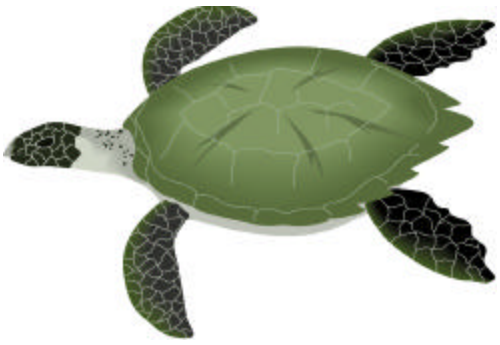
United States Air Force
15th Air Base Wing
Environmental Restoration Program

ENGINEERING EVALUATION/COST ANALYSIS (EE/CA) REPORT FOR SITE LF01

Operable Unit 1,
Bellows Air Force Station, Oahu, Hawaii



June 18, 2001

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Operable Unit 1,
Bellows Air Force Station, Oahu, Hawaii

Prepared for: Air Force Center for Environmental Excellence
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June 18, 2001

Executive Summary

Introduction

This Engineering Evaluation / Cost Analysis (EE / CA) Report has been prepared to support a removal action at Site LF01 at Bellows Air Force Station (AFS), Oahu, Hawaii. These efforts are part of the EE / CA for Operable Unit 1 (OU1) at Bellows AFS, which is being conducted in support of Installation Restoration Program (IRP) activities administered by the 15th Air Base Wing (15 ABW) Civil Engineer Squadron / Environmental Restoration Element (CES / CEVR) located at Hickam Air Force Base (AFB), Oahu, Hawaii. The work is being performed through the Air Force Center for Environmental Excellence (AFCEE) under delivery order F41624-97-D-8019-0005.

The EE / CA has been conducted in accordance with the U.S. Environmental Protection Agency's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (U.S. EPA, 1993). The *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) subpart (E), "Hazardous Substance Response," and the Hawaii Department of Health's *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (HDOH, 1996) were also consulted for guidance.

The next step in the decisionmaking process for Site LF01 will be the preparation of an Action Memorandum, which will describe the removal action selected for the site. The schedule for the removal action will depend on the timely regulatory approval of the Action Memorandum for Site LF01 and the availability of Air Force funding. Following implementation of the removal action and documentation that Site LF01 does not pose unacceptable risks to human health and the environment, No Further Response Action Planned (NFRAP) Category IV documentation will be prepared to recommend site closure.

Project Background

Site LF01 is a former landfill in the west-central portion of Bellows AFS, west of abandoned Runway 36 (Figure ES-1). A portion of Site DP17, immediately to the south of Site LF01, has also been included as part of Site LF01. The site is approximately 700 feet northwest of Waimanalo Stream and 3,300 feet west of Waimanalo Bay.

Site LF01 is located within a former coral borrow area excavated during World War II to provide coral fill for the expansion of Bellows AFS. Various sources (i.e., historical documents and drawings, environmental reports, and former Bellows AFS personnel) indicate that landfilling may have occurred at Site LF01 from World War II through the 1970s. An IRP Phase I Records Search (Engineering-Science [ES], 1984) reported that waste disposal at the "installation landfill" may have included hazardous materials such as oil,

paint thinner, and acid from military shop operations between 1943 and 1946; however, no documented evidence of such disposal at Site LF01 was presented in the ES report. The area encompassing Site LF01 was extensively quarried for coral fill during World War II, making simultaneous refuse and quarry operations at the site unlikely (CH2M HILL, 1998).

Aircraft operations and related activities at Bellows AFS ended in the 1950s, and since then the installation has been primarily used for military training exercises and recreation. It is expected that the installation (including Site LF01) will continue to be used for training exercises and recreation in the foreseeable future.

In 1999, more than 1,000 of the approximately 1,600 acres at Bellows AFS were transferred to the U.S. Marine Corps. Site LF01 is located within the Marine Corps Training Area Bellows and is generally inaccessible to the public. A variety of terrestrial avian and mammalian wildlife species use the site habitats (second-growth forests and shrublands) for foraging, nesting, and cover.

Site LF01 was one of four sites included in the EE/CA for OU1 at Bellows AFS; the other three sites (DP06, DP17, and SD22) have since been closed under the designation of NFRAP Category III. For Site LF01, a field investigation was conducted, soil and groundwater samples were collected and analyzed, and a screening-level risk evaluation was performed based on the findings of those activities and previous investigations. The results are documented in the Informal Technical Information Report (ITIR) for Site LF01 (CH2M HILL, June 15, 2001).

Based on the screening-level risk evaluation, lead in surface soil was identified as a chemical of concern (COC) posing potential risks to current and future occupational receptors (i.e., personnel involved in military training exercises) at Site LF01. Three metals in surface soil (lead, mercury, and zinc) were also identified as COCs posing potential risks to current and future ecological receptors. In the absence of other factors, the risks estimated for both human and ecological receptors at Site LF01 are marginal and would not warrant further action. However, Site LF01 in its current condition presents potential risks to occupational receptors in the form of physical hazards including broken glass, metal, and other debris at the surface, and potentially dangerous materials (e.g., pressurized canisters) in the landfill materials. Therefore, the marginal human and ecological risks potentially posed by metals in surface soil, combined with the physical hazards present at the site, are sufficient cause for further action.

Removal Action Objectives and Scope

The removal action under consideration in this report has the following objectives (RAOs):

- Mitigate current and future potential for human and ecological exposure to elevated levels of metals in surface soil through cost-effective measures.

- Mitigate current and future potential for site worker exposure to physical hazards in surface soil and in landfill materials (e.g., broken glass, metal debris, pressurized canisters) through cost-effective measures.
- Minimize impacts to current site operation and surrounding land uses during implementation of the removal action.
- Plan for "reasonably anticipated future land uses" in the removal action strategy. Reasonably anticipated future land uses include current Air Force categories (military training and outdoor recreation).

The scope of this removal action is to implement measures designed to mitigate potential threats to human health and the environment posed by chemical and physical hazards identified in surface and landfill materials. The identified RAOs are evaluated with respect to the overall IRP cleanup objectives, which are to provide permanent and cost-effective remedies for contaminated environmental media and to permanently and significantly reduce the toxicity, mobility, and/or volume of hazardous waste, thereby reducing potential risks to human health and the environment.

Preliminary Screening of Potential Technologies

A wide range of potential response actions were initially considered for Site LF01, and a preliminary screening of those response actions and associated technologies was performed to determine which of these would be viable at the site. U.S. EPA's *Treatment Technologies Screening Matrix* (1999), a technology application matrix for various types of media requiring treatment, was used as the primary source for identifying and screening potential response actions and associated technologies. The technologies were screened for their suitability and potential applicability at Site LF01.

Site- and waste-specific characteristics at Site LF01 were also considered in the screening, along with current and reasonably anticipated future land uses associated with the site. Evaluation of the preliminary response actions and selection of the retained potential technologies were based on available information about the site and professional judgment.

Identification and Evaluation of Alternatives

Based on current site conditions, the RAOs for the site, the preliminary screening of potential technologies, and current Air Force and HDOH policy, three removal action alternatives were identified for Site LF01:

1. No Action (Alternative 1)
2. Soil/Landfill Materials Excavation and Disposal/Recycling (Alternative 2)
3. Soil/Vegetative Cover with Long-Term Monitoring of Groundwater (Alternative 3)

In accordance with U.S. EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993), all the alternatives were evaluated in terms of three criteria: effectiveness, implementability, and cost. The alternatives are summarized below.

Alternative 1: No Action. Under this alternative, required under the NCP for inclusion in the analysis of alternatives, contaminated soil and landfill materials at Site LF01 would be left in place and no action would be taken. This alternative has no associated costs.

Alternative 2: Soil/Landfill Materials Excavation and Disposal/Recycling. Under Alternative 2, the surface soil and landfill materials constituting the chemical/physical hazards at Site LF01 would be excavated and transported offsite. It is assumed that approximately 8,500 cubic yards (12,800 tons) of soil and landfill materials would be removed. For cost estimating purposes, it is assumed that up to 40 percent of the landfill materials (concrete and metal debris) may be recyclable; that up to 40 percent of the materials may be disposed of at an off-island hazardous waste landfill; and that the remaining 20 percent of the materials would be disposed of at an on-island solid waste landfill. The assumption that up to 40 percent of the landfill materials may need to be disposed of as hazardous waste is based on worst-case estimates of samples that may exceed toxicity characteristic leaching procedure (TCLP) criteria. Following excavation, confirmatory soil samples would be collected and analyzed to verify that the removal action had been successfully implemented. Site restoration would then be performed, including the placement and grading of 2 feet of clean soil (approximately 4,300 cubic yards) and 6 inches of top soil (approximately 900 cubic yards), and the planting of drought-resistant vegetation. The estimated cost of implementing Alternative 2 is $5,171,100.

Alternative 3: Soil/Vegetative Cover with Long-Term Monitoring (LTM) of Groundwater. Under Alternative 3, Site LF01 would first be cleared of its existing vegetative cover. Two feet of clean soil (approximately 4,500 cubic yards) and 6 inches of top soil (approximately 1,100 cubic yards) would then be imported, laid over the top of the landfill at the site, and planted with drought-resistant vegetation. Alternative 3 would also involve operation and maintenance (O&M) of the cover, and LTM of groundwater in the vicinity of Site LF01. Finally, to ensure that the integrity of the landfill cover was maintained, institutional controls in the form of signs, gates, and an Excavation Management Plan (prohibiting excavation and digging of soil without a pre-approved health and safety plan, requiring the use of personal protective equipment [PPE], and other appropriate precautions) would be developed as part of Alternative 3. The estimated cost of implementing Alternative 3 is $1,049,500.

Recommended Removal Action Alternative

Based on the individual and comparative analyses of alternatives, Alternative 3 (Soil/Vegetative Cover with Long-Term Monitoring of Groundwater) is the recommended removal action alternative for Site LF01. Alternative 3 would be the most cost-effective action alternative for achieving the RAOs for the site, and would minimize worker exposure to site hazards.

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Attachments

Abbreviations and Acronyms

ABW	Air Base Wing
AFB	Air Force Base
AFS	Air Force Station
AFCEE	Air Force Center for Environmental Excellence
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CES	Civil Engineer Squadron
CEVR	Environmental Restoration Element
CFR	Code of Federal Regulations
cm^2	square centimeter
COC	chemical of concern
COE	U.S. Army Corps of Engineers
COPC	chemical of potential concern
DPS	direct-push sampling
EA	EA Engineering, Science, and Technology
EE/CA	Engineering Evaluation / Cost Analysis
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FR	Federal Register
FSP	Field Sampling Plan
ft	foot or feet
GPS	global positioning system
HAR	Hawaii Administrative Rules
HDOH	State of Hawaii Department of Health
HI	hazard index
HLA	Harding Lawson Associates
HQ	hazard quotient
ILCR	increased lifetime cancer risk
IRP	Installation Restoration Program
ITIR	Informal Technical Information Report
LOEL	lowest observed effects level

LTM	long-term monitoring
MDL	method detection limit
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MSL	mean sea level
µg/L	microgram(s) per liter
µg/dL	microgram(s) per deciliter
NA	not analyzed or not available
NCP	National (Oil and Hazardous Substances Pollution) Contingency Plan
ND	not detected
NFRAP	No Further Response Action Planned
NHPA	National Historic Preservation Act
O&M	operation(s) and maintenance
OSWER	Office of Solid Waste and Emergency Response
OU1	Operable Unit 1
PAH	polynuclear aromatic hydrocarbon
PA/SI	Preliminary Assessment / Site Inspection
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PQL	practical quantitation limit
PREE/CA	Presumptive Remedy Engineering Evaluation / Cost Analysis
PRG	preliminary remediation goal
PSG	passive soil gas
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAO	removal action objective
SAL	soil action level
SVOC	semivolatile organic compound
TBC	to be considered
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEQ	toxicity equivalent
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
UIC	Underground Injection Control
VOC	volatile organic compound

1.0 Introduction

This Engineering Evaluation/Cost Analysis (EE/CA) Report has been prepared to support a non-time-critical removal action at Site LF01 at Bellows Air Force Station (AFS), Oahu, Hawaii (Figure 1). These efforts are part of the EE/CA for Operable Unit 1 (OU1) at Bellows AFS, which is being conducted in support of Installation Restoration Program (IRP) activities administered by the 15th Air Base Wing (15 ABW) Civil Engineer Squadron/Environmental Restoration Element (CES/CEVR) located at Hickam Air Force Base (AFB), Oahu, Hawaii. The work is being performed through the Air Force Center for Environmental Excellence (AFCEE) under delivery order F41624-97-D-8019-0005.

The EE/CA has been conducted in accordance with the U.S. Environmental Protection Agency's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (U.S. EPA, 1993). The *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) subpart (E), "Hazardous Substance Response," and the Hawaii Department of Health's *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (HDOH, 1996) were also consulted for guidance.

An Informal Technical Information Report (ITIR) was completed for Site LF01 (CH2M HILL, June 15, 2001). The ITIR describes in detail the history of Site LF01, provides site characterization information based on field investigations conducted between 1989 and 2000, and presents the results of a site-specific screening-level risk evaluation. This EE/CA Report summarizes portions of the ITIR as needed for evaluating removal action alternatives for Site LF01.

The next step in the decisionmaking process for Site LF01 will be the preparation of an Action Memorandum, which will describe the removal action selected for the site. The schedule for the removal action will depend on the timely regulatory approval of the Action Memorandum for Site LF01 and the availability of Air Force funding.

Following implementation of the removal action and documentation that Site LF01 does not pose unacceptable risks to human health and the environment, No Further Response Action Planned (NFRAP) Category IV documentation will be prepared to recommend site closure.

1.1 Project Background

Site LF01 is one of four IRP sites comprising OU1 at Bellows AFS that are known or suspected to have been subject to the historical release of contaminants. The four sites, shown in Figure 2, are:

- Site LF01, Base Landfill
- Site DP17, Burn Disposal Site
- Site SD22, Abandoned Drums
- Site DP06, Multiple Dump Sites

Sites DP17, SD22, and DP06 have been closed under the designation of NFRAP Category III.

Site LF01 is a former landfill located in the west-central portion of Bellows AFS, west of abandoned Runway 36 (Figure 2). The site is approximately 700 feet northwest of Waimanalo Stream and 3,300 feet west of Waimanalo Bay. A portion of Site DP17, immediately south of Site LF01, has also been included as part of Site LF01. The northern portion of Site DP17 partially overlaps Site LF01; this portion was previously designated "Site DP17A" (EA Engineering, Science, and Technology [EA], 1996; Figure 3). A steep cliff, which forms the southwestern boundary of Site LF01, also forms the boundary between Sites DP17 and DP17A. Because Sites LF01 and DP17A overlap and have similar waste disposal histories and contaminant release mechanisms, the investigation of these two sites was combined for the purposes of the EE/CA for Site LF01.

Site LF01 has been included in three previous investigations:

1. The IRP Phase II Stage 1 Investigation conducted from 1989 through 1992 (Harding Lawson Associates [HLA], 1992)

2. The Preliminary Assessment/Site Inspection (PA/SI) of Site DP17A conducted from 1994 through 1996 (EA, 1996)

3. Most recently, the EE/CA investigation of Site LF01 conducted from 1998 through 2000 (CH2M HILL, June 15, 2001)

A pre-survey of Site LF01[1] was conducted in July 1998 and included monitoring well inspection and redevelopment, visual reconnaissance, clearing of vegetative cover, and a noninvasive geophysical survey and mapping. The subsequent EE/CA field investigation occurred in three phases. Phase I, conducted in October and November 1998, included a passive soil gas (PSG) survey; exploratory trenching; collection and analysis of surface soil, subsurface soil, and groundwater samples; and analysis of polychlorinated biphenyl (PCB) wipe test samples from three abandoned transformer casings near the landfill. Phase II, conducted from October through December 1999, included the collection of groundwater samples and manual and continuous water-level measurements to assess tidal influence on Site LF01; during Phase III, conducted in April 2000, groundwater samples were collected in an area not previously sampled (downgradient of the landfill); and during Phase IV, conducted in December 2000, surface soil samples were collected for analysis of dioxins and furans. These activities and the results are documented in the ITIR for Site LF01 (CH2M HILL, June 15, 2001).

Based on the results of the screening-level human health risk evaluation, lead was retained as a chemical of concern (COC) for surface soil. Based on the results of the screening-level ecological risk evaluation, three metals (lead, mercury, and zinc) were retained as COCs for surface soil. In both cases, screening level exceedances were marginal. However, these elevated levels of metals in surface soil, combined with the presence of physical hazards (broken glass, metal, and other debris at the surface, and potentially dangerous materials [e.g., pressurized canisters] in the landfill materials), are sufficient cause for further action.

[1] Former Site DP17A was addressed as part of the EE/CA pre-survey of Site LF01.

This EE/CA Report considers removal action alternatives that are designed to mitigate these risks.

1.2 The EE/CA Process and Project Objectives

U.S. EPA and Section 300.415(b)(4)(i) of the NCP require that an EE/CA be completed for all non-time-critical removal actions. The goals of an EE/CA are to:

1. Identify the objectives of the removal action.
2. Analyze the effectiveness, implementability, and cost of various alternatives that will satisfy the removal action objectives.
3. Recommend the preferred removal action that is selected after careful evaluation of the alternatives.

The specific objectives of this EE/CA Report for Site LF01 are to:

- Demonstrate that NCP requirements for non-time-critical removal actions are met.
- Provide detailed analyses, including cost estimates, for removal action alternatives.
- Document the removal action decisionmaking process for inclusion in the Administrative Record for the site.

1.3 Report Organization

Following Section 1.0, the remainder of this EE/CA Report contains the following:

- **Section 2.0** summarizes the history and physical characteristics of Site LF01, the nature and extent of contamination present, and the results of the screening-level risk evaluation that was conducted for the site as part of the EE/CA.
- **Section 3.0** describes the regulatory framework and the objectives and scope of the removal action.
- **Section 4.0** identifies removal action alternatives for Site LF01 following preliminary screening of potential response actions and associated technologies; evaluates the alternatives individually and comparatively in terms of effectiveness, implementability, and estimated cost; and identifies a recommended removal action alternative.
- **Section 5.0** lists the references cited in the main text of this report.
- **Figures and tables** referenced in the above sections are provided under separate tabs following Section 5.0.
- **Attachment A** provides a summary of the data obtained from Site LF01 during site investigations.

- **Attachment B** identifies potential applicable or relevant and appropriate requirements (ARARs) for the removal action at Site LF01.
- **Attachment C** presents detailed cost estimates for the removal action alternatives.
- **Attachment D** presents estimates of the proportion of existing soil samples that may exceed toxicity characteristic leaching procedure (TCLP) criteria under the "20 to 1" dilution rule.
- **Attachment E** provides the comments made by reviewers of a draft of this EE/CA Report (CH2M HILL, March 2001) and the Air Force/contractor responses to those comments.

2.0 Summary of Site Characterization Efforts and the EE/CA Risk Evaluation

The information summarized in this section was obtained during (1) the IRP Phase II Stage 1 Investigation of Site LF01 conducted from 1989 through 1992 (HLA, 1992), (2) the PA/SI of Site DP17A conducted from 1994 through 1996 (EA, 1996); and (3) the EE/CA investigation of Site LF01 conducted from 1998 through 2000. The ITIR for Site LF01 (CH2M HILL, June 15, 2001) contains the full details of the information about Site LF01 that is currently available, the analytical data obtained during the above projects, and the results of the EE/CA screening-level risk evaluation of the site.

2.1 Site Background

Section 2.1.1 briefly describes Site LF01. Section 2.1.2 summarizes available information about the history of the site, and Section 2.1.3 identifies the current and anticipated future land uses adjacent to the site. For further site background details, refer to Section 1.0 of the ITIR for Site LF01 (CH2M HILL, June 15, 2001).

2.1.1 Site Description

Site LF01 is a former landfill located in the west-central portion of Bellows AFS, west of abandoned Runway 36 (Figure 2). Site DP17 is located immediately south of Site LF01 (Figure 2). The northern portion of Site DP17 partially overlaps Site LF01; this portion, previously designated "Site DP17A" (EA, 1996), has been included as part of Site LF01 (Figure 3). A steep cliff, which forms the southwestern boundary of Site LF01, also forms the boundary between Sites DP17 and DP17A. Because Sites LF01 and DP17A overlap and have similar waste disposal histories and contaminant release mechanisms, the investigation of these two sites has been combined under the EE/CA investigation of Site LF01.

Site LF01 is approximately 700 feet northwest of Waimanalo Stream and 3,300 feet west of Waimanalo Bay. The topography of Site LF01 is gently sloping between approximately 10 and 40 feet above mean sea level (MSL). The surrounding topography consists of revetments (historically used to park aircraft) to the west, a ridge approximately 30 feet above MSL to the east, a relatively flat area approximately 10 feet above MSL to the north, and a hill approximately 76 feet above MSL to the south (within Site DP17).

2.1.2 Site History

The history of Bellows AFS and Site LF01, as presented in the Historical Review conducted as part of the EE/CA for OU1 (CH2M HILL, September 1998), is summarized in this section.

Site LF01 is located within a former coral borrow area excavated during World War II to provide coral fill for Bellows AFS expansion. Various sources (i.e., historical documents and

drawings, environmental reports, and interviews with former Bellows AFS personnel) indicate that landfilling may have occurred at Site LF01 from World War II through the 1970s (CH2M HILL, September 1998). An IRP Phase I Records Search (Engineering-Science [ES], 1984) reported that waste disposal at the "installation landfill" may have included hazardous materials such as oil, paint thinner, and acid from military shop operations between 1943 and 1946. The ES report, however, presented no documented evidence of such disposal at Site LF01. Although the Historical Review found no evidence of hazardous waste disposal at Site LF01 (CH2M HILL, September 1998), one drum remnant containing a small amount of tar-like materials was excavated during trenching that was conducted during Phase I of the EE/CA field investigation of the site (refer to Section 2.3.2).

The area encompassing Site LF01 was extensively quarried for coral fill from 1941 through at least 1945 (as shown in Figure 4), making simultaneous refuse disposal and quarry operations at this site unlikely. Aerial photos show the site as an active quarry in 1945 and only sparsely revegetated in 1950 (CH2M HILL, September 1998, Appendix C). Historical drawings from the late 1950s through the late 1960s, however, do identify the general area of Site LF01 as a "dump area" (CH2M HILL, September 1998); the surface and subsurface waste materials currently present at the site likely date from this period. Later drawings do not identify the site as a dump area, and it is not currently used for waste disposal.

2.1.3 Land Use

Aircraft operations and related activities at Bellows AFS ended in the 1950s, and since then the installation has been primarily used for military training exercises and recreation. It is expected that the installation (including Site LF01) will continue to be used for training exercises and recreation in the foreseeable future.

In 1999, more than 1,000 of the approximately 1,600 acres at Bellows AFS were transferred to the U.S. Marine Corps. Site LF01 is located within the Marine Corps Training Area Bellows and is generally inaccessible to the public. A variety of terrestrial avian and mammalian wildlife species use the site habitats (second-growth forests and shrublands) for foraging, nesting, and cover.

2.2 Geology and Hydrogeology

The geology and hydrogeology of Site LF01 are summarized in Sections 2.2.1 and 2.2.2, respectively.

2.2.1 Geology

Soils at Site LF01 were observed at 42 surface soil sampling locations, two trenches, and seven borings drilled using a direct-push sampling (DPS) method. The maximum depth explored was approximately 40 feet below ground surface (bgs).

Figure 5 shows a generalized geologic section of Site LF01 based on observations made during the EE/CA field investigation. As indicated in Figure 5, the fill materials consists of several types of waste mixed with silty sand, calcareous gravel, and ash (where the landfill

materials were burned). Below the landfill are lithified (cemented) calcareous sand dune deposits (light gray to pale yellow, weathered). This layer is stratified, with stiff and soft (weathered) layers. Below the lithified calcareous sand is a strongly cemented, more massive coralline sandstone that contains abundant evidence of secondary mineralization. These cemented calcareous units become stiffer or less weathered with depth. During trenching, brown clay with calcareous sand was encountered below lithified dune sand at the toe of the landfill. The clay is slightly plastic, soft, and moist to wet.

Site LF01 is located within a former coral borrow area excavated during World War II to provide coral fill for Bellows AFS expansion, as shown in Figure 4. During DPS work at Site LF01, the drilling hit refusal at depths ranging from 4 to 14 feet bgs along the eastern side of the landfill. It is presumed that the coralline deposit was encountered at those depths. This is consistent with the depiction of the coral excavation in Figure 4, which shows that the largest area excavated was to the north and east of the landfill.

2.2.2 Hydrogeology

The hydrogeology of Site LF01, including hydrostratigraphy, tidal influence on groundwater, and groundwater flow conditions and general chemistry, is summarized below. The tidal influence on groundwater in the upper aquifer beneath Site LF01 is described in more detail in the Technical Memorandum: Continuous Water-Level Monitoring at Site LF01 (provided as Attachment N in the ITIR for Site LF01 [CH2M HILL, June 15, 2001]).

2.2.2.1 Hydrostratigraphy

Based on the EE/CA field investigation results, shallow groundwater at Site LF01 occurs under unconfined conditions within a calcareous sand alluvial aquifer. Much of the surficial soil at Bellows AFS, which consists either of fill or native soil and coral, is sufficiently permeable to allow precipitation to infiltrate directly into the upper aquifer (except where the ground surface is paved). The water table at Bellows AFS generally occurs near MSL. The depth to groundwater ranges from approximately 4 to 12 feet bgs within the flatter, central portion of the installation, but increases to approximately 28 feet bgs in monitoring well LF01-MW05 (within Site LF01). Waimanalo Stream is approximately 700 feet southeast of Site LF01.

2.2.2.2 Tidal Influence on Groundwater

The influence of tides on groundwater has been evaluated during two studies conducted in the Site LF01 area: one in October 1990 (HLA, 1992), and the second during Phase II of the EE/CA investigation (CH2M HILL, June 15, 2001). For the EE/CA investigation, groundwater levels at Site LF01 and in the vicinity of Waimanalo Stream, as well as surface water levels in the stream, were monitored over an approximate 2-week period. Groundwater levels in the Site LF01 monitoring wells and the stream piezometers indicate a

tidal influence with an approximate maximum magnitude of 0.05 to 0.07 feet. The approximate groundwater lag times ranged from 1.5 to 8.5 hours.[2]

2.2.2.3 Groundwater Flow Conditions

As discussed above, groundwater beneath Site LF01 is affected by tidal fluctuations. To assess groundwater flow directions and gradients during the continuous water-level monitoring study, 71-hour mean groundwater elevations were calculated by a method developed by Serfes (1991). Hourly groundwater elevations recorded from 7:00 p.m. on November 20, 1999, to 5:00 p.m. on November 23, 1999 were used to calculate a 71-hour mean groundwater elevation for each of the monitoring points. This time period was chosen because it represented the average tidal response during the 2-week study period. Mean groundwater elevations were used to generate a groundwater surface water contour map, which is presented in Figure 6.

The regional groundwater flow direction at Bellows AFS is easterly towards Waimanalo Bay; however, both the stream and the topography influence groundwater flow direction in the vicinity of Site LF01. During the period monitored, Waimanalo Stream was characterized as "a losing stream"; that is, surface water from the stream was recharging to groundwater. Under these conditions, the groundwater flow direction was to the northwest away from the stream. Away from Waimanalo Stream, topography appears to be the primary influence on groundwater flow. Groundwater hydraulic gradients range from approximately 0.0002 to 0.0007 away from the stream.

While the results of the EE/CA field investigation indicate that net groundwater flow is away from the stream, it is possible that under different conditions, the stream could be a groundwater discharge point (the data collected during the 1990 study suggest this possibility).

2.3 Nature and Extent of Contamination

This section provides a summary of the data collected and observations made during the IRP Phase II Stage I investigation (HLA, 1992) and the EE/CA field investigation (CH2M HILL, June 15, 2001). Section 2.3.1 summarizes the results of a passive soil gas (PSG) survey conducted at the site; Section 2.3.2 summarizes the results of trenching through the landfill materials; Sections 2.3.3 and 2.3.4 summarize available soil and groundwater data, respectively; and Section 2.3.5 summarizes the results of PCB wipe test sampling. Attachment A of this EE/CA Report includes figures showing the site locations where samples were collected and provides summary tables from the ITIR (CH2M HILL, June 15, 2001), which contain the analytical data for chemicals detected in soil and groundwater at Site LF01.[3]

[2] Lag time estimates in this study have potentially high associated uncertainty because of the low rate and small magnitude of change in groundwater levels relative to the precision of the measurement equipment.

[3] Sampling for the Bellows OU1 EE/CA project was performed as specified in the Installation-Wide Field Sampling Plan (FSP) for Multiple Projects at 15 ABW Installations in Hawaii, Version 2.0 (CH2M HILL, October

The following summary of the nature and extent of contamination at Site LF01 focuses primarily on the chemicals that have been identified as potential human health and ecological risk drivers, those with relatively high frequencies of detection, and/or those that are potentially relevant to characterizing contaminant sources for Waimanalo Stream. Section 2.3.2 also describes the debris that presents physical hazards at the site.

2.3.1 Passive Soil Gas Testing

Overall, the PSG survey indicated very low to nondetectable masses of soil gas analytes randomly distributed throughout Site LF01, within and outside the landfill boundaries. Most of the PSG analytes were not detected at the majority of the sampling locations. Therefore, the results were not used to direct soil or groundwater sampling.

2.3.2 Trenching

During the EE/CA field investigation of Site LF01, two continuous trenches (a longitudinal north-south trench and a transverse east-west trench) were excavated to characterize the nature of the landfill materials and to determine the vertical extent of the landfill. The southern half of the longitudinal trench encountered predominantly Recreation Center-type waste (pop, beer, and liquor bottles) with minor construction/demolition waste (concrete, steel rebar, timbers, barbed wire, metal and plastic piping, and sheet metal). The northern half of the trench encountered predominantly construction/demolition waste; however, one segment of the trench (in the north-central portion of the landfill) included mostly vehicle waste (partially burned truck bodies, tires, fenders and other metal). Although there are no records of hazardous waste disposal, a pressurized gas cylinder and a drum remnant with a small amount of tar-like material (which was placed in an overpack drum and disposed of) were also discovered in the landfill materials in this trench during Phase I of the EE/CA field investigation. Observations recorded during trenching are provided in Table A-1 in Attachment A.

In the transverse trench, Recreation Center-type waste was encountered in the westernmost segment. A propellant canister from a Mark 15 steam-powered torpedo was uncovered just below ground surface in the second excavated segment. Further trenching was suspended upon discovery of the torpedo canister. The canister was vented but was found to contain no pressurized gas (or explosives), then was placed back in the trench. Based on the geophysical survey, visual observations of the cleared area, and the trenching that was completed, the horizontal and vertical extent of the landfilled materials was adequately delineated and no ongoing contaminant sources were observed during the field investigation.

1998a) and in the site-specific FSP (CH2M HILL, October 1998b). Analyses of the samples were performed as specified in the Installation-Wide Quality Assurance Project Plan (QAPP) (CH2M HILL, October 1998c); details on analytical methods and associated QA/QC results may be found in Attachments E and F of the ITIR for Site LF01(CH2M HILL, June 15, 2001).

2.3.3 Soil

Surface soil samples were collected from 42 locations at Site LF01, and subsurface soil samples were collected from 10 locations. These data were combined with the historical data from DP17A (EA, 1996) to evaluate whether chemicals detected in these media pose unacceptable risks to human and ecological receptors.

2.3.3.1 Surface Soil

As indicated in Tables A-2 and A-3 in Attachment A, chemicals detected in surface soil included diesel-range total petroleum hydrocarbons (TPH-diesel), 15 polynuclear aromatic hydrocarbons (PAHs), five semivolatile organic compounds (SVOCs), 20 pesticides, five PCBs, four herbicides, and 23 metals.

- TPH-diesel and PAHs were detected in most of the surface soil samples (TPH-diesel in 33 of 39 samples, one or more PAHs in 31 of 53 samples). TPH concentrations ranged from 2.3 to 53 milligrams per kilogram (mg/kg), and PAHs ranged from 0.002 to 0.68 mg/kg. Most concentrations were near or below sample-specific reporting limits.[4]

- SVOCs were detected at 11 surface soil sampling locations inside and outside the landfill boundaries. Butyl benzylphthalate, diethyl phthalate, and di-n-octylphthalate were each detected once at discrete locations; the concentrations were below sample-specific reporting limits. Di-n-butylphthalate was detected at three of the Site DP17A locations at estimated concentrations of 0.11 to 0.14 mg/kg, but was not detected elsewhere. Bis(2-ethylhexyl)phthalate was detected at six locations at concentrations ranging from 0.0425 to 6.97 mg/kg.

- Pesticides were detected in most of the surface soil samples inside and outside the landfill boundaries (33 of 39 samples) at concentrations ranging from 0.00022 to 0.14 mg/kg. All concentrations were below sample-specific reporting limits.

- PCBs were detected among seventeen surface soil sampling locations inside and outside the landfill boundaries. Three (Aroclor-1242, -1254, and -1260) were detected in one or more Site DP17A samples at concentrations ranging from 0.082 to 2.9 mg/kg. Aroclor-1254, -1016, and 1248 were detected during the EE/CA field investigation at concentrations below sample-specific reporting limits; these detections were in the southwestern portion of the landfill, near the Site DP17A sampling area.

- Herbicides were detected in 22 of the 39 surface soil samples (a total of 34 herbicides were detected). Herbicide concentrations (22 of the 34 detections) ranged from 0.022 to

[4] The discussion of whether or not chemicals were detected at concentrations above reporting limits is provided as a means to evaluate the uncertainty associated with the results; detected concentrations flagged as below the reporting limits are considered to be below levels that are regarded as representative of accurate and precise detection. In general, these values are close to laboratory method detection limits (MDLs), which represent concentrations near the limits of instrument sensitivity for each method. At these levels, background contamination and electronic noise may become significant contributors to false positive values. In addition, flags for blank contamination are not applied to concentrations below sample-specific reporting limits, increasing the possibility of false positive values.

18 mg/kg, and most were below sample-specific reporting limits. Detected concentrations of dalapon ranged from 0.94 to 3.1 mg/kg; detected concentrations of MCPA ranged from 6.9 to 11 mg/kg; and detected concentrations of MCPP ranged from 11 to 12 mg/kg.

- Metals concentrations varied widely between sampling locations. The highest concentrations of metals in surface soil were generally in the samples from Site DP17A (which may be the result of the biased sampling design and data quality issues). The highest concentrations of most metals detected during the EE/CA investigation occurred in the southern and central portions of the landfill, which is generally consistent with the nature of the landfill materials observed in these areas. Detected lead concentrations ranged from 1.4 to 2,910 mg/kg; detected mercury concentrations ranged from 0.0375 to 18.9 mg/kg; and detected zinc concentrations ranged from 8.8 to 2,950 mg/kg in surface soil at Site LF01.

In addition, low levels of dioxins and furans were detected in all seven surface soil samples collected during Phase IV of the EE/CA. Calculated dioxin/furan toxicity equivalents (TEQs) ranged from 0.00019 to 0.108 micrograms per kilogram (µg/kg), which are one to four orders of magnitude below the U.S. EPA residential preliminary remediation goal (PRG) of 1 µg/kg; therefore, in accordance with the data evaluation criteria specified in the project planning documents (CH2M HILL, October 1998), dioxins and furans were not included in the screening-level risk evaluation. The highest concentrations of dioxins and furans were detected in samples collected within the landfill boundaries; concentrations were similar in the samples collected from beyond the northern boundary of the landfill to those detected in samples from the uphill portion of the landfill.

2.3.3.2 Subsurface Soil

Three distinct subsurface soil types were evaluated: landfill materials, native soil beneath the landfill, and native soil outside the landfill. As indicated in Tables A-4 through A-7 in Attachment A, chemicals detected in the subsurface soil included TPH-diesel and -gasoline, 12 PAHs, eight volatile organic compounds (VOCs), two SVOCs, nine pesticides, three PCBs, four herbicides, and 22 metals.

- TPH-diesel and -gasoline were detected in all three soil types at concentrations ranging from 0.01 to 48 mg/kg, which were in most cases near or below sample-specific reporting limits. TPH-diesel concentrations were slightly higher in the landfill materials.

- PAHs were detected in the landfill materials and in native soil beneath the landfill at similar concentrations, ranging from 0.0023 to 0.019 mg/kg, that were near or below the reporting limits. PAHs were not detected in native soil outside the landfill.

- VOCs were detected in all three soil types. The number and concentrations of VOCs detected were highest in the landfill materials; only trichloroethylene (TCE) was detected in native soil outside the landfill. VOC concentrations ranged from 0.0002 to 0.0021 mg/kg, and were all below sample-specific reporting limits.

- Two phthalates (bis[2-ethylhexyl]phthalate and butyl benzylphthalate) were detected once each in the landfill materials only, at concentrations ranging from 0.28 to 0.64 mg/kg, and both were below sample-specific reporting limits.

- Pesticides were detected in subsurface soil samples inside and outside the landfill boundaries at concentrations that ranged from 0.00091 to 0.22 mg/kg and were near or below sample-specific reporting limits. Several pesticides (endosulfan sulfate, endrin aldehyde, heptachlor epoxide, and methoxychlor) were only detected in native soil outside the landfill.

- The PCB Aroclor-1016 was detected once in native soil beneath the landfill (at 0.022 mg/kg); Aroclor-1242 was detected once in the landfill materials (at 0.61 mg/kg); and Aroclor-1260 was detected in samples from all three subsurface soil types (at concentrations ranging from 0.0143 to 0.1 mg/kg). Concentrations of Aroclor-1260 were slightly higher in the landfill materials.

- Herbicides were detected in all three soil types, at a low frequency of detection and at concentrations ranging from 0.021 to 28 mg/kg, which were near or below sample-specific reporting limits. Concentrations of MCPP ranged from 4 to 28 mg/kg (all below sample-specific reporting limits).

- Metals concentrations varied widely between sampling locations. The highest concentrations of metals in subsurface soil were generally in the landfill materials, which is consistent with the abundant metal debris observed in the landfill. The highest concentrations were detected in the DP17A area. In the landfill materials, detected lead concentrations ranged from 59.9 to 1,670 mg/kg; detected mercury concentrations ranged from 0.07 to 0.33 mg/kg; and detected zinc concentrations ranged from 70 to 1,400 mg/kg.

2.3.4 Groundwater

As indicated in Table A-8 in Attachment A, chemicals detected in groundwater included TPH-diesel and -gasoline, two PAHs, three VOCs, one SVOC, 11 pesticides, seven herbicides, and 19 metals.

- TPH, PAHs, VOCs, and SVOCs were detected infrequently and at concentrations below sample-specific reporting limits. Detected concentrations ranged from 0.1 to 0.14 milligram per liter (mg/L) for TPH, from 0.01 to 0.043 micrograms per liter (µg/L) for PAHs, from 0.14 to 0.31 µg/L for VOCs, and from 2.86 to 2.86 µg/L for SVOCs.

- Pesticides were detected in nine of 21 samples at concentrations ranging from 0.016 to 18 µg/L, which were near or below reporting limits (which ranged from 0.23 to 8.1 µg/L). The highest concentrations were detected outside the landfill.

- The herbicide dalapon was detected in the samples from three monitoring wells at concentrations ranging from 570 to 830 µg/L (all flagged as estimated concentrations). Dalapon was not detected in the other groundwater samples. Dinoseb, 2,4-D, 2,4-DB, dichloroprop, and 2,4,5-TP (Silvex) were detected infrequently and at concentrations

ranging from 0.293 to 1.1 µg/L, which were below sample-specific reporting limits. MCPP was detected twice and the concentrations ranged from 53.2 to 142.7 µg/L, both below sample-specific reporting limits.

- Metals were detected at similar concentrations inside and outside the landfill, many at concentrations below sample-specific reporting limits. Detected lead concentrations ranged from 0.00048 to 0.007 mg/L; mercury was not detected; and detected zinc concentrations ranged from 0.003 to 0.0086 mg/L.

2.3.5 PCB Wipe Test Samples

PCB wipe test samples were collected from three abandoned transformer casings located on the ground surface at Site LF01. None of the individual Aroclors were detected. The casings are assumed to have contained PCBs in the past and are therefore considered "PCB articles" in accordance with the federal Toxic Substances Control Act (TSCA; 40 CFR Subpart 761.1). However, they are not considered "PCB-contaminated" under TSCA because they have a nonporous surface concentration of less than 10 micrograms per 100 square centimeters (cm^2), as measured by a standard wipe test in accordance with 40 CFR 761.123. Therefore, no special disposal requirements for the transformer casings were necessary, and they were disposed of offsite by the excavation subcontractor.

2.4 Risk Evaluation

As part of the EE/CA, a screening-level risk evaluation was conducted for Site LF01 to evaluate whether the site could contribute to potential human health and ecological risks at Waimanalo Stream. The overall objective of the risk evaluation was to help identify whether risks posed by the site are of sufficient magnitude to support one of three decisions: (1) proceed with preparation of an EE/CA Report, (2) proceed to a NFRAP designation for the site, or (3) refine the evaluation approach and/or acquire additional site characterization data. The risk evaluation consisted of three primary components:

1. Evaluation of relevant pathways of potential exposure to human and ecological receptors, and development of a conceptual exposure model for Site LF01.

2. Identification of those chemicals in surface soil, subsurface soil, and groundwater at the site that are most important to the screening-level risk evaluation (chemicals of potential concern, or COPCs).

3. Quantitative evaluation of surface soil, subsurface soil, and groundwater concentrations of COPCs at Site LF01 to identify whether they may occur at levels that support one of the three decisions identified above. COPCs exceeding action levels were evaluated as chemicals of concern (COCs).

Sections 2.4.1 through 2.4.3 describe the three components of the risk evaluation. Sections 2.4.4 summarizes the results of the evaluation, and Section 2.4.5 discusses uncertainties that may affect the evaluation results and the interpretation of them. The risk evaluation, including the specific methodology and regulatory guidance employed to estimate exposure

and subsequent risks, is described in detail in Section 5.0 of the ITIR for Site LF01 (CH2M HILL, June 15, 2001).

2.4.1 Exposure Pathways for Human and Ecological Receptors

The potential routes of human exposure that were evaluated included those associated with incidental soil ingestion, dermal contact, and inhalation of dust and VOCs from surface soil. U.S. Marine Corps personnel who use Bellows AFS for military field training are directed not to perform excavations of any kind in order to avoid potentially disturbing buried archaeological features. Therefore, exposure to subsurface soil by military personnel was not considered an exposure pathway of concern.

As noted in Section 2.2.2.1, groundwater occurs at depths ranging from approximately 4 to 28 feet bgs beneath Site LF01. The groundwater is also somewhat saline, and is not suitable as a drinking water source or for other domestic uses.[5] In addition, groundwater is not likely to be used for industrial purposes based on current and reasonably anticipated future uses of Site LF01.[6] Therefore, future incidental contact with chemicals in groundwater was not considered an exposure pathway of concern.

The potential routes of ecological exposure that were evaluated included the following:

- Direct ingestion of surface soil by avian or mammalian terrestrial species
- Bioconcentration or bioaccumulation of chemicals in surface soil through ingestion of food items (i.e., prey)
- Potential leaching of subsurface soil contaminants into groundwater and subsequent discharge of groundwater to Waimanalo Stream

The Hawaiian short-eared owl or "pueo" (*Asio flammeus sandwichensis*) was selected as the representative species for evaluating potential risks to terrestrial ecological receptors through the ingestion of soil and food items. Potential ecological receptors in Waimanalo Stream include aquatic organisms addressed by the risk-based surface water screening criteria (described in Section 2.4.3).

2.4.2 Chemicals of Potential Concern

Chemicals detected in soil or groundwater were initially identified as COPCs for those media. Additional factors that were considered in the selection of COPCs included the following:

[5] Bellows AFS is located seaward (makai) of the Underground Injection Control (UIC) line, which was established in 1977 by the State of Hawaii to separate aquifers (or portions of aquifers) that supply drinking water from exempt aquifers that do not supply drinking water. Aquifers makai of the UIC are designated as exempt (non-drinking water) aquifers; groundwater beneath the installation is therefore not considered a drinking water source (HLA, 1992).

[6] As noted in Section 2.1.3, the installation's current and anticipated future land uses are recreation and training, not industrial. In addition, elevated salinity and total dissolved solids (which make the groundwater unsuitable for drinking) might also adversely affect industrial operations.

- Chemicals that were detected at concentrations less than five times the concentrations in associated laboratory or field blanks were eliminated from consideration as COPCs.
- Essential nutrients such as calcium, magnesium, potassium, and sodium were eliminated from consideration as COPCs.
- Chemicals detected in soil or groundwater that do not have toxicity factors or screening levels were included as COPCs but could not be evaluated quantitatively.

Finally, for chemicals that were never detected, the method detection limits (MDLs) were compared to available risk-based comparison criteria for the protection of human health and ecological receptors. This served to verify that MDLs were adequate to achieve risk-based levels. Chemicals with MDLs below comparison criteria were eliminated from consideration as COPCs.

2.4.3 Risk Evaluation Methodology

Human health COCs for the direct-contact pathway were identified based on the following criteria:

- If the noncancer HQ for a specific chemical exceeded 1.0, that chemical was retained as a COC.
- If the multi-chemical cumulative increased lifetime cancer risk (ILCR) exceeded the action level of 10^{-4} or the cumulative noncancer hazard index (HI) exceeded 1.0, the major risk-contributing chemicals were identified as COCs.

Lead concentrations in surface soil were evaluated separately to determine whether risks could be posed through direct contact. If lead concentrations in surface soil exceeded the industrial PRG of 750 mg/kg or were calculated to result in a blood-lead level exceeding 10 micrograms per deciliter (µg/dL), lead was evaluated as a COC.

Ecological COCs were identified using the following criteria:

- For surface soil, if an ecological HQ for a specific chemical was greater than 1 for bioaccumulative compounds using the terrestrial avian food-chain model, that chemical was evaluated as a COC.
- For subsurface soil, chemical concentrations exceeding soil action levels (SALs) developed to protect aquatic receptors from risks posed by water infiltrating through soil and ultimately discharging to surface water (i.e., Waimanalo Stream) were evaluated as COCs.[7]

[7] SALs are derived either as Tier 1 table values in the HDOH guidance (December 1995, revised June 1996) or using the SESOIL model, with Tier 1 assumptions. If the depth to groundwater is less than 10 feet bgs, groundwater will be evaluated directly. This is based on HDOH's Tier 1 model requiring (1) that the zone of contamination for soil be less than 1 meter in thickness, and (2) that the distance between the contaminated soil and groundwater be at least 2 meters.

- For groundwater, chemical concentrations exceeding surface water screening levels developed to protect aquatic receptors from risks posed by non-potable groundwater discharging to surface water (i.e., Waimanalo Stream) were evaluated as COCs.[8]

2.4.4 Risk Evaluation Results

Section 2.4.4.1 summarizes the results of the human health screening-level risk evaluation and Section 2.4.4.2 summarizes the results of the ecological screening-level risk evaluation.

2.4.4.1 Human Health Risk Characterization

The estimated human health risks associated with exposure to **surface** soil at Site LF01 are summarized below.

- **Direct-Contact Pathway**. The estimated excess lifetime cancer risk for potential site workers is approximately $1x10^{-5}$. Arsenic ($1x10^{-5}$) and benzo(a)pyrene ($9x10^{-7}$) are the primary contributors to risk; however, the ILCR associated with Site LF01 is less than the action criterion of $1x10^{-4}$. Individual HQs for chemicals detected in surface soil samples, as well as their total HI, were below the action criterion of 1. *Therefore, no chemicals were retained as COCs for this pathway.*

- **Lead.** A separate risk screening evaluation was performed for lead. The exposure point concentration of 800 mg/kg of lead detected in surface soil exceeded the industrial PRG of 750 mg/kg. A number of individual soil sample concentrations of lead (16 of 53) also exceeded the PRG. Lead concentrations above the action level ranged between 880 mg/kg and 2,910 mg/kg. Of the 16 samples exceeding the action level, 12 were collected from Site DP17A (historical surface soil data) and four were from the remainder of Site LF01. *Based on this evaluation, lead was retained as a COC.*

  A blood-lead level of 6.8 µg/dL was calculated based on adult exposure to lead at Site LF01; this is below the target level of 10 µg/dL used in similar studies (Bower et al., 1994).

2.4.4.2 Ecological Risk Characterization

The ecological risk characterization included the calculation of ecological HQs based on a pueo food-web model for surface soil; comparison of chemical concentrations in subsurface soil to SALs developed for the protection of aquatic life; and comparison of chemical concentrations in groundwater to surface water criteria developed for the protection of aquatic life. The results of each evaluation are summarized below by media.

- **Surface Soil.** Based on the pueo food-chain model and using maximum concentrations in surface soil samples collected from Site DP17A, lead (HQ = 1.18), mercury (HQ = 1.25) and zinc (HQ = 1.51) each exceeded an ecological HQ of 1. *Therefore, lead, mercury, and zinc were retained as COCs.*

[8] The screening levels used for the ecological risk evaluation were the most stringent of HDOH Tier 1 action levels (excluding those based on human health risk), National Recommended Water Quality Criteria (64 FR 68357068364, December 10, 1998), or criteria based on lowest observed effects levels (LOELs) or proposed criteria for the protection of aquatic organisms.

- **Subsurface Soil (Landfill Materials).** Butyl benzylphthalate, alpha-chlordane, Aroclor-1242, Aroclor-1260, and lead exceeded SALs developed for the protection of surface water; however, *none of these constituents were retained as COCs.* Individual concentrations of butyl benzylphthalate, alpha-chlordane, and the PCBs were below reporting limits, and these chemicals were not detected in groundwater. The representative concentration of lead (1,140 mg/kg) exceeded the SAL of 400 mg/kg; five of the eight lead detections in landfill materials also exceeded the SAL. Dissolved lead was detected at 12 of 21 groundwater sampling locations, but dissolved lead concentrations did not exceed the groundwater screening level. *Therefore, lead was not retained as a COC.*
- **Subsurface Soil (Native Soil Beneath the Landfill).** Alpha-chlordane, Aroclor-1016, and Aroclor-1260 exceeded SALs developed for the protection of surface water; however, *none of these chemicals were retained as COCs.* Individual concentrations of alpha-chlordane and the PCBs were below reporting limits, and none were detected in groundwater.
- **Subsurface Soil (Native Soil Outside the Landfill).** Alpha-chlordane and Aroclor-1260 exceeded SALs developed for the protection of aquatic life; however, *neither of these chemicals was retained as COCs.* Individual concentrations of alpha-chlordane and Aroclor-1260 were below reporting limits, and neither was detected in groundwater.
- **Groundwater.** Seven pesticides (4,4'-DDT, gamma-chlordane, endosulfan II, endrin, heptachlor, heptachlor epoxide, and methoxychlor) exceeded groundwater screening levels developed for the protection of surface water; however, *none of these chemicals were retained as COCs.* With the exception of gamma-chlordane and endrin (each detected once as an estimated concentration), all pesticide concentrations were below reporting limits. In addition, with the exception of 4,4'-DDT (detected twice), heptachlor (detected five times), and heptachlor epoxide (detected seven times), each pesticide was only detected once in groundwater.

2.4.5 Uncertainties

Uncertainties associated with the screening-level human health risk evaluation include a lack of toxicity data for several chemicals detected in surface soil; the inclusion of historical data in the risk calculations; and the rejection of results for several pesticides. The lack of toxicity data and the rejected pesticide data may lead to an underestimation of risks; conversely, the inclusion of historical data in the risk calculations may overestimate risks because metals concentrations in the Site DP17A samples were significantly elevated compared with those in EE/CA samples, possibly because of the biased sampling design or data quality issues.

Uncertainties associated with the screening-level ecological risk evaluation include those identified above for the human health risk evaluation and, in addition, the assumptions regarding the pathway from subsurface soil to groundwater to surface water; the use of LF01 by avian species; and assumptions regarding the biomagnification of chemicals through the food chain and the bioavailability of chemicals at Site LF01.

3.0 Regulatory Framework, and Removal Action Objectives and Scope

Section 3.1 summarizes the regulatory framework for the removal action at Site LF01. The objectives and scope of the action are described in Sections 3.2 and 3.3, respectively. Section 3.4 outlines the currently planned schedule for the removal action and related activities.

3.1 Regulatory Framework

3.1.1 Justification for Removal Action

A response action is warranted when it is necessary to prevent, minimize, or mitigate risks to the public health or the environment. The NCP allows for the lead agency (in this case the U.S. Air Force) to determine whether conditions at a site may pose a threat to human health or the environment. Section 300.415 of the NCP identifies eight criteria that should be considered when determining the appropriateness of a remedial action. The following provision from Section 300.415 was used in determining the appropriateness of a remedial action at Site LF01:

> Prevention or abatement of actual or potential exposure of nearby human populations, animals, or the food chain from hazardous substances, pollutants, or contaminants.

Lead in surface soil has been identified as a COC at Site LF01 because it poses potential risks to current and future human receptors. In addition, three metals (lead, mercury, and zinc) in surface soil have been identified as COCs at Site LF01 because they pose potential risks to current and future ecological receptors. In the absence of other factors, the marginal risks estimated for both human and ecological receptors at Site LF01 would not warrant further action. However, Site LF01 in its current condition also presents potential risks to occupational receptors (i.e., personnel involved in military training exercises) in the form of physical hazards that include broken glass, metal, and other debris at the surface, and potentially dangerous materials (e.g., pressurized canisters) in the landfill materials. Therefore, the marginal human and ecological risks potentially posed by metals in surface soil, combined with the physical hazards present at Site LF01, are sufficient cause for further action.

3.1.2 Potential Applicable or Relevant and Appropriate Requirements (ARARs)

Section 300.415 of the NCP requires that removal actions under CERCLA be consistent with the requirements of federal and state environmental laws, regulations, standards, criteria, and limits that are determined to legally be ARARs. To be applicable, a state or federal requirement must directly and fully address the circumstances at a site and satisfy all of the jurisdictional prerequisites for legal applicability. Only those state requirements that are

more stringent than federal requirements are evaluated. A requirement that is not applicable may be relevant and appropriate if it addresses situations sufficiently similar to be of use in evaluating the site.

Only substantive requirements can be ARARs; administrative requirements such as permits, reporting, recordkeeping, or consultation with administrative bodies are not ARARs.

Nonpromulgated advisories or guidance issued by federal or state governments are not legally binding and are not ARARs. However, such advisories or guidance may be useful and are "to be considered" (TBC) during the identification of ARARs. TBCs are intended to complement the use of ARARs and may be used to establish removal action objectives in circumstances for which ARARs do not exist.

Pursuant to U.S. EPA guidance (*Compendium of CERCLA ARARs Fact Sheets and Directives* [OSWER Directive 9347.3-15], ongoing), ARARs are generally divided into three categories: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs establish numerical standards limiting the concentrations of substances in the medium of concern and/or the medium affected by the removal action. Location-specific ARARs are restrictions or considerations placed on the conduct of activities in specific locations. Action-specific ARARs are technology- or activity-based restrictions controlling the removal action, and include performance and design standards. This classification was developed to aid in the identification of ARARs; some do not fall precisely into one group or another.

The identification of ARARs is an iterative process. The removal action objectives and scope, and the evaluation of potential removal actions provide the basis for identifying the final ARARs and TBCs. These will then be documented by 15 CES/CEVR in the Action Memorandum for Site LF01, which will be reviewed and approved by HDOH.

The tables in Attachment B list the potential chemical-specific, location-specific, and action-specific ARARs and TBCs for Site LF01, and provide a preliminary determination of ARARs for the removal action at the site.

Action-specific ARARs potentially apply to activities conducted during the removal action and include Hawaii Air Pollution Control Standards, which require reasonable precautions to prevent fugitive dust emissions (Hawaii Administrative Rules [HAR] Title 11 Chapter 60.1-33) and state and federal worker protection standards. A potential location-specific ARAR has been identified based on Site LF01's potential for containing archeological resources. Consultation under the Archeological Resources Act (16 USC Part 470, 40 CFR 65) will be required for removal activities that have the potential to disturb archeological resources.

3.1.3 Statutory Basis for Removal Actions

Removal actions are governed by Section 104(b)(1) of CERCLA and by Section 300.415(b)(5) of the NCP. The initiative for performing the removal action for Site LF01 is taken under the delegated authority of the Office of the President of the United States by Executive Orders 12080 and 12580. These orders provide the U.S. Air Force with the authorization to conduct and finance removal actions. The removal action is within the authorization set

forth in CERCLA and the NCP and includes the preparation of an EE/CA Report and an Action Memorandum. The selected removal action will be conducted under the direction of 15 CES/CEVR following public input and regulatory approval. To document the selected removal action, the Action Memorandum for Site LF01 will be prepared and signed by the U.S. Air Force and approved by HDOH.

3.2 Removal Action Objectives

The removal action being considered in this EE/CA Report has the following objectives (RAOs):

- Mitigate current and future potential for human and ecological exposure to elevated levels of metals in surface soil through cost-effective measures.
- Mitigate current and future potential for site worker exposure to physical hazards in surface soil and in landfill materials (e.g., broken glass, metal debris, pressurized canisters) through cost-effective measures.
- Minimize impacts to current site operation and surrounding land uses during implementation of the removal action.
- Plan for "reasonably anticipated future land uses" (U.S. EPA, August 1997) in the removal action strategy. Reasonably anticipated future land uses include current Air Force categories (military training and outdoor recreation).

Section 4.0 evaluates potential removal action alternatives in terms of their ability to meet these RAOs for Site LF01.

3.3 Removal Action Scope

The scope of this removal action is to implement measures designed to mitigate potential threats to human health and the environment posed by chemical and physical hazards identified in surface and landfill materials at Site LF01. The identified RAOs are evaluated with respect to the overall IRP cleanup objectives, which are to provide permanent and cost-effective remedies for contaminated environmental media and to permanently and significantly reduce the toxicity, mobility, and/or volume of hazardous wastes, thereby reducing potential risks to human health and the environment.

3.4 Planned Schedule for Removal Action and Related Activities

Table 1 presents the schedule that is currently planned for the removal action and related activities at Site LF01. Adherence to the schedule will depend on the timely regulatory approval of the Action Memorandum for Site LF01 and the availability of Air Force funding.

4.0 Identification, Evaluation, and Comparison of Removal Action Alternatives

This section identifies, analyzes, and compares three removal action alternatives to address the RAOs for Site LF01 that are identified in Section 3.2. A wide range of potential response actions and associated technologies were initially considered, three of which were retained after the preliminary screening described in Section 4.1.

Following a discussion of the criteria specified by U.S. EPA for evaluating the alternatives (Section 4.2), the alternatives are evaluated individually against these criteria (Section 4.3) and then compared with each other (Section 4.4). Section 4.5 identifies a recommended removal action alternative that was selected based on the results of the individual and comparative evaluations.

4.1 Preliminary Screening of Potential Technologies

As part of the preliminary screening process, Site LF01 was evaluated against the criteria provided in two guidance documents to determine the applicability of potential presumptive remedies for contaminated soil. These guidance documents were: (1) (for capping) *U.S. Air Force Presumptive Remedy Engineering Evaluation/Cost Analysis* (PREE/CA) (U.S. Army Corps of Engineers [COE], May 1997), and (2) *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (U.S. EPA, December 1996).

Presumptive remedies are preferred technologies for common categories of sites based on historical patterns and U.S. EPA's evaluation of performance data on technology implementation (December 1996). The benefits of presumptive remedy approaches include:

- Significant time savings in selecting and implementing cleanup remedies;
- Early and substantial risk reduction; and
- Improvement in the consistency and predictability of the remedy selection process (and reduction of discrepancies in remedy selection).

Site LF01 was compared against each set of presumptive remedy criteria (i.e., those listed in COE PREE/CA and U.S. EPA CERCLA guidance), to evaluate whether either or both presumptive remedies would be applicable. Tables 2 and 3 list the criteria/profiles for each presumptive remedy and indicate whether Site LF01 matches or does not match the criteria. In summary, because of the low volume of landfill materials (approximately 8,500 cubic yards) at Site LF01, both presumptive remedy documents recommend that a more detailed analysis be conducted.

Therefore, based on a non-presumptive remedy approach, a wide range of potential response actions were initially considered for Site LF01, and a preliminary screening of those response actions and associated technologies was performed to determine which of these would be viable at the site. U.S. EPA's *Treatment Technologies Screening Matrix* (January 1999), a technology application matrix for various types of media requiring treatment, was used as the primary source for identifying and screening potential response actions and associated technologies.

The technologies were screened for their suitability and potential applicability at Site LF01. The primary objective of the preliminary screening phase was to eliminate technologies that:

- Do not have a reasonable chance of achieving the RAOs within an acceptable time frame;
- Have excessive implementation costs compared with other technologies; and/or
- Could not be implemented at Site LF01 because of site conditions.

Evaluation of the potential technologies and selection of the retained alternatives were based on available information about the site and on professional judgment. Site- and waste-specific characteristics at Site LF01 were also considered in the preliminary screening process, along with current and reasonably anticipated future land uses associated with the site.

Figure 7 presents the results of the preliminary screening of potential response actions and associated technologies. The figure indicates whether each technology was rejected or retained for more detailed evaluation, and provides the rationale for the decision about each technology.

Following the preliminary screening, three removal action alternatives for Site LF01 were evaluated in terms of the U.S. EPA criteria described in Section 4.2. Evaluation of the no-action alternative is required by the NCP. Of the other retained technologies shown in Figure 7, the Excavation Management Plan is included in the soil/vegetative cover alternative described in Section 4.3.3.

4.2 Evaluation Criteria

U.S. EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (1993) specifies three general criteria for evaluating removal action alternatives: effectiveness, implementability, and cost. Each criterion is further subdivided as described below.

4.2.1 Effectiveness

The effectiveness of an alternative refers to its ability to meet the RAOs for the site. The effectiveness criterion addresses the following issues:

- Ability to achieve RAOs (in the case of Site LF01, the RAOs are presented in Section 3.2)

- Reduction in toxicity, mobility, or volume through treatment
- Compliance with ARARs
- Short-term effectiveness
  - Protection of the community
  - Protection of workers during implementation
  - Environmental impacts
  - Time until RAOs are achieved
- Long-term effectiveness and permanence
  - Magnitude of risks following implementation
  - Adequacy and reliability of post-response action site controls

4.2.2 Implementability

The implementability (i.e., ease of implementation) of a removal action alternative depends on its technical and administrative feasibility, and on the availability of various services and materials required for its implementation. The implementability criterion addresses the following issues:

- Technical feasibility
  - Construction and operational considerations
  - Demonstrated performance / useful life
  - Adaptability to environmental conditions
  - Contribution to remedial performance
- Administrative feasibility
  - Requirement for permits and zoning variances
  - Impacts on adjoining property
  - Ability to impose institutional controls
- Availability of services and materials
  - Personnel and technology
  - Services and materials
  - Implementation of post-response action site controls
- State and community acceptance. The state (HDOH) and the local community will have the opportunity to review the removal action alternative that is recommended in this EE / CA Report and the alternative that is selected in the subsequent Action Memorandum for Site LF01. Therefore, the evaluations of the alternatives in Sections 4.3 and 4.4 of this EE / CA Report do not include assessments of state and community acceptance.
- This EE / CA Report provides additional evaluation of the alternatives using the following criteria:

- Future land use considerations
- Long-term monitoring
- Operation and maintenance (O&M)

4.2.3 Estimated Cost

The total estimated cost of a removal action alternative includes estimated direct capital costs, indirect capital costs, and post-response action site controls or long-term monitoring costs, if applicable. The cost criterion is subdivided as follows:

- Direct and indirect capital costs
  - Construction, equipment, and material costs
  - Design and engineering costs
  - Waste management costs
  - Analytical costs
- O&M and long-term monitoring (LTM) costs

The order-of-magnitude cost estimates presented in this EE/CA Report are based primarily on vendor and subcontractor quotes, historical cost information from similar projects, professional judgment, and standard Air Force (RACER) and commercial (e.g., Means, 1998) cost estimating tools.

4.3 Identification and Evaluation of Removal Action Alternatives

Based on current site conditions, the RAOs for the site, the screening of preliminary response actions and associated technologies, and current Air Force and HDOH policy, three removal action alternatives have been identified for Site LF01:

1. No Action (Alternative 1)
2. Soil/Landfill Materials Excavation and Disposal/Recycling (Alternative 2)
3. Soil/Vegetative Cover with Long-Term Monitoring (LTM) of Groundwater (Alternative 3)

The no-action alternative, required under the NCP for inclusion in the detailed analysis of alternatives, provides a baseline against which the other alternatives can be compared. Alternatives 2 and 3 actively address the chemical and physical risks and focus on mitigation of these risks, in accordance with the RAOs for the site.[9]

[9] Please note that in its comments on the draft EE/CA Report (March 2001), HDOH requested consideration of additional alternatives for the removal action at Site LF01. The Air Force/contractor responses to these comments included detailed evaluation of two additional alternatives: Limited Surface Soil Excavation/Disposal with Long-Term Monitoring of Groundwater, and Limited Phytoremediation with Long-

For the purposes of evaluating the alternatives, (especially in terms of cost), the portion of Site LF01 requiring remediation is assumed to be approximately 45,800 square feet (approximately 1 acre) and to consist of approximately 8,500 cubic yards (12,800 tons) of contaminated soil and landfill materials.[10] Although the actual impacted area and soil/landfill materials volume may be smaller or larger, the estimate is considered to be conservative.

Attachment C presents detailed cost estimates for the removal action alternatives for Site LF01. It should be noted that these are order-of-magnitude estimates intended for comparative and programming purposes. The actual costs of the alternatives may be 30 percent less to 50 percent more than those shown in Attachment C. Final project costs will depend on actual labor and material costs, actual site conditions, competitive market conditions, the final project scope, the final project schedule, and other variables.

Figure 8 shows the portion of Site LF01 that is subject to the removal action. Sections 4.3.1 through 4.3.3 evaluate the removal action alternatives in terms of their effectiveness, implementability, and estimated cost.

4.3.1 Alternative 1: No Action

4.3.1.1 Description

This alternative, required under the NCP for inclusion in the detailed analysis of alternatives, includes no specific response actions for environmental monitoring, controlling the migration of contaminants, reducing their concentrations, or preventing exposure to them. Under Alternative 1, contaminated soil and landfill materials at Site LF01 would be left in place and no further action would be taken.

4.3.1.2 Effectiveness

Ability to Achieve RAOs. Alternative 1 would not meet any of the RAOs for Site LF01. It would not reduce the risks to human and ecological receptors from metals in surface soil or to current and future site personnel from exposure to physical hazards in shallow soil at the site. There would be no impacts to site operations from implementation of this alternative because no action would be taken. In addition, Alternative 1 would not adequately address reasonably anticipated future land uses.

Reduction in Toxicity, Mobility, or Volume through Treatment. Alternative 1 includes no treatment actions that would reduce the toxicity, mobility, or volume of contaminants at Site LF01.

Term Monitoring of Groundwater. Please refer to the responses to the HDOH comments in Attachment E for the detailed evaluations of these alternatives. They are not included in the main text of this final EE/CA Report because the results of the evaluations indicated that the alternatives do not merit further consideration for Site LF01.

[10] The estimate of 8,500 cubic yards is based on multiplying the area of the landfill by 5 feet (estimated to be the average landfill depth [approximately half the area is estimated at 2 feet thick; approximately half the area is estimated at 10 feet thick]).

Compliance with ARARs. Because Alternative 1 would not reduce the risks posed by the site, it would not comply with NCP requirements for acceptable exposure levels.

Short-Term Effectiveness. Alternative 1 would have no impact on the reduction of risks in the short term. In addition, because this alternative involves no removal action, no short-term risk of impacts to the community, workers, or the environment would result from its implementation.

Long-Term Effectiveness and Permanence. Alternative 1 would not provide any long-term effectiveness or permanence.

4.3.1.3 Implementability

By definition, no technical or administrative feasibility issues would need to be addressed with Alternative 1 because no action would be taken. The implementation of Alternative 1 would be immediate. No services or materials would be required for this alternative, and there would be no impacts on adjoining property. Obtaining agency, stakeholder, and community acceptance for Alternative 1 may be difficult, as it would do nothing to mitigate real and perceived risks posed by the chemical and physical hazards present in shallow soil at Site LF01.

4.3.1.4 Cost

As indicated in Table C-1 in Attachment C, Alternative 1 would incur no costs. Incidental costs that might be required to prepare NFRAP documentation and to gain agency, stakeholder, and community acceptance have not been included.

4.3.2 Alternative 2: Soil/Landfill Materials Excavation and Disposal/Recycling

4.3.2.1 Description

Under Alternative 2, the surface soil and landfill materials constituting the chemical / physical hazards at Site LF01 would be excavated and transported offsite. The area where soil and landfill materials would be excavated, as well as cross sections through the landfill, are shown in Figure 9. It is assumed that approximately 8,500 cubic yards (12,800 tons) of soil and landfill materials would be excavated. For cost estimating purposes, it is assumed that up to 40 percent of the landfill materials (concrete and metal debris) may be recyclable; that up to 40 percent of the materials may be disposed of at an off-island hazardous waste landfill permitted to receive CERCLA waste; and that the remaining 20 percent of the materials would be considered solid waste and would be disposed of at an on-island solid waste landfill.

The assumption that up to 40 percent of the landfill materials may need to be disposed of as hazardous waste is based on worst-case *estimates* of samples that may exceed toxicity characteristic leaching procedure (TCLP) criteria. Details of the basis for these estimates are provided in Attachment D.

Prior to excavation, eight monitoring wells (LF01-MW01, -MW03, and -MW05 through -MW10) would be abandoned in accordance with State of Hawaii Well Construction and Pump Installation Standards. Following excavation, confirmatory soil samples would be

collected and analyzed to verify that the removal action had been successfully implemented. Site restoration would then be performed, including the placement and grading of 2 feet of clean soil (approximately 4,300 yards) and 6 inches of top soil (approximately 900 cubic yards), and the planting of drought-resistant vegetation.

4.3.2.2 Effectiveness

Ability to Achieve RAOs. Alternative 2 would meet the RAOs for Site LF01. By removing the chemical and physical hazards, it would mitigate current concerns about exposure to these hazards; it would not impact installation operations or adjoining land uses; and it would enable planning for reasonably anticipated future land uses. However, Alternative 2 would impact vehicle traffic during implementation of the removal action.

Reduction in Toxicity, Mobility, or Volume Through Treatment. Alternative 2 includes no treatment actions that would reduce the toxicity, mobility, or volume of contaminants at Site LF01.

Compliance with ARARs. Alternative 2 is expected to comply with chemical-specific, location-specific, and action-specific ARARs for Site LF01.

Short-Term Effectiveness. The impacts to human health and the environment that could occur during construction include potential exposure of construction workers to contaminants through fugitive dust emissions, surface water runoff, and spillage during hauling. Implementation of Alternative 2 would have short-term impacts on vehicle traffic: i.e., approximately 290 truckloads would be required to transport the landfill materials from Bellows AFS for disposal.[11] In addition, approximately 150 truckloads would be required to transport clean soil and top soil to Site LF01.[12] Alternative 2 would therefore require coordination between Hickam AFB, Bellows AFS, and the community of Waimanalo well in advance of implementation.

Long-Term Effectiveness and Permanence. Alternative 2 would have a high degree of long-term effectiveness because the contaminated soil and landfill materials would be excavated from Site LF01, and potential risks from exposure to chemical and physical hazards would thereby be minimized.

Implementation of Alternative 2 would not have a long-term impact on vehicle traffic, installation personnel, and the Bellows AFS and Waimanalo communities. The remedy would be permanent.

Removal of contaminated soil and landfill materials, followed by confirmatory soil sampling, would adequately address reasonably anticipated future land uses and comply with NCP requirements.

[11] Based on transport of approximately 8,500 cubic yards of soil and landfill materials from the site at approximately 30 cubic yards per truckload.

[12] Based on transport of approximately 4,300 cubic yards of clean soil and top soil to the site at approximately 30 cubic yards per truckload.

If additional contaminated areas were discovered following soil removal and confirmatory sampling, these areas would also need to be addressed and could require excavation and removal.

4.3.2.3 Implementability

Technical Feasibility. Alternative 2 would offer adequate protection of the community, would have minimal environmental impacts, and could be implemented in a relatively short period of time. Excavation and removal is a widely used and well-developed remediation technique.

A staging area would be required because heavy equipment and trucks would be required to move, load, and haul soil and landfill materials. Temporary barrier fencing or flagging may need to be erected around the entire work area to limit access. However, these are familiar requirements that would need no special materials or expertise.

Administrative Feasibility. Implementation requirements would include processing the Base Civil Engineer Work Clearance Report (Air Force Form 103) and consultation regarding Section 7 of the Endangered Species Act (ESA) and Section 106 of the National Historic Preservation Act (NHPA). Waste to be transported to an off-island hazardous waste landfill and an on-island solid waste landfill would require profiling and manifesting. In addition, coordination with installation operations would be required prior to conducting the work.

Land Use Considerations. Because the contaminated soil and landfill materials would be completely excavated and disposed of offsite, future land use restrictions would not be required under Alternative 2.

Availability of Services and Materials. Because Site LF01 is situated in an isolated location at the installation, excavation activities would be expected to have minimal impact on operations at Bellows AFS and Waimanalo. Recycling facilities are available on the island of Oahu.

Monitoring. Because the contaminated soil and landfill materials would be completely excavated and disposed of offsite, LTM of groundwater would not be required under Alternative 2.

Operation and Maintenance. Because the contaminated soil and landfill materials would be completely excavated and disposed of offsite, no O&M would be required under Alternative 2 following site restoration.

4.3.2.4 Cost

As indicated in Table C-2 in Attachment C, the cost of implementing Alternative 2 is estimated at $5,171,100.

4.3.3 Alternative 3: Soil/Vegetative Cover with Long-Term Monitoring of Groundwater

4.3.3.1 Description

Under Alternative 3, Site LF01 would first be cleared of its existing vegetative cover. Two feet of clean soil (approximately 4,500 cubic yards) would then be imported, laid over the top of the landfill at the site, and compacted to 85 percent of standard proctor. Six inches of top soil (approximately 1,100 cubic yards) would then be laid over the top of the compacted fill and planted with drought-resistant vegetation. The approximate extent of the cover, as well as cross-section views through the landfill that indicate the relationship of the cover to the surrounding topography, are shown in Figure 10. For the purposes of this EE/CA, it is assumed that the cover would extend no less than 5 feet beyond the boundary of the landfill materials and that the slope of the cover would not exceed 2:1.

Because the soil would be certified as clean by the soil distributor, no confirmatory or verification sampling would be required. Temporary silt fencing would be erected during construction to minimize offsite erosion during construction. Once the vegetation had matured and the soil had stabilized, the silt fencing would be removed. Signs would be posted at the site, and gates would be installed across roads accessing the site.

Alternative 3 would also involve O&M of the cover, and LTM of groundwater in the vicinity of Site LF01. O&M of the cover would include periodic inspection of the vegetation to assess whether it was adequately mitigating surface soil runoff. For cost-estimating purposes in this report, it is assumed that this inspection would be conducted once every 3 years for at least 15 years following placement of the cover; thereafter, periodic inspections may continue to be conducted.

Although no COCs were identified for groundwater in the screening-level risk evaluation, LTM of groundwater would be warranted because the soil and landfill materials would be left in place under Alternative 3. Dissolved metals analysis would be included based on a conservative estimate of what may be expected to leach from the landfill materials (presented in Attachment D). The results of this analysis indicated that soil and/or landfill materials have the potential to fail the TCLP criteria for cadmium, chromium, lead, and mercury.[13] However, LTM of groundwater may also include analysis for VOCs, SVOCs, pesticides, PCBs, and herbicides.[14]

Following placement of the cover it is estimated that LTM of groundwater would continue annually for up to 5 years, at which time the data would be evaluated to determine whether

[13] No actual TCLP data have been obtained for Site LF01; however, total analysis results may be conservatively screened against TCLP criteria using what is commonly referred to as the "20 to 1 Rule" (U.S. EPA, 1992). This rule simply states that if a total analyte concentration is less than 20 times the TCLP criterion, the sample could not fail the TCLP criterion for the analyte because a 20:1 dilution factor is built into the TCLP test procedure. Conversely, if a total analyte concentration is greater than 20 times the TCLP criterion, the sample theoretically could fail the TCLP criterion, but the outcome is uncertain because of the physical and chemical characteristics of the analyte and the matrix being sampled. Therefore, comparing total sample analyte concentrations to 20 times the TCLP criteria provides worst-case *estimates* of samples that could potentially fail the TCLP criteria.

[14] The specific analytes to be included in the LTM will be identified in the Action Memorandum for Site LF01.

further monitoring was necessary. The groundwater monitoring network would consist of eight existing wells to monitor upgradient, downgradient, and cross-gradient concentrations of chemicals in groundwater; the locations of these wells are shown in Figure 11.

Finally, to ensure that the integrity of the landfill cover was maintained, institutional controls in the form of an Excavation Management Plan (prohibiting excavation and digging of soil without a pre-approved health and safety plan, requiring use of personal protective equipment [PPE], and other appropriate precautions) would also be developed as part of Alternative 3.

Upon completion of O&M and LTM at the site, the eight wells used for groundwater monitoring (LF01-MW01, -MW03, and -MW05 through -MW10) would be abandoned in accordance with State of Hawaii Well Construction and Pump Installation Standards.

4.3.3.2 Effectiveness

Ability to Achieve RAOs. Alternative 3 would meet the RAOs for Site LF01. It would mitigate current concerns about human and ecological exposure to contaminants in surface soil at the site; it would mitigate concerns about human exposure to physical hazards in shallow soil at the site; it would not impact adjacent operations and land uses during implementation of the removal action; and it would enable planning for reasonably anticipated future land uses. In addition, institutional controls (the Excavation Management Plan), O&M of the cover, and LTM of groundwater would mitigate future risks associated with leaving the contaminated soil and landfill materials in place.

Reduction in Toxicity, Mobility, or Volume through Treatment. Alternative 3 includes no treatment actions that would reduce the toxicity, mobility, or volume of contaminants at Site LF01.

Compliance with ARARs. Alternative 3 is expected to comply with chemical-specific, location-specific, and action-specific ARARs for Site LF01.

Short-Term Effectiveness. Alternative 3 would offer adequate protection of the community, would subject workers to only very limited exposure during implementation, would have minimal environmental impacts, and could be implemented in 60 days or less. In addition, approximately 180 truckloads would be required to transport clean soil and top soil to Site LF01.[15] Alternative 3 would therefore require coordination between Hickam AFB, Bellows AFS, and the community of Waimanalo in advance of implementation.

Long-Term Effectiveness and Permanence. Alternative 3 would have a moderate degree of long-term effectiveness because although the landfill materials would remain in place, institutional controls (the Excavation Management Plan) would further minimize the potential for exposure to chemical and physical hazards at the site, and O&M (for up to 15 years) would monitor the integrity of the cover. The implementation of Alternative 3 would

[15] Based on transport of approximately 5,600 cubic yards of clean soil and top soil to the site at approximately 30 cubic yards per truckload.

not have a long-term impact on vehicle traffic, installation personnel, or the Bellows AFS and Waimanalo communities.

4.3.3.3 Implementability

Technical Feasibility. The approach represented by Alternative 3 has been widely used. A soil / vegetative cover similar to Alternative 3 has been implemented at other former landfills on Oahu, including the 18-hole Mamala Bay Golf Course on Hickam AFB, Sand Island Recreation Park, and Kakaako Waterfront Park.

Alternative 3 would provide adequate protection of the community, have minimal environmental impacts, and could be implemented within 60 days or less. No special techniques, materials, permits, or labor would be required. The materials and procedures are readily available and well established. General construction skills and experience would be needed to import and place the soil cover.

Administrative Feasibility. Implementation requirements for Alternative 3 would include processing of the Base Civil Engineer Work Clearance Report (Air Force Form 103) and consultation regarding Section 7 of the ESA and Section 106 of the NHPA. Because there are no active facilities underground or overhead utilities in the area, implementation would require minimal permitting to control surface water runoff.

Because of the isolated location of Site LF01, implementation would not impact vehicle traffic, installation personnel, or the Bellows AFS or Waimanalo communities. Because Site LF01 is located on U.S. Marine Corps property, the Marines could control access and provide maintenance.

Land Use Considerations. Alternative 3 would enable planning for reasonably anticipated future land uses. However, if a land use change occurred that required the site to be regraded, disruption of the soil cover would occur and provisions for the disposal of soil and landfill materials would be required. The Air Force, the Marines, or another U.S. Department of Defense (DoD) entity could be additionally responsible for funding any future investigative / remediation efforts if the land use or ownership changed (U.S. EPA, June 1997).

Currently, environmental baseline surveys are required when a land use changes or new construction is proposed. As an additional safeguard, if the land use in a particular area changes, the Air Force requires that site data be reevaluated against appropriate screening criteria. This requirement ensures, for example, that if an area is changed from industrial to residential use, site data are reevaluated against residential rather than industrial screening criteria. Land use (deed) restrictions and O&M and LTM requirements would need to be specified in any future property excess or transfer. The deed restrictions would not specifically prohibit land use changes or construction, but would require property owners to address risks if land use changes or construction occurred.

Availability of Services and Materials. Except for PPE, no special personnel, technology, services, or materials would be required under Alternative 3. The materials and procedures are readily available and well established.

Monitoring. Alternative 3 would involve LTM of groundwater in the vicinity of Site LF01. Any new property owners would be responsible for continuing to implement the LTM unless a new removal decision was made and implemented based on a change in land use or ownership.

Operation and Maintenance. O&M would be required to periodically maintain the soil/vegetative cover at the site and to inspect surface soil conditions to mitigate runoff. Any new property owners would be responsible for continuing to maintain the cover unless a new removal decision was made and implemented based on a change in land use or ownership.

4.3.3.4 Cost

As shown in Table C-3 in Attachment C, the cost of implementing Alternative 3 is estimated at $1,049,500.

4.4 Comparative Analysis of Removal Action Alternatives

Several potential alternatives were initially considered and screened (as described in Section 4.1) to result in three removal action alternatives. This section presents a comparative analysis of these alternatives based on the evaluation criteria (effectiveness, implementability, and estimated cost). The comparative analysis indicates the advantages and disadvantages of each alternative relative to the others so that key tradeoffs affecting the selection of a removal action can be identified.

Table 4 summarizes the results of the comparative analysis. The effectiveness and implementability ratings assigned to each alternative are based on the following:

- A rating of "high" is assigned if the alternative satisfies/fulfills all the evaluation criteria and subcriteria for effectiveness and implementability.
- A rating of "moderate" is assigned if the alternative satisfies/fulfills some of the evaluation criteria and subcriteria for effectiveness and implementability.
- A rating of "low" is assigned if the alternative satisfies/fulfills few or none of the evaluation criteria and subcriteria for effectiveness and implementability.

Comparative analyses of the alternatives in terms of the criteria of effectiveness, implementability, and cost are provided below.

4.4.1 Effectiveness of Alternatives

Alternative 1 was assigned a rating of "low" for effectiveness because it would not meet any of the RAOs for Site LF01: it would not eliminate or mitigate the surface soil exposure pathway, and it fails to address reasonably anticipated future land uses. Furthermore, Alternative 1 includes no treatment actions that would reduce the toxicity, mobility, or volume of contaminants at Site LF01. Because Alternative 1 would not reduce the risks

posed by contaminants at the site, it would not comply with NCP requirements, and therefore would not comply with the ARARs for the site. Alternative 1 would also have no impact on the reduction of risk in the short term and would not provide any long-term effectiveness or permanence.

Alternative 2 was assigned an effectiveness rating of "moderate to high". Under Alternative 2, the contaminated soil and landfill materials would be excavated from Site LF01 and, therefore, this would be the most effective alternative for reducing risks to ecological receptors and future site workers. However, the short-term effectiveness of Alternative 2 would only be low to moderate because of the potential short-term exposure to workers removing the contaminated soil and landfill materials from Site LF01. In addition, the transport of soil and landfill materials from the site would impact vehicle traffic during the removal action.

Alternative 3 was assigned an effectiveness rating of "moderate" because it includes measures (institutional controls, O&M of the cover, and LTM of groundwater) that would achieve a high degree of effectiveness in reducing risks to ecological receptors and future site workers, but would be less effective than Alternative 2 in achieving permanent reduction of chemical concentrations and physical hazards. Under Alternative 3 the contaminated soil and landfill materials would remain at the site, and their toxicity, mobility, and volume would not be reduced through treatment.

4.4.2 Implementability of Alternatives

Alternative 1 was assigned a rating of "moderate" for implementability. No technical and administrative feasibility issues would need to be addressed because no action would be taken; the implementation of Alternative 1 would be immediate; no services or materials would be required; and there would be no impacts on adjoining property. However, obtaining agency, stakeholder, and community acceptance for Alternative 1 may be difficult, as it would do nothing to mitigate risks at Site LF01.

Alternative 2 would have an advantage over Alternative 3 in that no O&M or LTM would be required. However, the extensive transport of soil and landfill materials from the site could impact local traffic and impart an element of risk associated with transport of potentially hazardous materials during implementation of the removal action. Therefore, Alternative 2 was assigned a "moderate" rating for implementability.

Alternative 3 was assigned a rating of "moderate to high" because except for PPE, no special personnel, technologies, services, or materials would be required, and the materials and procedures for constructing the cover area readily available and well established. Alternative 3 would also have minimal impacts on installation operations or adjoining land uses. However, contaminated soil and landfill materials would remain at the site and would require continued commitment to O&M and LTM.

4.4.3 Estimated Costs of Alternatives

Alternative 1 would incur no costs. Of the two action alternatives, Alternative 2 would incur the higher costs, estimated at approximately six times those for Alternative 3.

Attachment C provides a detailed breakdown of the estimated costs for each alternative.

4.5 Recommended Removal Action Alternative

Based on the individual and comparative analyses presented in Sections 4.3 and 4.4, **Alternative 3 (Soil/Vegetative Cover with Long-Term Monitoring of Groundwater)** is the recommended removal action alternative for Site LF01. It is considered to be the most cost-effective method of achieving the RAOs, and it would minimize worker exposure to site hazards. The effectiveness and implementability ratings of Alternative 3 are similar to those assigned to Alternative 2; however, the soil removal required under Alternative 2 would make this alternative approximately six times more expensive than Alternative 3.

Figure 10 shows the approximate extent of the soil/vegetative cover anticipated under Alternative 3. The cost of implementing Alternative 3 is estimated at $1,049,500.

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