHRA Standard[67] with HI from >3 to ≤10)	Replace top 12 inches of soil	**RO-1B**
0 to 12-inch depth	• HHRA 2 (2006 HHRA Standard with HI >10)	Replace top 12 inches of soil	**RO-1A**

The 2006 HHRA Standard was superseded by the "2011 Human Health Risk Evaluation (HHRE) Standard", which was developed during preparation of the *Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities* (*HHRE WP*).[68] The 2011 HHRE standard and the subsequent 2012 EHE Standard are described in detail in Chapter 11 and Appendix E.

Soils that exceed the 2011 HHRE Standard are currently managed on-site below one foot of acceptable fill or under hardscapes. The Environmental Hazard Evaluation (Appendix E), which is summarized in Chapter 11, evaluates the risks associated with these soils assuming unrestricted use of the Site (for example, the soil might be exposed if the Site were to be excavated and redeveloped). The Remedial Alternatives Assessment will evaluate options to address the risks associated with reasonably anticipated future exposure scenarios for the Site.

64 Removal Actions discussed in Chapter 10 that were implemented to address the applicable soils during the RI
65 2011 Human Health Risk Evaluation (Tetra Tech 2011e), replaced 2006 HHRA Standard
66 Analysis of Potential Removal Alternatives (Tetra Tech 2010h); interim standard
67 2006 Human Health Risk Assessment Standard (Tetra Tech 2006c)
HHRE: human health risk evaluation
HI: hazard index
68 (Tetra Tech 2011e)

4.4.2 Environmental Action Levels Associated with Relevant Standards

Table 4-2 presents the chemical-specific EALs for the principal organochlorine (OC) pesticides detected at the HC properties associated with each of the standards listed in Table 4-1. The principal OC pesticides at the Site are aldrin, dieldrin, technical chlordane, and the three major compounds associated with DDT: 4,4'-DDT, 4,4'-dichlorodiphenyldichloroethane (DDD), and 4,4'-DDE.

Table 4-2. EALs for the Principal Organochlorine Pesticides in Soil at Hickam Communities Property[1]

Standard	Aldrin (mg/kg)	Dieldrin (mg/kg)	4,4'-DDT (mg/kg)	4,4'-DDD (mg/kg)	4,4'-DDE (mg/kg)	Technical Chlordane (mg/kg)
2005 HDOH EALs	c: 0.029 nc: 1.8	c: 0.030 nc: 3.1	c: 1.7 nc: 36	c: 2.4 nc: -	c: 2.4 nc: -	c: 1.6 nc: 35
2011 HDOH EALs[2]	c: 0.029 nc: 1.8	c: 0.030 nc: 3.1	c: 1.7 nc: 36	c: 2.4 nc: -	c: 2.4 nc: -	c: 16 nc: 35
2006 HHRA	c: 0.42 nc: 1.8	c: 0.45 nc: 3.1	c: 1.7 nc: 36	c: 2.4 nc: -	c: 2.4 nc: -	c: 23 nc: 35
2010 APRA-1	c: na nc: 15	c: na nc: 15	c: na nc: na	c: na nc: -	c: na nc: -	c: na nc: 35
2010 APRA-2	c: na nc: 4.7	c: na nc: 7.7	c: na nc: na	c: na nc: -	c: na nc: -	c: na nc: 35
2010 APRA-3	c: na nc: 1.8	c: na nc: 3.1	c: na nc: na	c: na nc: -	c: na nc: -	c: na nc: 35
2011 HHRE[3]	c: 42.1 nc: 12	c: 20.4 nc: 9.80	c: 46.0 nc: 67.0	c: 48.7 nc: -	c: 34.4 nc: -	c: 23.4 nc: 35
2012 EHE	c: 42.1 nc: 12.2	c: 20.4 nc: 9.80	c: 46.0 nc: 67.0	c: 48.7 nc: -	c: 34.4 nc: -	c: 42.6 nc: 38.3

[1] The EALs shown are for both carcinogenic risk ("c") and non-carcinogenic risk ("nc"), and are used to calculate cumulative risk or HI's, respectively (see explanation in text) . "-" indicates the EAL was not determined. "na" indicates not applicable
[2] (HDOH 2011c)
[3] EALs for other compounds were also developed for the 2011 standard (refer to Chapter 11, and App E).

The EALs applicable to individual pesticide compounds listed in Table 4-2 have evolved since inception of the Hickam Communities housing project as information from current toxicological studies and site-specific data are evaluated. Also, as in the case of the APRA standards, some EALs address specific exposure scenarios. As discussed further in Chapter 10, the APRA standards applied to removal actions, to address immediate (non-carcinogenic) risks. The rationales for each of the standards are documented in the *HHRE WP*[69], and are discussed further in Chapter 11, and in the Environmental Hazard Evaluation report (Appendix E).

Many of the pesticides have EALs associated with both carcinogenic and non-carcinogenic toxicity characteristics. The concentrations shown in bold type in Table 4-2 represent the concentration equivalent to a Hazard Quotient of 1, which is the highest concentration at which adverse toxic effects are not expected to occur from exposure to the individual compound.

[69] (Tetra Tech 2011e)

4.4.3 Using the Site-Specific Standards to Account for Cumulative Effects

Where multiple pesticides are present, the combined effects from similar compounds must be accounted for. For non-carcinogenic effects, this is done by adding the proportional contributions of each compound to a hazard index (HI). An HI of 1 represents the highest level of non-cancer risk at which adverse effects are not expected to occur from multiple contaminants. HI values corresponding to the concentrations in each sample were calculated based on each of the standards used during the project.

Similarly, the cumulative carcinogenic risk from concentrations of multiple compounds can be calculated based on the individual contributions of the concentrations of each individual compound. Carcinogenic risk levels below 1 x 10^{-6} (one excess cancer per million exposed population) is the default risk threshold used by HDOH for lifetime exposure to most individual chemicals of concern. If concentrations exceed this default standard, or if many chemicals are present, then additional evaluation may be needed. Cumulative carcinogenic risk levels ranging from 1 x 10^{-6} to 1 x 10^{-4} are widely considered acceptable by regulatory agencies, provided that the risks are adequately characterized and managed.

The cumulative risk and the HI are calculated using the EALs associated with a given standard, by adding together the individual risks or hazard quotients (HQs) for each compound. The risk from one compound is the concentration divided by the EAL associated with carcinogenic risk, multiplied by the acceptable risk threshold. The HQ is the measured concentration divided by the non-cancer EAL. Thus, for example, if the measured concentration is 86 mg/kg, and the EAL is 43 mg/kg based on an acceptable risk threshold of 1 x 10^{-5}, then the individual risk for the compound is 2 x 10^{-5}. Similarly, if the concentration is 19 and the non-cancer EAL is 43, then the HQ for the compound is 0.5. The cumulative risk is the sum of all the individual risks, and the HI is the sum of all of the individual HQs.

The cumulative risks and the hazard indices (HIs) are calculated for each MI sample, representing each depth interval sampled. The resulting values are then compared to the standard applicable to the location, depth interval, or exposure scenario. For example, using the EALs associated with the 2006 HHRA standard, if the HI of a sample from a depth of either 0 to 6-inches, or 6 to 12-inches, (or both), exceeded 10, then (as indicated in the third column and last line of Table 4-1, the DU would be excavated to a depth of 12 inches and replaced with clean soil. As indicated in the last column of Table 4-1, this rule was applied in Removal Action No. 1. The Removal Actions are further described in Chapter 10.

Prior to 2006, when the first site-specific cleanup goals were established for the Study Area, pesticide concentrations were compared to the HDOH Tier 1 EALs used at the time. The HDOH EALs, which are periodically updated by HDOH, are used to identify soil that either does not require additional action or that may require additional action. Soil that meets these standards is considered suitable for unrestricted use at any site where the assumptions on which the standards are based are met.

In 2006, HC proposed site-specific standards for aldrin, dieldrin, and technical chlordane, based on an exposure duration of six years (instead of 30 years) that was considered more consistent with actual exposure durations of military families at Hickam. The site-specific standard was based on cumulative risk from the principal pesticides found at the site, and assumed an upper threshold of 1 x 10^{-5} ECR, which was well within EPA's (and HDOH's) target risk range of 1 x 10^{-6} to 1 x 10^{-4}. The site-specific standard (called the 2006 HHRA standard in this report), allowed unrestricted use of soil within the boundaries of the HC project area as long as the combined ECR was less than 1×10^{-5} and the hazard index (HI) was less than 1.

This decision criterion was applied to the soil within a DU, where the average concentrations of the pesticides were determined from MI sampling of the DU. Soil found to exceed the site-specific standard was considered to be "pesticide impacted" (PI), requiring additional management, but could be managed on-site provided that the soil was covered by hardscapes (building foundations, pavement, or other permanent hard surfaces) or was covered by at least one foot of non-PI soil. Additional procedures and requirements governing long-term on-site management of PI soil were described in the Management Plan for Pesticide-Impacted Soil.[70] As described in Chapter 3, these standards were applied to all soil in the HC project area until modified standards were adopted following completion of confirmation sampling of the Onizuka II-1, Earhart I-2, and Earhart I-3 neighborhoods.

Following confirmation sampling of the three neighborhoods, while an HHRE was under preparation, interim modified standards were developed to identify DUs where immediate action was needed, pending completion of the Environmental Hazard Evaluation for the Remedial Investigation of the Study Area. These interim standards were developed to meet specific objectives to protect residents from exposure to the short-term effects of pesticides in surface soil. These removal actions, which were designed to address immediate concerns even before a complete assessment of the Study Area was performed, are described in more detail in Chapter 10, and in a separate Removal Action Report[71]. As indicated in Table 4-2, the standards applied to the removal actions (named 2010 APRA standards referring to the Analysis of Potential Removal Alternatives report[72]) were based on non-carcinogenic risks.

After completion of the first two removal actions, comprehensive Site-specific standards were developed that also addressed carcinogenic risks. Although several alternative sets of assumptions were discussed in the work plan that guided the development of these standards, one set of standards was selected as the basis for the final removal action conducted at the Study Area (RO #3). This set of standards is referred to as the 2011 HHRE standard. The 2011 HHRE Standard was modified in 2012 when the chlordane non-cancer EAL (evaluated at a HQ of 1) was changed from 35 mg/kg to 38 mg/kg. The revised standard is called the 2012 EHE Standard.

When using the 2012 EHE standard a DU is not considered to pose a threat to human health and the environment due to organochlorine pesticides if all of the following criteria are met: (1) the cumulative ECR for aldrin plus dieldrin must not exceed 1×10^{-4}; (2) the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}; (3) the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}; and (4) the hazard index for all COPCs must not exceed 1.

70 (Tetra Tech 2009a).
71 (Tetra Tech 2011h)
72 Tetra Tech 2010n)

4.5 Quality Assurance/Quality Control (QA/QC)Goals

The following quality assurance/quality control (QA/QC) goals apply to this project, consistent with the Generic Quality Assurance Project Plan in the Pesticide-Impacted Soil Project Management Manual.[73]

Accuracy is the closeness of agreement between an observed value and an accepted reference value, such as a known concentration of a spike or standard. It reflects the total error associated with a measurement, including random error (variability due to imprecision) and systematic error (bias). Laboratory control spikes (LCSs), surrogate standards, and matrix spikes are used to assess accuracy of laboratory analyses. Accuracy is quantitatively assessed through calculation of percent recovery of a matrix spike, according to the following equation:

$$\%R = 100 \times \frac{X_S - X}{T}$$

where X_s is the measured concentration in the spiked sample, X is the measured concentration in the unspiked sample, and T is the known concentration of the spike solution. Accuracy limits are statistically generated by the laboratory or are specified in EPA methods. Current laboratory limits are provided in the applicable laboratory quality control plans. The middle column in Table 4-3 lists the percent recovery limits by analyte.

Table 4-3. Laboratory Quality Control Limits by Analyte

Analyte	**Accuracy** LCS Recovery Control Limits (%)	**Accuracy** MS Recovery Control Limits (%)	**Precision** LCS/LCSD RPD(%)	**Precision** MS/MSD RPD(%)
4,4'-DDD	39.6-123		30	
4,4'-DDE	45.3-123		30	
4,4'-DDT	52.8-134	24.6-134	30	30
alpha-BHC	44.2-125		30	
beta-BHC	44.2-125		30	
delta-BHC	61.5-116		30	
gamma-BHC	56.9-124	56.9-120	30	30
Aldrin	53-126	53.9-142	30	30
alpha-Chlordane	42.4-128		30	
gamma-Chlordane	68.7-123		30	
Dieldrin	44-128	29.2-130	30	30
Endosulfan I	61.2-119	44.1-121	30	30
Endosulfan II	56.7-112		30	
Endosulfan sulfate	62.1-116		30	
Endrin	44.1-126		30	
Endrin aldehyde	50.2-113		30	
Endrin ketone	53.9-120		30	
Heptachlor	63.6-125	52.2-117	30	30
Heptachlor epoxide	54.6-130		30	
Methoxychlor	55.2-126		30	
TCMX (surrogate)	52.5 - 121	52.5-139	30	30
DCBP (surrogate)	50.2 - 121	50.2-139	30	30

MS/MSD: matrix spike/matrix spike duplicate RPD: relative percentage difference

73 (Tetra Tech 2011g)

Precision is the degree of mutual agreement among independent measurements as the result of repeated application of the sample process under similar conditions. Analytical precision is measured by the relative percent difference (RPD) in duplicate matrix spike and laboratory control spike samples prepared by the laboratory, as follows:

$$RPD = 100 \times \frac{X_2 - X_1}{(X_2 + X_1)/2}$$

where X_2 is the larger of the two observed values and X_1 is the smaller of the two observed values. The applicable limits are shown in Table 4-3.

Field Sampling Reproducibility is evaluated from the percent relative standard deviation (RSD), also known as the coefficient of variation) among replicate (triplicate) samples using the following equation:

$$\%RSD = 100 \times (s) / \overline{X}$$

where s is standard deviation of the replicates and $\overline{X}$ is the mean of the replicates. Field replicates are collected at a minimum rate of one per 20 samples (five percent). The percent RSD includes both laboratory and field sources of error. The %RSD goal is 35 percent, based on HDOH guidance. RSDs that exceed the goal do not invalidate the results and do not necessarily indicate that corrective action is needed. For example, higher %RSDs are commonly associated with concentrations near the reporting limit. A higher %RSD may be an indication of non-normality in the distribution of the population being measured.

Completeness is the number of valid results divided by the number of possible results, expressed as a percentage:

$$\%Completeness = 100 \times \frac{N_V}{N_E}$$

where NV is the number of valid results and NE is the number of expected results.

The objective for completeness is 100 percent.

Representativeness is the degree to which data accurately and precisely represent selected characteristics of the media sampled. Representativeness of data collection is addressed by careful preparation of sampling and analysis programs. Representativeness is improved by the following:

- Specifying sufficient and proper numbers and locations of samples;
- Incorporating appropriate sampling methodologies;
- Specifying proper sample collection techniques and decontamination procedures;
- Selecting appropriate laboratory methods to prepare and analyze soil and soil gas samples; and
- Establishing proper field and laboratory QA/QC procedures.

Target Detection Limits. Laboratory detection limits include method detection limits (MDLs) and practical quantitation limits (PQLs). The objective is that the MDL should be lower than the HDOH Tier I EAL.

The MDL is the minimum concentration of a substance that can be unambiguously identified in the sample matrix, with 99 percent confidence that the concentration is greater than zero. MDLs for each of the standard compounds listed in EPA Method 8081A are shown in Table 4-4 and are compared to action levels relevant to the project.

Table 4-4. Target Detection Limits for Organochlorine Pesticides (mg/kg)

Analyte	CAS #	MDL	HDOH Tier I EAL	2006 HHRA EAL	2011 HHRE EAL
Aldrin	309-00-2	0.00044	na	0.42	12
Chlordane	57-74-9	0.010	na	24.3	43[1]
4,4-DDD	72-54-8	0.00047	2	-	14
4,4-DDE	72-55-9	0.00048	1.4	-	14
4,4'-DDT	50-29-3	0.00081	1.7	-	17
Dieldrin	60-57-1	0.00043	na	0.45	9.8
Endrin	72-20-8	0.00057	3.7	-	30
alpha-BHC	319-84-6	0.00044	-	-	-
alpha-Chlordane	5103-71-9	0.00036	-	-	-
beta-BHC	319-85-7	0.00036	-	-	-
delta-BHC	319-86-8	0.00049	-	-	-
Endosulfan I	959-98-8	0.00059	0.12	-	-
Endosulfan II	33213-65-9	0.0015	0.12	-	-
Endosulfan sulfate	1031-07-8	0.00049	-	-	-
Endrin aldehyde	7421-93-4	0.0010	-	-	-
Endrin Ketone	53494-70-5	0.0004	-	-	-
gamma-BHC	58-89-9	0.0004	0.09	-	-
gamma-Chlordane	5103-74-2	0.00042	-	-	-
Heptachlor	76-44-8	0.0011	na	-	-
Heptachlor epoxide	1024-57-3	0.00032	na	-	-
Methoxychlor	72-43-5	0.00062	25.5	-	-
Toxaphene	8001-35-2	0.010	0.44	-	-

[1] The chlordane EAL was lowered to 38.3 mg/kg in the 2012 EHE Standard.

The actual MDLs achieved for a given sample may be higher than the detection limits shown in Table 4-2 as a result of dilution of the sample extract necessary to accurately quantify the principal target compounds. For example, a 10-fold dilution increases the MDL by a factor of 10. Concentrations that are below the MDL are flagged with a "U" qualifier to indicate that the compound was not detected.

The PQL is the minimum concentration that is within the precision and accuracy control limits. A compound can be detected at a lower concentration than it can be accurately quantified. PQLs are typically three to ten times higher than the corresponding MDL. As indicated in Table 4-2, even with a 100-fold dilution, PQLs are expected to be lower than the 2006 HHRA EALs. Concentrations that are between the MDL and the PQL are flagged with a "J" qualifier to indicate that the reported concentration value is less reliable.

This page intentionally left blank

5.0 FIELD ACTIVITIES

5.1 Selection of DUs

Field sampling activities at the Study Area were conducted in accordance with two sampling and analysis plans (SAPs) that were prepared following the guidelines presented in the TGM[74], previous sampling protocols provided in SAPs from other HC sites, and the Program Manual[75]. The two SAPs prepared for this sampling at the Study Area are entitled *Sampling and Analysis Plan, Earhart I-2 and Earhart I-3 Neighborhoods, Hickam Air Force Base, O'ahu, Hawai'i*[76] *and Sampling and Analysis Plan, Onizuka II-1 Neighborhood, Hickam Air Force Base, O'ahu, Hawai'i*[77]*.* Detailed descriptions of the methods used for DU selection, soil sample collection, and soil sample preparation and analysis are provided in detail in the SAPs but are also summarized here.

All of the DUs at the Study Area represent open areas. Boundaries of DUs were selected to provide sufficient information for risk assessment and to provide data best suited for a remedial analysis of the Study Area. The selection of DU boundaries utilized sample results from previous Earhart I-2 and Earhart I-3 investigations. The initial DU layout was based on an approximate half-acre size for risk assessment purposes, as discussed below. After discussions with HDOH, HC further subdivided the approximately half-acre units into approximately 5,000 square foot (sq ft[78]) DUs, which corresponds to the size of a hypothetical residential lot,-as described in the HDOH TGM[79]. Based on discussions with HDOH during development of the SAPs, the 5,000-sq-ft DUs do not include area contributions from hardscapes, such as buildings or other permanent structures, driveways, roadways, sidewalks, patios, and parking areas. (The DU areas were determined using GIS map layers derived from construction drawings. The 5,000-sq-ft criterion was interpreted as accurate to one significant figure, allowing nominal DU sizes from calculated from GIS of up to 5,500 sq ft.) The numerical designation of the DUs included a number designating the approximately half-acre DU group, followed by a lowercase letter identifying the DU (as in DU-23a).

The factors used to delineate DU boundaries were based on anticipated location-specific patterns of land use by residents. Four DU types were defined for the Study Area:

1. **Playground DUs.** Playgrounds are covered with either impact matting or tan-bark over plastic. Playground DUs are defined such that they contain an area at least 30 feet beyond the perimeter of the matting/tan bark-covered playground area. Some of the playground DU boundaries were extended beyond these minimum boundaries to incorporate similar adjacent areas, to facilitate the field delineation of the DUs, and to facilitate implementation of any corrective action that may be applied to the DU. Playground DUs do not include the area inside the perimeter of the playground area, as the matting/tan bark-cover eliminates potential exposure to surface soil within the playground.

[74] (HDOH 2009)
[75] (Tetra Tech 2009a)
[76] (Tetra Tech 2010i)
[77] (Tetra Tech 2010j)
[78] 5,000 sq ft is approximately equal to 0.11 acres.
[79] (HDOH 2009)

2. **Backyard DUs.** Backyard DUs include the area from the rear walls of the housing units to a minimum of 30-feet behind each housing unit. HC permits residents to install backyard fencing up to 24 feet from the rear wall of the housing structure. The 30-foot distance selected for backyard DU boundaries includes additional distance to account for attached lanais, which can protrude up to five feet from the rear walls. Backyard DU boundaries extend beyond these minimum distances in some cases to incorporate similar adjacent areas, to facilitate the field delineation of the DUs, and to facilitate implementation of corrective actions that may be applied to the DU. Every residential building includes one or more backyard DUs.
3. **Front Yard DUs.** Front yard DUs include the area measured from the rear walls of the housing units to the curb in front of the housing units. Side yards between buildings are included in the front yard DUs. Each residential building is covered by one or more front yard DUs.
4. **Common Area DUs.** Common area DUs are those that are not included in the backyard and playground DUs. Common area DUs include such areas as ball fields, dog parks, and large grassy areas between groups of housing units. Common areas are expected to have generally less intensive use by any specific individual and less use by children. Use is more broadly dispersed among the larger community.

In addition to the above criteria for DU delineation, the DU sizes take remediation considerations into account. The DUs generally consist of contiguous areas, within which a remedial technique would be applied, if necessary, to protect residents from exposure to PI soil.

5.2 Field Methods and Procedures

Before sampling began at the Study Area, the DU boundaries were marked using a combination of spray paint and marking tape. The boundaries for each DU were presented in GIS maps provided in the SAPs, and the field technicians used street names, building layouts, and building number designations to complete these markings. In some DUs, the boundaries were adjusted to account for obstructions or other site features that were not anticipated during DU selection and map preparation, as follows:

- Due to the presence of a vegetated soil berm (see Section 5.4) along the eastern border of Earhart I-2, Tetra Tech eliminated seven common area DUs from Earhart I-2—DU-58g, DU-59d and -59e, and DU-60e, -60f, -60g, and -60h;
- To prevent DUs from covering more than 5,000 sq ft, Tetra Tech added an additional common area DU, DU-42l, in the northeast corner of Earhart I-3;
- Based on field measurements taken at the time of sampling, backyard DUs in Area 9 and Area 12 covered more than 5,000 sq ft. Tetra Tech added an additional DU to each area, DU-9e and DU-12e, to reduce the size of each DU in these areas;
- Surface soil along Melia Place, along the southwestern boundary of Earhart I-3, was remediated during construction at the adjacent Earhart I-4 neighborhood. As a result, Tetra Tech did not sample soil in this area. This reduced the size of DUs adjacent to Melia Place and eliminated DU-24e altogether; and
- No changes were made to the DU boundaries in the Onizuka II-1 neighborhood.

None of the DU boundary adjustments increased DU sizes beyond the 5,-square-foot criterion required by the HDOH.

Tetra Tech collected MI soil samples using the method recommended by the HDOH TGM[80]. For each DU at the Study Area, one MI soil sample was collected from the 0-6-inch depth and one sample from 6-12-inch depth intervals, measured from below grade. For each MI soil sample, Tetra Tech collected a total of 30 soil increments (subsamples) from stratified random locations within the DU. Generally, subsample locations were collected along a grid of five rows by six columns, or three rows by ten columns. In DUs with irregular boundaries, Tetra Tech selected subsample locations with spacing such that the final MI sample included material from all portions of the DU. Subsamples were collected using a 7/8-inch stainless steel soil-probe sampler, which was decontaminated between uses with a soap and water wash, followed by a tap water rinse and final rinse with de-ionized water.

For quality assurance purposes, Tetra Tech collected one triplicate sample (one MI soil sample and two replicates) for every 20 DUs sampled at each neighborhood. Triplicate samples were collected from the 0-6-inch depth interval at each of the four DU types listed in Section 5.1, above. The individual subsamples for each MI soil sample were composited in the field by placing each subsample in a one-gallon sealable plastic bag. To preserve sample integrity, each MI soil sample was clearly labeled and placed in an insulated ice-cooled chest for transport to Torrent Laboratory of Milpitas, California, under a chain-of-custody (COC) record, as detailed in Section 7.0, below.

5.3 Soil Sampling Activities

Field sampling at the Study Area lasted eight weeks, from August 12 through October 12, 2010. The Earhart I-2 neighborhood was sampled first, followed by the Earhart I-3 and the Onizuka II-1 neighborhoods. For this sampling effort, Tetra Tech collected a total of 1,155 samples; 711 samples from the Earhart I-2 neighborhood, 398 samples from the Earhart I-3 neighborhood, and 46 samples from the Onizuka II-1 neighborhood. Each day, the sample teams, composed of two to six field technicians, staged the field activities from a central sampling/decontamination station at the Study Area. Prior to sampling, a safety tailgate meeting was conducted and the field areas designated for the day's sampling were provided to the field crews by the field manager. The field crews generally sampled the DUs within a DU group on the same day and collected up to 40 MI soil samples per day. The MI soil samples were collected at each MI sampling point by one sampler using a sample probe marked at 6 inches to collect the MI soil sample from the 0-6-inch depth interval. Immediately following collection of the shallow sample, the 6-12-inch sample was collected by inserting a second marked sampler at the same location. In some instances, samples were collected at both depths at the same time and then separated after withdrawing the probe.

5.4 General Field Observations During Sampling

The soil sampled at the Study Area consisted mostly of dark brown to reddish brown, organic rich, sandy silts underlain by coral sands and gravel. Soil located in shaded areas with frequent irrigation tended to be more organic-rich than those in areas of high sun exposure or where irrigation occurs infrequently.

[80] (HDOH 2009)

The overall weather during this sampling was typical for coastal Hawaiʻi, consisting of warm sunny days with light breezes out of the north. Overcast days and scattered rain occurred infrequently. For the most part, sample collection continued regardless of weather conditions, except during torrential rain.

There is a vegetated soil berm higher than 30 feet along the eastern boundary of the Earhart I-2 neighborhood that serves as both a visual and noise barrier for the adjacent aircraft taxiways for the Honolulu International Airport. The DUs along this soil berm were sampled up to the tree-line, which was used to delineate the eastern boundary of these DUs.

6.0 SAMPLE CONTROL PROCEDURES

6.1 Sample Containers, Sample Preservation, and Chain-of-Custody

All MI soil samples were collected in accordance with the SAPs prepared for the sampling at the Study Area. The individual subsamples for each MI soil sample were composited in the field by placing each subsample in a one-gallon sealable plastic bag. To preserve sample integrity during transport to the analytical laboratory, each MI soil sample was clearly labeled and placed in an insulated ice-cooled chest for transport under a chain-of-custody record. Samples were labeled using the sample labeling protocol described in the SAPs; each sample ID included the neighborhood designation, DU group number, DU subgroup letter, depth information, and indication of a triplicate (if applicable).[81]

6.2 Laboratory Analytical Methods

A total of 1,155 MI soil samples were submitted to Torrent Laboratory, Milpitas, California, for analysis on a standard five-day turnaround time. At the analytical laboratory, each MI soil sample was prepared according to the HDOH MI subsampling protocol.[82] Material from each one-gallon bag was air dried at room temperature and sieved through a 2 millimeter (mm) sieve. The sieved material was then spread out, and 30 subsamples were collected by the laboratory, which were combined into one MI sample to be prepared for analysis. Each MI soil sample was analyzed for organochlorine pesticides by EPA Method 8081A.

[81] Tetra Tech 2010i, 2010j)
[82] (Tetra Tech 20011g; HDOH 2009)

This page intentionally left blank

7.0 DATA QUALITY

7.1 Introduction

Tetra Tech conducted MI sampling at the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods, as planned in the 2010 Sampling and Analysis Plans.[83] The samples were prepared according to the HEER TGM[84] and were analyzed for organochlorine pesticides using EPA Method 8081A. The samples were shipped on the day they were collected, or on the first business day following collection, to Torrent Laboratory, Inc., in Milpitas, California. Torrent Laboratory holds a USDA permit to import soil from Hawaiʻi. The project-specified analytical turnaround time was the laboratory's standard five business day turnaround time. An additional two business days were allotted for sample preparation, as discussed in the SAPs.

The laboratory provided analytical reports in electronic format (EDDs) and in pdf format. Analytical results are summarized in Tables C-1 through C-3 in Appendix C. Copies of final laboratory report packages are included in Appendix C.

Results that were not detected above the MDL were reported as less than the MDL and assigned a "U" flag.

The PQL is a laboratory determined value, typically 3 to 10 times the MDL that is estimated to be reproducible with 99 percent confidence. Results reported between the MDL and PQL are considered to be estimates and are qualified with a "J" flag.

In some cases, the original samples and surrogates required dilutions of greater than 10. For most samples, a single dilution factor applies to all analytes. In some samples a larger dilution was required to resolve the concentrations of one or more analytes (typically dieldrin or aldrin). These results are identified in Tables C-1 through C-3 using a "D" flag.

With the exception of toxaphene, all analyte MDLs were below the relevant regulatory screening levels. In samples with dilution factors of 50, the MDL for toxaphene was 0.50 mg/kg, slightly above the HDOH Tier I EAL of 0.44 mg/kg. However, since toxaphene was not detected in any samples, it is unlikely that toxaphene was present in the samples in which the MDL exceeded the HDOH Tier I EAL.

7.2 Data Quality Summary by Neighborhood

One hundred percent of the laboratory data packages were reviewed; Table 7-1 summarizes the results.

[83] (Tetra Tech 2010i, 2010j)
[84] (HDOH 2009)

Table 7-1. Data Validation Summary

Neighborhood	Total Number of Work Orders/ Laboratory Reports	Revisions to Technical Data[1]	Revisions to Analytical Data
Earhart I-2	24	9	0
Earhart I-3	17	8	0
Onizuka II-1	2	1	0

[1]Technical data includes non-analytical data. Most revisions involved corrections of information provided on the chain-of-custody, such as matching sample IDs to labels

7.2.1 Earhart I-2

A total of 712 soil samples were collected between August 14 and October 14, 2010, from 323 DUs in the Earhart I-2 neighborhood, including 33 sets of field triplicate samples. Table 7-2 lists the sample inventory by date and by the laboratory work order number.

Table 7-2. Earhart I-2 Replicates Summary

Work Order Number	Date Samples Received by Laboratory	Date Report Submitted to Tetra Tech	Number of Samples Submitted	Sets of Triplicate Samples
1008130	8/17/2010	8/26/2010	22	0
1008139	8/18/2010	8/26/2010	4	0
1008153	8/19/2010	8/30/2010	22	2
1008164	8/20/2010	8/31/2010	38	2
1008172	8/23/2010	9/1/2010	32	0
1008177	8/24/2010	9/2/2010	28	3
1008192	8/25/2010	9/3/2010	32	2
1008202	8/26/2010	9/7/2010	34	2
1008216	8/27/2010	9/8/2010	38	1
1008226	8/30/2010	9/9/2010	38	2
1008234	8/31/2010	9/11/2010	38	1
1009003	9/1/2010	9/13/2010	28	0
1009023	9/2/2010	9/14/2010	40	2
1009030	9/3/2010	9/15/2010	40	2
1009043	9/4/2010	9/16/2010	32	2
1009055	9/8/2010	9/17/2010	38	2
1009064	9/9/2010	9/20/2010	24	0
1009073	9/10/2010	9/21/2010	40	2
1009083	9/13/2010	9/22/2010	36	3
1009095	9/10/2010	9/23/2010	26	0
1009108	9/15/2010	9/24/2010	22	2
1009116	9/16/2010	9/27/2010	38	2
1010013	10/4/2010	10/13/2010	20	1
1010135	10/18/2010	10/25/2010	2	0
Total:			712	33

Note: See Appendix C and E for full laboratory reports and data validation checklists.

All samples were shipped by overnight package express in coolers with ice. Upon receipt, the laboratory assigned a work order number to the set of samples received each day, for each neighborhood. (To simplify sample tracking, samples from different neighborhoods were shipped in separate coolers and were logged under separate work orders.) The samples from Earhart I-2 were assigned to the 24 laboratory work orders listed in Table 7-1.

The laboratory logged in the samples and assigned a unique sample ID number to each sample, which was used to track the sample while under laboratory custody. The laboratory sample ID consists of the work order number, followed by a sequential three-digit number in order of listing on the COC. During login, the laboratory IDs are hand-written on the COC. This manual login is the key to the correspondence between the field sample ID and the laboratory ID.

Completeness. Minor revisions were requested to nine of the reports. Most of the revisions were to correct minor errors, including typographical errors, errors in field sample IDs, sample dates/times, incomplete sample receipt checklists or login summaries, missing MS/MSDs or LCSs, missing information in the case narrative, or missing signatures on the COC. These reports were revalidated after revisions between October 28 and November 12, 2010. There were no revisions to the analytical results.

Accuracy. All MS and MSD spike recoveries were within acceptance limits.

Precision. All MS/MSD RPDs were within acceptance criteria. All target analytes were nondetect in all field triplicates and lab triplicate samples.

Representativeness. All coolers were received within the required temperature limit of 4°C, ±2°. All samples were extracted and analyzed within the method holding times and project-specific turnaround times.

7.2.2 Earhart I-3

A total of 398 soil samples were collected between September 15 and October 12, 2010, from 181 DUs in the Earhart I-3 neighborhood. Eighteen sets of field triplicate samples were collected. Table 7-3 lists the sample inventory by date and by the laboratory work order number.

Completeness. The seventeen laboratory work orders listed in Table 7-3 were reviewed. Revised reports were issued for eight to correct minor errors, such as those described above for the Earhart I-2 reports. The following additional actions were noted:

1. Work order 1009156 received by the lab September 22, 2010 included seven samples in wet condition. Anticipating that it would take longer to air dry the samples for preparation to subsample them, the laboratory split the original work order and assigned the seven wet samples to a new work order (number 1009176). As it happened, the samples dried in about the same time as the other samples and the results were reported within the standard turnaround time.
2. An anomalously high DDT result was reported in one triplicate sample from DU-15a (EAR3-RA-15a-06-3; lab ID 1010014-15A). Tetra Tech requested that the lab review these data, and the lab reextracted and reanalyzed the sample. Although out of the

method holding time, the results confirmed the original result. The original report was reissued with minor revisions.

Table 7-3. Earhart I-3 Replicates Summary

Work Order Number	Date Samples Received by Laboratory	Date Report Submitted to Tetra Tech	Number of Samples Submitted	Number of Triplicate Samples
1009130	9/17/2010	9/29/2010	22	2
1009138	9/20/2010	9/29/2010	6	0
1009140	9/20/2010	9/29/2010	8	0
1009151	9/21/2010	9/30/2010	38	1
1009156	9/22/2010	10/1/2010	23	2
1009176	9/22/2010	10/1/2010	7	0
1009165	9/23/2010	10/5/2010	38	2
1009183	9/24/2010	10/6/2010	38	4
1009189	9/27/2010	10/7/2010	40	1
1009194	9/28/2010	10/7/2010	18	1
1009217	9/29/2010	10/8/2010	18	0
1009230	9/30/2010	10/12/2010	28	2
1010002	10/1/2010	10/13/2010	38	1
1010014	10/4/2010	10/14/2010	36	1
1010031	10/5/2010	10/15/2010	26	1
1010051	10/7/2010	10/18/2010	12	0
1010013	10/13/2010	10/20/2010	2	0
Total:			398	18

Note: See Appendix C and E for full laboratory reports and data validation checklists.

Accuracy. All spike recoveries were within acceptance limits.

Precision. All MS/MSD RPDs were within acceptance criteria.

Representativeness. All coolers were received within the required temperature limit of 4°C, ±2°. All samples were extracted and analyzed within the method holding times and project-specific turnaround times.

7.2.3 Onizuka II-1

As summarized in Table 7-4, a total of 46 soil samples were collected on October 4 and 5, 2010, from 21 DUs in the Onizuka II-1 neighborhood. Two sets of field triplicate samples were collected. All samples were received within the temperature limit of 4°C, ±2°, and all project and method holding times were met.

Table 7-4. Onizuka II-1 Replicates Summary

Work Order Number	Date Samples Received by Laboratory	Date Report Submitted to Tetra Tech	Number of Samples Submitted	Number of Triplicate Samples
1010042	10/6/2010	10/18/2010	30	2
1010052	10/7/2010	10/19/2010	16	0
Total:			46	2

Note: See Appendix C and E for full laboratory reports and data validation checklists.

Completeness. Tetra Tech submitted two laboratory work orders to Torrent for Onizuka II-1. After evaluating both work orders, one was submitted for revision. This request was for work order 1010042 (received by the lab on October 6, 2010) regarding a sample ID typo and a missing COC page. This report was revised and reissued on October 27, 2010. There were no revisions to the analytical results.

Accuracy. All spike recoveries were within acceptance limits.

Precision. All MS/MSD RPDs were within acceptance criteria.

Representativeness. All coolers were received within the required temperature limit of 4°C, ±2°. All samples were extracted and analyzed within the method holding times and project-specific turnaround times.

7.3 Field Data Quality Assessment

7.3.1 Earhart I-2

Table 7-5 presents the RSDs from the mean of the four principal analytes detected in the triplicates collected at Earhart I-2. Only those results that were above the MDL are included in the table. Replicate sets in which a compound was not detected in one or more of the replicates are not included.

The RSD is calculated by dividing the standard deviation from the mean among the three triplicate samples by the mean (the mean concentration is also shown in the table). A low RSD is generally indicative of good agreement among the triplicates and is a measure of the representativeness of the multi-incremental samples of the actual average concentration of the analyte in the DU. RSDs of less than 0.35 are generally considered to be adequate.

As can be seen in Table 7-5, most of the triplicate samples contained low concentrations of DDT and chlordane. These chemicals influence the overall risk from the Study Area but are not as important as aldrin and dieldrin. All of the samples contained detectable concentrations of dieldrin, and all but one had detectable concentrations of aldrin.

Six of the 33 RSDs calculated for dieldrin exceeded the goal of 35 percent. Five of these higher RSDs were within 45 percent, and one was nearly 100 percent of the mean. Some of the scatter in the triplicate results can be attributed to analytical uncertainty. Concentrations close to the reporting limit tend to be more variable. However, most of the mean concentrations are well above the reporting limit for dieldrin, and of the three that are close to the reporting limit, the RSDs did not exceed 35 percent.

The potential for over- or underestimating the actual average concentration of aldrin in a DU appears to be greater than for dieldrin. RSDs for aldrin exceeded 35 percent in about half of the triplicate sets and ranged from 6 percent to 117 percent, with seven triplicate RSDs over 50 percent. In general, as is discussed in the next chapter, aldrin concentrations also showed greater variability among the individual DU samples than did dieldrin.

Table 7-5. RSD and Mean Concentration for Selected Compounds Detected above MDL in Triplicate Samples from Earhart I-2 (mg/kg)

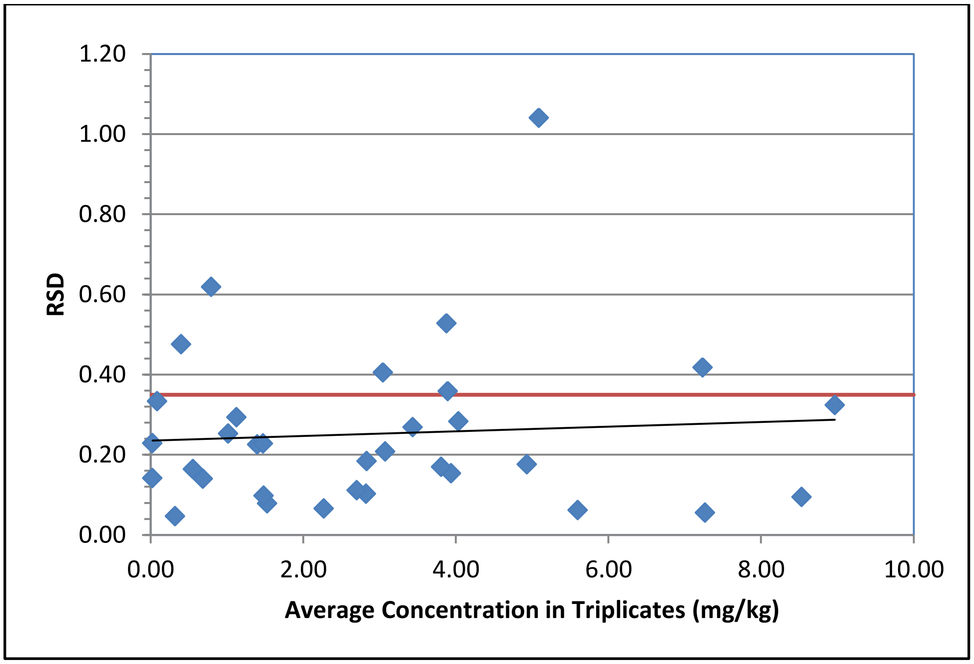
	4,4'-DDT		Aldrin		Chlordane		Dieldrin		Dieldrin+Aldrin	
DU	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]
05a	0.04	0.00	0.26	0.29	0.50	0.00	1.14	0.21	1.40	0.23
10a	0.03	0.30	0.29	0.29	0.86	0.28	0.73	0.24	1.02	0.25
13c			0.71	**0.60**			2.37	0.14	3.08	0.21
15a	0.10	**0.48**	0.40	0.06	0.71	0.06	1.87	0.08	2.27	0.07
16a			0.93	0.23			4.00	0.16	4.93	0.18
19b			1.90	0.24	0.73	0.20	6.63	0.06	8.53	0.09
20a			0.52	0.08	1.03	0.21	2.30	0.12	2.82	0.10
21a			0.80	**0.54**			3.13	0.16	3.94	0.15
23a			1.75	**1.17**			3.33	**0.98**	5.09	**1.04**
25a			0.94	**0.52**	6.37	0.04	2.50	0.17	3.44	0.27
26a			0.74	**0.37**	1.34	**0.55**	2.30	**0.42**	3.04	**0.41**
28a			0.97	0.21			2.83	0.17	3.81	0.17
31a			0.07	**0.61**	0.89	0.11	0.33	**0.45**	0.40	**0.48**
32a			0.12	0.35	1.83	0.11	0.57	0.10	0.69	0.14
35a	0.16	0.00	1.93	0.16	2.00	0.00	5.33	0.03	7.27	0.06
37a			3.97	**0.55**			5.00	0.14	8.97	0.32
38a	0.04	0.04	0.36	0.17	1.17	0.25	1.17	0.05	1.53	0.08
40a			1.13	**0.45**	1.00	0.00	2.77	0.32	3.89	**0.36**
43a			1.87	0.25			3.73	0.04	5.60	0.06
45a	0.45	**0.43**	0.06	0.30	1.03	0.06	0.26	0.10	0.32	0.05
47a	0.13	0.08			0.45	0.06	0.02	0.17	0.03	0.14
48b	0.04	0.00	0.60	0.28	0.96	0.17	2.23	0.16	2.83	0.18
50a			0.47	0.11	0.51	0.02	2.23	0.11	2.70	0.11
51a			0.27	0.28			1.20	0.22	1.47	0.23
53a	0.05	**0.42**	0.01	**0.39**			0.07	0.33	0.09	0.33
53j	0.02	0.04	0.09	0.22			0.47	0.16	0.56	0.16
55a	0.01	0.32			0.10	0.00	0.02	0.28	0.02	0.23
56a			0.27	**1.02**			0.53	**0.42**	0.79	**0.62**
56j			0.98	**0.58**			2.90	**0.51**	3.88	**0.53**
58a			0.74	**0.44**			3.30	0.25	4.04	0.28
60a	0.06	0.29	2.37	**0.49**	1.57	0.24	4.87	**0.38**	7.23	**0.42**
61a	0.09	**0.54**	0.42	0.22	2.07	0.24	1.06	0.07	1.48	0.10
62a	0.28	**0.69**	0.34	**0.40**	1.06	0.24	0.78	0.25	1.13	0.29

Note: (1) RSD is unitless

Aldrin and dieldrin are strongly linked in occurrence at the Study Area. Aldrin and dieldrin were probably both present in the pesticide product applied to the buildings in the Earhart Village Housing Area. Aldrin degrades to dieldrin in the environment, and the properties of the two chemicals, including their toxicities, are similar. Because of this link, it makes sense to evaluate the RSDs of the sum of the aldrin and dieldrin concentrations in the triplicates.

Figure 7-1 shows the relation between the RSDs and the mean concentrations of aldrin and dieldrin combined. The horizontal red line on the graph separates the points above an RSD of 0.35 from those below. The black line is the linear best fit to the data, showing that the magnitude of the concentration had little effect on the RSDs. The graph is almost identical to the graph of RSD versus dieldrin only, and most of the RSDs fall within the desired range of less than 35 percent. These results suggest that despite the higher variability of aldrin concentrations, the MI samples reliably estimate the combined concentrations of aldrin plus dieldrin.

Figure 7-1. RSDs and Average Concentrations in Triplicates from Earhart I-2



7.3.2 Earhart I-3

As described above, RSDs were calculated for the analytes detected in the 18 triplicate samples from Earhart I-3. Table 7-6 presents the results of this evaluation.

As was the case for Earhart I-2, the main constituents detected in the triplicate samples for Earhart I-3 were dieldrin and aldrin. Aldrin shows more variability than dieldrin, with eight of the RSD greater than the goal of 0.35. Only two triplicate RSDs exceeded 0.35 for dieldrin. Using the sum of dieldrin and aldrin, three triplicates (16 percent of the triplicates) have RSDs greater than 0.35. Of these, two were less than 50 percent.

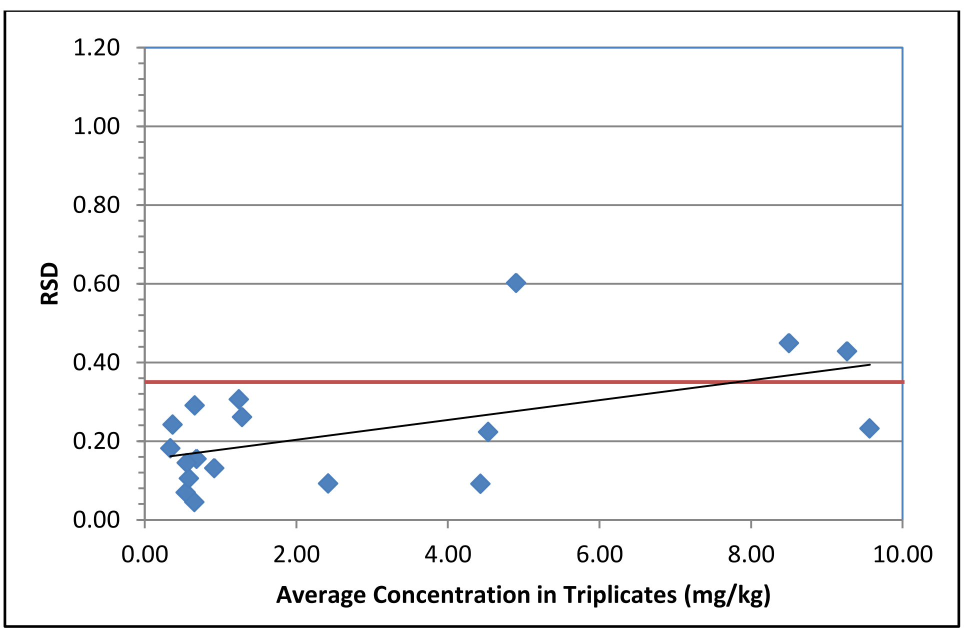
Table 7-6. RSD and Mean Concentration for Selected Compounds Triplicate Samples from Earhart I-3 (mg/kg)

	4,4'-DDT		Aldrin		Chlordane		Dieldrin		Dieldrin + Aldrin	
DU	**mean**	**RSD[1]**	**mean**	**RSD[1]**	**mean**	**RSD[1]**	**mean**	**RSD[1]**	**mean**	**RSD[1]**
05a			2.00	**0.78**	4.80	**0.61**	2.90	**0.48**	4.90	**0.60**
08a	0.22	0.11	0.22	0.16	1.77	0.16	0.69	0.12	0.92	0.13
10a	0.43	**0.54**	0.19	**0.59**	1.80	0.17	0.47	0.17	0.66	0.29
12b			4.43	**0.63**	6.20	**0.43**	4.83	0.25	9.27	**0.43**
15a							0.46	0.06	0.54	0.07
18a	0.10	0.21	1.47	0.08	2.40	0.15	2.97	0.10	4.43	0.09
20a			4.43	0.27	2.93	0.10	5.13	0.20	9.57	0.23
23a	0.20	0.16	0.13	0.26	1.37	0.08	0.53	0.03	0.66	0.04
25a	0.25	**0.44**	0.13	0.16	1.80	0.19	0.55	0.16	0.68	0.16
27a	0.06	0.10	0.15	0.14	1.67	0.17	0.44	0.09	0.58	0.10
30a	0.12	0.12	0.46	**0.48**	2.10	0.10	0.82	0.14	1.28	0.26
32a			0.30	**0.40**	1.43	0.15	0.94	0.28	1.24	0.31
33c			3.57	**0.51**	3.53	**0.36**	4.93	**0.41**	8.50	**0.45**
35a	0.14	0.11	1.60	0.27	4.03	0.29	2.93	0.20	4.53	0.22
37a	0.04	0.21	0.06	**0.55**	2.30	**0.43**	0.28	0.12	0.34	0.18
40a	0.14	0.14	0.62	0.11	5.00	0.10	1.80	0.10	2.42	0.09
41a	0.29	0.22	0.13	0.20	1.09	0.10	0.43	0.13	0.55	0.14
42a	0.18	0.33	0.08	**0.43**	3.43	**0.39**	0.29	0.23	0.37	0.24

Note: (1) RSD is unitless

Figure 7-2 shows the relationship between RSDs and the mean concentrations in the triplicate samples. As with the results for the triplicates from Earhart I-2, these results suggest that the

Figure 7-2. RSDs and Average Concentrations in Triplicates from Earhart I-3



combined concentrations of dieldrin and aldrin in the MI samples are likely to be a good predictor of the actual average concentrations of the two compounds in the soil from the DUs. Most of the triplicate RSDs are below the 35 percent goal. The trend line indicates that there is a tendency in these data for the RSDs to increase with the concentration, but correlation between the RSDs and concentration is poor.

7.3.3 Onizuka II-1

Two sets of triplicate samples were collected from Onizuka II-1. The primary pesticide present in the Onizuka II-1 neighborhood is chlordane. Table 7-7 shows the mean concentrations and the calculated RSDs for the triplicates. The RSDs were well below the goal of 35 percent for all constituents.

Table 7-7. RSDs and Average Concentrations in Triplicates from Onizuka II-2 (mg/kg)

	4,4'-DDT		Aldrin		Technical Chlordane		Dieldrin		Dieldrin+Aldrin	
DU	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]	mean	RSD[1]
1a	0.043	0.22	0.035	0.16	1.083	0.25	0.200	0.09	0.235	0.08
4a	0.029	0.02	0.039	0.14	1.200	0.08	0.133	0.04	0.173	0.06

Note: (1) RSD is unitless

7.4 Conclusions

7.4.1 Comparability and Data Usability

All data are considered usable for the purposes of this project.

Some of the replicate samples had RSDs above the project goal. Higher RSDs occur when there is poor agreement among replicates. Higher RSDs have little impact when the concentrations involved are much higher or lower than the action level. A potential source of poor agreement among replicates of aldrin and dieldrin may be the rate at which aldrin degrades to dieldrin. As indicated in the tables above, considering the sum of aldrin and dieldrin may help to offset this effect, lowering the RSDs of the combined concentrations in the replicate samples. Similarly, since the final decision criterion for each DU is the cumulative risk associated with the combined concentrations of pesticides in the samples, the RSDs of the resulting combined risks are expected to be lower than the RSDs of the concentrations of the individual compounds.

This page intentionally left blank

8.0 ANALYTICAL RESULTS

Analytical results are summarized in Tables C-1, C-2, and C-3 of Appendix C for the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods, respectively, along with copies of the final laboratory reports.

8.1 Chemicals of Concern and Relationships Among Chemicals

All of the samples from the Study Area were analyzed by EPA Method 8081 for organochlorine pesticides. The laboratory reports include results for all of the standard analytes that can be detected by the method. However, most of these compounds were either not detected or were detected in only a few samples at low concentrations.

Compounds that were not detected in any samples at concentrations above the PQL include α-BHC, β-BHC, δ-BHC, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin ketone, γ-BHC, methoxychlor, and toxaphene. These compounds are not discussed further.

Endrin ketone, heptachlor, and heptachlor epoxide were detected in only a few samples at concentrations very close to their respective PQLs.

Technical chlordane is a mixture of many compounds, including mainly α-chlordane, γ-chlordane, and heptachlor.[85] The analytical method used to quantify technical chlordane involves comparing the unknown chlordane mixture to a chlordane standard, similar to the way that gasoline and diesel are quantified. Since toxicological data and regulatory standards are typically based on technical chlordane rather than the individual compounds that comprise technical chlordane, the remaining discussion of the investigation results focuses on technical chlordane rather than the individual compounds it contains.

The chemical breakdown products of 4,4'-DDT are 4,4'-DDD and 4,4'-DDE. All three compounds behave similarly in the environment; for example, they tend to bind strongly to soil particles and are relatively immobile. DDT (and to a lesser extent DDD, and DDE) are widespread in the environment at low concentrations. The sources of DDT at the Site are not known but may include past agricultural use and treatments against mosquitoes and other pests. In the 1940s and 1950s it was common to apply DDT by aerial spraying, which would have broadly distributed the pesticide. DDT might have been applied at higher rates to drainage ditches and low-lying areas. Subsequent grading would have dispersed the residual DDT. DDT was probably not used as a termiticide, so it is not expected to be found preferentially in subfoundation soil. As shown in Table 8-1, DDT and DDE were the most commonly detected of the DDT compounds.

Aldrin and dieldrin are chemically similar compounds that were probably both present in the technical grade pesticide historically applied to treat termites under and around foundations in the Earhart Housing Area. The technical grade of each of these products was required to contain not less than 85 percent of the compound, and the technical grade of each product contains some percentage of the other as an impurity. Technical aldrin may also contain approximately 0.5 percent chlordane. Under most environmental conditions, aldrin is converted to dieldrin, and dieldrin is the more stable of the two compounds. This process of conversion to

[85] (ATSDR 1994)

dieldrin is probably much slower where the aldrin is protected from exposure to weathering, water, sunlight, and biological activity, such as under the foundations of buildings.

Peak use of aldrin and dieldrin in the United States was in 1966, when 19 million pounds of aldrin and one million pounds of dieldrin were reportedly used. The much higher proportion of aldrin use suggests that aldrin might have been the main termiticide product applied to the Earhart Housing Area and that the concentrations of dieldrin may be primarily due to the conversion of the original aldrin to dieldrin.

Domestic production of aldrin and dieldrin halted in 1972, when the EPA cancelled all but three uses (one of which was treatment of subterranean termites). Manufacture of aldrin and dieldrin was discontinued in 1987.[86]

Based on the discussion above, the primary chemicals of concern in the Earhart I-2 Area are the DDD, DDE, and DDT, aldrin, dieldrin, and technical chlordane. The analytical results for these compounds are discussed below by housing area.

8.1.1 Earhart I-2

Table 8-1 summarizes the range of concentrations of the most commonly detected pesticides and the number of detections above the PQL.

Table 8-1. Summary of Detected Pesticides, Earhart I-2

Analyte	Depth	Number of Detects above PQL	Average Concentration (mg/kg)	Maximum Concentration (mg/kg)
4,4-DDD	0-6”	39	0.035	0.23
“	6-12”	38	0.042	1.1
4,4-DDE	0-6”	271	0.090	1
“	6-12”	220	0.13	6.6
4,4-DDT	0-6”	159	0.11	4.8
“	6-12”	145	0.19	10
Aldrin	0-6”	375	1.29	46
“	6-12”	306	1.76	36
α-Chlordane[1]	0-6”	343	0.14	1.1
“	6-12”	280	0.13	1
Technical Chlordane	0-6”	210	1.15	6.6
“	6-12”	164	1.74	6.3
Dieldrin	0-6”	374	2.34	11
“	6-12”	336	2.19	15
γ-Chlordane[1]	0-6”	326	0.13	0.92
“	6-12”	273	0.13	0.85

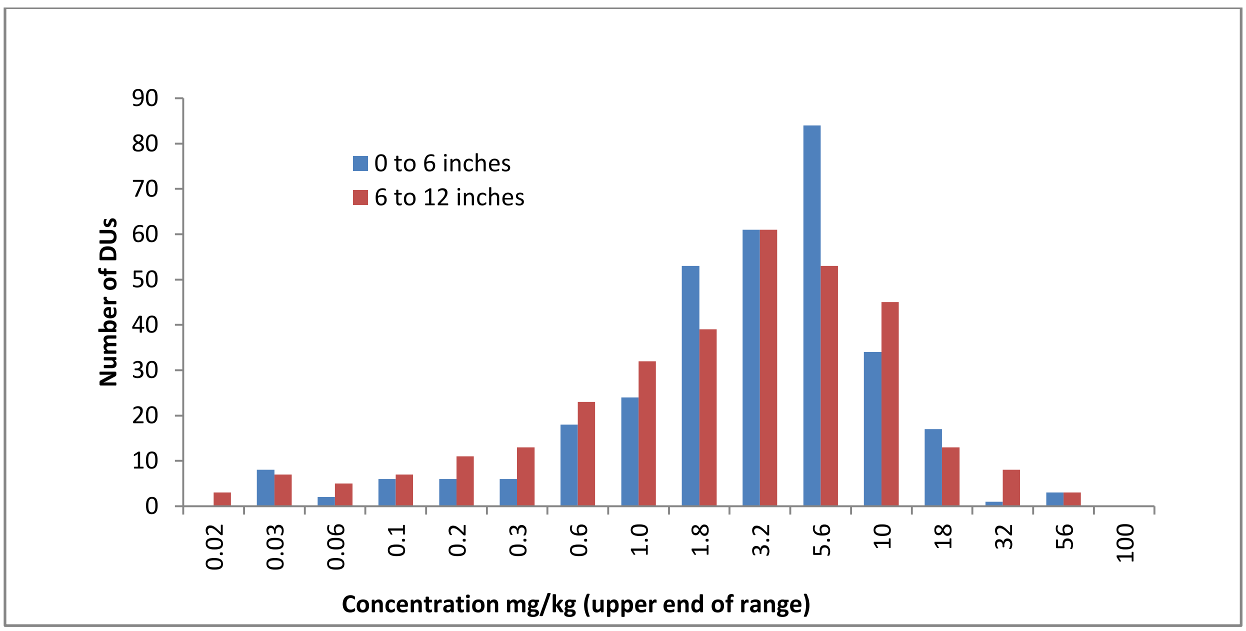
[1]Included in technical chlordane

[86] (US EPA 2003)

Each of the data sets was tested using the EPA's PRO UCL software program to determine whether the data fit a normal, log-normal, or gamma distribution. The dieldrin results from the 6-12-inch depth fit a gamma distribution with 95 percent confidence. The other data do not fit any of the distributions with this level of confidence, but all of the data sets have characteristics of log-normal distribution. (A data set is log-normally distributed if the logarithms of the concentrations are normally distributed.)

Figure 8-1 shows the distribution of the sums of the concentrations of aldrin plus dieldrin in samples from each depth. The bars represent the number of samples with concentrations that fall within the ranges shown on the horizontal axis of the graph. Each of the values on the horizontal axis represents the upper end of the range. Thus, for example, the bar above the value of 1.8 mg/kg indicates that 53 samples had concentrations between 1.0 and 1.8 mg/kg. (Note that only the highest value in each set of triplicates was used to construct the graph, so that each DU is represented by only one value. Each tic on the horizontal axis corresponds to one-quarter log unit, but the logarithms were converted back to concentrations so that the concentrations can be read directly from the graph.) The mean of the log-transformed data representing the 0-6-inch samples is 0.389, which corresponds to a concentration of 2.5 mg/kg, and the mean of the log-transformed data representing the 6-12-inch samples is 0.498, which corresponds to 3.15 mg/kg. The figure illustrates the distributions of the concentration of the other chemicals of concern.

Figure 8-1. Aldrin +Dieldrin - Earhart I-2



As mentioned above, technical aldrin and dieldrin could contain a small percentage of chlordane as an impurity (on the order of one-half of one percent). However, as illustrated in Figure 8-2, the concentrations of chlordane detected in the samples from Earhart I-2 are higher than expected if the chlordane was only an impurity in the technical aldrin/dieldrin product applied to the former buildings. (Only samples in which chlordane was detected are plotted on the graph. The vertical axis is extended to enable comparison of the data from Earhart I-2 to data from Earhart I-3, below.) Linear trend lines on the figure show the best estimate of the underlying relationship, if any, between chlordane and dieldrin+aldrin. The correlation factors

(R^2) indicate how closely the points agree with the trend lines. The more closely all of the points plot along a straight line, the closer the correlation factor approaches 1.0.

The low R^2 values associated with the trend lines on Figure 8-2 indicate poor correlation between chlordane and dieldrin+aldrin in the samples from either depth interval. Instead, the chlordane concentration appears to vary somewhat randomly within a range of nondetect to about 6 mg/kg without regard to the concentration of dieldrin and aldrin.

Figure 8-2. Chlordane vs Dieldrin+Aldrin

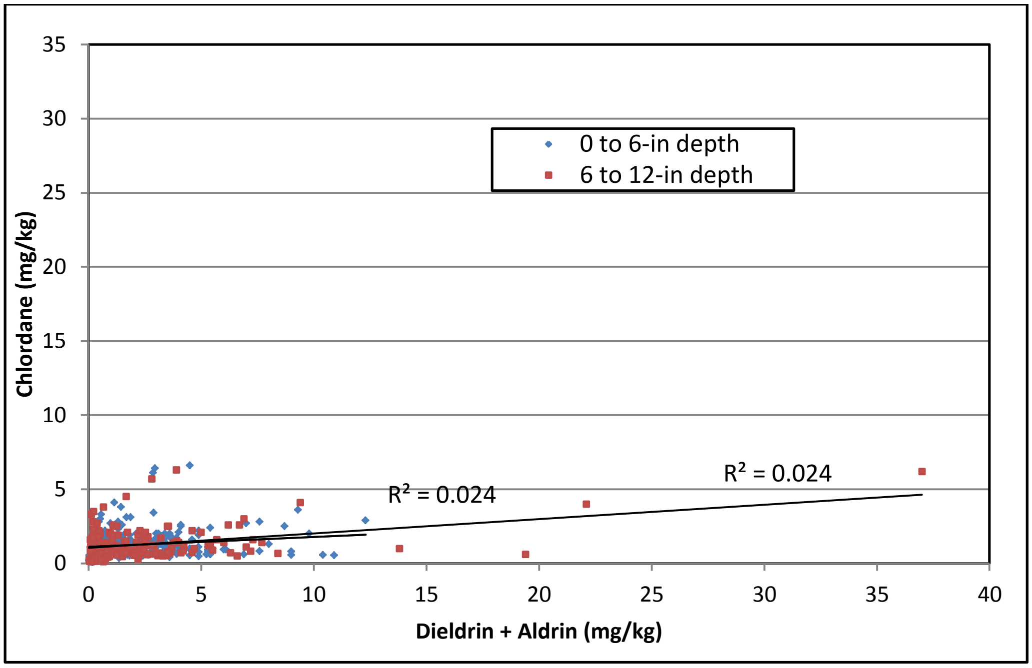


Figure 8-3 shows the sum of the combined concentrations of DDD, DDE, and DDT plotted against the sum of the concentrations of aldrin plus dieldrin. As with chlordane, there is poor correlation between the concentrations of DDD, DDE, and DDT, and aldrin+dieldrin (DDD, DDE, and DDT concentrations do not appear to increase proportionally with aldrin+dieldrin concentrations). This is expected because DDT was not used as a termiticide. Most of the combined concentrations of DDT, DDD, and DDE are less than 1 mg/kg, but the higher DDT concentrations tend to be found in the 6-12-inch samples rather than in the 0-6-inch samples. Samples from 10 DUs contained combined concentrations of DDT, DDD, and DDE greater than 1 mg/kg in the 6-12-inch depth, versus only three DUs in the 0-6-inch depth. The DUs that contained concentrations above 1 mg/kg in the 0-6-inch depth samples also contained concentrations above 1 mg/kg in the corresponding 6-12-inch depth samples. The distribution of DDT concentrations is discussed in more detail in Chapter 9.

Figure 8-4 shows the relationship between the concentrations of aldrin and dieldrin in samples from 0 to 6-inches and from 6 to 12-inches. The figure shows that in both depth intervals, the highest concentrations are aldrin concentrations. Since aldrin degrades to dieldrin when it is exposed to sunlight and weathering processes, most of the aldrin is expected to convert to dieldrin in shallow soil samples over time. Therefore, samples with elevated aldrin concentrations relative to dieldrin may indicate soil that has not been exposed to weathering processes as long as soil that has higher dieldrin concentrations relative to aldrin.

Figure 8-3. Combined DDD, DDE, and DDT vs Dieldrin+Aldrin - Earhart I-2

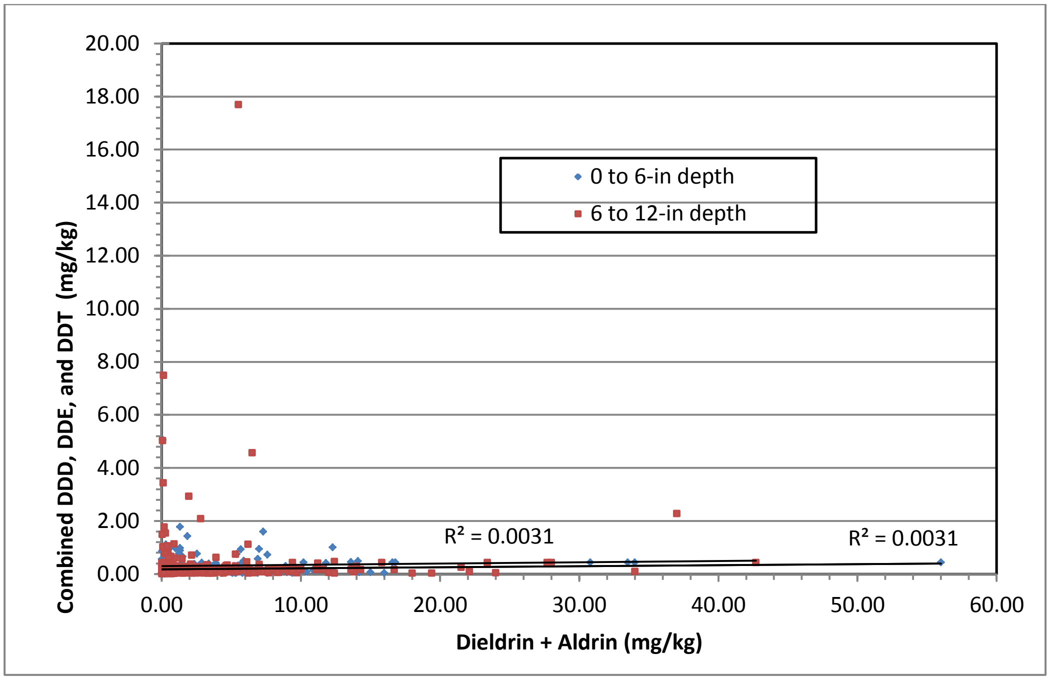


Figure 8-4. Aldrin vs Dieldrin Concentrations - Earhart I-2
0 to 6-inches and 6 to 12-inches

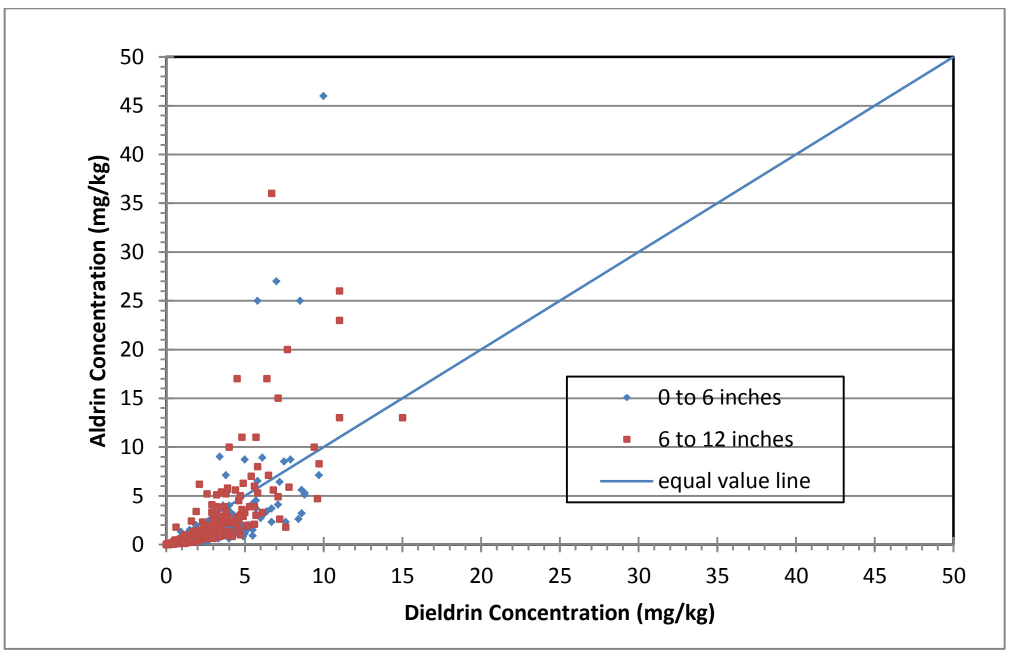
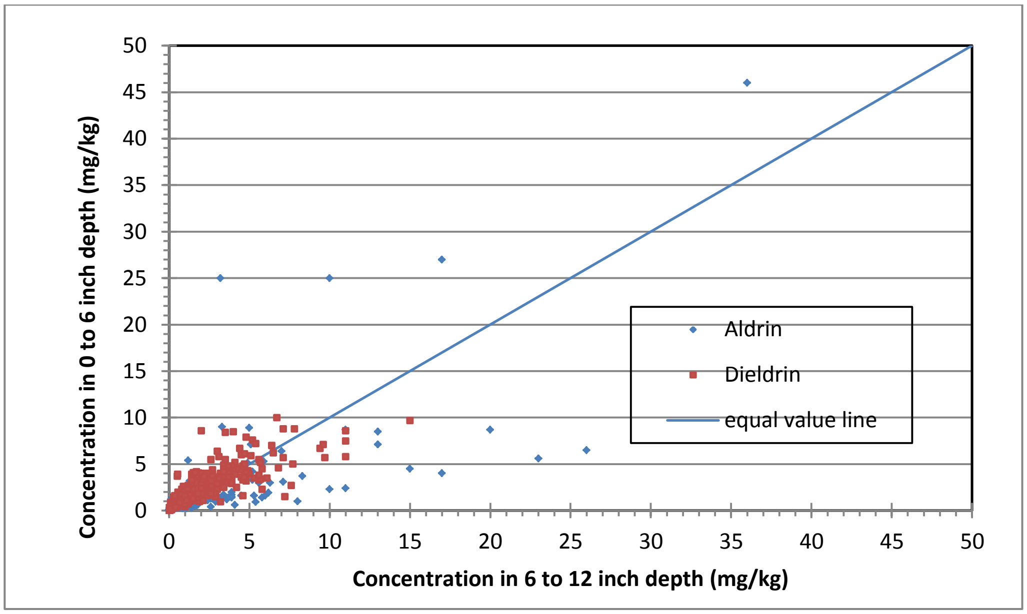


Figure 8-5 shows how closely the concentrations in the 0-6-inch depth match the concentrations detected in the 6-12-inch depth. Each point represents the concentrations of aldrin (blue diamonds) or dieldrin (red squares) at the two depths in a single DU. As noted above, the highest concentrations tend to be aldrin. Points that plot above the diagonal “equal value line” represent DUs in which the highest concentrations were in the shallower depth and points that plot below the diagonal represent DUs in which the concentrations are higher in the deeper depth interval. Overall, about as many points plot above the line as below it, suggesting that there is not a tendency for higher concentrations to be associated with either depth interval. The trend lines (not shown) for the two sets of data plot slightly below the diagonal that represents equal concentrations in the 0-6-inch and 6-12-inch depths. This suggests that overall, there is about as much chance for higher concentrations to be found in the upper six inches as in the lower six inches. Since higher aldrin concentrations suggest less exposure to weathering processes, the higher aldrin concentrations might be expected to occur more frequently in the deeper samples. The geographic distribution of the aldrin concentrations is discussed further in Chapter 9.

Figure 8-5. Aldrin and Dieldrin Concentrations - Earhart I-2
0-6-inch versus 6-12-inch



8.1.2 Earhart I-3 Area

As discussed above for Earhart I-2, Table 8-2 summarizes the range of detected concentrations in the samples from Earhart I-3, except that α-chlordane and γ—chlordane are not shown, because they are constituents of technical chlordane. With the exception of chlordane, the ranges of concentrations in the samples from Earhart I-3 are narrower than in Earhart I-2.

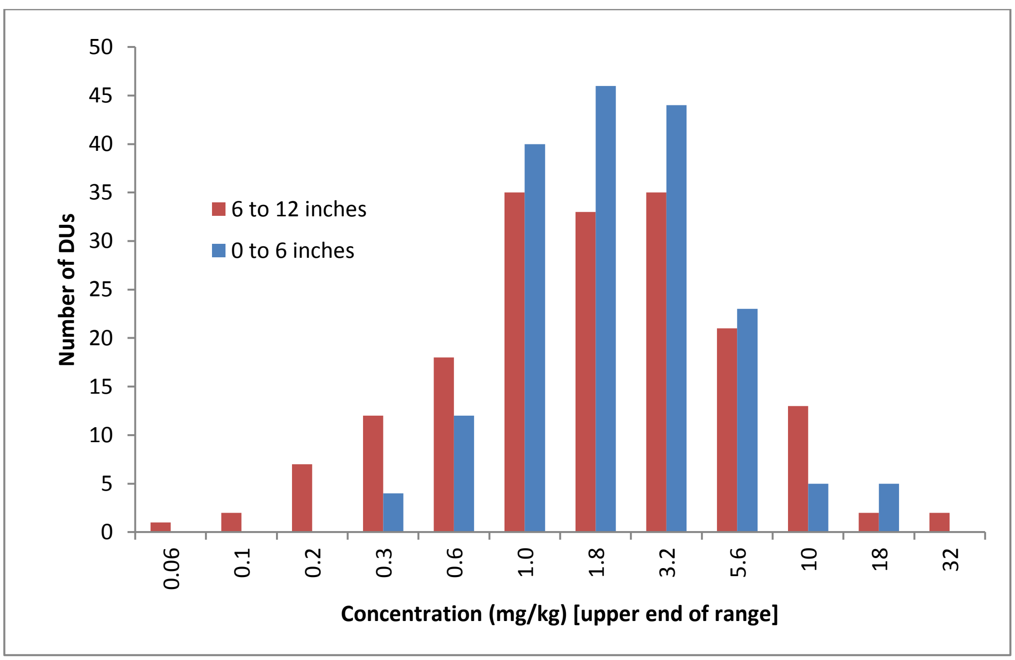
Table 8-2. Summary of Detected Pesticides, Earhart I-3

Analyte	Depth	Number of Detects above PQL	Average Concentration (mg/kg)	Maximum Concentration (mg/kg)
4,4-DDD	0-6”	44	0.036	0.47
“	6-12”	48	0.034	0.19
4,4-DDE	0-6”	207	0.14	0.68
“	6-12”	169	0.16	0.83
4,4’-DDT	0-6”	193	0.24	4.2
“	6-12”	157	0.20	2.5
Aldrin	0-6”	215	0.86	17
“	6-12”	178	1.02	16
Technical Chlordane	0-6”	214	2.53	11
“	6-12”	180	2.78	32
Dieldrin	0-6”	216	1.43	6.3
“	6-12”	180	1.32	11

PRO UCL was used to evaluate the distributions of the concentrations of the chemicls of concern. This analysis indicates that the concentrations of aldrin, dieldrin, chlordane, and combined concentrations of DDD, DDE, and DDT are each log-normally distributed.

Figure 8-6 illustrates the log-normal distribution of combined aldrin + dieldrin in the two depth layers sampled.

Figure 8-6. Aldrin +Dieldrin-Earhart I-3



Chlordane was detected at concentrations greater than 10 mg/kg in samples from five DUs in the Earhart I-3 area (the highest chlordane concentration detected in the Earhart I-3 area was 6.3 mg/kg). One of the samples was from the 0 to 6-inch depth and four of the samples were from the 6 to 12-inch depth.

Figure 8-7 shows the concentrations of chlordane versus aldrin + dieldrin by depth. Although not well correlated, the data indicate a tendency for chlordane concentrations to increase with aldrin + dieldrin concentrations. One sample, which contained the highest concentration of chlordane (32 mg/kg, from the 12-inch depth in DU-12b) lies well outside the range of the other data.

Figure 8-7. Chlordane vs. Dieldrin+Aldrin - Earhart I-3

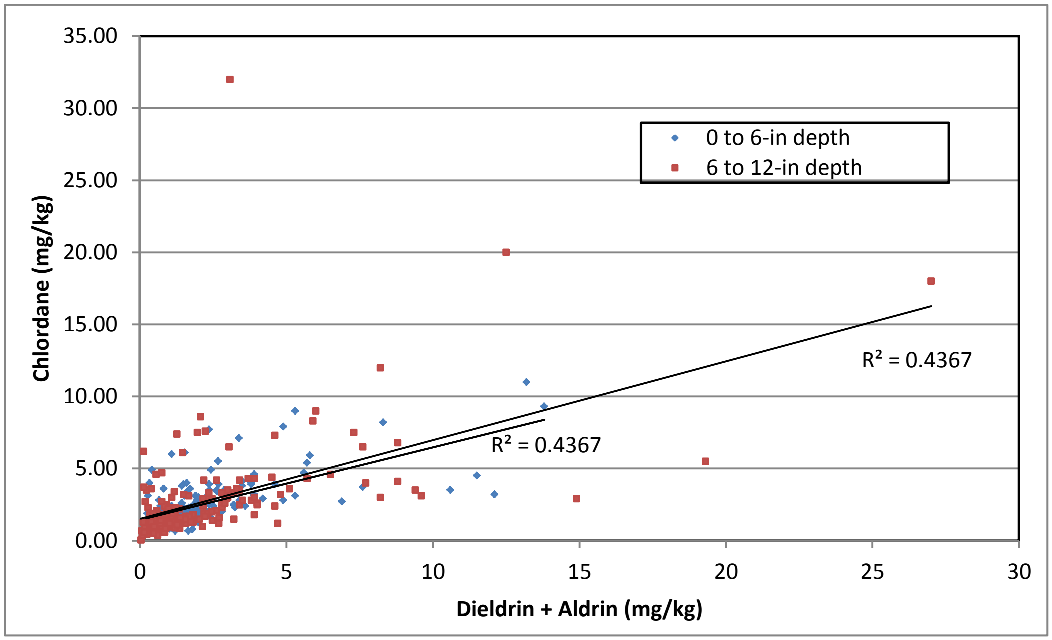


Figure 8-8 shows the sum of the concentrations of DDD, DDE, and DDT plotted against the sum of the concentrations of aldrin plus dieldrin. As with chlordane, there is poor correlation between the concentrations of the DDT series and aldrin+dieldrin. The data are plotted at the same scale as Figure 8-3 for Earhart I-2. Comparison of Figures 8.3 and 8.8 indicates generally lower concentrations in the soil at Earhart I-3. As with Earhart I-2, most of the concentrations of DDT, DDD, and DDE are less than 1 mg/kg, but there is little difference between DDT concentrations detected in the 0 to 6-inch samples compared to the 6 to 12-inch sample. Samples from eight DUs in the 0 to 6-inch depth and from 10 DUs in the 6 to 12-inch depth contained concentrations of DDT, DDD, and DDE greater than 1 mg/kg, but these concentrations were not detected in the same DUs at both depths. The distribution of DDT concentrations is discussed in more detail in Chapter 9.

Figure 8-8. Combined DDD, DDE, and DDT vs. Dieldrin+Aldrin - Earhart I-3

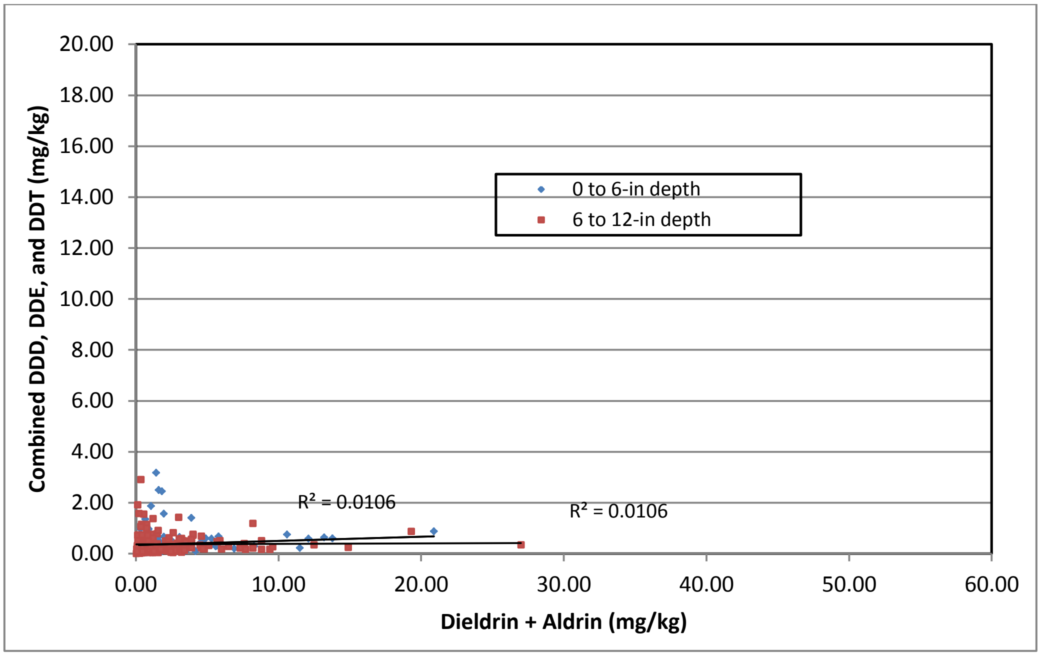


Figure 8-9 shows aldrin versus dieldrin concentrations in samples from 0 to 6-inches, and from 6 to 12-inches. Comparison with Figure 8-4 indicates that overall, aldrin predominates in the higher-concentration samples, and there is more aldrin in the 6 to 12-inch samples, similar to the results at Earhart I-2.

Figure 8-9. Aldrin vs. Dieldrin Concentrations
0 to 6 inch and 6 to 12 inch

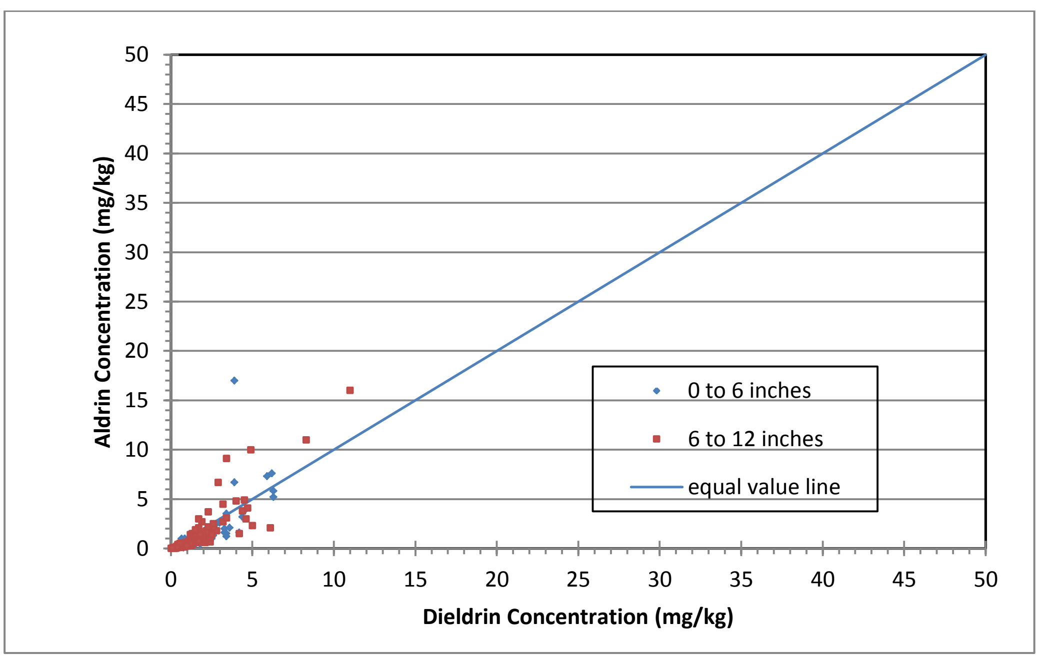
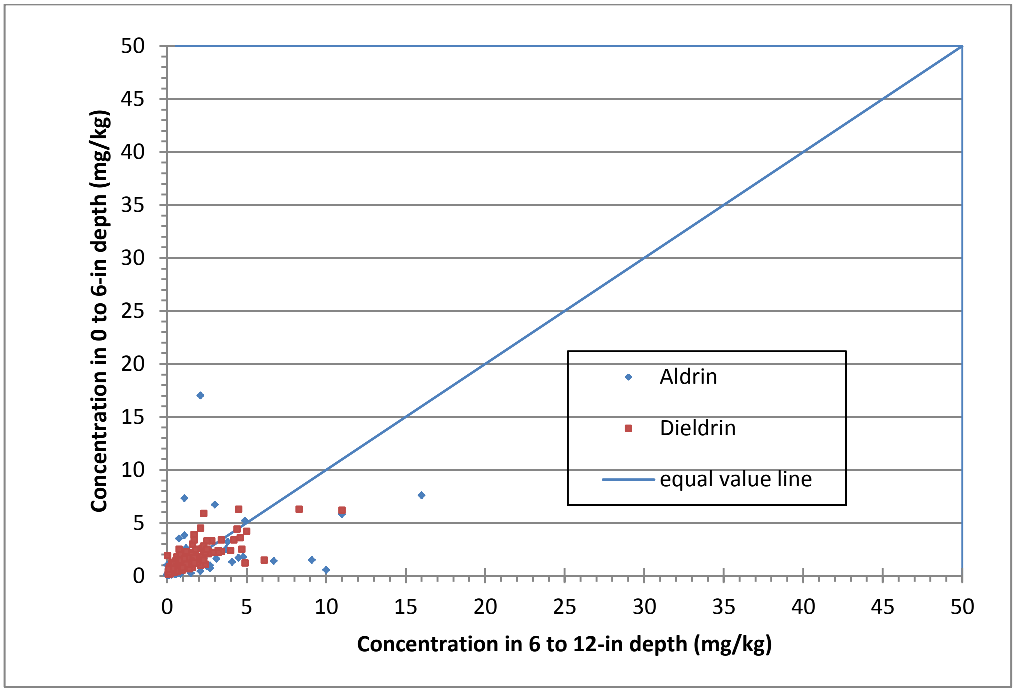


Figure 8-10 compares the concentrations of aldrin (blue diamonds) and dieldrin (red squares) in the 0 to 6-in and 6 to 12-inch samples from each DU. As for Earhart I-2 (Figure 8-5), about as many DUs have higher concentrations in the upper six inches as in the lower six inches.

Figure 8-10. Aldrin vs. Dieldrin Concentrations
0 to 6 inch and 6 to 12 inch



8.1.3 Onizuka II-1 Area

The chemicals detected above the PQL in the 46 samples collected from 21 DUs at Onizuka II-1 included DDD, DDE, DDT, aldrin, alpha-chlordane, technical chlordane, dieldrin, and gamma-chlordane. The number detections, range, and average concentration of the remaining compounds are presented in Table 8-3.

The COCs at the Onizuka II-1 Area are the same as in the Earhart Areas, based on their contribute to the cumulative risk. As discussed above, technical chlordane incorporates the alpha and gamma isomers of chlordane, so alpha and gamma chlordane are not shown in the table. Comparison of Table 8-3 to Tables 8-1 and 8-2 shows that the concentrations of the chemicals of concern are much lower in the soil in the Onizuka II-1 Area than in the soil at Earhart I-2 and Earhart I-3.

One or more of DDD, DDE, or DDT were detected above the PQL in 20 of the 0 to 6-inch samples, and in 18 of the 6 to 12-inch samples. The highest detected concentration was 0.11 mg/kg.

Chlordane was detected above the PQL in samples from all of the DUs at concentrations up to 5.5 mg/kg.

Table 8-3. Summary of Detected Pesticides, Onizuka II-1

Analyte	Depth	Number of Detects above PQL	Average Concentration (mg/kg)	Maximum Concentration (mg/kg)
4,4'-DDD	0-6"	0	0.01	0.02
"	6-12"	1	0.02	0.06
4,4'-DDE	0-6"	15	0.045	0.093
"	6-12"	11	0.047	0.15
4,4'-DDT	0-6"	18	0.052	0.099
"	6-12"	13	0.055	0.11
Aldrin	0-6"	21	0.10	0.35
"	6-12"	14	0.12	0.54
Technical Chlordane	0-6"	25	2.1	4.7
"	6-12"	21	2.3	5.5
Dieldrin	0-6"	25	0.34	1.0
"	6-12"	20	0.3	1.2

Aldrin or dieldrin was detected in samples from all of the DUs. Concentrations above the 2006 HHRA EALs for dieldrin (0.45 mg/kg) were detected in five of the samples from each detph interval.

Results of pre-construction sampling in the Onizuka II-1 Area suggests that chlordane, rather than aldrin and dieldrin, was applied for termite control at Onizuka. The observed chlordane concentrations, therefore, are likely the result of inaccurate placement of the excavated soil from within the former building footprints. However, the observed aldrin and dieldrin concentrations may have been introduced from outside the Onizuka II-1 Area with fill soil imported from elsewhere in the project area. Both types of soil would have been dispersed over the Study Area during grading and site preparation activities.

To further assess the independence of chlordane and aldrin plus dieldrin, Figure 8-11 shows chlordane concentrations plotted agains the sum of aldrin plus dieldrin in the 0 to 6-inch and 6 to 12-inch depths. The graph reveals very poor correlation between chlordane and aldrin + dieldrin.

Figure 8-12 shows the concentrations of aldrin relative to dieldrin in each DU and by depth interval. Unlike the graphs of this relationship for Earhart I-2 and Earhart I-3 (Figures 8.4 and 8.9, respectively), aldrin concentrations show close correlation to dieldrin concentrations in the samples from the Onizuka II-1 Area, with aldrin concentrations approximately four tenths of dieldrin concentrations. This close correlation is consistent with the aldrin and dieldrin having originated from imported soil in which the aldrin to dieldrin ratio was about four parts to ten parts. Thus, the ratio of aldrin to dieldrin did not change, although mixing of the soils during grading resulted in a range of absolute concentrations.

Figure 8-11. Chlordane vs. Dieldrin+Aldrin - Onizuka II-1

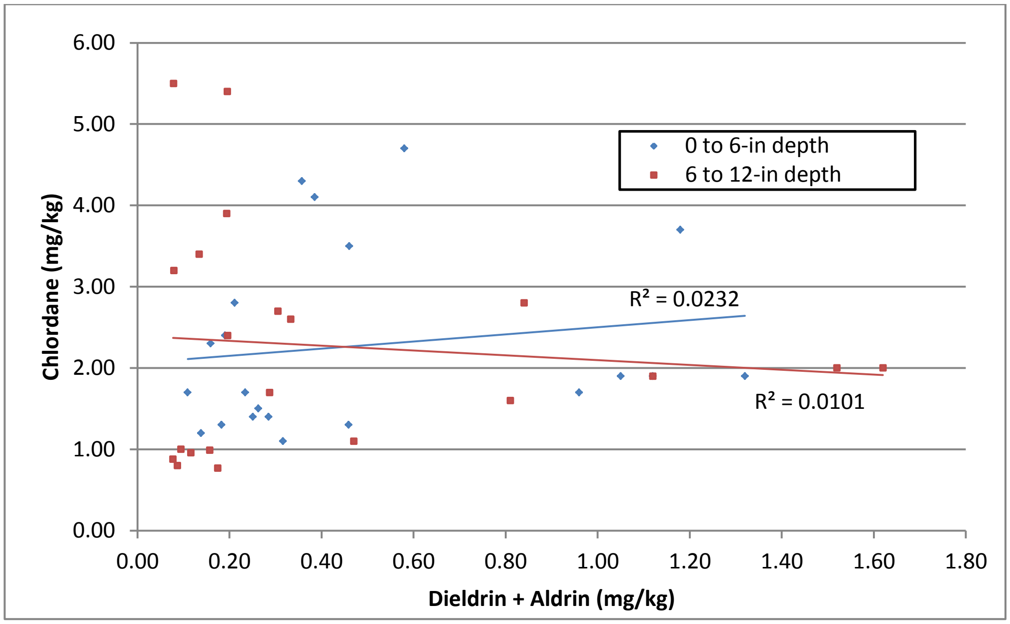
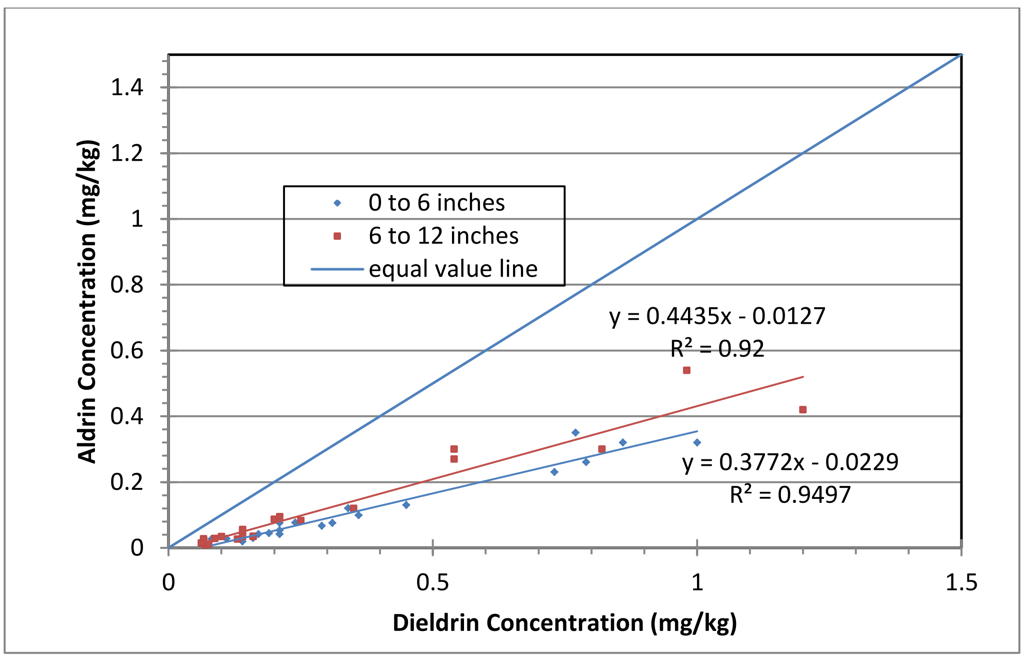


Figure 8-12. Aldrin vs. Dieldrin Concentrations
0 to 6 inch and 6 to 12 inch



9.0 DISCUSSION OF MAGNITUDE AND DISTRIBUTION OF CONTAMINATION

In the preceding pages, this report has focused on attributes of the data without reference to location. In this chapter, the geographic distribution of the data are discussed.

The investigation of the Study Area was designed to evaluate the risks posed by residual pesticide concentrations in shallow soil to which residents of the neighborhoods might be exposed over the course of many years. Sampling was conducted at the scale of the backyards and front yards of the multifamily buildings, as well as similar-sized portions of common areas. Each of the DUs were defined to contain up to 5,500 square feet (a little more than one-tenth acre) of open areas. The average DU size was less than 5,500 square feet. Samples were collected so as to be representative of the average concentration of pesticides in the upper six inches of soil, and in the underlying six inches.

In the preceding chapter we have seen that the average concentrations in the upper six inches of soil in any particular DU are not necessarily the same as in the lower six inches, even though overall, across the Study Area, the concentrations in the two depth intervals are similar. In this Chapter, the differences in the concentrations with depth are examined in more detail, geographically, to aid in later evaluating the risks associated with concentrations in both intervals.

The magnitude and distribution of pesticide concentrations at the Site may be the result of several factors. The investigation described in this report was conducted to determine the locations of elevated pesticide concentrations in the shallow soil at the Site. Trends in the distribution of pesticides may also provide clues as to the underlying causes of the observed pesticide distributions.

Pesticides are present at concentrations above the HDOH Tier 1 EALs, or above the 2012 EHE Standard, in many areas of the Site where although they do not pose an immediate threat, they might present a threat under future reasonably anticipated conditions. PI soil is managed beneath hardscapes or beneath one foot of acceptable fill soil at locations documented in the LUCID[87] and the EHMP[88].

9.1 Earhart I-2

Distribution of Aldrin and Dieldrin. As discussed in Chapter 8, aldrin and dieldrin are the principal pesticides of concern in the Earhart I-2 Area. Chlordane contributes to the risk, but the concentrations are generally below levels that would trigger a concern if chlordane were the only compound present. (The highest chlordane concentration was 6.6 mg/kg, which is about one-fourth of the 2006 HHRA EAL). Also, chlordane concentrations do not correlate closely with aldrin and/or dieldrin concentrations. Similarly, DDD, DDE, and DDT were detected in samples from a few DUs at concentrations approaching the 2006 HHRA EALs, but DDT was not used as a termiticide, so its concentration and distribution is likely independent of aldrin, dieldrin and chlordane.

[87] (Tetra Tech 2012b)
[88] (Tetra Tech 2012a)

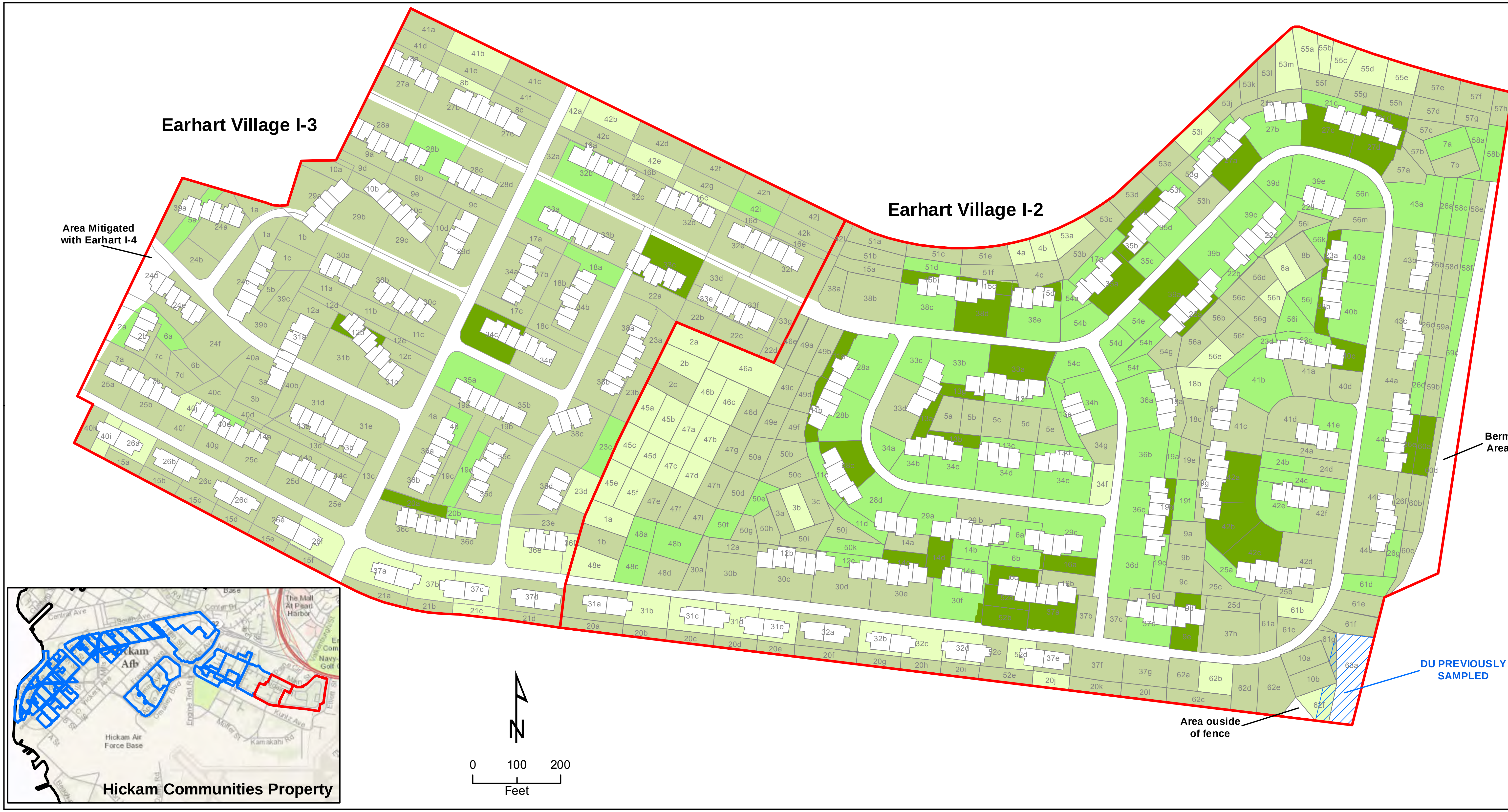
Figures 9-1 through 9-4 show the distribution of aldrin and dieldrin concentrations in each depth range as color-coded ranges. No color indicates concentrations of less than 0.45 mg/kg. Light green is 0.45 to 2.5 mg/kg, darker green is 2.5 to 4.5 mg/kg, and the darkest green represents concentrations greater than 4.5 mg/kg. The color-coded DUs are overlain on a map showing the former building footprints.

Although the DU boundaries were designed to evaluate risk to current residents based on current land use, rather than to assess the distribution of pesticides relative to the former building footprints, the figure shows that the distribution of aldrin and dieldrin is not entirely random across the Study Area. Instead, there is a tendency for the higher concentrations of aldrin and dieldrin to occur in the vicinity of the former footprints. Two-thirds of the 150 DUs with combined aldrin and dieldrin concentrations greater than 3 mg/kg overlap former building footprints, while only 32 of the 176 DUs with combined concentrations of aldrin and dieldrin of less than 3 mg/kg overlap any portion of a former footprint.

Sampling conducted prior to construction to investigate subfoundation samples in selected buildings along the south edge of Earhart I-2, south of Ohana Nui Circle, did not contain evidence of pesticides. There were seven buildings in this strip, and they had a different floor plan from the buildings in the rest of the Earhart I-2 area. Only DU-20d, which does not overlap a former building footprint, has aldrin or dieldrin concentrations greater than 4.5 mg/kg. The rest of the DUs along this strip have concentrations below 3 mg/kg.

Distribution of DDD, DDE, and DDT. There is a large area on the west side of the Earhart I-2 area that did not contain any buildings prior to construction of the new buildings. The DUs in this area tend to have lower concentrations of aldrin and dieldrin than elsewhere in the Earhart I-2 neighborhood. However, several of these DUs contain higher than average levels of DDE and DDT. Higher than average concentrations of DDE and DDT were detected more frequently in the 6 to 12-inch soil. Since this area was less disturbed than other areas where buildings were demolished, it may be that the DDT from past applications was preserved in the subsurface soil. The DUs with higher than average DDE and DDT are 1a, 45a and 45b, 47a and 47b, and 49a, on the west side of the Study Area; 51a on the northwest edge of the Study Area, and 61d on the southeast corner of the Study Area. DUs 37a and 37b in the south-central part of the Study Area, and 39c in the north-central part of the Study Area also contained higher than average concentrations of DDE and DDT.

Distribution of Chlordane. Chlordane concentrations are generally low in the Earhart I-2 Area. There are no concentrations above the HDOH Tier 1 EAL for chlordane of 16 mg/kg. DUs with concentrations from 3 to 6 mg/kg were found mainly around the margins of the Study Area, in DUs 2a, 45f, and 31a on the west side of the Study Area, and in 37b, 37d, and 37g; and 25b and 25c in the south central portion of the Study Area. Samples from six DUs had higher than normal reporting limits (of 5 mg/kg instead of 1 mg/kg), due to dilutions needed to quantify aldrin and dieldrin. This means that chlordane has to be assumed to be present at these levels even though it was not detected and could be present at much lower concentrations. Since these samples contained elevated concentrations of aldrin and dieldrin, the contribution to the cumulative risk from chlordane would be relatively small.



Earhart Village I-2/I-3
Old Hardscapes
1 0 b Decision Unit Number

Dieldrin Concentration Samples

>4.5
>0.45 - 2.5
>2.5 - 4.5
0.018 - 0.45

Dieldrin Concentration Samples - Depth 0-6 inches
Earhart I-2 and I-3 Neighborhoods

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Figure 9-1

Earhart Village I-2/I-3

Old Hardscapes

1 0 b Decision Unit Number

Dieldrin Concentration Samples

>4.5	>0.45 - 2.5
>2.5 - 4.5	0.018 - 0.45

Aldrin Concentration Samples - Depth 0-6 inches
Earhart I-2 and I-3 Neighborhoods

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Figure 9-2

R:\NEW\29064\Layouts\Revisions\Aldrin Concentration Samples - Depth 0-6 inches Earhart I-2 and I-3.mxd 04/26/12 - YE

Earhart Village I-2/I-3

Old Hardscapes

1 0 b Decision Unit Number

Dieldrin Concentration Samples

- >4.5
- >0.45 - 2.5
- >2.5 - 4.5
- 0.018 - 0.45

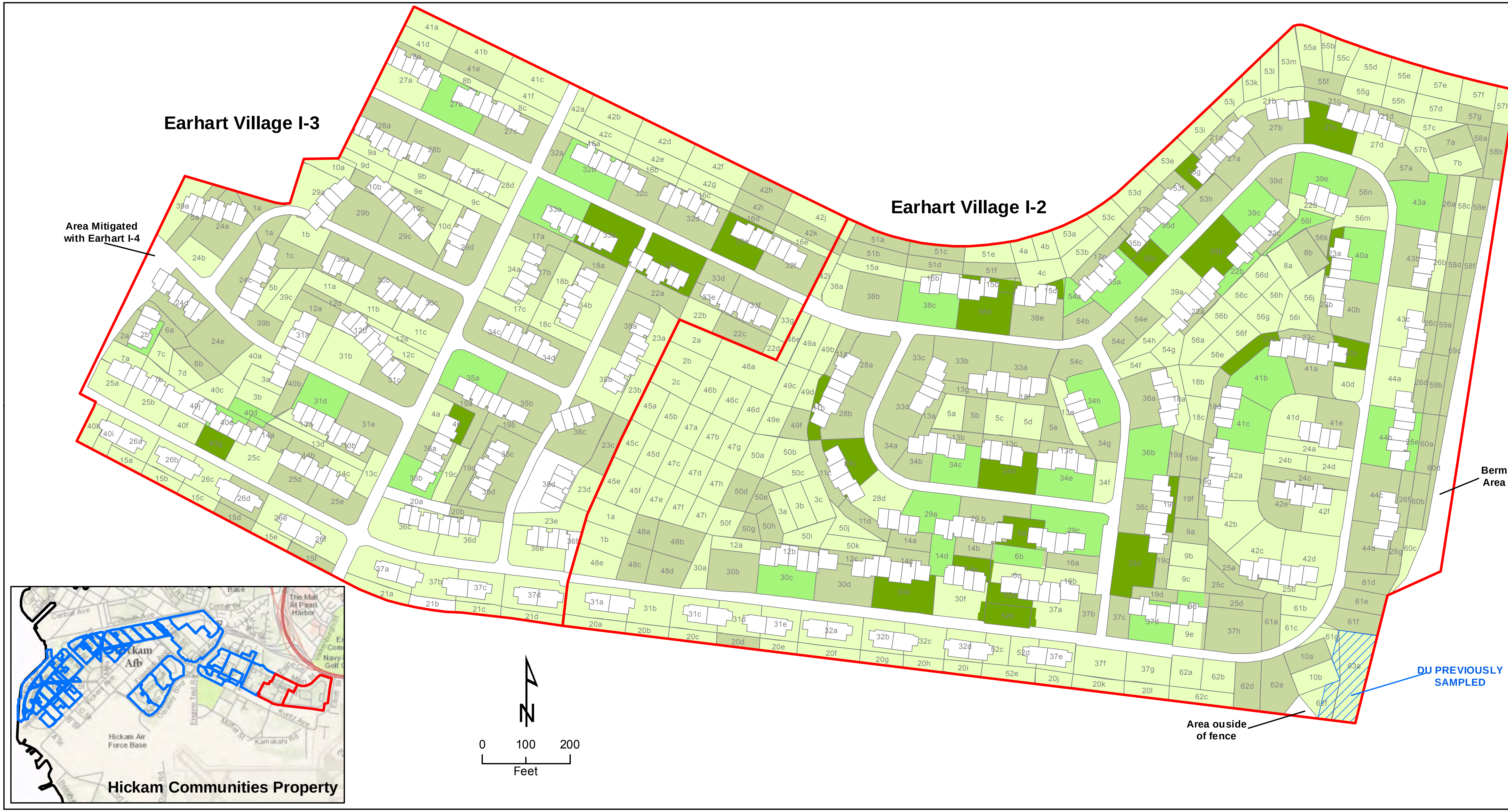
Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Dieldrin Concentration Samples - Depth 6-12 inches
Earhart I-2 and I-3 Neighborhoods

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 9-3



Earhart Village I-2/I-3

Old Hardscapes

10b Decision Unit Number

Aldrin Concentration Samples

>4.5	>0.45 - 2.5
>2.5 - 4.5	0.018 - 0.45

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Aldrin Concentration Samples - Depth 6-12 inches
Earhart I-2 and I-3 Neighborhoods

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 9-4

R:\NEW\29064\Layouts\Revisions\Aldrin Concentration Samples - Depth 6-12 inches Earhart I-2 and I-3.mxd 04/26/12 - YE

9.2 Earhart I-3

As discussed in Chapter 8, fewer samples in the Earhart I-3 Area had elevated concentrations similar to those detected in the Earhart I-2 Area.

Distribution of Aldrin and Dieldrin. Figures 9-1 through 9-4 show the distribution of aldrin and dieldrin at Earhart I-3. As in the Earhart I-2 Area, the highest concentrations of aldrin seem to be associated with the former footprints. Figures 9-2 and 9-4 show that concentrations of aldrin greater than 4.5 mg/kg were found in shallow soil in only five of the 182 DUs investigated, and in the 6 to 12-inch depth of four additional DUs. Four out of five of these DUs overlap the footprints of former buildings, and the others are adjacent to former building footprints.

Distribution of DDD, DDE, and DDT. DDT and DDE were detected at concentrations above 1 mg/kg in shallow soil in six DUs (6a and 6b, 11b, 13b, 29a, and 39b), and in the deeper soil layer in seven additional DUs (9a and 9c, 11d, 14b, 23b, 29b, 42b). The DDT was found in both layers at these concentrations in only three of the DUs (6a and 6b, and 29a).

Distribution of Chlordane. Chlordane was generally detected at concentrations less than half the 2006 HHRA EAL. For example, it was detected at concentrations above 10 mg/kg only in the 6 to 12-inch depth interval, and in only four DUs (4b, 12b, 12d, and 14b).

9.3 Onizuka II-1

Based on previous sampling of the Onizuka Village area, as discussed in Chapter 4, chlordane was the primary termiticide applied to the buildings in this area. As discussed in Chapter 8, aldrin and dieldrin appear to have been introduced during construction and grading of the Study Area.

Initial post-construction sampling of the Onizuka II-1 area identified the eastern portion of the residential neighborhood as the area with the highest concentrations of pesticides. Table 9-1 summarizes the results of samples representing division of the Onizuka II-1 neighborhood into five approximately one acre to 2.5-acre DUs.

Table 9-1. Summary Results of Samples from Five DUs Collected May 2010 at Onizuka II-1 (mg/kg)

Sample Name	Area (ac)[1]	Chlordane	Aldrin	Dieldrin
ONI2-OA-1-06	1.8	3.8	0.077	0.22
ONI2-OA-1-12		4.8	0.044	0.12
ONI2-OA-2-06-1	1.4	1.3	0.032	0.12
ONI2-OA-2-06-2		2.0	0.04	0.11
ONI2-OA-2-06-3		2.1	0.023	0.09
ONI2-OA-2-12		1.2	0.038	0.1
ONI2-OA-3-06	1. 9	2.6	0.16	0.42
ONI2-OA-3-12		5.7	0.16	0.32
ONI2-OA-4-06	2.5	1.9	0.058	0.19
ONI2-OA-4-12		1.7	0.015	0.05
HOMF-OA-1-06	1.2	0.7	0.038	0.11
HOMF-OA-1-12		1.7	0.13	0.34

Notes: (1) Areas excluding hardscapes

Based on these results, it was determined that soil in DU-OA-3 and the soil in the 6 to 12-inch depth of the HOMF DU met the criteria of PI soil.

To further evaluate the soil within DU-OA-3, it was subdivided into 21 smaller DUs less than 5,500 square feet, representing backyards, front yards, and common areas, as had been done for the entire Earhart I-2 and I-3 neighborhoods. Samples were collected from each of the smaller DUs from the 0 to 6-inch and 6 to 12-inch depths.

Table 9-2 shows the concentrations of the principal pesticides detected in the samples from Onizuka II-1; the complete sample results are presented in Table C-3.

Table 9-2. Summary Results for Onizuka II-1 Decision Units (mg/kg)

Client Sample ID	DU	Depth (in)	Chlordane		Aldrin		Dieldrin	
ONI-RA-1a-06-1	1a	06	1.4		0.041		0.21	
ONI-RA-1a-06-2	1a	06	1.4		0.041		0.21	
ONI-RA-1a-06-3	1a	06	0.9		0.034		0.18	
ONI-RA-1a-12	1a	12	0.77		0.034		0.14	
ONI-RA-1b-06	1b	06	1.5		0.053		0.21	
ONI-RA-1b-12	1b	12	0.99		0.027		0.13	
ONI-RA-1c-06	1c	06	4.1		0.075	J	0.31	
ONI-RA-1c-12	1c	12	5.4		0.035	J	0.16	
ONI-RA-2a-06	2a	06	2.8		0.041		0.17	
ONI-RA-2a-12	2a	12	3.2		0.0089	J	0.07	
ONI-RA-2b-06	2b	06	4.7		0.13		**0.45**	
ONI-RA-2b-12	2b	12	5.5		0.022	U	0.067	J
ONI-RA-2c-06	2c	06	4.3		0.067		0.29	
ONI-RA-2c-12	2c	12	3.9		0.034	J	0.16	
ONI-RA-2d-06	2d	06	3.5		0.12		0.34	
ONI-RA-2d-12	2d	12	3.4		0.034	J	0.10	
ONI-RA-2e-06	2e	06	2.3		0.019	J	0.14	
ONI-RA-2e-12	2e	12	0.8		0.011	J	0.076	
ONI-RA-2f-06	2f	06	1.7		0.044		0.19	
ONI-RA-2f-12	2f	12	1		0.028		0.066	
ONI-RA-2g-06	2g	06	3.7		0.32		**0.86**	
ONI-RA-2g-12	2g	12	2.6		0.083		0.25	
ONI-RA-2h-06	2h	06	2.4		0.03	J	0.16	
ONI-RA-2h-12	2h	12	2.8		0.3		**0.54**	
ONI-RA-3a-06	3a	06	1.1		0.076		0.24	
ONI-RA-3a-12	3a	12	2.4		0.056		0.14	
ONI-RA-3b-06	3b	06	1.3		0.099		0.36	
ONI-RA-3b-12	3b	12	1.1		0.12		0.35	
ONI-RA-3c-06	3c	06	1.2		0.028		0.11	
ONI-RA-3c-12	3c	12	0.96		0.029		0.087	
ONI-RA-3d-06	3d	06	1.7		0.027		0.082	
ONI-RA-3d-12	3d	12	2.7		0.095		0.21	
ONI-RA-4a-06-1	4a	06	1.1		0.042		0.14	
ONI-RA-4a-06-2	4a	06	1.2		0.043		0.13	
ONI-RA-4a-06-3	4a	06	1.3		0.043		0.14	

Table 9-2. Summary Results for Onizuka II-1 Decision Units (mg/kg)

Client Sample ID	DU	Depth (in)	Chlordane		Aldrin		Dieldrin	
ONI-RA-4a-12	4a	12	0.88		0.015	J	0.062	
ONI-RA-4b-06	4b	06	1.4		0.075		0.21	
ONI-RA-4b-12	4b	12	1.7		0.087		0.20	
ONI-RA-4c-06	4c	06	1.9		0.35		**0.77**	
ONI-RA-4c-12	4c	12	1.6		0.27		**0.54**	
ONI-RA-5a-06	5a	06	1.9		0.26		**0.79**	
ONI-RA-5a-12	5a	12	2		**0.54**		**0.98**	
ONI-RA-5b-06	5b	06	1.7		0.23		**0.73**	
ONI-RA-5b-12	5b	12	1.9		0.3		**0.82**	
ONI-RA-5c-06	5c	06	1.9		0.32		**1.0**	
ONI-RA-5c-12	5c	12	2		**0.42**		**1.2**	
Concentration Range			**0.8 to 5.5**		**0.009 to 0.54**		**0.06 to 1.2**	

Notes: J= detected above MDL and below PQL. Concentration flagged as uncertain
U= not detected above MDL shown
Bold = concentration above 2006 HHRA EAL

Distribution of Aldrin and Dieldrin. As indicated in Table 9-2, concentrations of aldrin and dieldrin exceeded the 2006 HHRA EALs in eleven samples from seven DUs. With the exception of DU 2b, these DUs are clustered along the eastern edge of the Onizuka II-1 neighborhood.

Distribution of Chlordane. Chlordane was detected in all of the samples at low to moderate concentrations. The highest concentration was 5.5 mg/kg, which is less than one-quarter of the 2006 HHRA EAL. Except for the presence of aldrin and dieldrin, none of the DUs would have exceeded the 2006 HHRA standard for PI soil in effect at the time of construction.

Distribution of DDD, DDE, and DDT. Concentrations of DDD, DDE, and DDT were relatively low and similar throughout the area sampled. DDD was detected above the PQL in only one sample. The maximum detected concentrations of DDT and DDE were well below the HDOH Tier 1 EALs, probably reflecting background concentrations.

Based on the results in Table 9-2, the concentrations of aldrin and dieldrin observed on the eastern margin of the sampled area appear to explain the exceedence of the 2006 HHRA standard in the sample from DU-OA-03.

This page intentionally left blank

10.0 RESULTS OF REMOVAL ACTIONS

10.1 Introduction

Based on the preliminary analytical results for the MI soil sampling conducted at the Study Area, three rounds of ROs were performed to address immediate concerns about residential exposure to pesticides in the short term. The ROs were conducted between October 2010 and August 2011, under a Voluntary Agreement between HC and HDOH (HC 2011a).

- RO #1 implementation commenced on October 15, 2010. Except for minor repairs of the soil caps and reseeding of select areas, the work conducted under RO #1 was completed by December 20, 2010.[89]
- RO #2 implementation commenced on January 4, 2011. Except for reseeding of select areas, the work conducted under RO #2 was completed by April 13, 2011[90]. The excavated soil from RO#1 and RO#2 was permanently managed in an on-site burial pit on April 22, 2011.
- RO #3 implementation commenced on July 5, 2011, and was completed by August 4, 2011.[91] The soil from the RO #3 was temporarily managed at the soil management area located southwest of the Earhart I-2 Neighborhood pending regulatory concurrence with a proposal to use it to create a sound berm along the northeast boundary of the Earhart I-2 neighborhood.

The RO's were conducted in accordance with work plans reviewed and approved by HDOH.[92] Interim reports were prepared to document the results of the first two RO's and a draft Removal Action Report (RAR) documenting the results of all three removal actions was prepared and submitted to HDOH for review on September 13, 2011.[93] A revised draft RAR is in preparation at the time of preparation of this report. This chapter summarizes the information presented in the revised draft RAR.

Each of the RO's was based on EALs derived using assumptions specific to the objectives of the RO's. Table 10-1 summarizes the standards that were used and the actions taken when the standards were exceeded. The standards listed under the Action Criteria are defined in Table 4-2. As indicated in Table 10-1, RO's #1 and #2 included several different actions. Each of these is referred to by a different name, to distinguish them (for example, RO#1 included the actions described in Section 10.2, which are referred to as RO-1A and RO-1B). On the right side of Table 10-1 the number of DUs that exceeded the standard are shown, with the number of DUs requiring the action shown below it (for example, for RO-2C 147 DUs exceeded an HI of 1 based on the APRA-3 standard. After inspection, it was determined that only 13 of these DUs required reseeding). Each of the removal actions is described below. (Note that none of the DUs in Onizuka II-1 exceeded the standards, and therefore, no removal actions were performed at Onizuka II-1.)

89 (Tetra Tech 2011a)
90 (Tetra Tech 2011c)
91 (Tetra Tech 2011h)
92 (Tetra Tech 2010m; 20111b; and 2011f)
93 (Tetra Tech 2011h)

Table 10-1. Summary of Removal Actions

Removal Action	EAL (Hazard Quotient = 1)[1] (mg/kg)			Action Taken [2]	Number of DUs Affected [3]			
	Chlordane	Aldrin	Dieldrin		EAR I-2	EAR I-3	ONI II-1	Total
RO-1A	35	1.8	3.1	If HI >10, replace top 12-in of soil	4/4[4]	1/1	0/0	5/5
RO-1B	35	1.8	3.1	If 3 > HI ≤ 10, inspect grass cover, and if bare soil area is greater than 200 square feet, replace top 12-in of soil	1/17	0/5	0/0	1/22
RO-2A	35	15	15	If HI > 1, replace top 6-in of soil	1/1	0/0	0/0	1/1
RO-2B1	35	4.7	7.7	If HI > 1, remove vegetation, place geotextile beneath gravel	11/33	0/8	0/0	11/40
RO-2B2	35	4.7	7.7	If HI > 1 and large, well-established plants or dense growth present, remove low ground cover, place geotextile, gravel	13/33	4/8	0/0	17/41
RO-2C	35	1.8	3.1	If HI > 1, inspect and reseed damaged grass areas	13/147	8/48	0/0	21/195
RO-3	69	12	9.8	If HI > 1, remove top 9-in of soil, install geotextile and replace with new fill	10/10	4/4	0/0	4/14

Notes:
1 Hazard Quotient of 1 is concentration at non-cancer no-effects level
2 Initiate action if Hazard Index (sum of hazard quotients based on detected concentrations of principal compounds in each DU) is greater than action criterion shown.
3 Top value is number of DUs where removal action was implemented; bottom number is number of DUs that exceeding the applicable standard.
4 Soil in additional adjacent DUs were also excavated, though not required (see Table 10-2)

10.2 Removal Action #1

Based on comparison of the results of the confirmation sampling of Earhart I-2, Earhart I-3, and Onizuka II-1 relative to the 2006 HHRA EALs, an Action Plan (referred to as the "HC Action Plan"[94]) was developed in consultation with HDOH. HDOH determined that DUs containing soil with concentrations corresponding to an HI greater than 10 (based on the assumptions of the 2006 HHRA) should be addressed immediately, through an RO, by excavating and replacing the soil to a depth of 12 inches. This action is identified as RO-1A in Table 10-1. As indicated in Table 10-1, a total of 4 DUs (DUs 6c, 9d, 42c, and 52a) exceeded this criterion in Earhart I-2, but only one DU (DU 2a) in Earhart I-3. Additional adjacent DUs were also excavated and soil was replaced in conjunction with RO-1A as a preemptive measure, although the soil in these DUs did not exceed the removal action criteria.

Soil corresponding to an HI between 3 and 10 was considered to present an intermediate hazard, where immediate action was needed only if significant amounts of bare soil was

94 (Tetra Tech 2010m)

exposed, such as in areas not well covered by turf. A total of 17 DUs in Earhart I-2 and 5 DUs in Earhart I-3 exceeded this criterion. The turf covering soil in DUs in which intermediate concentrations of pesticides had been identified was inspected, and any DUs with poor cover were scheduled for additional action. Only one DU in Earhart I-2 (DU 15d) had a bare soil area greater than 200 sq ft that required action. The action was to replace the soil to a depth of 12 inches, as described for Action RO-1A.

HC elected to replace soil in DUs (6b, 9e, and 52b) and small parts of four other DUs in Earhart I-2 because these DUs were adjacent to the DUs that required soil replacement under Response Action #3 of the Action Plan. The DUs where soil was replaced are shown in Figure 10-1. None of the DUs in the Onizuka II-1 neighborhood had concentrations that required action under RO#1.

Table 10-2 lists the DUs where soil was replaced under RO #1.

Table 10-2. DUs Excavated and Backfilled During RO #1

Neighborhood	DU	Reason for Action	Date Excavated and Backfilled	Approximate in-situ Volume (CY)
Earhart I-2	**42c**	HI>10	October 15- 20, 2010	166
	9d	HI>10	October 20-25, 2010	139
	9e	Adjacent to 9d		126
	Parts of 4c, 30f, 37a, and 37d	Small areas adjacent to other removals	October 20-25, 2010	66
	6b	Adjacent to 6c	October 25- November 2, 2010	154
	6c	HI>10		178
	52a	HI>10	October 25- November 2, 2010	181
	52b	Adjacent to 52a		152
	15d	HI=3 to 10, bare soil> 200 sq-ft	November 5, 2010	84
Earhart I-3	**2a**	HI>10	November 18-22, 2010	72
			Total:	**1,318**

Table 10-3 summarizes the concentrations of the principal COPCs detected in the DUs listed in Table 10-2.

This page intentionally left blank

Earhart Village I-2/I-3

Hardscapes

10 b Decision Unit Number

Decision Units excavated under RO1

Decision Units excavated under RO2

Decision Unit excavated under RO3

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Decision Units Excavated under RO1, RO2 and RO3
Earhart I-2 and I-3

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 10-1

R:\NEW\29064\Layouts\Revisions\Decision Units Excavated under RO1, RO2, and RO3 Earhart I-2 and I-3.mxd 04/26/12 - YE

Table 10-3. Concentrations (mg/kg) of Pesticides Detected in DUs Excavated Under RO # 1

DU	Sample ID	Depth Interval (inches)	Aldrin	Dieldrin	Chlordane
04c	EAR2-RA-04c-06	06	0.65	2.3	0.5U
	EAR2-RA-04c-12	12	0.43	1.6	0.89
06b	EAR2-RA-06b-06	06	3.6	3.3	1U
	EAR2-RA-06b-12	12	3.4	1.9	1U
06c	EAR2-RA-06c-06	06	46	10	5U
	EAR2-RA-06c-12	12	36	6.7	5U
09d	EAR2-RA-09d-06	06	25	5.8	5U
	EAR2-RA-09d-12	12	3.2	3.1	1U
09e	EAR2-RA-'09e-06	06	8.7	7.9	5U
	EAR2-RA-'09e-12	12	11	4.8	5U
15d	EAR2-RA-15d-06	06	5.1	8.8	0.5U
	EAR2-RA-15d-12	12	4.9	7.1	0.5U
30f	EAR2-RA-30f-06	06	4	3.6	1U
	EAR2-RA-30f-12	12	17	4.5	3U
37a	EAR2-RA-37a-06-1	06	6.5	5.8	2.9J
	EAR2-RA-37a-06-2	06	2.8	4.8	2.8J
	EAR2-RA-37a-06-3	06	2.6	4.4	2.7
	EAR2-RA-37a-12	12	26	11	6.2J
37d	EAR2-RA-37d-06	06	1.4	2.7	2.5
	EAR2-RA-37d-12	12	3.7	3.2	3
42c	EAR2-RA-42c-06	06	27	7	5U
	EAR2-RA-42c-12	12	17	6.4	5U
52A	EAR2-RA-52A-06	06	25	8.5	5U
	EAR2-RA-52A-12	12	10	4	2.5U
52B	EAR2-RA-52B-06	06	6.4	7.2	2U
	EAR2-RA-52B-12	12	7	5.4	2U
02a	EAR3-RA-02a-06	06	17	10	3.9
	EAR3-RA-02a-12	12	2.1	2.8	1.7
Concentration at Hazard Quotient = 1 [1]			**1.8**	**3.1**	**35**

Notes: (1) based on 2006 HHRA EAL non-cancer risk assumptions
"U" = not detected at the detection limit indicated
"J" = detected between MDL and PQL

As shown in Table 10-2, a total of approximately 1,318 in-place cubic yards (CY) of soil, equivalent to approximately 1,986 CY ex-situ (assuming an expansion factor of 1.5), were excavated from the DUs in RO #1. The soil was transported to a temporary soil stockpile area designed for the purpose that was located southwest of Earhart I-4. The soil was stockpiled pending permanent management in Burial Pit#6b constructed at Onizuka II-3. Burial Pit#6b is located near, but separate from a different burial pit used to manage the soil removed from Onizuka II-3 and the Historic Homes District (Figure 1-1).

10.3 Removal Action #2

Following development of the Action Plan described in Section 10.2.1, HDOH and HC continued to assess the need to further reduce risks to residents in advance of completing the Remedial Investigation and selection of a final remedy for the Program Area.

As part of this continued assessment, adjusted alternative action levels (ALs) were developed and approved by HDOH.[95] The results of this reassessment were summarized in a memorandum dated November 10, 2010 entitled *Revised Analysis of Potential Removal Alternatives, Earhart I-2, Earhart I-3 and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam Hawai'i* (the "APRA Memo").[96] The alternative action levels associated with the APRA Memo are listed in Table 4.2.

Building upon the general approach initiated in the Action Plan that guided removal action (RO) #1, three types of RO Types were identified in the APRA Memo, forming the basis for RO #2. Table 10-4 lists the DUs that exceeded the respective APRA standards, potentially requiring action.

Table 10-4. DU's That Exceeded APRA Standards, by Action Type, RO #2

Earhart I-2						Earhart I-3	
DU Name	RO Type	DU Name	RO Type	DU Name	RO Type	DU Name	RO Type
EAR2-DU-03c	1	EAR2-DU-25b	1	EAR2-DU-40a	1	EAR3-DU-01a	1
EAR2-DU-04c	1	EAR2-DU-25d	1	EAR2-DU-40b	1	EAR3-DU-01c	1
EAR2-DU-06a	1	EAR2-DU-26a	1	EAR2-DU-40c	1,2	EAR3-DU-02b	1
EAR2-DU-06b	1,2	EAR2-DU-26c	2	EAR2-DU-41a	1	EAR3-DU-03a	1
EAR2-DU-07a	1	EAR2-DU-26d	1	EAR2-DU-41b	1	EAR3-DU-03b	1
EAR2-DU-07b	1	EAR2-DU-26e	1,2	EAR2-DU-41c	1,2	EAR3-DU-03d	1
EAR2-DU-11a	1,2	EAR2-DU-26g	1	EAR2-DU-41e	1	EAR3-DU-04b	1
EAR2-DU-11b	1,2	EAR2-DU-27a	1,2	EAR2-DU-42a	1,2	EAR3-DU-05a	1,2
EAR2-DU-11c	1	EAR2-DU-27b	1	EAR2-DU-42b	1,2	EAR3-DU-06a	1
EAR2-DU-11d	1	EAR2-DU-27c	1,2	EAR2-DU-42e	1,2	EAR3-DU-10b	1
EAR2-DU-12b	1	EAR2-DU-27d	1,2	EAR2-DU-43a	1	EAR3-DU-12b	1,2
EAR2-DU-12c	1,2	EAR2-DU-28a	1	EAR2-DU-43b	1	EAR3-DU-13a	1
EAR2-DU-13a	1,2	EAR2-DU-28b	1	EAR2-DU-44b	1	EAR3-DU-14a	1
EAR2-DU-13a	1,2	EAR2-DU-28c	1,2	EAR2-DU-44c	1	EAR3-DU-16d	1
EAR2-DU-13b	1	EAR2-DU-28d	1	EAR2-DU-44d	1	EAR3-DU-18a	1
EAR2-DU-13c	1	EAR2-DU-29a	1,2	EAR2-DU-48a	1	EAR3-DU-19a	1
EAR2-DU-13d	1	EAR2-DU-29a	1,2	EAR2-DU-48b	1	EAR3-DU-19b	1
EAR2-DU-13e	1	EAR2-DU-29b	1	EAR2-DU-48c	1	EAR3-DU-19d	1
EAR2-DU-13f	1	EAR2-DU-29c	1	EAR2-DU-48d	1	EAR3-DU-20a	1,2
EAR2-DU-13g	1,2	EAR2-DU-30b	1	EAR2-DU-50a	1	EAR3-DU-20b	1
EAR2-DU-14b	1	EAR2-DU-30e	1	EAR2-DU-50e	1	EAR3-DU-23c	1
EAR2-DU-14c	1,2	EAR2-DU-30f	1,2	EAR2-DU-50f	1	EAR3-DU-24c	1
EAR2-DU-14d	1	EAR2-DU-33a	1,2	EAR2-DU-50g	1	EAR3-DU-24d	1
EAR2-DU-14e	1,2	EAR2-DU-33b	1,2	EAR2-DU-50h	1	EAR3-DU-24e	1
EAR2-DU-15b	1,2	EAR2-DU-33c	1	EAR2-DU-50k	1	EAR3-DU-28a	1
EAR2-DU-15b	1,2	EAR2-DU-34a	1	EAR2-DU-51d	1	EAR3-DU-28b	1
EAR2-DU-15c	1,2	EAR2-DU-34b	1	EAR2-DU-51e	1	EAR3-DU-29c	1
EAR2-DU-16a	1	EAR2-DU-34c	1	EAR2-DU-53f	1	EAR3-DU-29d	1
EAR2-DU-17a	1	EAR2-DU-34d	1,2	EAR2-DU-53g	1	EAR3-DU-30c	1
EAR2-DU-17b	1	EAR2-DU-34e	1	EAR2-DU-54a	1	EAR3-DU-31d	1
EAR2-DU-19a	1	EAR2-DU-34g	1	EAR2-DU-54b	1	EAR3-DU-32b	1

95 (HDOH 2010b)
96 (Tetra Tech 2010n)

Table 10-4. DU's That Exceeded APRA Standards, by Action Type, RO #2

Earhart I-2						Earhart I-3	
DU Name	**RO Type**	**DU Name**	**RO Type**	**DU Name**	**RO Type**	**DU Name**	**RO Type**
EAR2-DU-19b	1,2	EAR2-DU-34h	1	EAR2-DU-54c	1	EAR3-DU-32e	1
EAR2-DU-19c	1	EAR2-DU-35a	1,2	EAR2-DU-54d	1	EAR3-DU-33a	1,2
EAR2-DU-19e	1	EAR2-DU-35b	1,2	EAR2-DU-54e	1	EAR3-DU-33c	1,2
EAR2-DU-19f	1	EAR2-DU-35c	1	EAR2-DU-54f	1	EAR3-DU-33d	1
EAR2-DU-20a	1	EAR2-DU-35d	1	EAR2-DU-54h	1	EAR3-DU-33e	1
EAR2-DU-21a	1	EAR2-DU-36a	1	EAR2-DU-56i	1	EAR3-DU-34c	1,2
EAR2-DU-21c	1	EAR2-DU-36b	1	EAR2-DU-56j	1	EAR3-DU-34d	1
EAR2-DU-21d	1	EAR2-DU-36c	1,2	EAR2-DU-56k	1	EAR3-DU-35a	1
EAR2-DU-22a	1	EAR2-DU-36d	1,2	EAR2-DU-56n	1	EAR3-DU-35b	1
EAR2-DU-22b	1	EAR2-DU-37a	1,2	EAR2-DU-57a	1	EAR3-DU-35d	1
EAR2-DU-22c	1	EAR2-DU-37c	1	EAR2-DU-57b	1	EAR3-DU-36a	1
EAR2-DU-22d	1	EAR2-DU-37d	1	EAR2-DU-58a	1	EAR3-DU-36b	1
EAR2-DU-23a	1,2	EAR2-DU-38c	1	EAR2-DU-58b	1	EAR3-DU-38c	1
EAR2-DU-23b	1,2	EAR2-DU-38d	1,2	EAR2-DU-58c	1	EAR3-DU-38d	1
EAR2-DU-23b	1,2	EAR2-DU-38e	1	EAR2-DU-58e	1	EAR3-DU-40a	1
EAR2-DU-23c	1	EAR2-DU-39a	3	EAR2-DU-58f	1	EAR3-DU-40b	1
EAR2-DU-23d	1	EAR2-DU-39b	1	EAR2-DU-59b	1	EAR3-DU-40c	1,2
EAR2-DU-24b	1	EAR2-DU-39c	1	EAR2-DU-59c	1	EAR3-DU-40d	1
EAR2-DU-24c	1	EAR2-DU-39d	1	EAR2-DU-60a	1,2	EAR3-DU-40e	1,2
EAR2-DU-25a	1	EAR2-DU-39e	1	EAR2-DU-61d	1	EAR3-DU-40g	1
						EAR3-DU-42i	1
						EAR3-DU-42k	1

Type 1 = grass cover
Type 2 = landscaping strips
Type 3 = full DU soil replacement

RO-2A (2010 APRA-3 Standard applied to full DU). For this scenario, ALs were developed based on an alternative child soil ingestion rate and alternative oral reference dose. The aldrin and dieldrin residential soil ALs under this scenario were both 15 mg/kg. The Response Action under Removal Action Type 3 was excavation of the DU to a minimum of 6-inches below grade and placement of a geotextile fabric barrier overlain by clean fill. Only one DU in Earhart I-2 (39a) required action under RO-2A. Table 10-5 shows the pesticide concentrations detected in the samples from the DU.

Table 10-5. Concentrations (mg/kg) of Pesticides Detected in DUs Excavated Under RO #2

DU	Sample ID	Depth Interval (inches)	Aldrin	Dieldrin	Chlordane
39a	*EAR2-RA-39a-06*	*7.1*	*5*	*9.7*	*7.1*
	EAR2-RA-39a -12	*13*	*5*	*15*	*13*
Concentration at Hazard Quotient = 1 [1]			***1.8***	***3.1***	***35.2***

Notes: (1) based on 2006 HHRA EAL non-cancer risk assumptions
"U" = not detected at the detection limit indicated
"J" = detected between MDL and PQL

RO-2B (2010 APRA-2 Standard for areas with exposed soil in landscaping strips). RO-2B was designed to address risks associated with exposed soil in landscaping strips adjacent to buildings, where it was thought that exposed surface soil might present a greater exposure hazard than in areas covered by grass. For this scenario, site-specific ALs were developed based on an alternative child soil ingestion rate. The aldrin and dieldrin residential soil ALs associated with an HI of 1 under this scenario were 4.7 mg/kg and 7.7 mg/kg, respectively.

For DUs where an HI greater than 1 was identified based on the revised ALs, the RO was to place a geotextile fabric barrier over soil in the landscaping strips (i.e. the planter boxes located in the 2 to 3-foot strips adjacent to buildings), and to cover the fabric with gravel (to hold the fabric in place). A total of 33 DUs in Earhart I-2 and 8 DUs in Earhart I-3 exceeded the standard and required inspection. After inspection a variant of the removal action was developed to preserve large and well-established plants, and because landscaping strips at some locations were found to contain sufficiently dense vegetation cover that placement of geotextile fabric was deemed unnecessary. The main action was designated RO-2B1, and the variant, which was to remove soil from the portion of the landscaping strip presenting an immediate risk, was designated RO-B2.

A total of 13 DUs in Earhart I-2 required full replacement, and none required it in Earhart I-3. Eleven DUs in Earhart I-2 required partial replacement and 4 required it in Earhart I-3. Initially landscaping strips were identified for inspection based on the results of the samples from the original set of DUs. However, the landscaping strips occupy only a small portion of the exposed soil within the DUs, and are associated with specific units of each building. As a result, multiple landscaping strips were identified with many of the DUs, and only some of these required action. Furthermore, a number of the DUs that exceeded the standard did not contain landscaping strips at all (for example, the DUs were in common areas rather than backyards). To track the landscaping strips where action was taken, these smaller areas were each designated with a separate DU identification number, consisting of the original DU ID, followed by a "LS" suffix followed by a number representing the address of the building unit where the strip was located. Table 10-6 lists the landscaping strip DUs where the prescribed actions were completed.

Table 10-6. RO-2B1 and RO-2B2 Landscaping Strip Replacement Assessment and Management

DU Name	Inspection Date	Building Number	Landscaping Strip Unit Number	Total Replacement [1]	Management Date
EAR2-DU-27b-LS797	1/4/2011	6336	797	No	2/14/2011
EAR2-DU-27b-LS791	1/4/2011	6336	791	Yes	2/14/2011
EAR2-DU-27a-LS817	1/4/2011	6338	817	Yes	2/15/2011
EAR2-DU-27a-LS811	1/4/2011	6338	811	No	2/15/2011
EAR2-DU-35a-LS835	1/4/2011	6340	835	Yes	2/15/2011
EAR2-DU-28c-LS903	1/4/2011	6347	903	Yes	2/15/2011
EAR2-DU-29a-LS921	1/4/2011	6349	921	Yes	2/15/2011
EAR2-DU-34d-LS932	1/4/2011	6353	932	No	2/15/2011
EAR2-DU-33b-LS864	1/4/2011	6356	864	Yes	2/15/2011
EAR2-DU-38d-LS863	1/4/2011	6342	863	No	2/16/2011
EAR2-DU-38d-LS865	1/4/2011	6342	865	No	2/16/2011
EAR2-DU-34d-LS938	1/4/2011	6353	938	No	2/16/2011

Table 10-6. RO-2B1 and RO-2B2 Landscaping Strip Replacement Assessment and Management

DU Name	Inspection Date	Building Number	Landscaping Strip Unit Number	Total Replacement [1]	Management Date
EAR2-DU-36d-LS1036	1/4/2011	6359	1036	Yes	2/16/2011
EAR2-DU-36d-LS1038	1/4/2011	6359	1038	Yes	2/16/2011
EAR2-DU-36c-LS1022	1/4/2011	6360	1022	Yes	2/16/2011
EAR2-DU-30f-LS544	1/4/2011	6380	544	Yes	2/17/2011
EAR2-DU-42a-LS722	1/4/2011	6372	722	No	2/18/2011
EAR2-DU-37a-LS564	1/4/2011	6379	564	No	2/18/2011
EAR2-DU-37a-LS566	1/4/2011	6379	566	No	2/18/2011
EAR2-DU-37a-LS562	1/4/2011	6379	562	Yes	2/18/2011
EAR2-DU-14e-LS542	1/4/2011	6380	542	Yes	2/18/2011
EAR2-DU-40c-LS758	1/4/2011	6369	758	No	2/22/2011
EAR2-DU-42a-LS728	1/4/2011	6372	728	No	2/22/2011
EAR3-DU-40e-LS332	1/4/2011	6303	332	No	2/24/2011
EAR3-DU-34c-LS402	1/4/2011	6401	402	No	2/24/2011
EAR3-DU-33a-LS948	1/4/2011	6397	948	No	2/24/2011
EAR3-DU-33c-LS922	1/4/2011	6391	922	No	2/24/2011
EAR3-DU-33c-LS928	1/4/2011	6391	928	No	2/24/2011

Notes:
[1] Yes=Remove all plants to install geotextile (RO-2B1); No=partial removal (RO-2B2)

RO-2C (2010 APRA-1 Standard for areas with inadequate grass cover). RO-2C was designed to address risks associated with remaining areas with poor quality grass cover underlain by PI soil. Under this scenario site-specific residential soil ALs[97] for aldrin and dieldrin of 1.8 mg/kg and 3.1 mg/kg, respectively, were used as a basis for the HI of 1. (The APRA-1 standard is equivalent to the 2006 HHRA standard). Under RO-2C, VSIs of grass-covered areas were conducted for DUs with an HI>1. The Response Action to address areas where poor grass cover was reseeding of the exposed soil. Within some of the DUs there was more than one area requiring reseeding.

The inspections were conducted on January 4 and 5, 2011. Table 10-7 lists the results of the inspections and describes the areas that were reseeded. In the table, individual reseeded areas are identified with separate DU ID numbers derived from the original DU numbers.

[97] The listed aldrin and dieldrin ALs represent aldrin-only or dieldrin-only situations. In accordance with standard risk assessment practices, when multiple chemicals are present, the risk posed by an individual DU was evaluated using a cumulative HI based on all detected chemicals. The HI represents the sum of the chemical-specific hazard quotients (i.e., individual pesticide soil concentration divided by the chemical-specific AL) for all detected chemicals.

Table 10-7. RO #2 Results of Grass Cover Inspection (Action Type RO-2C)

Neighborhood	DU Name	Inspection Date	Contiguous Bare Areas [1] >200 sq ft	Bare Areas [2]	Field Observations [3]
Earhart 1-2	EAR2-DU-01c-BA01	4 Jan-11	No	Yes	Area surrounding tree trunks, 20 x 40 feet of patchy grass
Earhart 1-2	EAR2-DU-02b-BA01	4 Jan-11	No	Yes	Patchy grass adjacent to trunk of papaya tree
Earhart 1-2	EAR2-DU-03c-BA01	4 Jan-11	No	Yes	Bare earth due east of playground
Earhart 1-2	EAR2-DU-03c-BA02	4 Jan-11	No	Yes	Area is about 30 feet northeast of playground
Earhart 1-2	EAR2-DU-13a-BA01	5 Jan-11	No	Yes	Bare earth surrounds tree behind building 6355
Earhart 1-2	EAR2-DU-13c-BA01	5 Jan-11	No	Yes	Adjacent to back lanai of building 6353
Earhart 1-2	EAR2-DU-14a-BA01	5 Jan-11	No	Yes	3 x 3 foot patch in swale behind building 6303
Earhart 1-2	EAR2-DU-14d-BA01	5 Jan-11	No	Yes	Area north of and between buildings 6380 and 6381
Earhart 1-2	EAR2-DU-15b-BA01	5 Jan-11	No	Yes	Area contiguous and behind back lanai of building 6343
Earhart 1-2	EAR2-DU-23b-BA01	5 Jan-11	No	Yes	Soil exposed beneath swing set behind building 6368
Earhart 1-2	EAR2-DU-24b-BA01	5 Jan-11	No	Yes	Soil beneath tree in two large patches behind building 6373
Earhart 1-2	EAR2-DU-24c-BA01	5 Jan-11	No	Yes	Small patch behind building 6374
Earhart 1-2	EAR2-DU-25d-BA01	5 Jan-11	No	Yes	Adjacent to lanai inside “Yard of the Year”
Earhart 1-2	EAR2-DU-28b-BA01	4 Jan-11	No	Yes	Area consists of roughly 50% soil and 50% patchy grass
Earhart 1-2	EAR2-DU-29b-BA01	5 Jan-11	No	Yes	Area consists of roughly 50% soil and 50% patchy grass
Earhart 1-2	EAR2-DU-56j-BA01	5 Jan-11	No	Yes	Bare earth beneath basketball net behind building 6368
Earhart 1-2	EAR2-DU-58b-BA01	5 Jan-11	No	Yes	Large area with patchy grass cover in northeast corner of neighborhood.
Earhart 1-3	EAR3-DU-16d-BA01	4 Jan-11	No	Yes	Bare earth beneath children’s swings behind building 6393
Earhart 1-3	EAR3-DU-19d-BA01	4 Jan-11	No	Yes	5 x 10 foot area beneath child's play table behind building 6406
Earhart 1-3	EAR3-DU-19d-BA02	4 Jan-11	No	Yes	5 x 15 foot area along back patch of building 6406
Earhart 1-3	EAR3-DU-20b-BA01	4 Jan-11	No	Yes	Patchy grass adjacent to HiTel and TV boxes behind building 6407
Earhart 1-3	EAR3-DU-28a-BA01	4 Jan-11	No	Yes	Patchy grass along west side of building 6426
Earhart 1-3	EAR3-DU-35d-BA01	4 Jan-11	No	Yes	Patchy grass adjacent to HiTel and TV boxes behind building 6407

Notes: Only DUs requiring action are listed
sq ft Square feet
1 Excavation of DU only required if a single area of exposed soil >200 sq ft
2 Area of one or more exposed soil areas have a combined area of >200 sq ft, but since individual areas of exposed soil are <200 sq ft, only reseeding of exposed soil areas is required.
3 all measurements were made in the field and are an approximate.

10.4 Removal Action #3

As part of the continuing evaluation of risk at the Study Area, the *HHRE WP*[98] presented adjusted EALs for aldrin and dieldrin, and four risk criteria for assessing PI soil, referred to as the 2011 HHRE Standard, were developed. HDOH accepted the *HHRE WP* in its letter dated June 7, 2011[99].

The four criteria presented under the 2011 HHRE Standard were applied to soil analytical results from the 0 to 6-inch depth interval for the remaining DUs not previously addressed under RO #1 and RO #2. The four criteria that comprise the 2011 HHRE Standard are:

1. the cumulative excess cancer risk for aldrin plus dieldrin must not exceed 1 x 10^{-4};
2. the cumulative excess cancer risk for all other organochlorine pesticides must not exceed 1 x 10^{-5};
3. the cumulative excess cancer risk for all COPCs must not exceed 1 x 10^{-4}; and
4. the HI for all COPCs must not exceed 1.

Soil with organochlorine pesticide concentrations exceeding any one of these criteria was defined as PI soil. Soil meeting all four criteria is considered acceptable for use within the Program Area

Based on application of the 2011 HHRE Standard, a total of fourteen DUs in the Earhart I-2 and Earhart I-3 neighborhoods were identified as containing PI soil above the standard, including ten DUs in the Earhart 1-2 neighborhood and four DUs in the Earhart I-3 Neighborhood. Table 10-8 summarizes the concentrations of the principal pesticides detected in these DUs.

Table 10-8. Concentrations (mg/kg) of Pesticides Detected in DUs Excavated Under RO #3[1]

DU	Sample ID	Depth Interval (inches)	Aldrin	Dieldrin	Chlordane
11b	EAR2-RA-11b-06	06	5.3	0.50	8.8
	EAR2-RA-11b-12	12	5.9	0.50	7.8
14c	EAR2-RA-14c-06	06	2.6	2.5	8.4
	EAR2-RA-14c-12	12	1.5	1.0	3.5
15b	EAR2-RA-15b-12	12	23	0.50	11
	EAR2-RA-15c-06	06	3.0	0.50	4.6
23a	EAR2-RA-23a-06-1	06	0.81	1.0	1.2
	EAR2-RA-23a-06-2	06	4.1	2.0	7.1
	EAR2-RA-23a-06-3	06	0.4	0.5	1.7
	EAR2-RA-23a-12	12	4.7	2.0	9.6
23b	EAR2-RA-23b-06	06	3.2	2.0	8.6
	EAR2-RA-23b-12	12	1.3	1.0	2.0

[98] Tetra Tech 2011e)
[99] (HDOH 2011a)

Table 10-8. Concentrations (mg/kg) of Pesticides Detected in DUs Excavated Under RO #3[1]

DU	Sample ID	Depth Interval (inches)	Aldrin	Dieldrin	Chlordane
27d	EAR2-RA-27d-06	06	8.5	0.50	7.5
	EAR2-RA-27d-12	12	13	0.50	11
29a	EAR2-RA-29a-12	12	3.3	1.0	2.9
	EAR2-RA-29b-06	06	0.70	0.50	2.2
37a	EAR2-RA-37a-06-1	06	6.5	2.9	5.8
	EAR2-RA-37a-06-2	06	2.8	2.8	4.8
37a	EAR2-RA-37a-06-3	06	2.6	2.7	4.4
	EAR2-RA-37a-12	12	26	6.2	11
38d	EAR2-RA-38d-06	06	8.9	0.50	6.1
	EAR2-RA-38d-12	12	5.0	0.50	4.7
12b	EAR3-RA-12b-06-1	06	7.6	9.3	6.2
	EAR3-RA-12b-06-2	06	3.4	4.5	4.2
	EAR3-RA-12b-06-3	06	2.3	4.8	4.1
	EAR3-RA-12b-12	12	16	18	11
20a	EAR3-RA-20a-06-1	06	5.8	3.2	6.3
	EAR3-RA-20a-06-2	06	3.6	3.0	4.4
	EAR3-RA-20a-06-3	06	3.9	2.6	4.7
	EAR3-RA-20a-12	12	11	5.5	8.3
33c	EAR3-RA-33c-06-1	06	5.2	4.5	6.3
	EAR3-RA-33c-06-2	06	3.9	4.0	5.9
	EAR3-RA-33c-06-3	06	1.6	2.1	2.6
	EAR3-RA-33c-12	12	4.9	3.5	4.5
34c	EAR3-RA-34c-06	06	7.3	11	5.9
	EAR3-RA-34c-12	12	1.1	2.5	2.3
Concentration at Hazard Quotient = 1 [2]			**12**	**9.8**	**35.2**

Notes: (1) DUs were excavated to 9 inches and geotextile placed before backfilling
(2) Based on 2011 HHRE non-cancer risk assumptions applied to concentrations in 0 to 6-inch soil depth only.
"U" = not detected at the detection limit indicated
"J" = detected between MDL and PQL

None of the concentrations in the upper 6-inch depth interval exceeded the first three criteria of the 2011 HHRE Standard. The fourth criterion (the HI for all COPCs must not exceed 1) was the only criterion exceeded, and effectively drove the need for RO#3.

Between July 8 and August 3, 2011, soil from the upper nine inches of the affected DUs was removed and replaced. As indicated in Table 10-9, approximately 1,390 CY of soil was transported to the temporary soil stockpile area southwest of the Earhart I-2 neighborhood, pending final management of the soil on-site.

Table 10-9. Excavated Soil Volumes RO #3

Building Number	Neighbor-hood	DU#	Date Completed	DU Area	In-place DU volume (CY)
6346	EARI-2	11b	July 15, 2011	3,640	101
6381	EARI-2	14c	July 19, 2011	4,316	121
6343	EARI-2	15b	July 15, 2011	3,058	85
6367	EARI-2	23a	July 19, 2011	2,345	66
6368	EARI-2	23b	July 19, 2011	3,032	85
6335	EARI-2	27d	July 8, 2011	2,327	65
6349	EARI-2	29a	August 3, 2011	4,357	122
6379	EARI-2	37a	August 1, 2011	2,417	68
6342	EARI-2	38d	July 11, 2011	3,617	101
6375	EARI-2	42b	July 15, 2011	4,948	138
6417	EARI-3	12b	August 3, 2011	3,932	110
6408	EARI-3	20a	August 3, 2011	3,190	89
6391	EARI-3	33c	August 3, 2011	4,377	122
6401	EARI-3	34c	August 3, 2011	4,198	117
Total:					**1,390**

10.5 Management of PI Soil Resulting from Removal Actions

PI soil generated during the removal actions was managed in accordance with the approved work plans prepared for each RO. Residents were notified of the ROs in accordance with the Resident Involvement Plan developed for the Remediation program.[100] Following resident notification, plastic fencing was placed around the designated DUs to mark the areas where the removals would be performed and to exclude non-workers from the work area. Dust was suppressed using water spray to limit resident and worker exposure to airborne particulates and pesticides. Upwind and downwind perimeter ambient air monitoring was performed during the ROs to verify the effectiveness of the dust control measures. Air monitoring of worker exposure was also performed. A detailed description of the methods and results of the air monitoring are presented in the draft RAR.[101]

In accordance with the RO work plans, no PI soil was staged, stockpiled, or managed within occupied HC neighborhoods. All excavated soil was transported to a temporary soil management area located south of Ohana Nui Circle opposite the Earhart I-4 neighborhood. All potential PI materials excavated during RO #1 implementation (e.g. soil, debris, and removed vegetation) were segregated by material and stockpiled pending further management or disposal. The soil management area consisted of an approximately half-acre site enclosed by a six-foot chain link fence and locking gate. The interior of the area was graded, with a 6- to 12-inch soil berm to prevent runoff from leaving the area, and was lined with 40-millimeter geotextile fabric. The PI stockpile was covered by a minimum 6-millimeter polyethylene sheeting and secured with anchors or sand bags to prevent wind or water erosion. Excavators used to regrade the PI stockpile were decontaminated with shovels, brooms, and wire brushes before exiting the lined soil management area.

[100] (Tetra Tech 2011d)
[101] (Tetra Tech 2011h)

The soil generated from RO #1 and RO #2 was transported to a borrow pit site at the Onizuka II-3 Neighborhood for permanent management in Burial Pit #6b (see Figure 3-1), which was capped on April 22, 2011. Soil generated from RO #3 was incorporated into an engineered soil berm capped with clean soil, located on the northeast perimeter of Earhart I-2 .[102] The berm was completed on February 29, 2012 (Figure 10-2). Long-term management of PI soil is described in the Pesticide Soil Management Plan.[103] All residual PI soil within the project area will be documented and tracked in the LUCID[104] and the EHMP.[105]

10.6 Replacement Soil Characterization and Placement

Replacement soil was characterized prior to use on the remediated DUs. Detailed descriptions of the replacement soil sources, characterization procedures, and results of characterization are presented in the Summary of Findings Reports (SoFRs) included in the draft RAR[106]. After placement of at least 10 inches of acceptable fill soil on the remediated DUs, and an additional two inches of topsoil, the DUs were re-seeded with grass to return the surface to original condition.

10.7 Summary of Findings

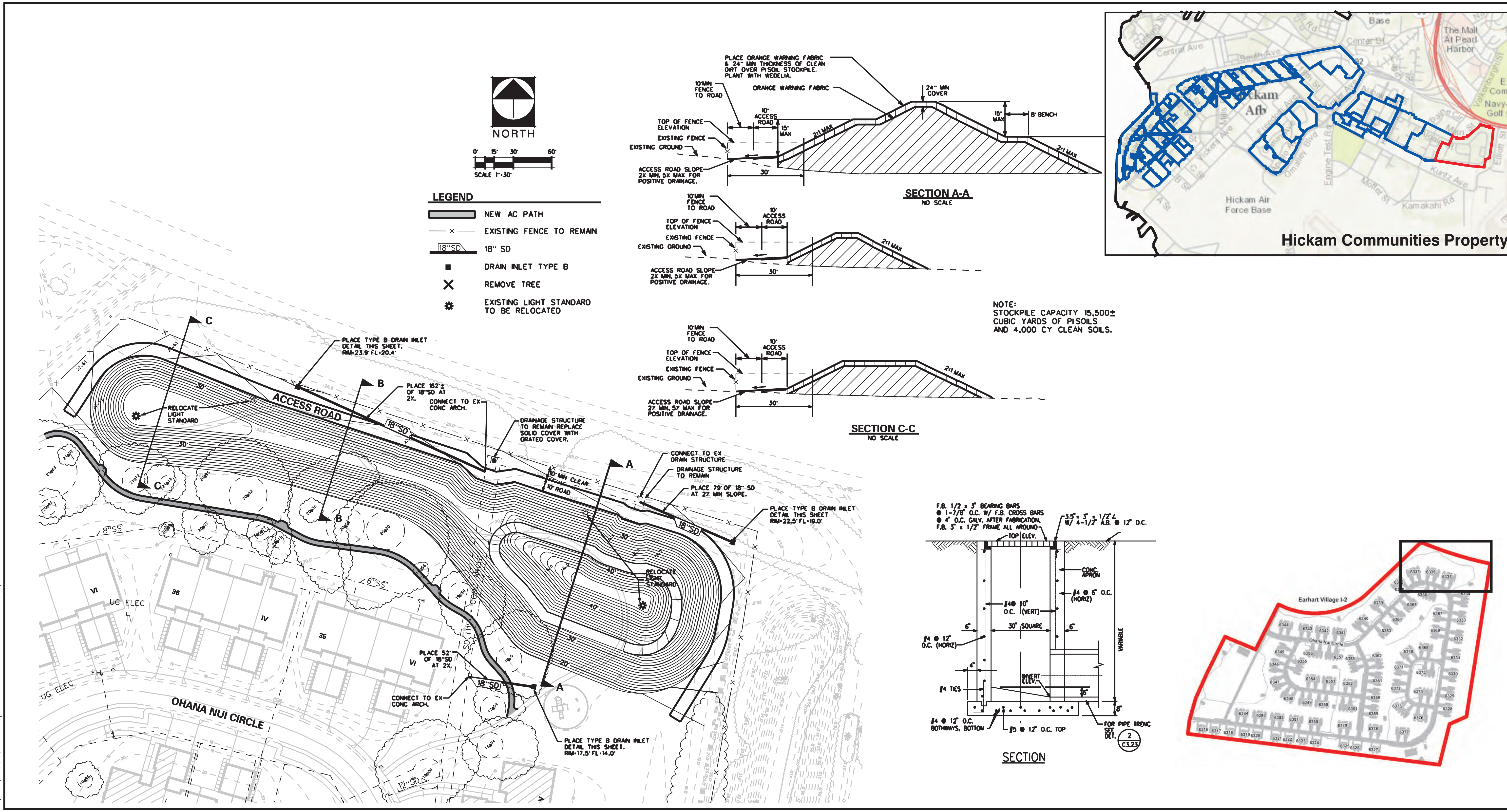
The ROs were implemented to reduce immediate risks from residential exposure to PI soil to acceptable levels pending development of a comprehensive remedy to address remaining concentrations of pesticides in soil in the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods.

Based on the analytical results from sampling 21 DUs in the Onizuka II-1 neighborhood, it was concluded that none of the DUs contain pesticide concentrations above levels requiring immediate action, and that no removal actions were needed to address these soils.

Sampling of 324 DUs in the Earhart I-2 neighborhood, and 181 DUs in the Earhart I-3 neighborhood revealed concentrations of pesticides significantly above the 2006 HHRA EALs triggering three Removal Action Plans to address DUs considered to present an immediate risk to residents from exposure to surface soil. RO #1 was conducted to address DUs in which the HI based on the 2006 HHRA EALs was greater than 10, or where large areas of bare soil was exposed in DUs with HI greater than 3. Five DUs in Earhart I-2 and one DU in Earhart I-3 exceeded these standards and the DUs were excavated to replace the upper one foot of soil. HC decided to excavate and replace soil in three additional DUs in the Earhart I-2 area that were adjacent to the selected DUs, and to remove soil from small parts of three other adjacent DUs.

RO #2 was designed to address DUs in which pesticide concentrations exceeded an HI of 1, based on modified exposure assumptions that were developed as part of the HHRE. One additional DU in the Earhart I-2 area was selected for excavation and replacement of the upper 1-foot of soil on the basis of this analysis. In addition, geotextile barriers were installed in

102 (Tetra Tech 2012c)
103 (Tetra Tech 2011g)
104 (Tetra Tech 2012b)
105 (Tetra Tech 2012a)
106 (Tetra Tech 2011h)



Earhart I-2 Soil Berm

Earhart Village I-2

Hardscapes

Joint Base Pearl Harbor-Hickam O'ahu, Hawai'i

Figure 10-2

TETRA TECH

Source: KASL March 2011

r:\new\29064\Corel\Proposed Berm Location.cdr - 04/26/12 - YE

landscape strips, and grass cover was improved by hydroseeding certain DUs containing intermediate pesticide concentrations.

Based on the 2011 HHRE standard developed for the Study Area, RO #3 was conducted to address DUs with an HI greater than 1. Ten DUs in Earhart I-2 and four DUs in Earhart I-3, were excavated to a depth of six inches, and the soil was replaced and reseeded. Soil at a depth of 6 to 12-inches in six DUs in Earhart I-2 and in two DUs in Earhart I-3 contained concentrations of pesticides that exceeded the 2011 HHRE standard, and geotextile was placed over the soil that was left in place before filling with clean soil.

As a result of these actions, all exposed soil exceeding the 2011 HHRE EALs that was identified in the comprehensive soil investigations of Earhart I-2, Earhart I-3, and Onizuka II-1 has been addressed, and PI soil at a depth of 6 to 12-inches in eight DUs is marked with geotextile fabric. Additional measures to improve grass cover and to prevent exposure to soil in landscape strips has further reduced the risk of exposure to pesticides.

In 2012 the non-cancer EAL for chlordane was further evaluated, and was revised from 64 mg/kg to 38 mg/kg. As a result of this change, soils in three additional DUs in Earhart I-3 exceeded the 2012 EHE Standard. These include soils in the 6- to 12-inch depth in DUs 12d and 14b, and soils in the 0- to 6-inch depth in DU 33a.

This page intentionally left blank

11.0 ENVIRONMENTAL HAZARD EVALUATION

This chapter describes the environmental hazard evaluation process and summarizes the results of the environmental hazard evaluation (EHE) conducted for the Site.

11.1 Description of the Environmental Hazard Evaluation Process

The environmental hazard evaluation is the link between the discovery of contaminated soil or groundwater during site investigation and response actions taken (if warranted) to address contamination. The purpose of the EHE is to identify and evaluate potential hazards to human health and sensitive ecological receptors posed by contaminants of concern identified at a site under current and potential future site conditions and provide the basis for evaluating if remedial actions or the implementation of engineering/institutional controls is warranted. In general, the EHE process consists of the following steps:

- Identify contaminants of potential concern;
- Identify potential environmental hazards;
- Evaluate targeted environmental hazards;
- Prepare environmental hazard maps; and
- Recommend follow-up response actions

The potential hazards evaluated as part of the EHE are as follows:

- Direct exposure risks to human health (this includes reasonably expected future exposure scenarios such as potential for residential and industrial worker exposure to previously buried PI soil due to excavation or erosion);
- Intrusion of subsurface vapors in buildings;
- Leaching;
- Impacts to terrestrial habitats;
- Gross contamination and general resource degradation; and
- Impact to drinking water supplies

The EHE for this Site has been prepared in accordance with HDOH guidelines summarized in the HDOH guidance document titled, *Screening for Environmental Hazards as Sites with Contaminated Soil and Groundwater*[107]*.*

11.2 Contaminants of Potential Concern

Chemicals of potential concern (COPCs) are chemicals that have been detected in the environment that may adversely impact human or ecological receptors. COPCs were identified based on the most recent soil sampling data collected from August 12 through October 12, 2010 to characterize the DUs identified in accordance with HDOH guidelines within the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods. All soil samples were analyzed by EPA

[107] (HDOH 2008)

Method 8081 for organochlorine pesticides. For this evaluation, all pesticides detected in at least one soil sample were identified as COPCs and evaluated further in the EHE. Chemicals detected at the Site are summarized in Table 11-1 and include aldrin, chlordane, dieldrin, DDD, DDE, DDT, endrin, endrin ketone, endosulfan sulfate, delta-BHC, and methoxychlor. The primary chemicals of concern identified at the Site are organochlorine pesticides, including technical chlordane, aldrin, dieldrin, DDD, DDE, and DDT. Other organochlorine pesticides, such as endosulfan sulfate, endrin, endrin ketone, delta –BHC, and methoxychlor, have been detected sporadically at concentrations close to their detection limits. These compounds do not contribute significantly to the cumulative risk from organochlorine pesticides at the Study Area.

Table 11-1. Contaminants of Potential Concern

Chemical[a]
Aldrin
Chlordane[b]
Dieldrin
DDD
DDE
DDT
Endrin
Endrin Ketone
Endosulfan Sulfate[c]
Delta-BHC[c]
Methoxychlor[c]

Notes:

[a] All organochlorine pesticides detected in soil as part of past site investigation activities conducted at the Site in 2010 are included in this table.

[b] Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

[c] Listed chemical detected at low levels in one sample.

11.3 Evaluation of Environmental Hazards

As indicated in HDOH guidance[108], a basic understanding of environmental hazards associated with contaminated soil and groundwater is a critical component in the overall environmental response process. The potential environmental hazards and targeted environmental hazards evaluated as part of the EHE are summarized in the following sections.

11.3.1 Potential Environmental Hazards

Table 11-2 indicates which of the common environmental hazards, (that HDOH guidance recommends should be evaluated at release sites) are considered potentially significant at the Site.

[108] (HDOH 2008)

Table 11-2. Potentially Significant Environmental Hazards

Medium	Potential Environmental Hazard	Potentially Significant?
Soil	Direct exposure threats to human health	**Yes**
	Intrusion of subsurface vapors in buildings	**No**
	Leaching and subsequent impacts to groundwater	**No**
	Impacts to terrestrial habitats	**No**
	Gross contamination and general resource degradation	**No**
Groundwater	Impacts to drinking water sources	**No**
	Impacts to aquatic habitats	**No**
	Intrusion of subsurface vapors into buildings	**No**
	Gross contamination and general resource degradation	**No**

Potential environmental hazards were evaluated for their applicability to the Site. Potential environmental hazards that are considered to be insignificant at the Site based on available information were eliminated from further consideration and are not evaluated further. Potential environmental hazards identified as posing a potential threat to human health and/or the environment are evaluated further in the EHE.

11.3.2 Targeted Environmental Hazards

A conceptual Study Area model (CSM) summarizing the potential and retained environmental hazards for organochlorine pesticides at the Site is presented in Table 11-3. As described in more detail in the EHE report, one of the common potential environmental hazards identified by HDOH (i.e., direct exposure to soil) was retained for further evaluation in the EHE. Vapor intrusion was eliminated as a potential environmental hazard because none of the COPCs are classified as volatile compounds buy EPA or HDOH. Gross contamination was eliminated because the maximum detected levels of pesticides within the Site are well below the corresponding HDOH screening levels for gross contamination. The chlorinated pesticides detected at the Site have low solubilities and bind tightly soils (i.e., have very limited mobility) and therefore, are not considered to pose a significant soil leaching hazard in regard to contamination of groundwater. Contamination of drinking water supplies was eliminated due to the following: the limited mobility of the COCs, groundwater beneath the Site is brackish and is not suitable for commercial, residential, or recreational use, and because potable water is supplied to Hickam AFB from US Navy storage tanks outside the base. As discussed in the EHE (Appendix E), terrestrial and aquatic ecotoxicity was eliminated from consideration due to the low mobility of the COCs and due to a lack of sensitive habitat within the Site and immediately adjacent to the Site.

Table 11-3. Conceptual Site Model for Organochlorine Pesticides[a]

Primary Sources	Primary Release Mechanism	Secondary Sources	Potential Environmental Hazards		Hazards Present Under Current or Future Conditions?			
					Current		Future	
					Residents	Construction/ Maintenance Workers	Residents	Construction/ Maintenance Workers
Historical Maintenance Activities for Residential Units (Application of pesticides under and around building foundations for termite control)	Soil moving activities associated with recent construction work	Soil	Risk to Human Health	Direct Exposure[b] - ingestion - dermal contact - dust inhalation	No[i]	No[i]	Yes	Yes
				Vapor Intrusion into Buildings	----	----	----	----
			Risk to Terrestrial Ecological Habitats[c]		No		No	
			Leaching[d]		No		No	
			Gross Contamination[e]		No		No	
		Groundwater	Risk to Human Health[f]	Direct Exposure	----		----	
				Vapor Intrusion into Buildings	----		----	
			Risk to Aquatic Ecological Habitats[g]		----		----	
			Gross Contamination[h]		----		----	

Notes:

[a] Conceptual Site Model (CSM) is based on EAL Surfer Summary Reports for organochlorine pesticides (HDOH 2011) . It is assumed that the Site is not located within 150 meters of a surface water body or sensitive aquatic habitat, and groundwater is not a current drinking water resource.

[b] Human health hazards include direct exposure to contaminated soil or inhalation of airborne dust.

[c] Assumes significant terrestrial ecological habitat is impacted due to contamination with resulting toxicity to flora/fauna.

[d] Assumes potential leaching of soil contaminants resulting in impacts to underlying groundwater.

[e] Gross contamination hazards for soil include potential explosive hazards, odors and general nuisance concerns, and general resource degradation.

[f] Human health hazards include ingestion of contaminated groundwater and potential dermal and inhalation exposures during showering.

[g] Assumes contaminated groundwater discharges/migrates to an aquatic habitat. Contaminants in groundwater screened using chronic aquatic toxicity action levels for sites < 150 meters from a surface water body.

[h] Gross contamination hazards for groundwater include taste and odor concerns for drinking water, presence of free product, odors, and general resource degradation.

[i] Due to remediation activities completed at the Site, current hazards are not likely to exist for current residents. Similarly, for landscape/maintenance and construction workers who may engage in intrusive soil activities, institutional controls are currently in place to ensure that Occupational Safety and Health Administration safe practices are followed by maintenance and construction workers in areas of the Site associated with remaining PI soils.

Sources: Hawai'i Department of Health (HDOH). 2011. Tier 1 Environmental Action Levels Surfer.

11.4 Exposed Populations and Exposure Pathways

The identification of potentially exposed populations and exposure pathways is a critical component of developing health protective environmental action levels. An exposure pathway describes the course a chemical takes from a source to an exposed individual. Based on current and anticipated future conditions at the Site, the chemical exposures that could potentially be associated with the three neighborhoods were identified considering the following four factors:

- Sources of COPCs;
- Environmental media in which COPCs have been detected (i.e., soil);
- Exposure of contact points with the environmental media (e.g., direct contact with soil); and
- Exposure routes for chemical intake by a receptor (e.g., soil ingestion).

The exposure pathways identified for the Site are based on evaluations of the likelihood of receptors directly contacting COPCs and the mechanisms governing the fate and transport of the COPCs.

11.4.1 Potentially Affected Human Populations

Potentially exposed human populations (receptors) were identified for current and expected future land-use scenarios. As described above, the Site is currently developed for residential land use and it is anticipated that it will remain this way for the foreseeable future. Human populations that could potentially be exposed to pesticide impacted soil within the Site under current and expected future conditions, include residential receptors (adults and children), landscaping/maintenance workers, and construction workers.

11.4.2 Retained Potentially Affected Human Populations

Within the Site, all work performed by landscaping/maintenance workers and construction workers is conducted in accordance with the Pesticide-Impacted Soil Investigation and Management Program Manual (the “PI Soil Program Manual”)[109]. As described in the PI Soil Program Manual, landscaping/maintenance workers and construction workers must be provided with adequate training so they are familiar with the potential health hazards posed by PI soil. This training consists of a hazard communication briefing conducted by the employer’s Program Safety Officer and a PI soil awareness briefing conducted by Tetra Tech. Site workers are also familiarized and provided with the required personal protective equipment (PPE) to eliminate or minimize any potential exposures. Lastly, in addition to the training and use of PPE, all activities performed by Site workers are conducted following required safeguards in accordance with the health and safety plan (HASP)[110]. Although potential exposures to maintenance/landscaping workers and construction workers are covered under the documents described above, a reasonably anticipated future exposure scenario for these worker populations includes exposure to previously buried PI soil due to excavation or erosion.

[109] (Tetra Tech 2011g)
[110] (Tetra Tech 2011g)

Therefore, these worker populations were retained for further evaluation in the EHE. Similarly, if PI soil remaining at the Site is brought to the surface in the future, residents could also be potentially exposed.

In summary, the following potentially affected human populations were retained for further evaluation:

- Residential receptors (adults and children),
- Landscaping/Maintenance Workers, and
- Construction Workers

11.4.3 Exposure Media and Exposure Pathways

The potentially contaminated exposure media within the Site that will be the focus of the EHE is soil. The complete exposure pathways evaluated for potentially exposed residential receptors are identified in the following sections.

For this evaluation, it is assumed that potential receptors may ingest soil inadvertently (e.g., transfer soil from fingers to mouth) while at home or work. It is also assumed that potential receptors may be exposed to soil through dermal contact with soil and windblown particulates. Based on these considerations, the complete exposure pathways evaluated in the EHE include: 1) incidental ingestion of soil; 2) dermal contact with soil; and 3) inhalation of airborne particulates. Each potentially complete exposure pathway is summarized below in Table 11-4.

Table 11-4. Potential Receptors and Exposure Pathways

Receptor	Medium	Exposure Pathway
On-Site Resident (Adult and Child)	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Landscaping/Maintenance Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation
Construction Worker	Soil	Incidental Ingestion
		Dermal Contact
		Dust Inhalation

11.5 Previous Action Levels

HDOH has derived conservative screening values for contaminants called Tier 1 EALs.[111] HDOH Tier 1 EALs are concentrations of contaminants in soil, soil gas and groundwater above which the contaminants could pose a potential adverse impact to human health and the environment. Individual HDOH Tier 1 EALs have been developed for each of the potential environmental hazards discussed in Section 11.3.1 (e.g., gross contamination, direct exposure, vapor intrusion, leaching, ecotoxicity, etc.). As described in the HDOH TGM (Section 13.1), “the environmental hazard that drives the potential need for remedial action at a contaminated site

[111] (HDOH 2008)

depends on the toxicity and mobility of the targeted contaminants".[112] Soil containing chemicals that are toxic to humans and relatively immobile (e.g., organochlorine pesticides detected at the Site) primarily pose a potential direct exposure hazard. As indicated in Section 11.3.2, direct exposure to humans is the potential environmental hazard retained for evaluation in the EHE. Therefore, EALs protective of direct exposure are used to identify areas the Site that could pose a potential human health risk.

The remainder of this section describes the applicability of site-specific EALs, summarizes previous EALs developed for the Site in 2006 (referred to as "2006 HHRA EALs"), and presents a comparison of the 2006 HHRA EALs to Site soil data.

11.5.1 Applicability of Site-Specific Environmental Action Levels

As described in HDOH guidance (HDOH 2008), the most important use of HDOH Tier 1 EALs (the most conservative screening levels) is the rapid identification of potential environmental hazards associated with contaminated soil or groundwater at a site. The guidance also notes that, exceeding the HDOH Tier 1 EALs does not necessarily indicate that contamination at a site poses an environmental hazard; however, it is an indication that additional evaluation is warranted. When measured concentrations of contaminants at a site do exceed HDOH Tier I EALs, a more advanced evaluation of potential environmental hazard may be done in which site-specific EALs are derived by incorporating site-specific considerations into the equations used to derive the HDOH Tier 1 EALs. In 2006, after discussions with HDOH regarding preliminary screening evaluations, Tetra Tech conducted a site-specific evaluation and prepared a memorandum documenting the basis for and the assumptions used to derive the 2006 HHRA EALs for aldrin, chlordane, and dieldrin, which were approved by HDOH. The use of the site-specific EALs was contingent on the concurrent, continuing application of specific land-use controls which included stringent residential activity prohibitions (e.g., prohibitions on excavation) as well as limitations on residential exposure periods based on the assumption of military housing as the ongoing land-use.

11.5.2 2006 Site-Specific Environmental Action Levels

The 2006 HHRA EALs for aldrin, chlordane, and dieldrin were derived based on two site-specific adjustments to the HDOH Tier 1 EALs associated with the assumed residential exposure duration and target risk levels. Specifically, a 6 year residential exposure duration (Tier 1 default is 30 years) and target risk level of 1×10^{-5} were used (Tier 1 default is 1×10^{-6}). For the noncancer endpoint, a target hazard quotient (HQ) of 1 was used (Tier 1 default is 0.2). For other detected pesticides, HDOH Tier 1 EALs were used to evaluate cumulative risks and hazards assuming a target cumulative risk of 1×10^{-5} and a target hazard index (HI) of 1.

11.6 Comparison of 2006 Site-Specific EALs to Site Data

This section presents an evaluation of the retained potential environmental hazards identified in Section 11.4.3. Potentially exposed residential receptors were evaluated based on current and expected future conditions at the Site (i.e., residential use).

[112] (HDOH 2009)

Direct Exposure Evaluation

The 2006 site-specific residential EALs for the contaminants of concern in soil for the direct exposure hazard are summarized in Table 11-5 for child and adult residents. As described in Section 11.4.3, the direct exposure EALs for residential receptors were developed based on the following exposure pathways:

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of airborne particulates

Of these direct exposure pathways, the majority of the estimated risk and hazard is associated with soil ingestion with only minor contributions from dermal contact and inhalation. The results of the direct exposure evaluation are presented below for each neighborhood. The lowest 2006 HHRA EALs are associated with the child resident and, therefore, are protective of other potential receptors (i.e., adult residents). For this reason, only the evaluation results for the child resident are discussed below.

Risk Characterization

The estimated risks and hazards were calculated using ratio of each pesticide's representative soil concentration and its corresponding cancer and noncancer 2006 HHRA EALs. The risk and hazard ratios for each chemical were summed to determine the cumulative multi-pathway carcinogenic risk estimates and noncarcinogenic HI for potentially exposed receptors. For this evaluation, a target cumulative risk of 1×10^{-5} and target HI of one were used to evaluate if pesticides in soils presented a potential health risk. The equations used to estimate cumulative risk and hazard for each DU are provided in the EHE report (Appendix E).

11.6.1 Earhart I-2 Neighborhood

Child Resident

Figure 11-1 identifies DUs within the Earhart I-2 neighborhood associated with cumulative risks for the child resident exceeding the target risk level of 1×10^{-5} based on the soil sampling results collected within the 0-12 inch depth interval and the 2006 site-specific child resident EALs. A total of 281 DUs are associated with estimated cumulative risks greater than 1×10^{-5}. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-2.

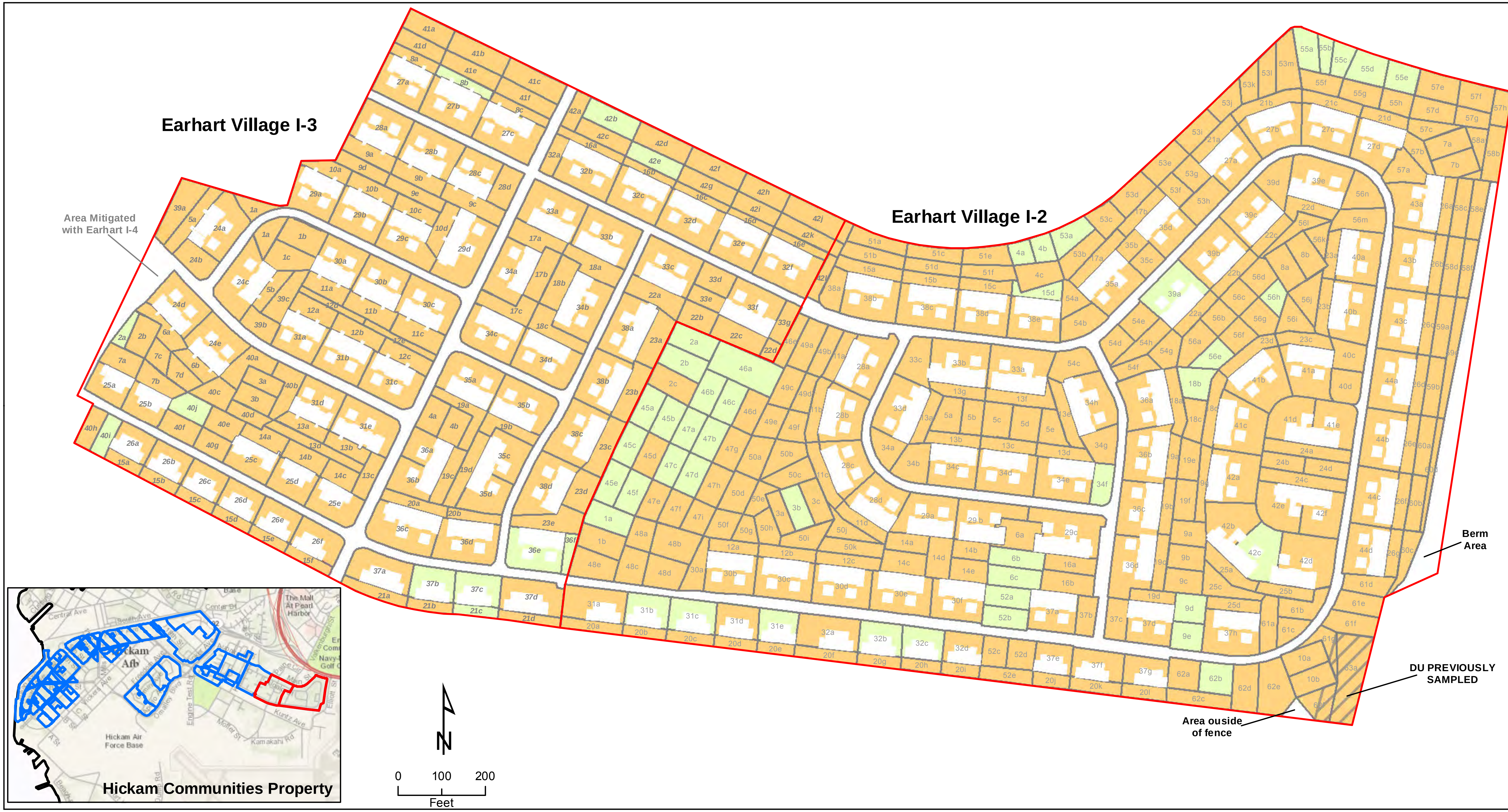
Figure 11-4 identifies DUs within the Earhart I-2 neighborhood associated with an estimated HI for the residential child exceeding the target hazard level of 1. A total of 161 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-5.

Table 11-5. 2006 Environmental Action Levels for Soil - Child and Adult Residents[a,b]

Chemical	HC Site-Specific Soil Screening Levels (mg/kg)				Final EAL
	Child		Adult		
	Cancer-based	Noncancer-based	Cancer-based	Noncancer-based	
	Target Risk[c]	Target HQ = 1[d]	Target Risk[c]	Target HQ = 1[d]	
Aldrin	0.42	1.8	3.6	15.7	0.42
Chlordane[e]	23.4	35.2	209.8	314.7	23.4
Dieldrin	0.45	3.1	3.8	26.1	0.45
DDD	2	-	2	-	2
DDE	1.4	-	1.4	-	1.4
DDT	1.7	36	1.7	36	1.7
Endrin	-	18	-	18	18
Endrin ketone	-	18	-	18	18
Endosulfan sulfate	-	370	-	370	370
delta-BHC	-	21	-	21	21
Methoxychlor	-	310	-	310	310

Notes:
HC = Hickam Communities mg/kg = milligram per kilogram
HQ = Hazard quotient [shaded] - identifies Tier 1 EALs
[a] EALs for aldrin, chlordane, and dieldrin listed in this table were derived based on the EAL equations listed in HDOH Guidance (HDOH 2011) using the 2006 Site-Specific EAL adult and child exposure parameters and toxicity criteria listed in Table 8-1 (refer to "2006 Hickam EAL" section of the table). Equations used to calculate 2006 EALs are presented in Appendix B.
[b] Listed EALs for chemicals other than aldrin, chlordane, and dieldrin (i.e., shaded compounds) are the HDOH Tier 1 EALs for direct contact with soil (refer to Table I-1 HDOH 2011).
[c] The target risk of 1E-05 applies only to aldrin, chlordane, and dieldrin. Target risk of 1E-06 applies to all other chemicals.
[d] For chemicals other than aldrin, chlordane, and dieldrin, the listed noncancer Tier 1 EALs are based on a target HQ of 1 for purpose of estimating cumulative hazard.
[e] Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.

This page intentionally left blank



DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2006 EALs
Earhart I-2 and Earhart I-3

Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

- ≤10-5 Carc. Risk
- >10-5 Carc. Risk
- Earhart Village I-2/I-3
- Hardscapes
- 1 0 b Decision Unit Numbers

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 11-1

R:\NEW\29064\Layouts\Revisions\Earhart I-2 and I-3 Cumulative Risks 0-12 Inches.mxd 04/26/12 - YE

11.6.2 Earhart I-3 Neighborhood

Child Resident

Figure 11-1 identifies the DUs within the Earhart I-3 neighborhood with cumulative risks for the child resident exceeding the target risk level of 1 x 10^{-5} based on the soil sampling results collected within the 0-12 inch depth interval and the 2006 site-specific child resident EALs. A total of 170 DUs are associated with estimated risks for the residential child exceeding the target risk level of 1 x 10^{-5}. A histogram summarizing the distribution of the residential child cumulative risk estimates based on the 2006 EALs for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-3.

Figure 11-4 identifies DUs within the Earhart I-3 neighborhood associated with an estimated HI for the residential child exceeding the target hazard level of 1. A total of 65 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-6.

11.6.3 Onizuka II-1 Neighborhood

Child Resident

Figure 11-7 identifies DUs within the Onizuka II-1 neighborhood with cumulative risks for the child resident exceeding the target risk level of 1 x 10^{-5} based on the soil sampling results collected within the 0- to12-inch depth interval and the 2006 site-specific child resident EALs. As indicated in the figure, nine DUs are associated with estimated risks for the residential child exceeding the target risk level of 1 x 10^{-5}. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Onizuka II-1 neighborhood is presented in Figure 11-8.

Within the Onizuka II-1 neighborhood, no DUs (21 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1.

Figure 11-2. Earhart I-2: Distribution of Estimated and Cumulative Risks for DUs (0 to 12 inches) - 2006 EALs

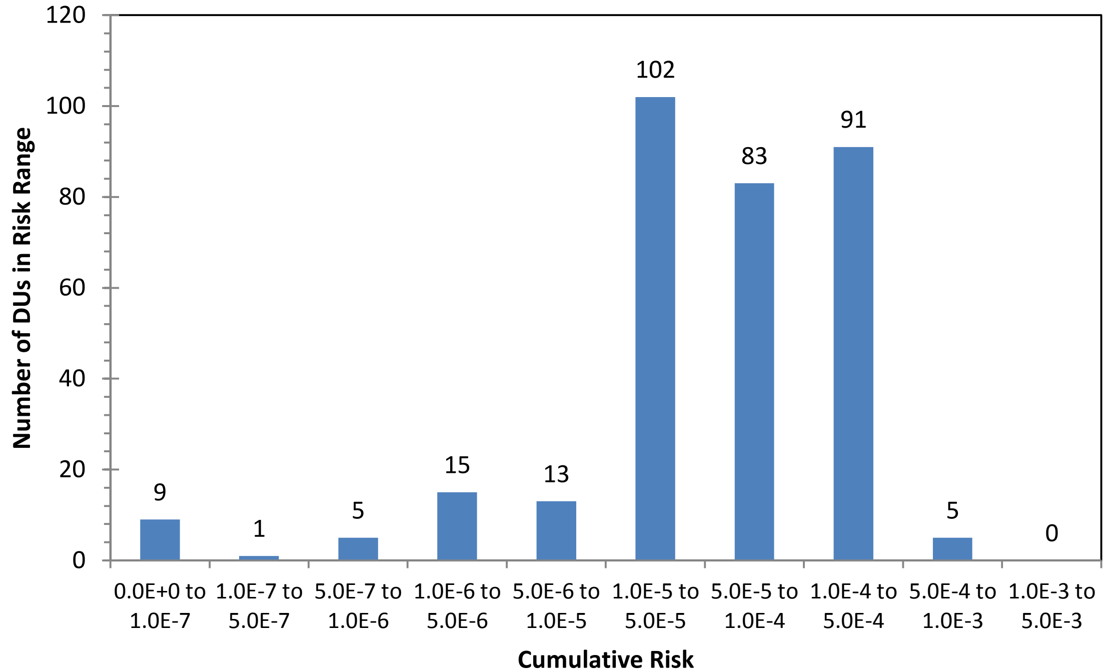
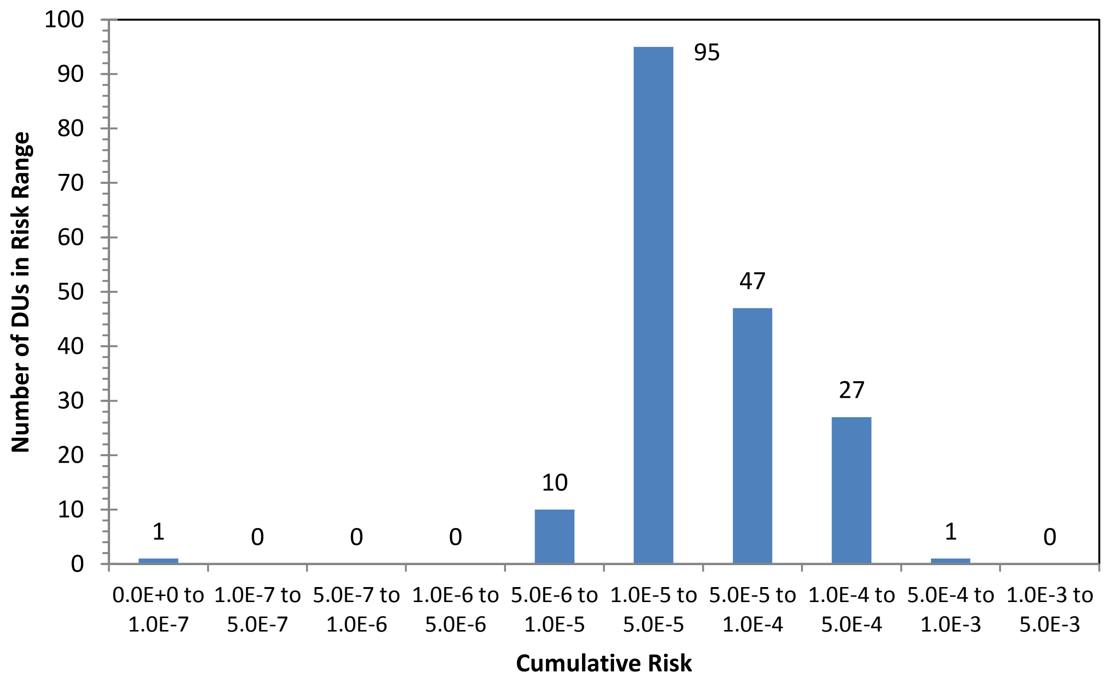
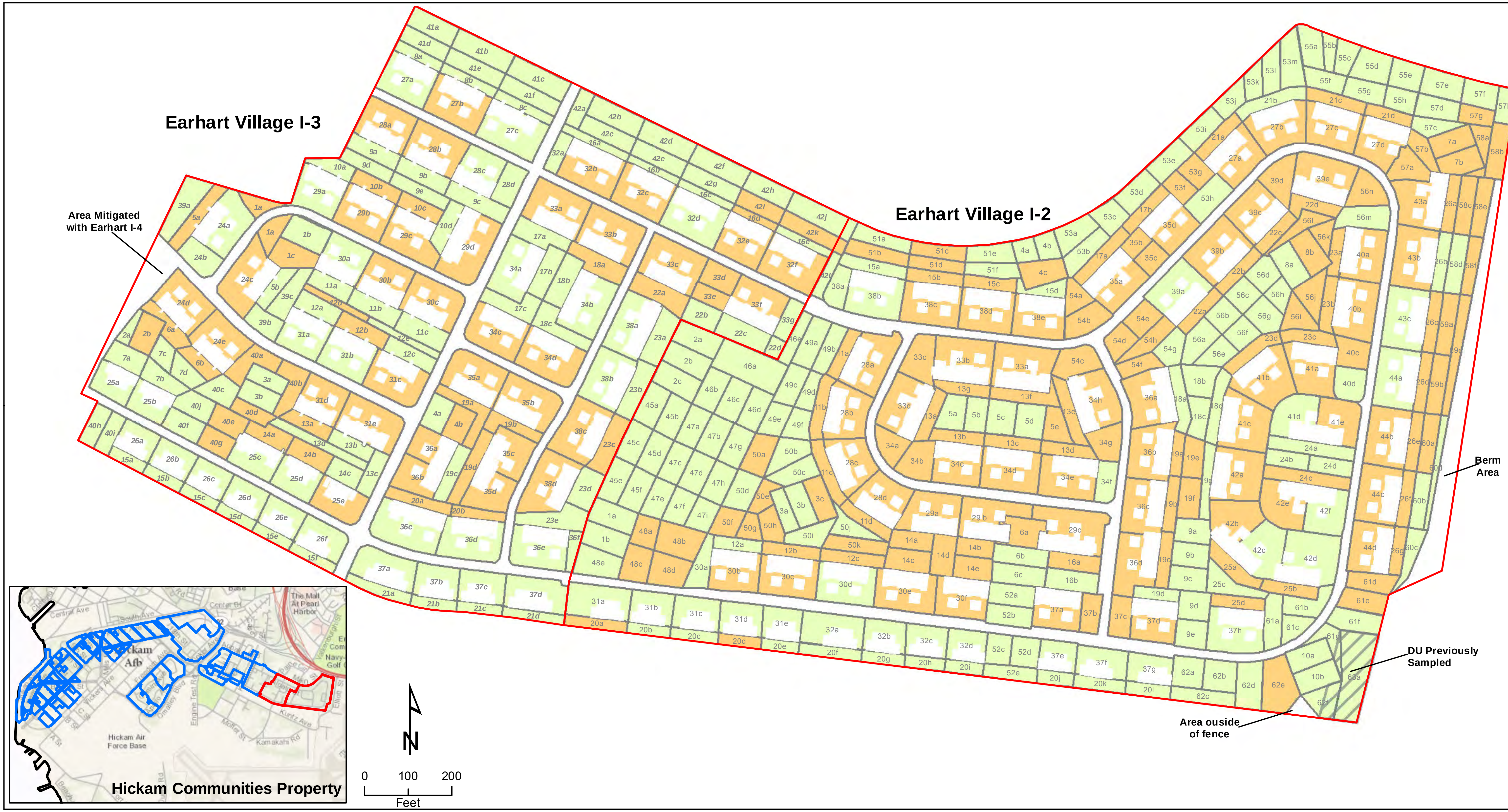


Figure 11-3. Earhart I-3: Distribution of Estimated and Cumulative Risks for DUs (0 to 12 inches) - 2006 EALs





Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

- HI 0-1
- HI >1
- Earhart Village I-2/I-3
- Hardscapes
- 10 b Decision Units

DUs with Hazard Index Exceeding Target Hazard (0-12 inches) - 2006 EALs Earhart I-2 and Earhart I-3

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 11-4

Figure 11-5. Earhart I-2: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2006 EALs

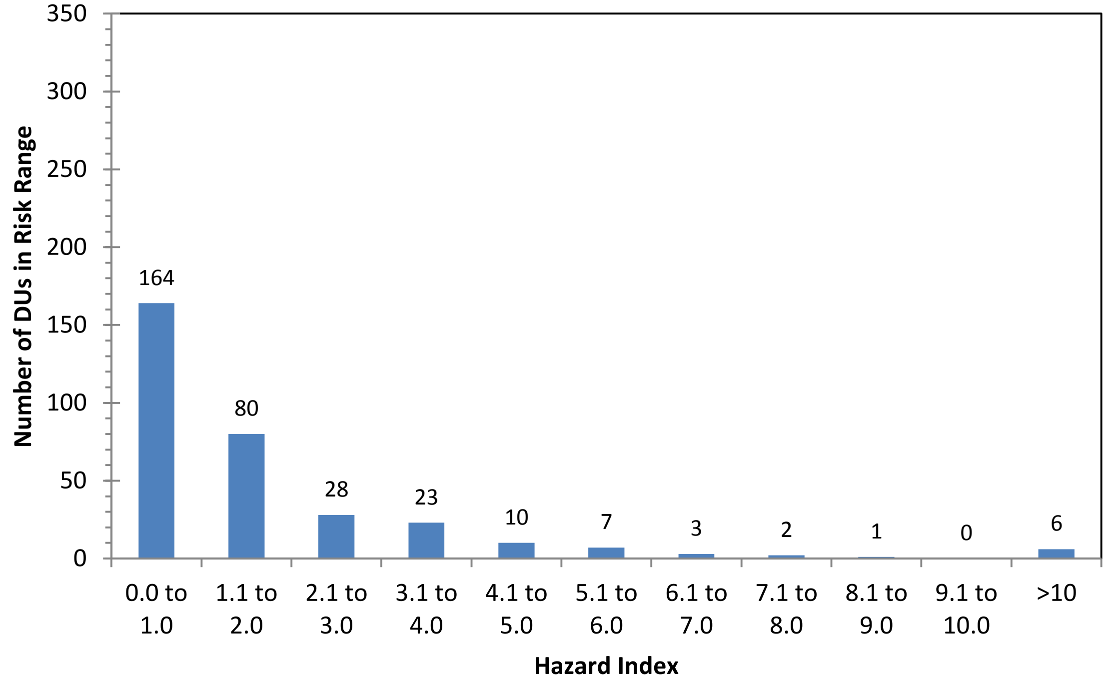
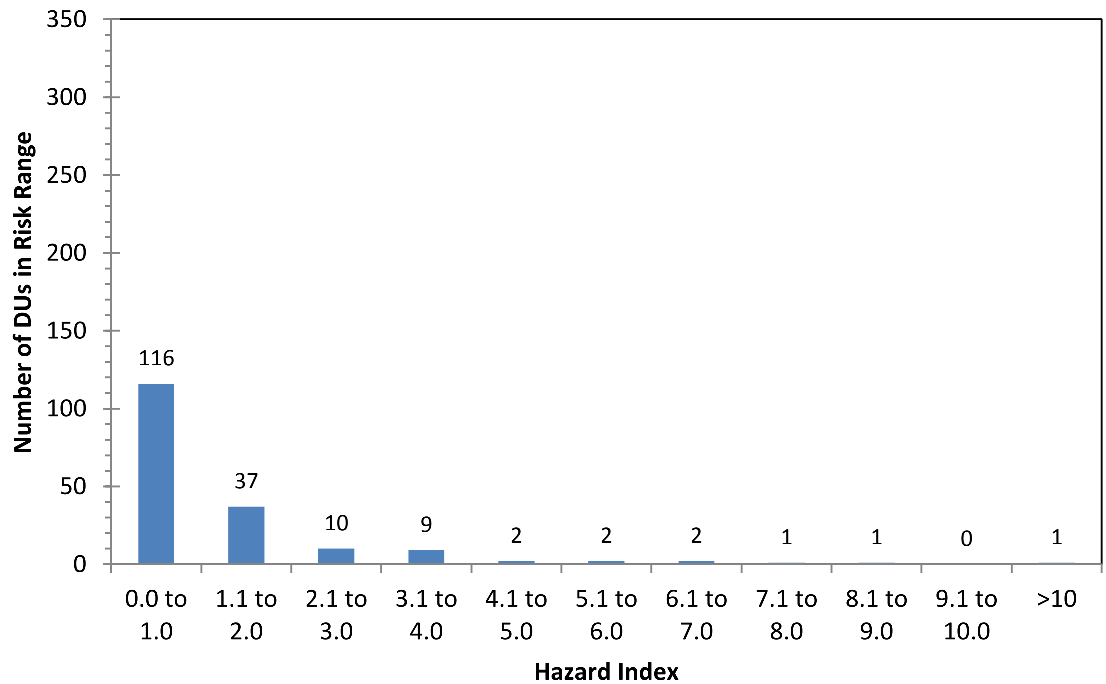
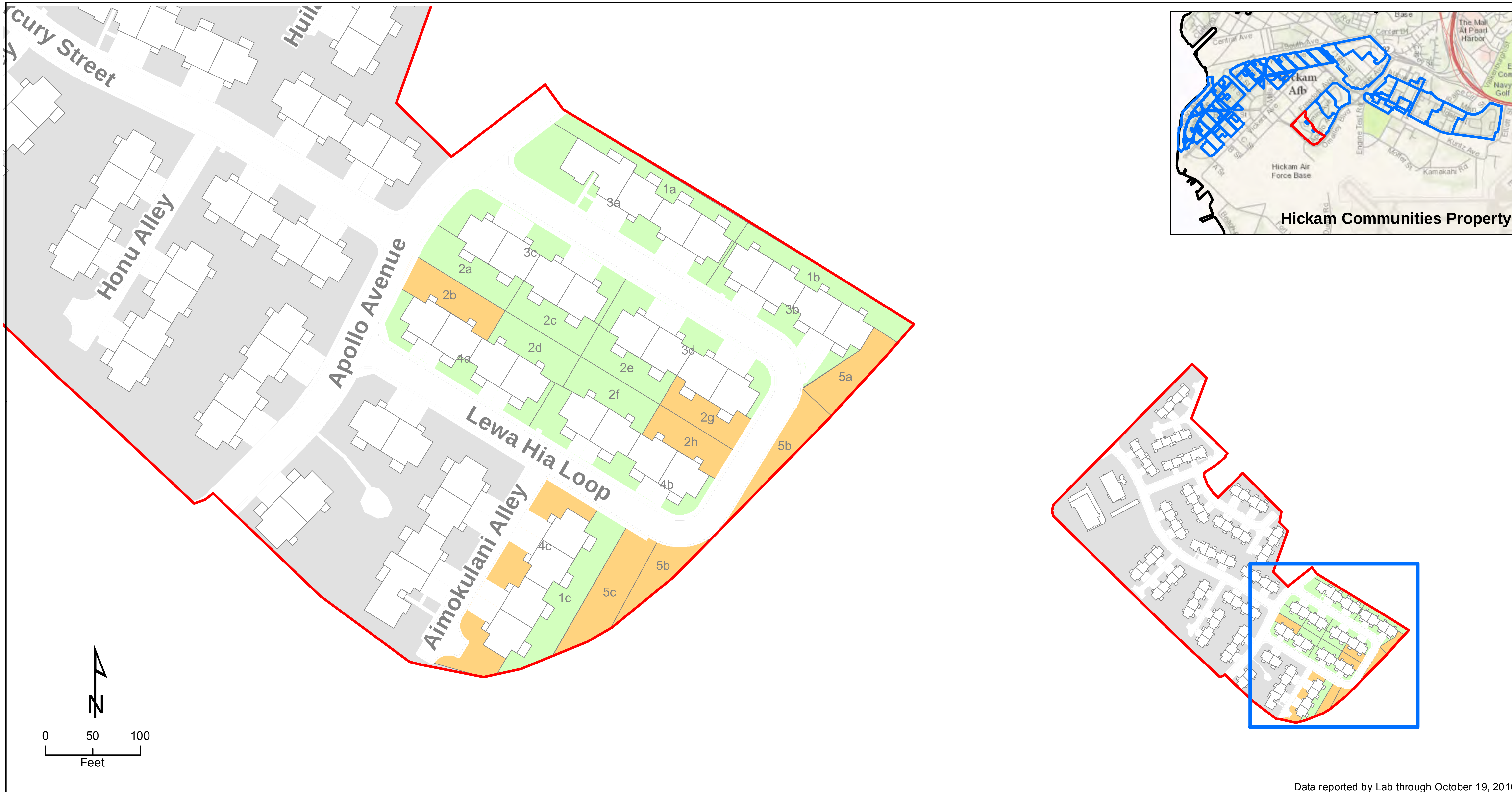


Figure 11-6. Earhart I-3: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2006 EALs



This page intentionally left blank



DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2006 EALs
Onizuka II-1

Hickam Air Force Base, O'ahu, Hawai'i

4 b Decision Unit Numbers

Earhart Village I-3

Hardscapes

Preliminary Risk Estimate (Based on 2006 Tier 2 EALs)

≤10-5 Carc. Risk

>10-5 Carc. Risk

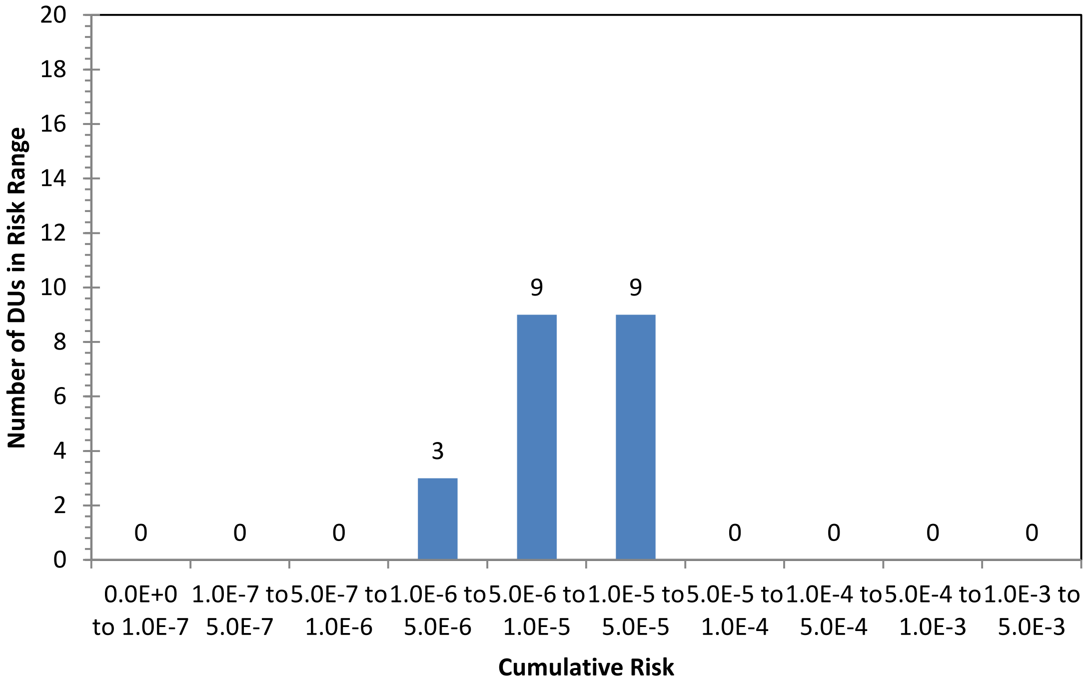
Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Figure 11-7

R:\NEW\29064\Layouts\Revisions\Onizuka II-1 Cumulative Risks 0-12 Inches.mxd 04/27/12 - YE

Figure 11-8. Onizuka II-1: Distribution of Estimated Cumulative Risks for DUs (0 to 12 inches) - 2006 EALs



11.6.4 Hale Na Koa I-1 Neighborhood

Child Resident

Within the Hale Na Koa I-1 neighborhood, no DUs (11 total) are associated with a cumulative risk exceeding the target risk level of 1 x 10^{-5} based on the soil sampling results collected within the 0- to 12-inch depth interval and the site-specific child resident 2006 HHRA Standard EALs (Figure 11-9).

Within the Hale Na Koa I-1 neighborhood, no DUs (11 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1 (Figure 11-10).

11.7 2012 Site-Specific EALs

As described in Section 11.3.1, when measured concentrations of contaminants at a site exceed EALs, a more advanced evaluation of environmental hazard may be done in which EALs are refined to better reflect actual site conditions by incorporating site-specific considerations into the HDOH equations used to derive the HDOH Tier 1 EALs. Based on the screening results associated with the 2006 HHRA EALs and discussions with HDOH, refined site-specific EALs protective of direct exposure (referred to as "2011 HHRE EALs") were developed based on the following five adjustments to the 2006 HHRA EALs:

- Cancer slope factors for aldrin and dieldrin
- Target risk levels

Figure 11-9. Hale Na Koa I-1: Distribution of Cumulative Risks for DUs (0 to 12 inches) - 2006 HHRA EALs

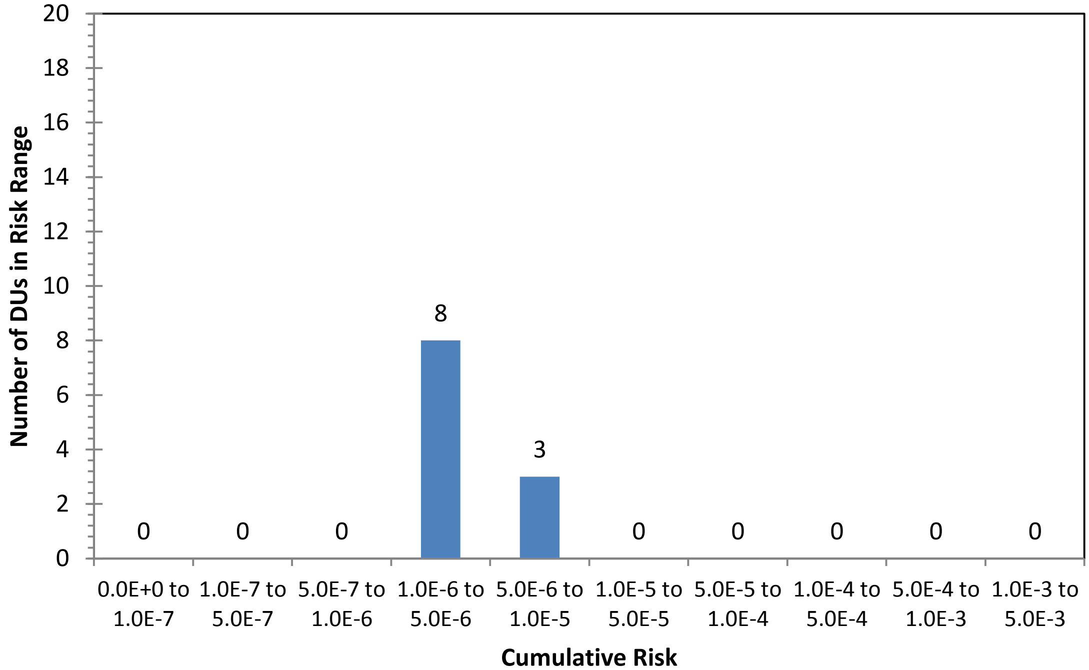
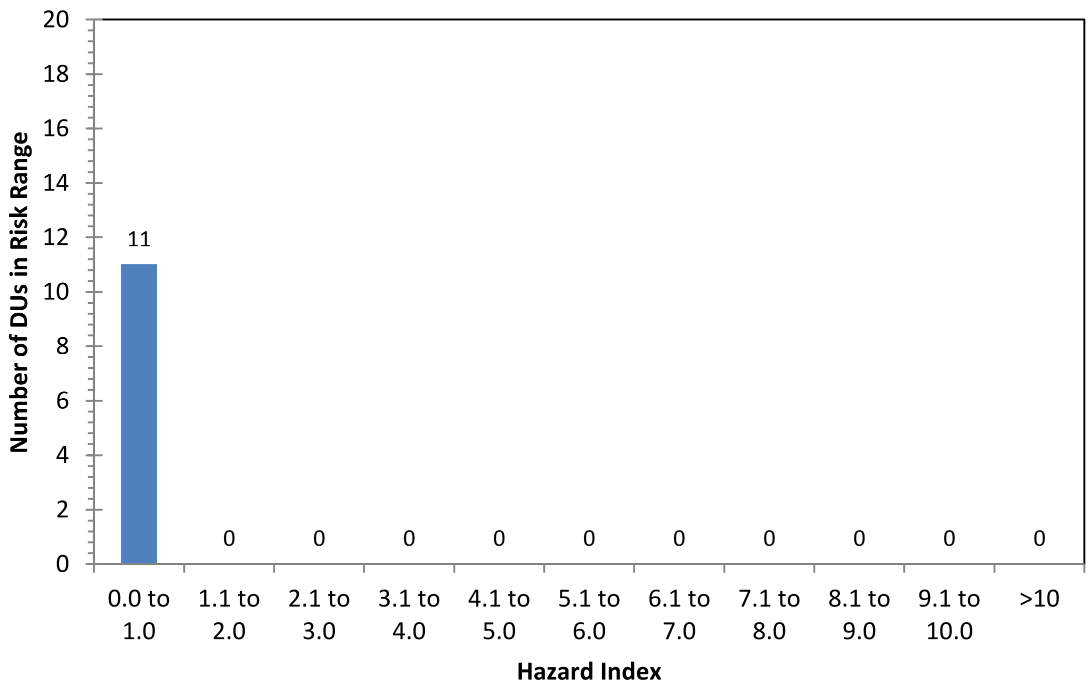


Figure 11-10. Hale Na Koa I-1: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2006 HHRA EALs



- Noncancer toxicity criteria for aldrin and dieldrin

- Child soil ingestion rate
- Dermal absorption factors for aldrin and dieldrin

The exposure parameters, toxicity criteria, and methodology used to derive the current 2012 EHE EALs are described in the EHE report provided in Appendix E.

The 2012 Site-specific residential EALs for the contaminants of concern in soil for the direct exposure hazard are summarized in Table 11-6 for child and adult residents. As described above, the direct exposure EALs for residential receptors were developed based on the following exposure pathways:

- Incidental ingestion of soil
- Dermal contact with soil
- Inhalation of airborne particulates

11.7.1 2012 EHE Standard – Target Risk and Hazard Levels

For this evaluation, the soil within each DU is evaluated using the 2012 HC EHE standard developed by HDOH.[113] As per the HDOH approved 2012 HC EHE standard, a DU is not considered to pose a risk to human health and the environment due to organochlorine pesticides if all of the following criteria are met: (1) the cumulative for aldrin plus dieldrin must not exceed 1 x 10^{-4}; (2) the cumulative ECR for all other organochlorine pesticides must not exceed 1 x 10^{-5}; (3) the cumulative ECR for all COPCs must not exceed 1 x 10^{-4}; and (4) the hazard index for all COPCs must not exceed 1. If any of these criteria are not met, then the soil within the DU is considered to pose a threat to human health and the environment and must be treated accordingly.

[113] (HDOH 2011d; HDOH 2012)

Table 11-6. 2012 Site-Specific Environmental Action Levels (EALs) for Soil – Child and Adult Residents[a]

Chemical[b]	HC Site-Specific Soil Screening Levels (mg/kg)				Final EAL
	Child		Adult		
	Cancer-based	Noncancer-based	Cancer-based	Noncancer-based	
	Target Risk[c]	Target HQ = 1	Target Risk[c]	Target HQ = 1[d]	
Aldrin	42.1	12.2	209.4	60.9	12.2
Chlordane[d]	42.6	38.3	209.8	190.0	38.3
Dieldrin	20.4	9.8	101.4	48.7	9.8
DDD	48.7	-	253.6	-	48.7
DDE	34.4	-	179	-	34.4
DDT	46	67	223.7	326	46.0
Endrin	-	30.1	-	156.5	30.1
Endrin ketone[e]	-	30.1	-	156.5	30.1
Endosulfan sulfate[e,f]	-	601.6	-	3,130.5	601.6
delta-BHC[e,f]	-	38.3	-	188.9	38.3
Methoxychlor[e,f]	-	501.4	-	2,609	501.4

Notes:
EHE =Environmental Hazard Evaluation HQ = Hazard quotient HDOH = Hawaii Department of Health
HC = Hickam Communities mg/kg = milligram per kilogram

[a] EALs listed in this table were derived based on the EAL equations listed in HDOH Guidance (HDOH 2011) and presented in Table 8-3 of EHE using the child and adult parameters listed in Table 8-1 (EHE) and the toxicity/dermal criteria summarized in Table 8-2 (EHE). A summary of modifications to default HDOH parameters is as follows:

<u>Modifications to Chemical-Specific Parameters</u>
1) Aldrin - cancer slope factor modified to 3.4 $(mg/kg\text{-}day)^{-1}$, oral reference dose (RfD) modified to 1×10^{-4} (mg/kg-day), and dermal absorption factor modified to 0.05.
2) Dieldrin - cancer slope factor modified to 7 $(mg/kg\text{-}day)^{-1}$, oral reference dose (RfD) modified to 8×10^{-5} (mg/kg-day), and dermal absorption factor modified to 0.05.

<u>Modifications to Site-Specific Parameters</u>
3) Target Risk - target risk for aldrin and dieldrin modified to 1×10^{-4}; target risk for other pesticides is 1×10^{-5}.
4) Target hazard quotient (HQ) - HQ = 1 for all chemicals.
5) Exposure duration - assumed to be 6 years for adult and child residents
6) Child soil ingestion rate - soil ingestion rate for residential child modified to 100 mg/day based on site-specific considerations.

[b] All organochlorine pesticides detected in soil as part of site investigation activities conducted at the site in 2010 are included in this table.
[c] As indicated in Footnote a, the target risk of 1×10^{-4} applies only to aldrin and dieldrin.
[d] Chlordane is representative of technical chlordane which consists of chlordane isomers, heptachlor, and heptachlor epoxide. For this reason, other chlordane isomers, heptachlor, and heptachlor epoxide are evaluated as chlordane and are not listed individually in this table.
[e] Endrin used as a surrogate for endrin ketone; endosulfan used as a surrogate for endosulfan II and endosulfan sulfate; and gamma-BHC (Lindane) used as a surrogate for delta-BHC.
[f] Listed chemical detected at low levels in one sample.

11.8 Comparison of 2012 Site-Specific EALs to Site Data

The results of the direct exposure evaluation using the 2012 Site-specific residential EALs are presented below for each neighborhood. As described above, the lowest site-specific EALs are associated with the child resident and, therefore, are protective of adult residents. For this reason, only the evaluation results for the child resident are discussed/summarized below. The estimated risks and hazards associated with potential residential child and adult exposures for all DUs are summarized in in the EHE report (Appendix E).

11.8.1 Earhart I-2 Neighborhood

Child Resident

Table 11-7 summarizes the DUs within the Earhart I-2 neighborhood with cumulative risks for the child resident exceeding at least one of the HDOH cumulative risk criteria associated with the 2012 HC EHE standard based on the soil sampling results collected within the 0- to 12-inch depth interval and the 2012 Site-specific EALs. As indicated in the table, two DUs (DU-37a and DU-15b) are associated with estimated cumulative risks exceeding at least one of the HDOH cumulative risk criteria. The locations of these DUs, where contaminants have the potential to pose a direct exposure risk, are shown in Figure 11-11. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-12. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates less than 5 x 10^{-5}.

As shown in Table 11-7, a total of 19 DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. The locations of these DUs, where contaminants in soil have the potential to pose a direct exposure hazard, are shown in Figure 11-14. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-15. As indicated in the histogram, all of the estimated HIs exceeding the target level of 1 are less than 4 with most (i.e., 15 out of 19) being between 1 and 2.

11.8.2 Earhart I-3

Child Resident

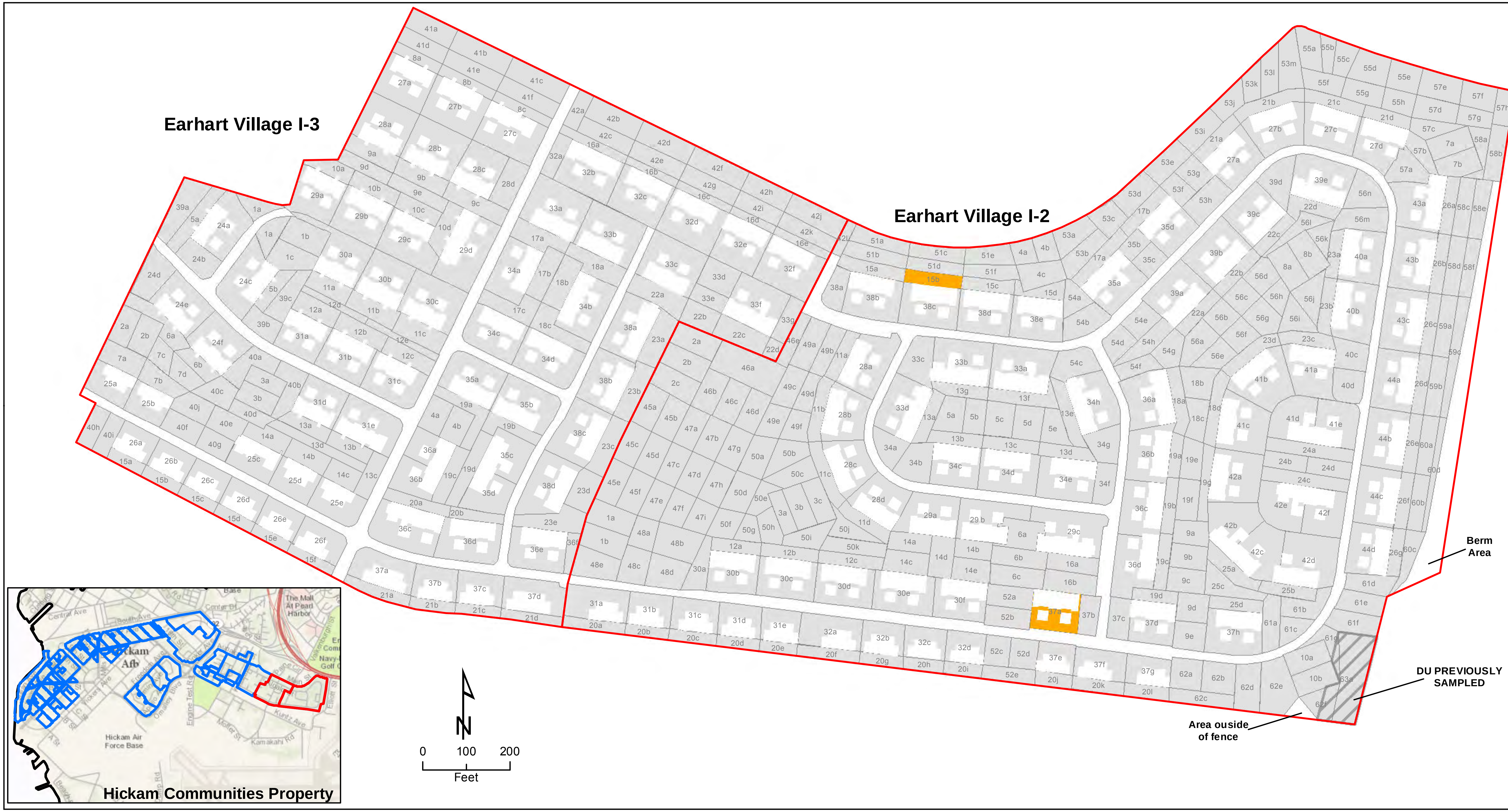
Within the Earhart I-3 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 HC EHE standard based on the soil sampling results collected within the 0-12 inch depth interval and the 2012 Site-specific EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-13. As indicated in the histogram, the vast majority of DUs are associated with cumulative risk estimates less than 5 x 10^{-5}.

As shown in Table 11-7, a total of eight DUs are associated with an estimated HI for the residential child exceeding the target hazard level of 1. The locations of these DUs, where contaminants in soil have the potential to pose a direct exposure hazard, are shown in Figure 11-14. A histogram summarizing the distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-16. As indicated in the histogram, all of the estimated HIs exceeding the target level of 1 are less than 3 with most being between 1 and 2.

Table 11-7. Evaluation of Decision Units with Cumulative ECRs and Hazard Indices Exceeding Target Levels[a,b]

Decision Unit[c]	Cumulative ECR - Child Resident		HI Screening - Child Resident[d]	
	ECR (0-6 inches)	ECR (6-12 inches)	HI (0-6 inches)	HI (6-12 inches)
Earhart I-2				
27d	e	e	1.46	2.19
38d	e	e	1.35	0.89
11b	e	e	1.34	1.28
15b	5.5E-05	1.1E-04	1.34	3.01
42b	e	e	1.22	2.43
37a	4.5E-05	1.2E-04	1.21	3.44
23b	e	e	1.14	0.31
29a	e	e	1.08	0.57
14c	e	e	1.07	0.48
23a	e	e	1.06	1.36
42a	e	e	0.95	2.06
19b	e	e	0.90	1.80
35b	e	e	0.89	1.25
27c	e	e	0.88	1.67
15c	e	e	0.72	1.15
30f	e	e	0.70	1.85
28d	e	e	0.54	1.48
23d	e	e	0.52	1.06
30e	e	e	0.35	1.27
Earhart I-3				
12b	e	e	1.50	2.90
34c	e	e	1.49	0.39
20a	e	e	1.21	1.90
33c	e	e	1.19	0.95
4b	e	e	0.68	1.62
14b	e	e	0.27	1.12
12d	e	e	0.21	1.14
33b	e	e	0.22	1.40

Notes:
ECR = Excess cancer risk HI = Hazard index
[shaded] = DUs where the estimated HI for surface soil (i.e., 0-6 inch depth interval) are below target HI of 1.
[a] No other decision units within the Site had cumulative ECRs or HIs exceeding the four HDOH target risk and hazard criteria associated with the HC 2012 EHE standard (HDOH 2012), which are as follows:
Criteria #1 - the cumulative ECR for aldrin plus dieldrin must not exceed 1×10^{-4}
Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}
Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}
Criteria #4 - the hazard index for all COPCs must not exceed 1.0.
[b] The chemical-specific risks and cumulative ECRs and HIs for all DUs are presented in Appendix E.
[c] No decision units within the Onizuka II-1 or Hale Na Koa neighborhoods were associated with a hazard index exceeding the target HI of one for the child resident.
[d] Target HI is 1 (Criteria #4 in footnote a).
[e] Cumulative ECR does not exceed target risk criteria associated with the HC 2012 EHE Standard (see footnote a).



Cumulative Risk

Exceeds HDOH 2011 HHRE Standard target risk criteria

Earhart Village I-2/I-3

Hardscapes

10 b Decision Unit Numbers

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Earhart I-2 and Earhart I-3: DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2012 EALs

Hickam Communities

Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 11-11

R:\NEW\29064\Layouts\Revisions\Earhart I-2 and I-3 DUs with Cumulative Risks Exceeding Target Risk (0-12 inches) - 2011 EALs.mxd 04/27/12 - YE

Figure 11-12. Earhart I-2: Distribution of Estimated Cumulative Risks for DUs (0 to 12 inches) - 2012 EALs

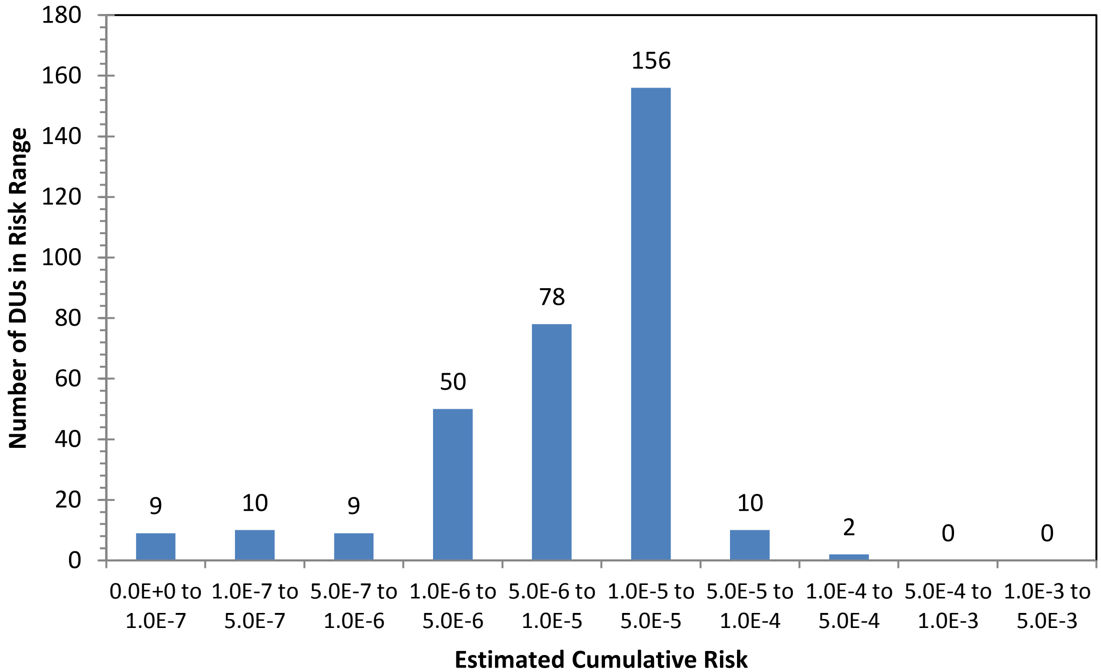
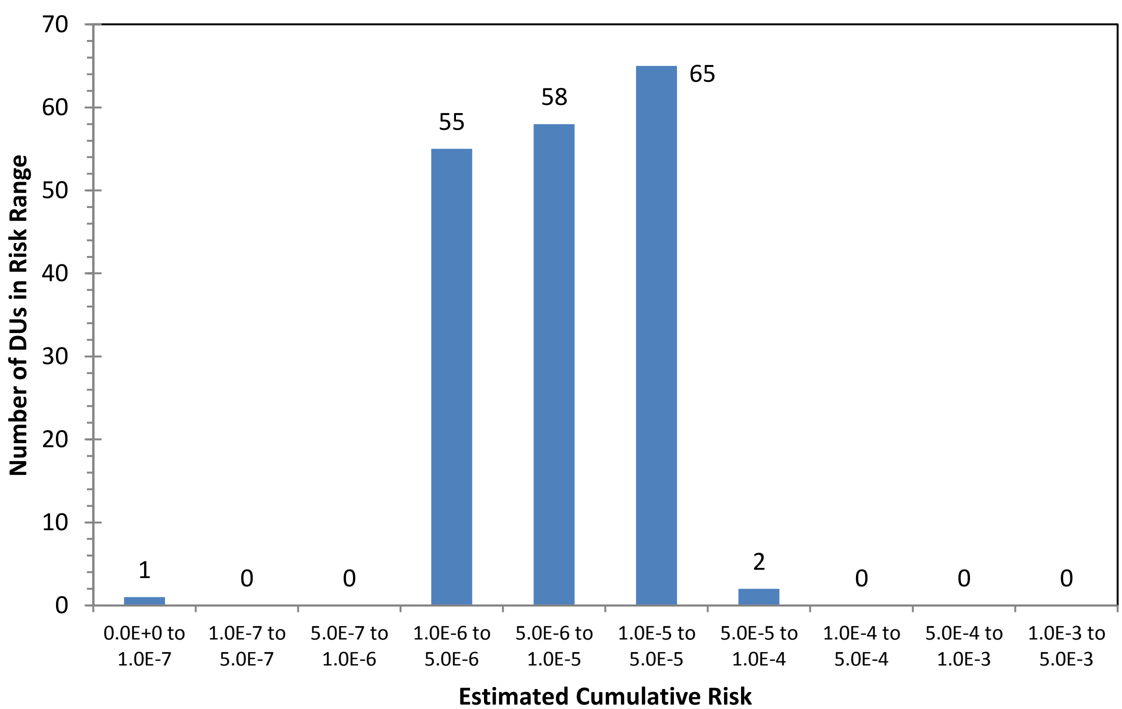


Figure 11-13. Earhart I-3: Distribution of Estimated Cumulative Risk for DUs (0 to 12 inches) - 2012 EALs



This page intentionally left blank

Cumulative Hazard

HI > 1

Earhart Village I-2/I-3

Hardscapes

10b Decision Unit Numbers

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Earhart I-2 and Earhart I-3: DUs with Hazard Index Exceeding Target Hazard (0-12 inches) - 2012 EALs

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 11-14

R:\NEW\29064\Layouts\Revisions\Earhart I-2 and I-3 Decision Units with Hazard Index Exceeding Target Hazard-2012 EALs.mxd 04/27/12 - YE

Figure 11-15. Earhart I-2: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2012 EALs

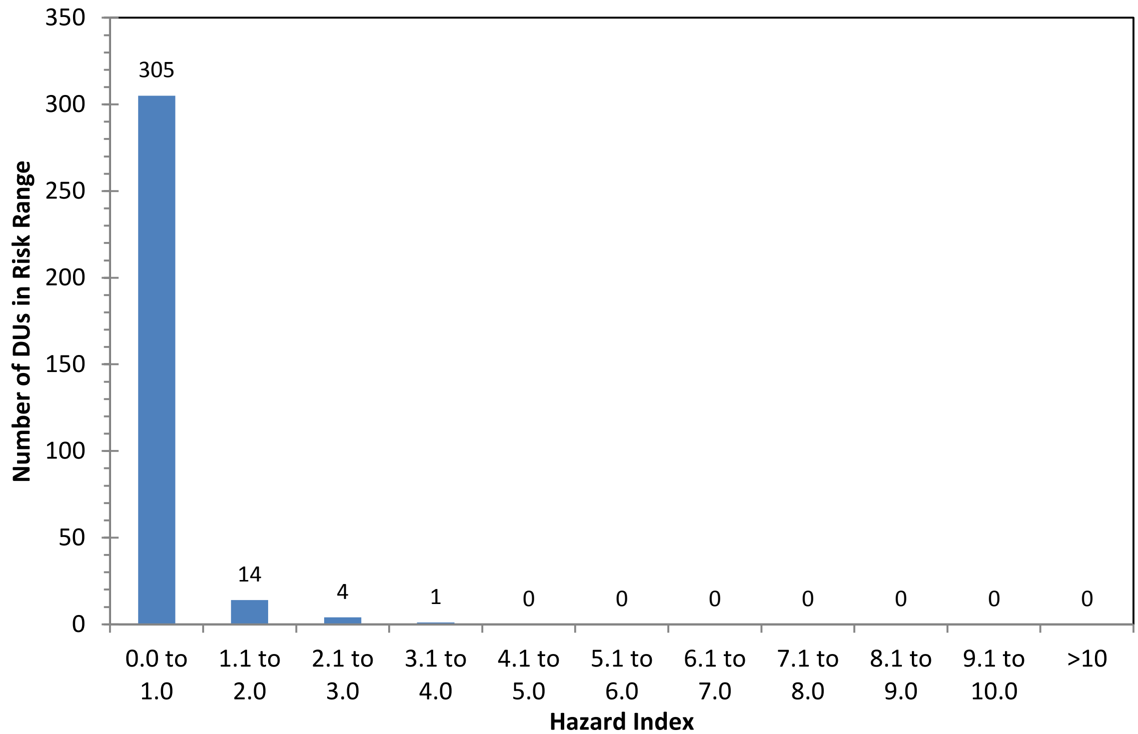
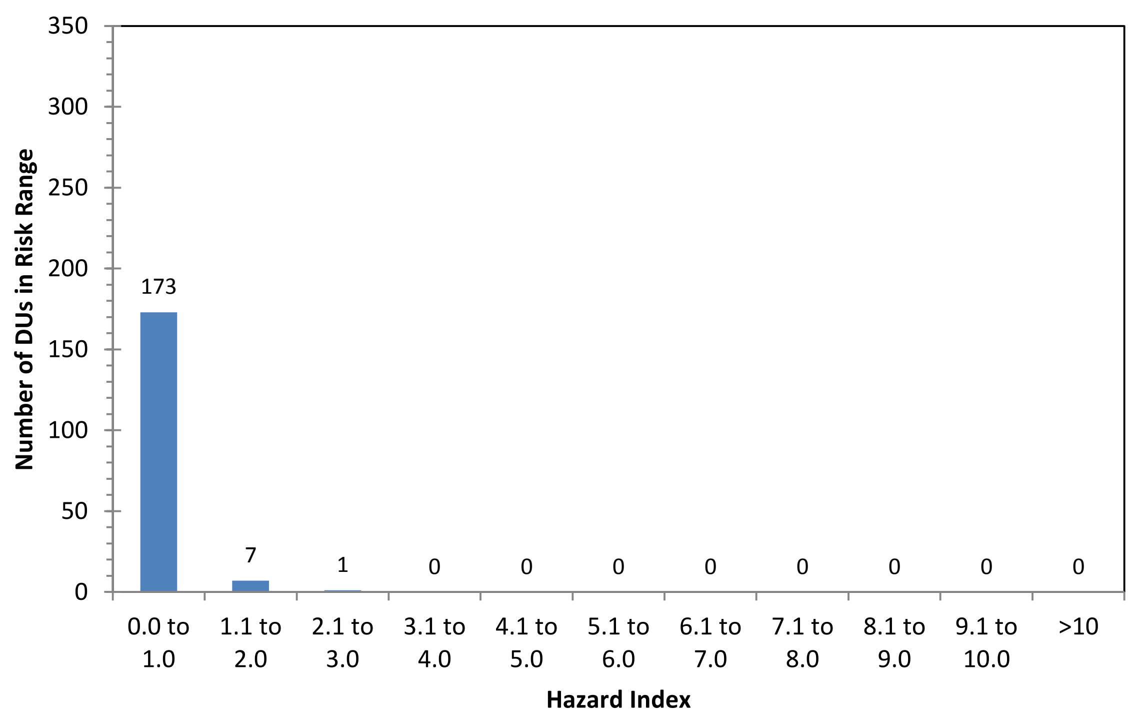


Figure 11-16. Earhart I-3: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2012 EALs



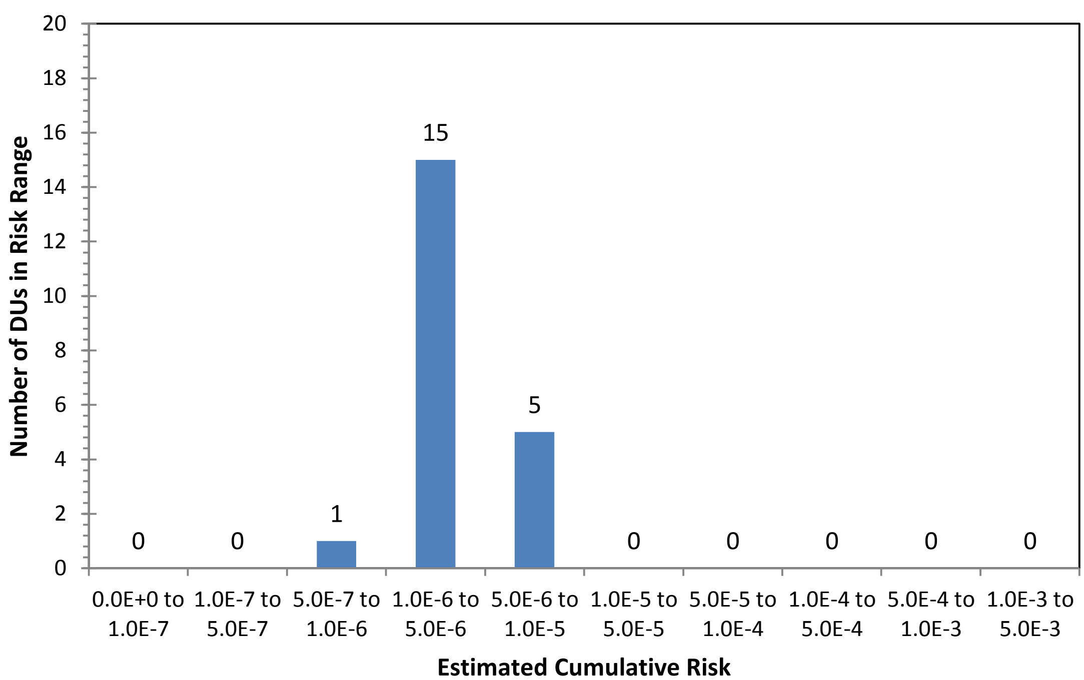
11.8.3 Onizuka II-1

Child Resident

Within the Onizuka II-1 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 EHE Standard based on the soil sampling results collected within the 0-12 inch depth interval and the 2012 Site-specific EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Onizuka II-1 neighborhood is presented in Figure 11-17. As indicated in the histogram, no DUs are associated with cumulative risk estimates greater than 1 x 10^{-5}.

Similar to the cumulative risk estimates described above, no DUs (21 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1. As shown in Appendix E of the EHE report, the estimated HIs for the child resident range from 0.03 to 0.21, which are well below the target level of 1.

Figure 11-17. Onizuka II-1: Distribution of Estimated Cumulative Risks for DUs (0 to 12 inches) - 2012 EALs



11.8.4 Hale Na Koa II-1

Child Resident

Within the Hale Na Koa I-1 neighborhood, no DUs are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria associated with the 2012 EHE Standard based on the soil sampling results collected within the 0 to 12-inch depth interval and the site-specific 2012 EHE Standard EALs. A histogram summarizing the distribution of the residential child cumulative risk estimates for all of the DUs located within the Hale Na Koa I-1 neighborhood is presented in Figure 11-18. As indicated in the histogram, no DUs are associated with cumulative risk estimates greater than 1×10^{-5}.

Similar to the cumulative risk estimates described above, no DUs (11 total) are associated with an estimated HI for the residential child exceeding the target hazard level of 1. As shown in Figure 11-19, the estimated HIs for the child resident are well below the target level of 1.

11.8.5 Summary of Principal Environmental Hazards

Based on the evaluation presented above using the 2012 site-specific EALs, a total of 28 DUs were associated with contaminant levels in soil corresponding to a cumulative risk greater than at least one of the HDOH cumulative risk criteria or a cumulative hazard (i.e., HI) greater than the target level of 1. As indicated in Table 11-6, the noncancer EALs for the child resident associated with the primary COCs detected at the Site (i.e., aldrin and dieldrin) are lower than (i.e., more conservative/health protective) the corresponding EALs developed to be protective of carcinogenic effects. Thus, only two DUs were identified with estimated cumulative risks greater than at least one of the HDOH cumulative risk criteria and 28 DUs were identified with estimated HIs greater than the target level of 1 (including the two DUs with estimated cumulative risks exceeding at least one of the 2012 EHE Standard target risk criteria [DU-37a and DU-15b]).

The 28 DUs identified within the Earhart I-2 and Earhart I-3 neighborhoods with contaminants in soil resulting in an estimated HI greater than 1 for the child resident are summarized in Table 11-7. These DUs were screened in a conservative manner in which the maximum HI estimated for either the 0- to 6-inch depth interval or the 6- to 12-inch depth interval was used to identify DUs with an HI greater than 1. In an effort to determine which DUs may require remedial vs. mitigation efforts, the estimated child resident HIs for both the 0-to 6-inch and 6- to 12-inch depth intervals are summarized.

Surface Soil (0-6 inch Depth Interval)

As shown in Table 11-7, ten DUs in Earhart I-2 and four DUs in Earhart I-3 have contaminant levels in soil that result in an estimated HI greater than 1 for the child resident within the 0- to 6-inch depth interval. Without remediation or the implementation of engineering and/or institutional controls, direct exposure to soil within these DUs could potentially pose risk to residential receptors under current and future conditions. The ten DUs in Earhart I-2 with an HI greater than 1 within the 0- to 6-inch depth interval include DU-11b, DU-14c, DU-15b, DU-23a, DU-23b, DU-27d, DU-29a, DU-37a, DU-38d, and DU-42b,. The four DUs in Earhart I-3 with an HI greater than 1 within the 0- to 6-inch depth interval include DU-12b, DU-20a, DU-33c, and DU-34c. The locations of these DUs are shown in Figure 11-20.

Figure 11-18. Hale Na Koa I-1: Distribution of Cumulative Risk for DUs (0 to 12 inches) - 2012 EALs

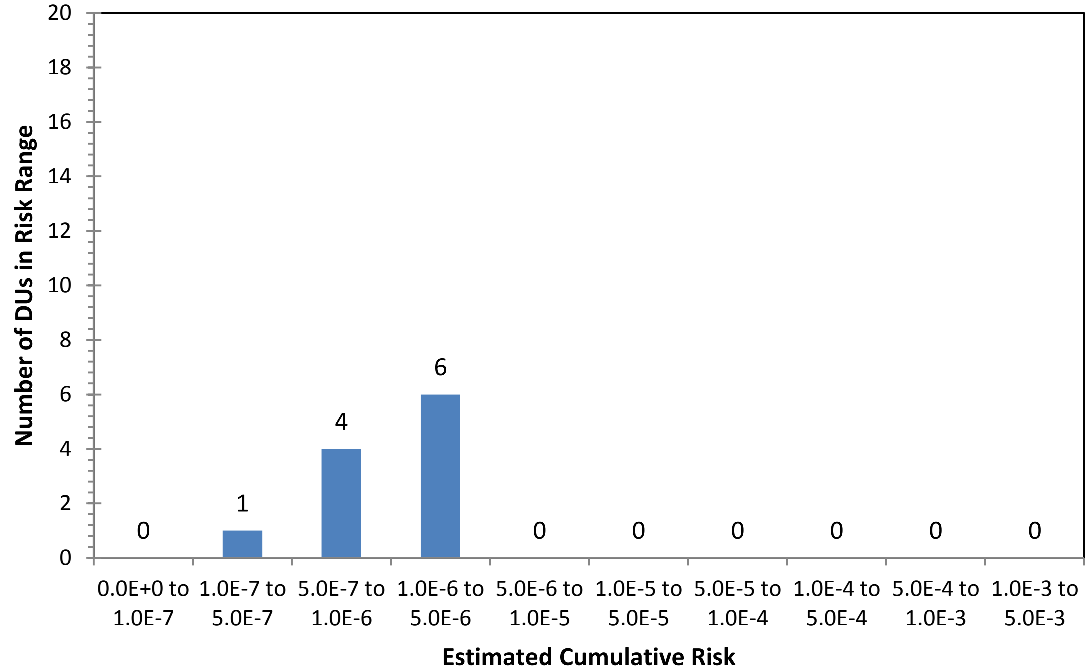
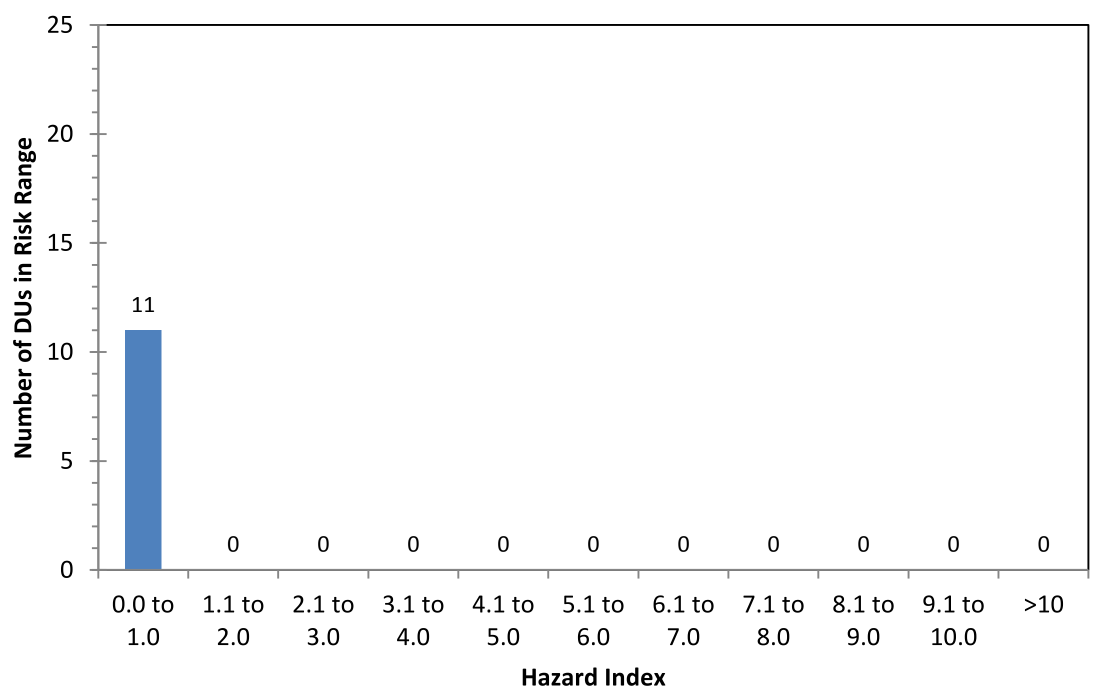


Figure 11-19. Hale Na Koa I-1: Distribution of Hazard Indices for DUs (0 to 12 inches) - 2012 EALs



Earhart I-2 and Earhart I-3: Decision Units Requiring Remediation/Mitigation - 2012 EALs

Cumulative Hazard

- HI > 1 in 6-12" only
- HI > 1 in 0-6"
- Earhart Village I-2/I-3
- Hardscapes
- 10b Decision Units

Notes:

- Inset map shows Hickam Communities Property Boundary Line.

Hickam Communities
Joint Base Pearl Harbor-Hickam, Hawai'i

Figure 11-20

R:\NEW\29064\Layouts\Revisions\Earhart I-2 and I-3 Decision Units Requiring Remediation/Mitigation - 2011 EALs.mxd 04/27/12 - YE

Sub-surface Soil (6-12 inch Depth Interval)

As shown in Table 11-5, nine DUs in Earhart I-2 and four DUs in Earhart I-3 have contaminant levels in soil within the 6- to 12-inch depth interval that result in an estimated HI greater than 1 for the child resident. However, the estimated HIs for the child resident within surface soil (i.e., 0- to 6-inch depth interval) in these DUs are below the target hazard level of 1 indicating that potential residential exposures to surface soil would not be expected to result in adverse health effects. Thus, for these DUs, as long as institutional and/or engineering controls are in place to control contact with soil within the 6- to 12-inch depth interval, potential residential exposures within these DUs would not be expected to result in adverse health effects. The nine DUs in Earhart I-2 requiring engineering or institutional controls to mitigate potential residential exposures to soil within the 6- to 12-inch depth interval include DU-15c, DU-19b, DU-23d, DU-27c, DU-28d, DU-30e, DU-30f, DU-35b, and DU-42a. The four DUs in Earhart I-3 requiring engineering or institutional controls to mitigate potential residential exposures to soil within the 6- to 12-inch depth interval include DU-4b, DU-12d, DU-14b, and DU-33b. The locations of these DUs are shown in Figures 11-19 (Earhart I-2) and 11-20 (Earhart I-3).

11.9 Post-Removal Site Conditions

This section summarizes potential risk and hazard levels associated with post-removal Site conditions within each neighborhood. As was done in the previous section, only the evaluation results for the child resident are discussed below since the child-specific EALs are lower (i.e., more conservative) than the EALs developed for adult residents. The estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in the EHE report (Appendix E). Table 11-8 lists the DUs that that contain concentrations above the 2012 EHE Standard following implementation of the removal actions.

In addition to evaluating potential residential exposures to PI soil within the Site DUs, potential risks posed under reasonably anticipated future exposure scenarios are also described.

11.9.1 Earhart I-2 Neighborhood

Child Resident

As described in Section 11.8.1, two DUs (DU-15b and DU-37a) in Earhart I-2 were associated with estimated cumulative risks exceeding at least one of the HDOH cumulative risk criteria associated with the 2012 EHE Standard. Both of these DUs were excavated as part of Removal Action #3 (RO #3) conducted at the Site. Thus, under post-removal Study Area conditions, no DUs in Earhart I-2 are associated with levels of organochlorine pesticides in soil that result in estimated risks exceeding the HDOH cumulative risk criteria. For the noncarcinogenic endpoint, 19 DUs were identified with estimated HIs for the residential child exceeding the target hazard level of 1. Ten of the 19 DUs were associated with levels of organochlorine pesticides in soil within the 0- to 6-inch depth interval that exceed the target HI of 1 for the child resident and were excavated as part of RO #3. The other nine DUs have levels of organochlorine pesticides in soil within the 6- to 12-inch depth interval that exceed the target HI of 1 for the child resident, however, the estimated HIs for the child resident within the 0- to 6-inch depth interval (i.e., surface soil) in these DUs were below the target hazard level of 1. For

Table 11-8. Decision Units with Cumulative ECRs and Hazard Indices Exceeding Target Levels Following Removal Actions[(a),(b)]

Decision Unit[(c)]	Cumulative ECR - Child Resident		HI Screening - Child Resident[(d)]	
	ECR (0-6 inches)	ECR (6-12 inches)	HI (0-6 inches)	HI (6-12 inches)
Earhart I-2				
27d	[(f)]	[(e)]	[(f)]	2.19
11b	[(f)]	[(e)]	[(f)]	1.28
15b	[(f)]	1.1E-04	[(f)]	3.01
42b	[(f)]	e	[(f)]	2.43
37a	[(f)]	1.2E-04	[(f)]	3.44
23a	[(f)]	[(e)]	[(f)]	1.36
42a	[(e)]	[(e)]	0.95	2.06
19b	[(e)]	[(e)]	0.90	1.80
35b	[(e)]	[(e)]	0.89	1.25
27c	[(e)]	[(e)]	0.88	1.67
15c	[(e)]	[(e)]	0.72	1.15
30f	[(e)]	[(e)]	0.70	1.85
28d	[(e)]	[(e)]	0.54	1.48
23d	[(e)]	[(e)]	0.52	1.06
30e	[(e)]	[(e)]	0.35	1.27
Earhart I-3				
12b	[(f)]	[(e)]	[(f)]	2.90
20a	[(f)]	[(e)]	[(f)]	1.90
4b	[(e)]	[(e)]	0.68	1.62
14b	[(e)]	[(e)]	0.27	1.12
12d	[(e)]	[(e)]	0.21	1.14
33b	[(e)]	[(e)]	0.22	1.40

Notes:

ECR = Excess cancer risk HI - Hazard index

(shaded) = DUs where the estimated HI for surface soil (i.e., 0-6 inch depth interval) are below target HI of 1.

[(a)] No other decision units within the Site had cumulative ECRs or HIs exceeding the four HDOH target risk and hazard criteria associated with the HC 2012 EHE Standard (HDOH 2012), which are as follows:
- Criteria #1 - the cumulative ECR for aldrin plus dieldrin must not exceed 1×10^{-4}
- Criteria #2 - the cumulative ECR for all other organochlorine pesticides must not exceed 1×10^{-5}
- Criteria #3 - the cumulative ECR for all chemicals of potential concern (COPCs) must not exceed 1×10^{-4}
- Criteria #4 - the hazard index for all COPCs must not exceed 1.0.

[(b)] The chemical-specific risks and cumulative ECRs and HIs for all DUs are presented in Appendix E.

[(c)] No decision units within the Onizuka II-1 or Hale Na Koa neighborhoods were associated with a hazard index exceeding the target HI of one for the child resident.

[(d)] Target HI is 1 (Criteria #4 in footnote a).

[(e)] Cumulative ECR does not exceed target risk criteria associated with the HC 2012 EHE Standard (see footnote a).

[(f)] Upper nine inches of soil replaced, and geotextile installed over underlying soil, as part of RO #3. Only three inches of soil remains, from 9 to 12 inches, within the 6 to 12-inch interval.

these nine DUs, engineering controls (e.g., maintaining good lawn cover) and institutional and controls are in place to mitigate contact with soil within the 6- to 12-inch depth interval. As described in the EHE report, residential lease agreements stipulate that residents are prohibited from digging, excavating or gardening in order to control potential exposures. For this reason, potential residential exposures within these DUs would not be expected to result in adverse health effects. The locations of the nine DUs, where institutional controls are in place to control contact with subsurface soil, are shown in Figure 11-20.

A histogram summarizing the post-removal distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-21. Under post-removal conditions, the soil within all DUs meets all of the target risk criteria associated with the HDOH 2012 EHE Standard. As indicated in the histogram, no DUs exceed the target risk level of 1 x 10^{-4} for aldrin and dieldrin and the vast majority of DUs are associated with cumulative risk estimates less than 5 x 10^{-5}. A histogram summarizing the post-removal distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-2 neighborhood is presented in Figure 11-22. As indicated in the histogram, there are nine DUs remaining with estimated HIs exceeding the target level of 1. However, these are the nine DUs described above (and shown in Figure 11-20) where the estimated HIs for the child resident in surface soil (i.e., 0- to 6-inch depth interval) are below the target level of 1 and institutional controls are in place to control potential contact with sub-surface soil. The estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in the EHE report (Appendix E).

11.9.2 Earhart I-3 Neighborhood

As described in Section 11.8.2, no DUs in Earhart I-3 were associated with estimated cumulative risks exceeding any of the cumulative risk criteria associated with HDOH's 2012 EHE Standard. Thus, under post-removal Study Area conditions, no DUs in Earhart I-3 are associated with levels of organochlorine pesticides in soil that result in estimated risks exceeding the HDOH cumulative risk criteria. For the noncarcinogenic endpoint, eight DUs were identified with estimated HIs for the residential child exceeding the target hazard level of 1. Four DUs were associated with levels of organochlorine pesticides in soil within the 0- to 6-inch depth interval that exceed the target HI of 1 for the child resident and were excavated as part of RO #3. Four DUs have levels of organochlorine pesticides in soil within the 6- to 12-inch depth interval that exceed the target HI of 1 for the child resident, however, the estimated HIs for the child resident within the 0-6 inch depth interval (i.e., surface soil) in these DUs were below the target hazard level of 1. For these four DUs, engineering controls (e.g., maintaining good lawn cover) and institutional and controls are in place to mitigate contact with soil within the 6- to 12-inch depth interval. For this reason, potential residential exposures within these DUs would not be expected to result in adverse health effects. The locations of the four DUs, where institutional controls are in place to control contact with subsurface soil, are shown in Figure 11-20.

A histogram summarizing the post-removal distribution of the residential child cumulative risk estimates for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-23. As indicated in the histogram, no DUs exceed the target risk level of 1 x 10^{-4} for aldrin and dieldrin and the vast majority of DUs are associated with cumulative risk estimates less than 5 x 10^{-5}. A histogram summarizing the post-removal distribution of the estimated HIs for the residential child for all of the DUs located within the Earhart I-3 neighborhood is presented in Figure 11-24. As indicated in the histogram, there are five DUs remaining with estimated HIs exceeding the target level of 1. Four of these are the DUs described above (and shown in Figure 11-20) where the estimated HIs for the child resident in surface soil (i.e., 0-6 inch depth interval) are below the target level of 1 and institutional control are in place to control potential contact with sub-surface soil. The estimated risks and hazards associated with potential residential child and adult exposures under post-removal Site conditions for all DUs are summarized in the EHE report (Appendix E).

Figure 11-21. Earhart I-2: Distribution of Post-Removal Cumulative Risks for DUs (0 to 12 inches) - 2012 EALs

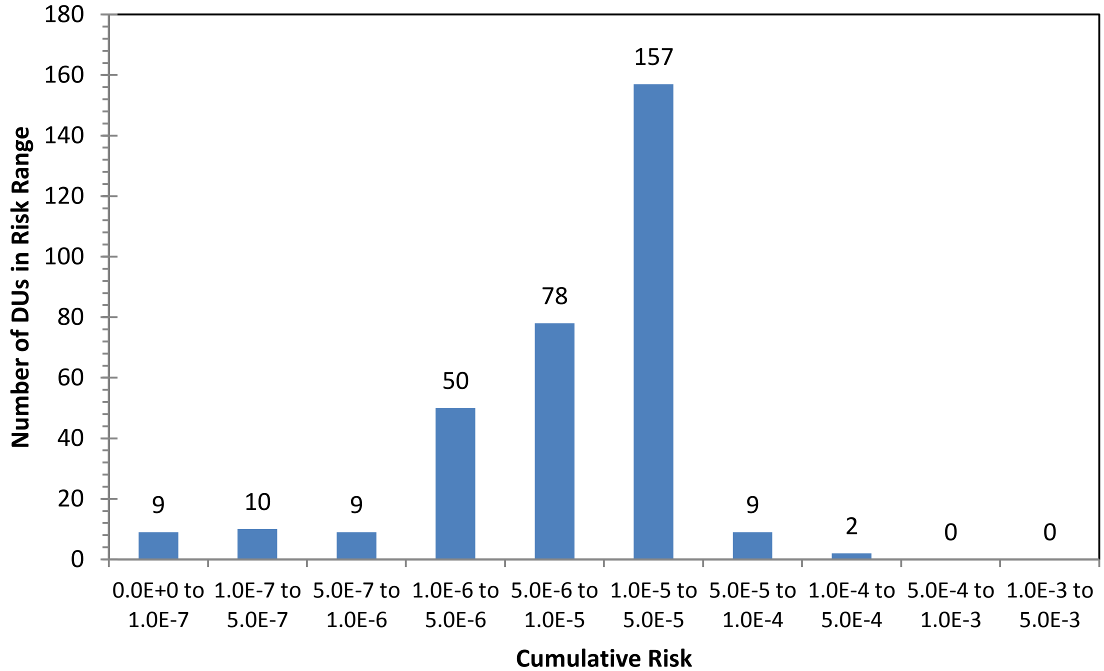


Figure 11-22. Earhart I-2: Distribution of Post-Removal Hazard Indices for DUs (0 to 12 inches) - 2012 EALs

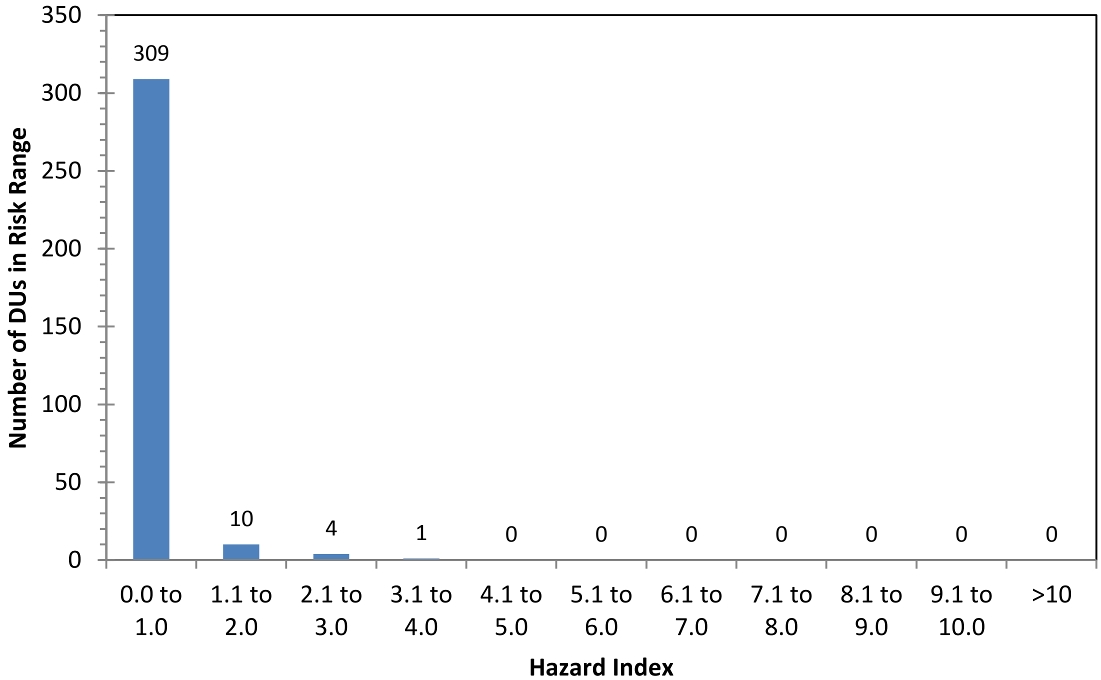


Figure 11-23. Earhart I-3: Distribution of Post-Removal Cumulative Risks for DUs (0 to 12 inches) - 2012 EALs

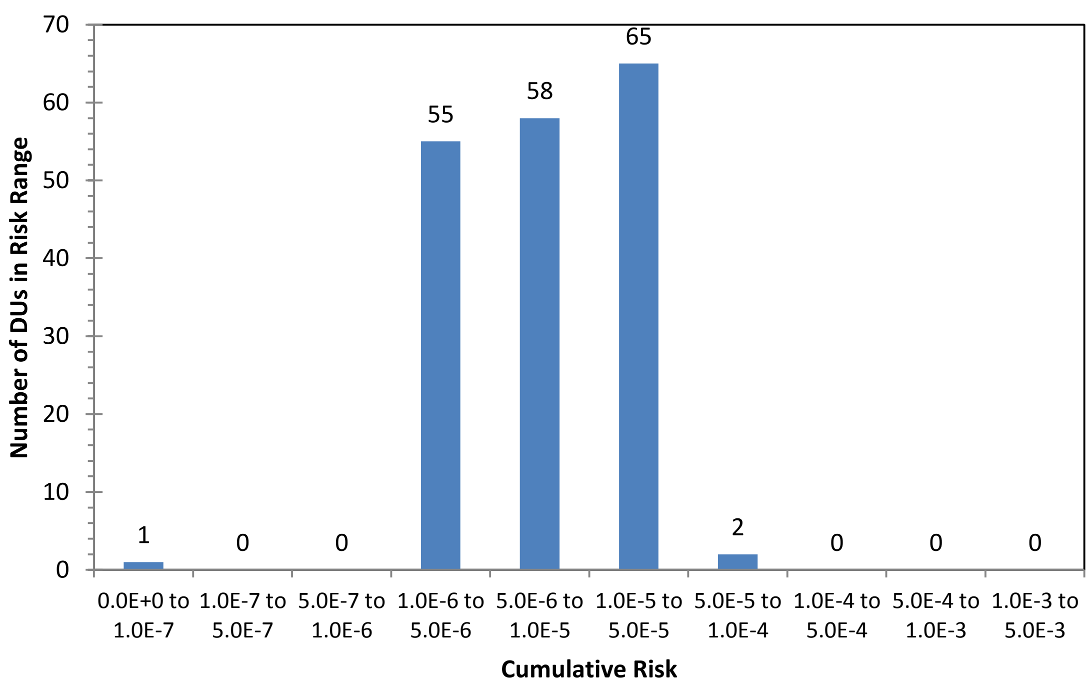
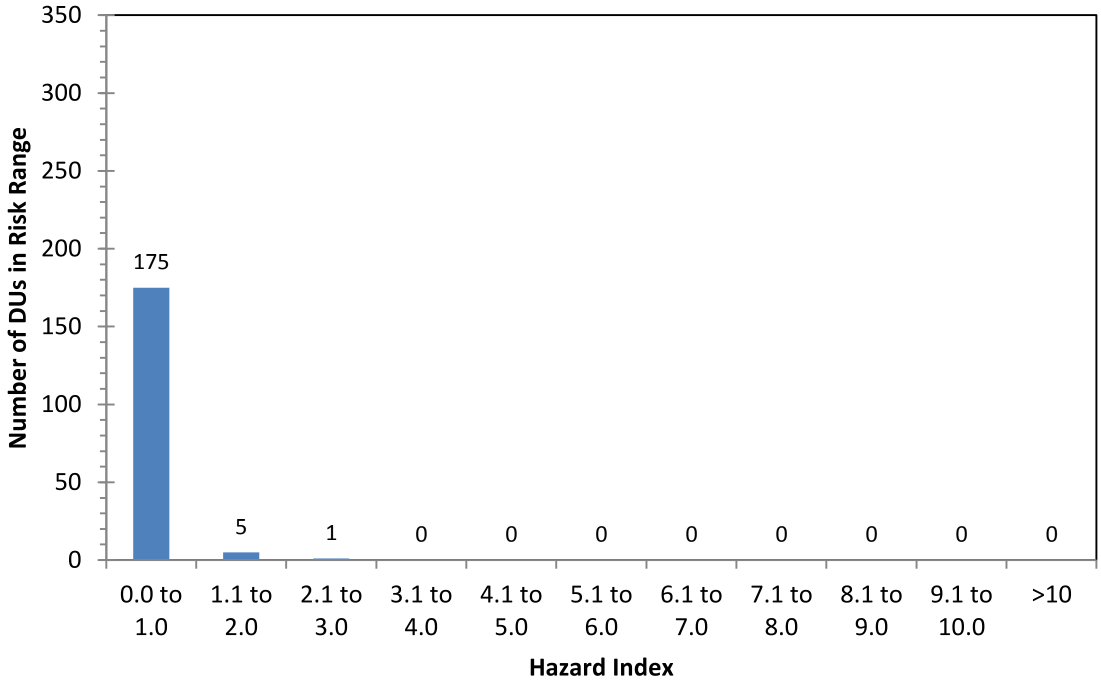


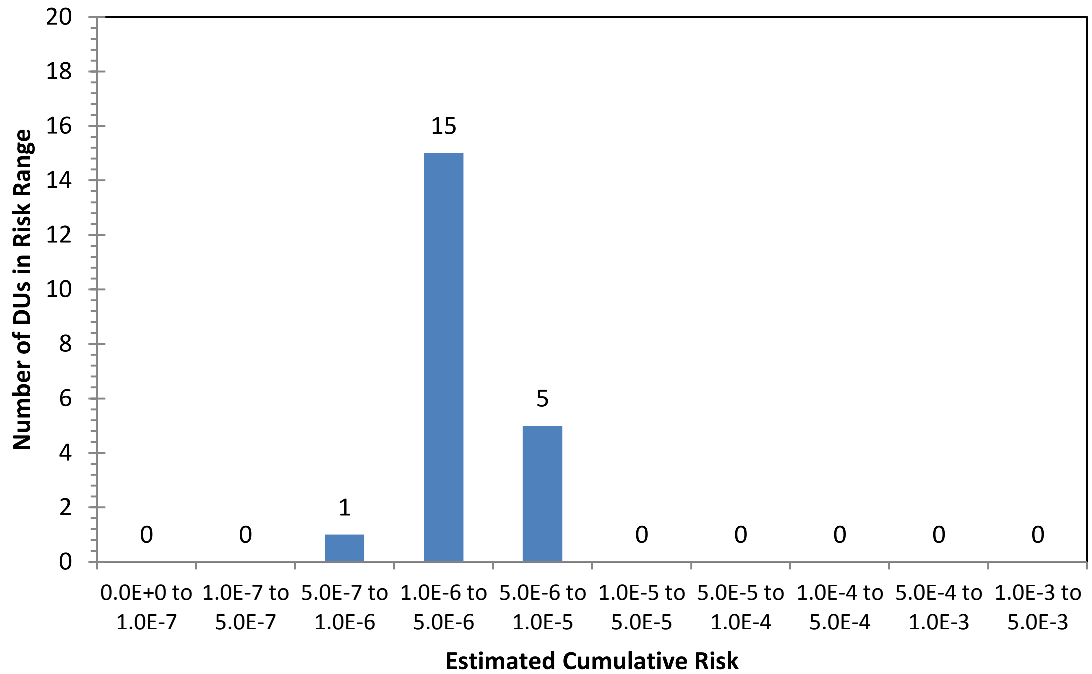
Figure 11-24. Earhart I-3: Distribution of Post-Removal Hazard Indices for DUs (0 to 12 inches) - 2012 EALs



11.9.3 Onizuka II-1 Neighborhood

As described in Section 11.8.3, no DUs within the Onizuka-II-1 neighborhood are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria based on the soil sampling results collected within the 0-12 inch depth interval and the 2012 site-specific EALs (see Figure 11-25). Similarly, there are no DUs with estimated HIs for the child resident that exceed the target level of 1.

Figure 11-25. Onizuka II-1: Distribution of Post-Removal Cumulative Risks for DUs (0 to 12 inches) - 2012 EALs



11.9.4 Hale Na Koa I-1 Neighborhood

As described in Section 11.8.4, no DUs within the Hale Na Koa I-1 neighborhood are associated with estimated risks for the residential child exceeding the HDOH cumulative risk criteria based on the soil sampling results collected within the 0- to 12-inch depth interval and the site-specific 2012 EHE Standard. Similarly, there are no DUs with estimated HIs for the child resident that exceed the target level of 1.Potential Future Exposures to PI Soil Remaining at the Site

In addition to potential exposures to PI soil remaining with the Site DUs, other reasonably anticipated future exposure scenarios to PI soil remaining at the Site include potential worker and residential exposures to:

1) PI soil that has been or will be placed into long-term management units (e.g., burial pits and soil berms);
2) PI soil that was placed into utility trenches as backfill;
3) Soil currently beneath buildings and hardscapes; and
4) Any other soil at the Site that is presumed to be pesticide-impacted, such as soil deeper than 12 inches bgs located beneath former building footprints.

Landscape/maintenance workers and construction workers could potentially contact PI soil remaining at the Site in areas described above because they may perform intrusive soil activities as part of their jobs. Similarly, if PI soil remaining at the Site is brought to the surface in the future, residents could potentially be exposed. For this reason, institutional controls should be implemented to ensure Occupational Safety and Health Administration safe work practices are followed by landscape/maintenance workers and construction workers in areas of the Site associated with remaining PI soil. Soil management practices should also be implemented to ensure that PI soil is not moved to, and left at the surface, where residents could potentially be exposed.

12.0 CONCLUSIONS AND RECOMMENDATIONS

12.1 Chemicals of Concern

The primary chemicals of concern identified at the Site are organochlorine pesticides, including technical chlordane, aldrin, dieldrin, DDD, DDE, and DDT.

Other organochlorine pesticides, such as endosulfan II, endrin, endrin ketone, and methoxychlor, have been detected sporadically at concentrations close to their detection limits. These compounds do not contribute significantly to the cumulative risk from organochlorine pesticides at the Study Area.

12.2 Distribution of Chemicals of Concern

Soil investigations conducted from 2004 to 2006, prior to new housing construction in the Earhart Village area, indicate that aldrin and dieldrin were present in soil within the driplines of buildings, and beneath the slab foundations of existing buildings. No records of pesticide applications have been identified, but based on these results it is likely that technical aldrin, or possibly a combination of aldrin and dieldrin, were applied to building foundations for termite control. Technical aldrin contains a small percentage of chlordane, and some dieldrin. Dieldrin is also a degradation product of aldrin. Dieldrin has been observed in varying proportions to aldrin in soil samples from the Earhart Village area.

Technical chlordane, which is a mixture of many compounds, including mainly alpha- and gamma-chlordane, heptachlor and its metabolite heptachlor epoxide, was the primary pesticide detected beneath slab foundations in the Onizuka Village housing area prior to new housing construction.

DDT in commercial products used for pesticide applications was also a mixture of compounds, the principal one being 4,4’-DDT, with smaller amounts of 4,4’-DDD and 4,4’-DDE and other constituents. DDD and DDE are also degradation products of 4,4’-DDT, and therefore may be present as a result of the breakdown of the original DDT over time.

Based on the pre-demolition sampling conducted throughout the project area, pesticide concentrations above the HDOH Tier 1 EALs in the Earhart Village and Onizuka Village areas were almost entirely limited to sub-foundation soil treated by termiticides prior to the mid-1980s.

Sub-foundation samples from buildings along the southern margin of Earhart Village (south of Ohana Nui Circle) contained low concentrations of pesticides, suggesting less intensive applications of organochlorine termiticides in this area.

Soil samples from open areas prior to new housing construction generally did not contain organochlorine termiticides at concentrations above the HDOH Tier 1 or the 2006 HHRA EALs. Prior to new housing construction, organochlorine termiticides were primarily limited to sub-slab soil.

DDD, DDE, and DDT have been detected in soil from the Earhart neighborhoods, but their distribution differs from the distribution of aldrin and dieldrin, (and of chlordane), suggesting that DDT was applied independently of aldrin and dieldrin and chlordane.

12.3 Discovery of Pesticide Concentrations Above the 2006 HHRA EALs

In 2006, risk-based EALs were established for the project area based on certain assumptions about the toxicity of the chemicals of concern, and the amount of exposure of residents to the chemicals. A cumulative upper limit of excess cancer risk of 1 x 10^{-5} was established as the action level for the Study Area, and a hazard index of 1 was similarly established as the upper limit of acceptable non-cancer risk.[114] This 2006 HHRA standard was based on the assumption that the land would continue to be used for housing of military personnel and their families, which was the basis for assuming a less than lifetime exposure duration.

A Management Plan for Pesticide Impacted Soil (MPPIS) was developed to guide management of PI soil during construction of new housing.[115] Since the new buildings would be constructed on new slab foundations not necessarily overlapping the former foundations, and the building sites would be regraded during construction, the plan called for excavating PI soil from within the footprints of the former buildings, after demolition of the slabs, to a depth at least one foot below the final grade. The excavated soil would be segregated in stockpiles pending re-use at the Program Area, and clean soil would be used to bring the excavations up to final grade. The excavated PI soil was to be placed under new hardscapes such as roads and building foundations. Some of the soil was also used as backfill for utility trenches.

Shortly before completion of construction of new buildings in the Earhart I-4 neighborhood, in August, 2009, it was discovered that concentrations of pesticides greater than the risk-based thresholds established for the Study Area were present in surface soil in open areas. As a result of this discovery, the upper one foot of soil from open areas throughout the Earhart I-4 neighborhood was excavated and replaced with clean soil imported from a borrow area in the Onizuka II-3 neighborhood, which was just beginning construction. This action was performed prior to completion of construction and landscaping in the Earhart I-4 neighborhood, and therefore before the buildings were occupied by residents.

Subsequent preliminary verification sampling of the Earhart I-2, Earhart I-3, and Onizuka II-1 neighborhoods in June 2010 indicated concentrations of mainly aldrin and dieldrin in the Earhart I-2 and Earhart I-3 neighborhoods that were elevated relative to the 2006 HHRA EALs. Samples from the Onizuka II-1 neighborhood indicated concentrations of pesticides slightly above the 2006 HHRA EALs in some portions of the neighborhood. Although HDOH commented that some of the DUs significantly exceeded the one-half acre size generally considered appropriate for defining residential exposure areas, the results of the additional verification sampling conducted in the Hale Na Koa I-1 neighborhood indicated acceptable levels of pesticides, especially when compared against the 2012 EHE Standard that replaced the 2006 HHRA standard.

Based on the preliminary sampling results, a detailed Remedial Investigation of the three neighborhoods (the Site) was conducted in from August to October 2010, under work plans approved by HDOH. The investigation involved dividing the Earhart I-2 and Earhart I-3

[114] (Tetra Tech 2006c)
[115] (Tetra Tech 2006e)

neighborhoods into DUs representing exposure areas corresponding to backyards, front yards, play areas, and common areas of approximately 5,500 square feet or less. The Earhart I-2 neighborhood was divided into 324 DUs. The Earhart I-3 neighborhood was divided into 181 DUs, and the eastern portion of the Onizuka II-1 neighborhood was divided into 21 DUs. Each DU was sampled by collecting depth-stratified multi-increment samples consisting of 50 incremental samples from the 0 to 6-inch and 6 to 12-inch depth intervals within each DU. Triplicate samples were collected at a rate of one set of triplicate samples per 20 DUs.

The results of this sampling were immediately reported to HDOH, and cumulative risks were calculated to compare against the 2006 HHRA standard. Concentrations of pesticides above the 2006 HHRA standard were observed in many parts of the Earhart I-2 and Earhart I-3 neighborhoods and in some of the DUs in the eastern portion of the Onizuka II-1 neighborhood.

The distribution of pesticides in the 0 to 6-inch and 6 to 12-inch depth intervals sampled generally showed a high degree of correlation, as expected where the upper one foot of soil became contaminated by spreading of disturbed soil. Elevated concentrations also appear correlated with the former building footprints.

12.4 Removal Actions

Due to concern for protecting residents from exposure to PI soil at the ground surface, HDOH and Hickam Communities developed plans to conduct removal actions to reduce risks to residents in areas containing the highest concentrations of pesticides. RO#1, which was conducted in October through December 2010, resulted in replacement of the upper one foot of soil in five DUs in which the HI, based on the 2006 HHRA EALs, was greater than 10. Three additional DUs adjacent to these were also excavated and replacement soil was imported to cover these DUs. RO#1 also included visual inspection of grass cover in all DUs with concentrations corresponding to an HI greater than 3. One DU, which was identified as having poor grass cover, with bare soil areas totaling more than 200 square feet, was also excavated to a depth of one foot and replaced with clean soil. As a result of RO#1, risk from exposure to surface soil in the Earhart neighborhoods was significantly reduced.

Following RO#1, additional evaluation of the risks from exposure to the pesticides of concern at the Study Area was undertaken, and an interim set of risk-based goals was developed. RO#2 was conducted to further reduce residential exposure to pesticides where the cumulative non-cancer risk exceeded a hazard index of 1. As part of RO#2, which was conducted from January through April 2011, soil in landscaping strips was replaced in DUs where the combined concentrations of pesticides exceeded an H.I. of 1.

In July and August of 2011 RO#3 was conducted to excavate and replace the upper 6-inches of soil in DUs where the HI was greater than 1 based on the results of the 2011 Preliminary HHRE. Soil in the upper six inches of ten DUs in the Earhart I-2 neighborhood, and four DUs in the Earhart I-3 neighborhood, was excavated and replaced in RO#3.

12.5 Remaining PI Soil

Following completion of RO#3, all soil in open areas of the Study Area within the upper six inches meets the 2012 EHE Standard, with the exception of soil in DU-33a in Earhart I-3, which slightly exceeds an HI of 1.

Eight DUs in Earhart I-2 (11b, 15b, 23a, 27d, 37a, and 42b), and two DUs in Earhart I-3 (12b and 20a) contain PI soil in the 9- to 12-inch depth following implementation of RO #3. Geotextile fabric was placed over the PI soil in these DUs before placing clean soil to grade.

Nine additional DUs in Earhart I-2 (15c, 19b, 23d, 27c, 28d, 30e, 30f, 35b, and 42a), and four additional DUs in Earhart I-3 (4b, 12d, 14b, and 33b) contain PI soil at depths between 6 and 12 inches based on comparison of sampling results to the 2012 EHE Standard. This soil does not present an immediate risk to residents, but because the PI soil is within one foot of the ground surface and is not marked by geotextile fabric, the permanent remedy for the soil in these DUs will be further evaluated. Alternatives for addressing these residual concentrations of pesticides in the 6 to 12-inch depth range will be presented in the Remedial Action Alternatives (RAA) Report.

PI soil present at depths below one foot elsewhere within the Hale Na Koa, Earhart I-2, Earhart I-3, Earhart I-4, Onizuka II-1, and Onizuka II-3 neighborhoods includes:

- Soil within the footprints of former buildings;
- PI soil that was used to backfill new utility trenches during construction (Earhart I-2 and Earhart I-3);
- PI soil that may be present below the depth of one foot investigated by confirmation sampling in October 2010 at Earhart I-2, Earhart I-3, or Onizuka II-1;
- PI soil that is below the depth of one foot addressed by the soil replacement action at Earhart I-4;
- PI soil that is below the depth of one foot investigated at Hale Na Koa;
- Soil that is below a depth of one foot in the former footprints of the slab foundations of lanais that were removed as part of renovation of the Historic District;
- PI soil that has been managed in burial pits at Onizuka II-3, and
- PI soil generated from RO #3 that is managed in a soil berm constructed along the northeast perimeter of Earhart I-2.

The location of all known or presumed PI soil in the HC Project Area is documented and tracked in the LUCID.[116] All remaining PI soil documented in the LUCID will be managed in accordance with procedures in the EHMP,[117] and the Pesticide-Impacted Soil Investigation and Management Program Manual[118].

[116] Tetra Tech 2012b)
[117] (Tetra Tech 2012a)
[118] (Tetra Tech 2011g)

13.0 REFERENCES

ATSDR, 1994, Toxicological Profile for Chlordane (May 1994): Agency for Toxic Substances and Disease Registry, http://www.atsdr.cdc.gov/toxprofiles/tp31.html

Dames and Moore. 1986. Installation Restoration Program Phase II: Confirmation/Quantification Stage 1, Final Report for Period January 1985 to September 1985. Prepared for Headquarters Pacific Air Force, Hickam Air Force Base, Hawaiʻi, and US Air Force Technical Services Division, Brooks Air Force Base, Texas.

ETC (EnviroServices & Training Center LLC). 2010. Limited Hazardous Waste Sampling Activities, Hickam Community Housing, Ohana Nui Circle, Honolulu, Oʻahu, Hawaiʻi. TMK(1) 1-1-2 - Parcel 4 (portion). Prepared for State of Hawaiʻi, Department of Health. HEER Doc Number 92620. August.

HC (Hickam Communities LLC). 2010. *Hickam Communities Resident Guide and Community Standards Handbook, Attachment A to Tenant Lease. Effective as of 1 January 2010*. Prepared by Hickam Communities LLC. 2010.

______. 2011a. *Voluntary Agreement for Environmental Response Actions*. Agreement between Hickam Communities LLC and Hawaiʻi Department Health. 2011.

______. 2011b. *RE: Draft Removal Action Report Comment Response.* Email correspondence from Jeffrey Seibert, Hickam Communities LLC Development Manager, and Yvonne Parry, Tetra Tech Project Manager. November 9, 2011.

HDOH (Hawaiʻi Department of Health). 2008. *Screening for Environmental Hazards at Sites with Contaminated Soil and Groundwater.* Summer (updated March 2009).

______. 2009. *Interim Final Technical Guidance Manual for Implementation of the Hawaiʻi State Contingency Plan.* Prepared by: Hawaiʻi Department of Health Environmental Management Division. June 21, 2009.

______. 2010a. *Subject: Comments on the HC-HI/Soil Management Plan/Final Draft.* Email transmission, from Fenix Grange (HDOH) to Roger Franklin (Lend Lease), Gerry Schmitz (Lend Lease), et. al. September 24, 2010.

______. 2010b. *Hickam Communities Removal Action #2, Air Force MFH HAFB Earhart Phase I-2 and Phase I-3, 2010-682-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). November 5, 2010.

______. 2010c. *Review of draft Removal Action Work Plan No. 2 (29 Nov 2010) Air Force MFH HAFB Earhart Phase I-2 and Phase I-3, 2010-720-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). December 1, 2010.

______. 2010d. *Review of draft Removal Action Work Plan No. 2 (10 Dec 2010) Air Force MFH HAFB Earhart Phase I-2 and Phase I-3, 2010-754-ES*. Letter to Roger Franklin, (Lend Lease) from Eric Sadoyama (HDOH). December 21, 2010.

______. 2011a. Screening for Environmental Hazards at Site with Contaminated Soil and Groundwater, Fall 2011 Updates. Memorandum to Interested Parties, from Roger Brewer, Ph.D., Environmental Risk Assessor, HEER, December, 2011. Available online at: http://hawaii.gov/health/environmental/hazard/docs/ealcoverletterfall2011.pdf

______. 2011b. Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater, Appendix 1 Tables, Fall 2011, [revised January 2012 to correct TPH toxicity factors & action levels]. Available online at: http://hawaii.gov/health/environmental/hazard/eal2005.html

______. 2011c. Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater Volume 1: User's Guide, Hawaiʻi Edition, Fall 2011, [revised January 2012 to correct TPH toxicity factors & action levels; see Appendix 1]. Available online at: http://hawaii.gov/health/environmental/hazard/docs/ealvolume1fall2011.pdf

______. 2011d. Review of *Draft Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam. 2011-303-ES*. Letter from Eric Sadoyama HDOH to Roger Franklin, Actus Lend Lease LLC. June 7, 2011.

______. 2012. *Review of Revised Draft, Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam*. 2012-137-ES. Letter from Eric Sadoyama HDOH to Roger Franklin, Lend Lease LLC. February 27, 2012.

HAFB (Hickam Air Force Base). 2006, Final Environmental Impact Statement, Housing Privatization Phase II, Hickam Air Force Base and Bellows Air Force Station, Oʻahu, Hawaiʻi. December 2006.

______. 2007 Management Action Plan (MAP) Hickam Air Force Base, Environmental Restoration Program, Hickam AFB, Oʻahu, Hawaiʻi. Prepared by 15CES/CEVR, Hickam AFB, Hawaiʻi. May 2007.

KJC (Kennedy, Jenks, Chilton Consulting Engineers). 1991. *Final Pre-Construction Survey (PCS) of Hickam Family Housing Project Site, 90 Dwelling Units, FY 90-92. Onizuka Village, Hickam AFB, Oʻahu, Hawaiʻi*. July, 1991.

Mink, J.F., and Lau, L.S. 1990. Aquifer identification and classification for Oʻahu – ground-water protection strategy for Hawaiʻi. University of Hawaiʻi. Water Resources Research Center Technical Memorandum Report no. 179.

Nichols, W. D., P. J. Shade, and C. D. Hunt, Jr. 1996. Summary of the Oʻahu, Hawaiʻi, Regional Aquifer-System Analysis. US Geological Survey Professional Paper 1412-A.

Tetra Tech. 2004a. *Phase I Environmental Site Assessment, Capehart and Earhart Village Housing Areas, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for GMAC Commercial Mortgage on behalf of Actus Lend Lease LLC. March 19, 2004.

______. 2004b. *Phase II Environmental Site Assessment Capehart and Earhart Village Housing Areas, Hickam Air Force Base Oʻahu, Hawaiʻi*. Prepared for GMAC Commercial Mortgage on behalf of Actus Lend Lease LLC. March 19, 2004.

______. 2005. *Phase I Environmental Site Assessment, Capehart and Earhart Village Housing Areas, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for GMAC Commercial Mortgage on behalf of Actus Lend Lease LLC. January 26, 2005.

______. 2006a. *Letter Report from S. Toma to J. Apitz. Subject: Capehart and Earhart Village Housing Areas Site Characterization, Hickam Air Force Base, Oʻahu, Hawaiʻi, Soil Sampling for Chlordane, Dieldrin, and Aldrin*. June 5, 2006.

______. 2006b. *Letter Report from S. Toma to K. Chuck. Subject: Hickam Community Housing Earhart Village 1-Acre Sampling Protocol,* September 1, 2006.

______. 2006c. *Summary of Human Health Risk Assessment of Chlordane (including Heptachlor and Heptachlor Epoxide), Dieldrin, and Aldrin in Soil, Hickam Community Housing Areas, Hickam Air Force Base, Hawaiʻi*. Prepared for Hickam Community Housing LLC. June 30, 2006.

______. 2006d. *Hickam Community Housing Earhart Village 1-Acre Sampling Protocol Memorandum to Kelly Chuck*. Hickam Community Housing LLCSeptember 1, 2006.

______. 2006e. *Management Plan for Pesticide-Impacted Soils, Hickam Community Housing, Hickam Air Force Base, Oʻahu, Hawaiʻi. Rev*. Prepared for Hickam Community Housing LLC. October 16, 2006.

______. 2007a. *Phase I Environmental Site Assessment, Hickam Phase II Military Family Housing (MFH), Hickam Air Force Base, Honolulu, Hawaiʻi*. Prepared for Actus Lend Lease, LLC. July 2007.

______. 2007b. *Final Report, Phase II Environmental Assessment Surface and Subsurface Soil Investigation Report Hickam AFB and Bellows AFS Oʻahu, Hawaiʻi*. Prepared for Actus Lend Lease, LLC. July 18, 2007.

______. 2007c. *Hickam Community Housing Soil Samples Data Summary as of April 17, 2007, Data Table.*. April 17, 2007.

______. 2008. *Letter Report on Results of Soil Sampling of Eight Buildings at Onizuka Village, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Communities LLC. August 22, 2008.

______. 2009a. *Pesticide-Impacted Soils Investigation and Management Program Manual. DCN: 392501.0001.F01.* Prepared for Hickam Community Housing LLC. May 2009.

______. 2009b. *TO#24, Leachability of Aldrin, Dieldrin, and Chlordane from Soils Literature Review, Hickam Air Force Base, Oʻahu, Hawaiʻi.* Prepared for Hickam Community Housing LLC. December 1, 2009.

______. 2009c. *TO#18, Letter Report on Results of Additional Open Area Verification Sampling at the Earhart 1-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi.* Prepared for Hickam Community Housing LLC. December 11, 2009.

______. 2009d. *TO#18, Letter Report on Results of Open Area Verification Sampling (September/October 2009) at the Earhart 1-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. December 31, 2009.

______. 2010a. *TO#36 Summary of Findings Report for Post Remediation Confirmation Sampling at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. April 14, 2010.

______. 2010b. *TO#36 Summary of Findings Report for Post Remediation Confirmation Sampling of Area B at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 3, 2010.

______. 2010c. *TO#48 Summary of Findings Report for Surface Soil Investigation at the Onizuka II-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 17, 2010.

______. 2010d. *TO#36 – Summary of Findings Report for Post-Remediation, Confirmation Soil Sampling of Decision Unit C at the Earhart I-4, Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 22, 2010.

______. 2010e. *TO#50 Summary of Findings Report for Surface Soil Investigation at the Earhart I-2 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. June 24, 2010.

______. 2010f. *TO#51 Summary of Findings Report for Surface Soil Investigation at the Earhart I-3 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. July 2, 2010.

______. 2010g. *TO#55 Memorandum: HDOH Sampling Oversight and Split Sample Collection at Earhart I-2, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. July 6, 2010.

______. 2010h. *TO#36 – Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit D at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. August 5, 2010.

______. 2010i. *TO#56, Sampling and Analysis Plan, Earhart I-2 and Earhart I-3 Neighborhoods, Hickam Air Force Base, Oʻahu, Hawaiʻi*. DCN: 2616902.0001.F01. Prepared for Hickam Communities, LLC. August 6, 2010.

______. 2010j. *TO#56, Sampling and Analysis Plan, Onizuka II-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi.* DCN: 2616902.0002.F01. Prepared for Hickam Communities, LLC. August 6, 2010.

______. 2010k. *TO#36 – Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit E at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. August 19, 2010.

______. 2010L. *TO#36 – Revised Summary of Findings Report for Post-Remediation Confirmation Soil Sampling of Decision Unit Da at the Earhart I-4 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing, LLC. September 30, 2010.

______. 2010m. *TO#56, Draft Removal Action Work Plan No. 1, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. *DCN: 2653504.001.D05.* October 11, 2010.

______. 2010n. *TO#56, Revised Analysis of Potential Removal Alternatives, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Oʻahu Hawaiʻi*. Prepared for Hickam Communities, LLC. DCN 2653504.006.F01. November 24, 2010.

______. 2010p. *Sampling And Analysis Plan, Verification Soil Sampling, Hale Na Koa I-1, Earhart I-2, Earhart I-3, and Onizuka II-Neighborhoods, Hickam Air Force Base, Oʻahu, Hawaiʻi*. Prepared for Hickam Community Housing LLC. March 24, 2010.

______. 2010q. TO#49 Summary of Findings Report for Confirmation Soil Sampling at the Hale Na Koa I-1 Neighborhood, Hickam Air Force Base, Oʻahu, Hawaiʻi. June 28, 2010.

______. 2011a. TO#56, Technical Memorandum for the Actions Implemented under Removal Action No. 1, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl *Harbor-Hickam, Oʻahu, Hawaiʻi*. Prepared for Hickam Communities, LLC. DCN: 2653504.003.F01. February 16, 2011.

______. 2011b. *TO#56, Removal Action No. 2 Work Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. DCN: 2653504.002.D05. March 1, 2011.

______. 2011c. *TO#56, Draft Removal Action Report, Actions Implemented Under Removal Actions No. 1 and No. 2, Earhart I-2, Earhart I-3, and Onizuka II 1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Oʻahu, Hawaiʻi. DCN: 2653504.004.D01.* April 2011.

______. 2011d. *TO#56, Draft Residential Involvement Plan for Pesticide-Impacted Soil, Hickam Communities Neighborhood, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. DCN: 2653504.018.D04. April 30, 2011.

______. 2011e. *TO#56, Preliminary Human Health Risk Evaluation Work Plan for Hickam Communities, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. DCN: 2653504.021.D01. May 13, 2011.

______. 2011f. *TO#56, Removal Action No. 3 Work Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawaiʻi*. Prepared for Hickam Communities LLC. DCN: 2653504.020.F01. June 14, 2011.

______. 2011g. *TO#68, Pesticide-Impacted Soil Investigation and Management Program Manual. DCN: 2770101.0001.F03.* Prepared for Hickam Communities LLC. August 31, 2011.

______. 2011h. *Removal Action Report, Actions Implemented Under Removal Actions No. 1, No. 2, and No. 3, Earhart I-2 Neighborhood, Joint Base Pearl Harbor-Hickam, Hawai'i. DCN: 2653504.004.D04*. Prepared for Hickam Communities LLC. September 13, 2011.

______. 2012a. *Environmental Hazard Management Plan, Earhart I-2, Earhart I-3, and Onizuka II-1 Neighborhoods, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2883401.0001.F03*. Prepared for Hickam Communities LLC. June 7, 2012.

______. 2012b. *Land Use Controls Inventory Document, Hickam Communities Property, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DCN: 2884201.0001.F03*. Prepared for Hickam Communities LLC. June 7, 2012.

______. 2012c. *Removal Action Report, Actions Implemented Under Removal Actions No. 1, No. 2, and No. 3, Earhart I-2 and Earhart I-3 Neighborhoods, Joint Base Pearl Harbor-Hickam, Hawai'i. DCN: 2653504.004.F05*. Prepared for Hickam Communities LLC. June 7, 2012.

USAF (US Air Force). 1946. General layout map of Hickam Airfield, Air Corps Construction Utilities Division, Air Depot APO 953. August 30, 1946.

______. 1991. Final Hickam AFB Federal Facility Preliminary Assessment/Site Inspection Review, Hickam Air Force Base, O'ahu, Hawai'i. September 26, 1991.

______. 1998. *Final Base Hydrogeology and Regional Mapping Report. Underground Fuel Storage and Distribution System Site Verification and Remediation Program*. Prepared for 15th Air Base Wing CES/CEVR, Hickam AFB, by Air Force Center for Environmental Excellence, Environmental Services Office. May 1998.

______. 2000. *Environmental Baseline Survey, Capehart Housing and Earhart Village Military Family Housing Areas, Hickam Air Force Base, Hawai'i*. Headquarters Air Force Center for Environmental Excellence, Environmental Planning Division. June 2000.

______. 2002. *Supplemental Environmental Baseline Survey, Capehart, Earhart Village, and Original 36 Military Family Housing Areas, Hickam Air Force Base, Hawai'i.* Headquarters Air Force Center for Environmental Excellence, Environmental Planning Division. October 2002.

______. 2003. *Addendum to Supplemental Environmental Baseline Survey.* 15th Civil Engineer Squadron, Environmental Flight. November 7 2003.

USACE (US Army Corps of Engineers). 1997. *Final Environmental Assessment and Finding of No Significant Impact. Temporary Lodging Facility. Hickam Air Force Base. Honolulu, O'ahu, Hawai'i.* Prepared for Department of the Air Force, Pacific Air Forces, Hickam AFB. Prepared by US Army Corps of Engineers, Pacific Ocean Division. August 1997.

US Environmental Protection Agency (EPA). 2003. *Health Effects Support Document for Aldrin/Dieldrin* . EPA 822-R-03-001. February 2003. Available online at: http://water.epa.gov/action/advisories/drinking/upload/2004_1_16_support_cc1_aldrin-dieldrin_healtheffects.pdf.

Waller (J.M. Waller Associates). 2005. *Environmental Baseline Survey for the Military Family Housing Privatization Phase II Hickam AFB* . Prepared for United States Air Force 15th Airlift Wing, Hickam AFB, Hawaiʻi. November 2005.

This page intentionally left blank

APPENDIX A

Previous Investigation Data

APPENDIX B

Earhart I-2 DU-63a Summary of Findings Reports

B1: Tetra Tech Summary of Findings Report

B2: EnviroServices and Training Center Summary of Findings Report

APPENDIX C

Laboratory Reports

APPENDIX D

Quality Control (Data Validation Reports) and Corrections

APPENDIX E

Environmental Health Evaluation Report

APPENDIX F

Data Summary Tables

TETRA TECH