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ENVIRONMENTAL ASSESSMENT OF DIOXIN CONTAMINATION AT BIEN HOA AIRBASE

Environmental Assessment

FINAL

May 3, 2016

This document was produced for review by the United States Agency for International Development. It was prepared by CDM International, Inc. and Hatfield Consultants.

Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase

Environmental Assessment in Compliance with 22 CFR 216 - FINAL

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CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	micrograms per liter
10-80 Division	10-80 Division of the Ministry of Health
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4-D	2,4- dichlorophenoxyacetic acid
ACC	American Chemistry Council
ADAFC	Air Defense Air Force Command
ADB	Asian Development Bank
ADS	Automated Directive System
Airbase	Bien Hoa Airbase
AMST	Academy of Military Science and Technology
ASEAN	Association of Southeast Asia Nation
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AXYS	AXYS Analytical Services Ltd.
BEM	BEM Systems, Inc.
BEO	Bureau Environment Officer
BMP	best management practice
CC	Chemical Command
CDCS	Country Development and Cooperation Strategy
CDM Smith	CDM International, Inc.
CEDAW	United Nations Convention on the Elimination of Discrimination against Women
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFIA	Canadian Food Inspection Agency
CFR	United States Code of Federal Regulations
CIA	United States Central Intelligence Agency
cm	centimeter
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalent
COPC	contaminant of potential concern
CSF	concentration safety factor
DE	destruction efficiency
dioxin	2,3,7,8-tetrachlorodibenzo-p-dioxin
DOD	United States Department of Defense
DONRE	Department of Natural Resources and Environment
DQO	data quality objective
DU	decision unit

EA	Environmental Assessment
EDL	Environmental Decontamination, Ltd.
EIA	Environmental Impact Assessment
EMMP	Environmental Mitigation and Monitoring Plan
ESS	Environmental Scoping Statement
EU	European Union
FAA	Foreign Assistance Act
FAR	Federal Acquisition Regulation
FDA	Food and Drug Administration
FS	feasibility study
GAC	granular activated carbon
GCL	geosynthetic clay liner
GDP	gross domestic product
GEF	Global Environment Facility
GFH	granular ferric hydroxide
GGI	Gender Gap Index
GHG	greenhouse gas
GII	gender Inequality Index
GIS	geographic information system
GNI	gross national income
GPS	global positioning system
GSO	General Statistics Office
GVN	Government of Vietnam
H&S	Health and Safety
ha	hectare
Hatfield	Hatfield Consultants Partnership
HDI	Human Development Index
HDPE	high density polyethylene
hp	horsepower
hr	hour
HR-GCMS	high-resolution gas chromatography – mass spectrometry
IBT	Institute of Biotechnology
ICEM	International Centre for Environmental Management
IEE	Initial Environmental Examination
ILO	International Labor Organization
IPTD®	In-Pile Thermal Desorption
IR	Intermediate Result
ITRC	Interstate Technology and Regulatory Council
JAC	Joint Advisory Committee
KAP	knowledge, attitude, and practice

kg bw/d	kilograms body weight per day
km	kilometer
km^2	square kilometer
kWh	kilowatt-hour
L	liter
LLDPE	linear low-density polyethylene
LVTP	liquid vapor treatment plant
LWIC	lightweight insulating concrete
m	meter
M	million
m^2	square meter
m^3	cubic meter
masl	meters above sea level
MCD	mechano-chemical destruction
MCL	maximum contaminant level
MCS	Matrix Constituent Separator
mg/kg	milligrams per kilograms
MIS	multi-increment® sampling
mm	millimeter
MMBTU	million British Thermal Unit
MND	Ministry of National Defense
MOH	Ministry of Health
MOLISA	Ministry of Labor, Invalids and Social Affairs
MONRE	Ministry of Natural Resources and Environment
MPPE	macroporous-polymer extraction
MSD	Military Science Department
NAPL	non-aqueous phase liquid
NCFAW	National Committee for the Advancement of Women in Vietnam
NIP	National Implementation Plan
No.	number
NOx	nitrous oxide
O&M	operation and maintenance
Office 33	Office of National Steering Committee 33
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbons
PAP	project affected people
PAVN	People's Army of Vietnam
PCB	polychlorinated biphenyls
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran

pg	picograms
pg/g	picograms per gram
pg/L	picograms per liter
POP	persistent organic pollutant
PPE	personal protective equipment
ppm	parts per million
PPP	purchasing power parity
ppq	parts per quadrillion
ppt	parts per trillion
QA/QC	quality assurance/quality control
RAP	Resettlement Action Plan
RCE	Request for Categorical Exclusion
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCM	site conceptual model
SEP	stakeholder engagement plan
SITE	Superfund Innovative Technology Evaluation
SPLP	Synthetic Precipitation Leaching Procedure
SpO	Special Objective
SRB	sex ratio at birth
Study	Environmental Assessment at Bien Hoa Airbase
SVOC	semivolatile organic compound
t	ton
TCDD	tetrachlorodibenzo-p-dioxin
TCH	Thermal Conductive Heating
TCLP	Toxicity Characteristic Leaching Procedure
TDI	tolerable daily intake
TEQ	toxicity equivalent
TOC	total organic carbon
tph	tons per hour
U.S.	United States
UCL	upper confidence limit
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNPF	United Nations Population Fund
UNVN	United Nations Vietnam
USAID	United States Agency for International Development

USD	U.S. Dollar
USEPA	United States Environmental Protection Agency
USG	United States Government
UXO	unexploded ordnance
VAST	Vietnamese Academy of Science and Technology
VCP	Vietnamese Communist Party
VEA	Vietnam Environment Administration
VOC	volatile organic compound
VPHA	Vietnam Public Health Administration
VRTC	Vietnam-Russia Tropical Center
WHO	World Health Organization
ZT	Z1 Taxiway

Executive Summary

On September 29, 2013, the United States Agency for International Development (USAID) awarded a contract to CDM International, Inc. (CDM Smith) to carry out the project, "Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase." The purpose of the project is to complete an Environmental Assessment (EA) at the Bien Hoa Airbase (referred herein as the Airbase) that meets the requirements of Title 22 of the United States (U.S.) Code of Federal Regulations (CFR), Part 216. The Airbase is a key dioxin contamination hotspot due to past usage, storage, and handling of Agent Orange and other herbicides during the U.S.-Vietnam War. The overall objective of the EA at Bien Hoa Airbase (Study) is to inform potential future actions on the Airbase to address dioxin-related contamination.

An Environmental Scoping Statement (ESS), prepared as the first step in the development of the EA and approved by the USAID Asia Bureau Environment Officer (BEO) in October 2014, defined the scope of the EA. The scope of work for the EA at the Airbase included addressing significant potential adverse health-related, environmental, and social issues associated with implementing activities for remediation of dioxin-contaminated soil and sediment to Government of Vietnam (GVN) standards and enhancing beneficial use of the Airbase. The ESS determined that the EA would need to document stakeholder engagement discussions and consultations, applicable GVN standards for remediation, supplemental investigation sampling and analyses, the site conceptual model, evaluations of remediation alternatives, affected environment and environmental consequences of implementing remediation, consequences to social resources if they are indirectly affected through changes in the physical and natural environment from implementing remediation, approaches for environmental mitigation and monitoring, and resettlement.

Dioxin Contamination on and Around Bien Hoa Airbase

Prior to this Study, there had been at least eleven studies characterizing dioxin contamination in and around the Airbase since 1990. Seven of the eleven studies were obtained, but only five of the studies had data available. There are multiple areas of known or suspected contamination on the Airbase (Z1 Area, Southwest Area, Pacer Ivy Area, Northeast Area, and Northwest Area) and areas outside of the Airbase (west of the Pacer Ivy Area, and Gate 2 Lake and Bien Hung Lake to the south of the Airbase). The locations of these areas are shown in **Figure 2-1**.

Considering the results from historical sampling efforts, it was evident that dioxin-contaminated soil and sediment exists as a result of past handling, storage, and disposal of Agent Orange and other herbicides. When released, these extremely hydrophobic/water insoluble compounds became associated with the organic fractions of Airbase soils and sediment. Contaminated surface soils and sediments have spread from their original sites of storage, handling, and spills through several primary transport and release mechanisms: runoff during rainfall events; excavation and movement of contaminated material during the course of Airbase activities, such as construction and agriculture; and through wind erosion.

However, while the historical data provided good information on the nature of the contamination, there remained potential discrepancies in historical data and areas in need of further and better characterization to determine the full extent of contamination and to calculate a reliable estimate for the volume of dioxin-contaminated soil and sediment. To address these data gaps and needs, a sampling program was designed and implemented in close collaboration with the Vietnamese-assigned Study counterpart, the Vietnam Ministry of National Defense's Academy of Military Science and Technology (AMST). Samples were collected at the Airbase as part of this Study from 76 different areas called decision units during two separate field mobilizations in 2014 and 2015. These samples were collected using a comprehensive sampling methodology known as multi-increment® sampling (MIS), which is designed to best account for heterogeneity in soils and generate results with significantly less variability and a higher statistically-defensible level of confidence than discrete sampling or other less robust composite sampling methods. In total, the sampling program generated more than 1,400 samples, which included more than 1,300 composite soil and sediment samples for potential dioxin analysis and 100 samples of soil, sediment, groundwater, and biota for various chemical and/or physical property testing. The number of samples collected and analyzed as part of this Study is unprecedented in Vietnam and is the largest dioxin sampling program undertaken to date in the country.

Approximately 550 composite dioxin soil and sediment samples were analyzed and compared with the land use based dioxin limits approved by the Ministry of National Defense (MND) for the Airbase. The MND-approved dioxin limits are consistent with the Government of Vietnam's land use based standards for allowable limits of dioxin in soils (QCVN 45:2012/BTNMT) and sediment (TCVN 8183: 2009) and were applied based on current and likely future land use. Based on laboratory results, dioxin contamination was confirmed in known source areas (i.e., the Z1, Southwest, and Pacer Ivy Areas), other known, less contaminated areas on and off the Airbase (i.e., the Northeast and Northwest Areas, areas to the west of Pacer Ivy Area, and Gate 2 lake), and was also identified in a few new areas on and off Airbase (i.e., the Z1 Taxiway Area, and other portions of the Southwest and Pacer Ivy Areas). The total estimated volume of dioxin-contaminated soils and sediments identified during this Study is approximately 408,500 to 495,300 cubic meters (m^3). This consists of approximately 315,700 to 377,700 m^3 of contaminated soil and 92,800 to 117,600 m^3 of contaminated sediment found both on and off the Airbase.

Given the distribution of dioxin contamination in Airbase soils and sediments, as well as some off base sediments and fish, there remains exposure risk to receptors both inside and outside of the Airbase. Previous studies (Hatfield and Office 33 2011; Durant et al. 2014) have identified that the main pathway for exposure to dioxin from the site is consumption of fish and other aquatic organisms. All but one of the fish samples analyzed during the 2014/2015 sampling effort was contaminated, and fishing bans have historically not been effective (Thanh 2015). Thus, the raising, harvesting, and transport of contaminated fish and other aquatic animals to consumers both inside and outside the Airbase results in a high potential for dioxin contamination in the general population of Bien Hoa. There are other exposure pathways that remain open, but this potential consumption of fish and other aquatic animals remains the largest contributor to human health risk.

A subset of the soil and sediment samples was also analyzed to understand the influence of physical properties and/or potential impacts from the presence of other compounds and contaminants of potential concern (COPC) on a future remediation project. These analyses indicate that remediation alternatives need to consider the potential human health impact of arsenic in soils and sediments, but no other COPC were found to be located in areas of identified dioxin contamination, nor were they present at concentrations above applicable GVN standards or appropriate U.S. Environmental Protection Agency (USEPA) risk-based screening levels.

Samples of drinking water and shallow groundwater were also collected to understand current exposure pathways and pathways that may arise during future remediation. Several historical samples and two recent samples from shallow groundwater (not a drinking water source) collected on the Airbase adjacent to identified source areas have contained dioxin concentrations above the GVN wastewater discharge standard of 10 parts per quadrillion (ppq) as well as the USEPA drinking water standards (30 ppq) in unfiltered water. In the two recent samples with exceedances, the filtered water exceeded only the GVN wastewater discharge standard, and not the higher USEPA standard. Samples from on-site drinking water sources as well as off-site groundwater production wells did not contain concentrations of dioxin above applicable USEPA or GVN standards.

Remediation Alternatives

Data and information collected during the EA process were used to generate several remediation alternatives for evaluation ranging from no action through complete containment to complete treatment. The alternatives were developed using technologies identified from a literature review and that met screening criteria for maturity, cost competitiveness, and GVN acceptance. The alternatives evaluated in this EA include the following:

- <u>Alternative 1</u>: No Action (baseline; for comparison purposes).
- <u>Alternative 2</u>: Provide containment of all soil and sediment above the MND-approved dioxin limits established for the various areas of the Airbase:
  - Alternative 2A: Contain in a Passive or Active Landfill.
  - Alternative 2B: Contain using Solidification/Stabilization.
- <u>Alternative 3</u>: Treat all soil and sediment above 2,500 ppt; contain the soil and sediment between MND-approved dioxin limits and 2,500 ppt.
- <u>Alternative 4</u>: Treat all soil and sediment above 1,200 ppt; contain the soil and sediment between the MND-approved dioxin limits and 1,200 ppt.
- <u>Alternative 5</u>: Treat all soil and sediment above the MND-approved dioxin limits established for the various areas of the Airbase:
  - Alternative 5A: Treat using Incineration/*Ex Situ* Thermal Treatment.
  - Alternative 5B: Treat using *Ex Situ* Thermal Conductive Heating (TCH).
  - Alternative 5C: Treat using Mechano-Chemical Destruction (MCD).

Conceptual designs of the above alternatives were developed and evaluated with regard to effectiveness, implementability, cost, and environmental and social impact. All alternatives (except for the No Action Alternative, Alternative 1) would comply satisfactorily with GVN regulations and the MND-approved dioxin limits for the Airbase and achieve acceptable environmental and social impacts, including the removal and destruction of all fish and aquatic animals in all lakes. As such, all actionable alternatives reduce risk of human exposure to dioxin contamination. Therefore, any of the actionable alternatives (Alternatives 2 through 5) presented herein are preferable to the No Action Alternative.

Given the current and foreseen land use of a large majority of the contaminated area as a military airbase, a hybrid alternative that treats the highest risk material and contains all other excavated material is a reasonable option that balances U.S. Government (USG) and GVN regulatory preferences for treatment with more practical, lower-cost options for management of the lower risk material. Between the two containment technologies, the solidification/stabilization option is preferable to landfilling as it requires less maintenance and is a potentially permanent solution that could allow some reuses of the land, whereas landfilling requires maintenance and monitoring for the anticipated life of the landfill (typically 50 years, after which the integrity of the landfill may become compromised) and no land reuse within the landfill footprint. Among the treatment technologies, incineration and *ex situ* TCH are preferable to MCD, as incineration and *ex situ* TCH are well demonstrated for dioxin remediation at full scale, and can be implemented with effective treatment of off-gases at the concentrations found at Bien Hoa. While the MCD technology has been demonstrated for concentrations found at the Airbase, the test was not full scale (6 kilograms batches), upgrades are needed to improve issues associated with fugitive dust and off-gas controls, and air emissions control still needs to be verified through strict stack testing. Incineration bears more upfront capital costs but has the advantage of not requiring a patent and is something that could be sustained by the Vietnamese and used after dioxin remediation for treatment of other persistent organic pollutants. *Ex sit*u TCH, on the other hand, must be conducted by a patented vendor, and while the good performance of such technology at the Danang Airport remediation project provides more certainty in implementation, this technology is not something that could be "left behind" for the Vietnamese to use for other contaminants and/or at lesser dioxin hotspots.

A preliminary estimated overall cost was developed for each alternative (with the exception of Alternative 1 – No Action) based on the conceptual-level design presented in the EA. At the alternatives evaluation stage, the designs for the remediation alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." **The remediation alternative preliminary estimated overall costs were developed during the EA primarily for the purpose of comparing alternatives during the remediation alternative selection process, not for establishing Project budgets.** Costs for remediation alternatives are expected to have accuracies between -40% to +75% of actual costs, based on the scope presented.

Alternative 2A is the least expensive while Alternative 5A is the most expensive. Based on the contaminated volume estimate of 495,300 m^3, the preliminary estimated overall cost estimate for a passive landfill under Alternative 2A is $137 million (with an estimated cost range of $82 million to $239 million) over 5 to 6 years of implementation while for incineration under Alternative 5A the preliminary estimated overall cost estimate is $794 million (with an estimated cost range of $476 million to $1.4 billion) over 8 to10 years of implementation. For Alternative 1 – No Action, there are no costs associated with implementation or long-term operation and maintenance (O&M). However, there could be significant externalized costs, such as the costs associated with illness that might result from exposure to elevated concentrations of dioxin. While these costs cannot be quantified, they are important to note and could be substantial.

All remediation alternatives have a number of positive environmental consequences as a result of removing dioxin exposure pathways and reducing exposure risk to dioxin, as well as removing dioxin concentrations on the Airbase as a constraint to land use changes and development. In general, the overall environmental and associated social and gender impacts of all remediation alternatives are potentially substantial. However, there are mitigation and monitoring measures available to address all potential environmental and associated social and gender impacts and at a small fraction of the costs for any of the alternatives.

Additional Future Considerations

All remediation alternatives require planning and engineering designs, project approval by the GVN, and procurement. It is anticipated this process could take three to five years prior to implementation of any alternative. In general, once an alternative and technology(ies) have been selected and a design contractor has been procured (a process which could take one to two years), approximately two to three years should be allowed for the development of full implementation designs, the GVN's required environmental impact assessment, and all associated approval processes.

Moving forward, project stakeholders have several considerations and actions that are necessary to develop a remediation project from the conceptual designs discussed within this EA. In approximate chronological order according to a typical project lifecycle (i.e., study through implementation), project stakeholders should consider some additional targeted site characterization and baseline data gathering to assist with future design and planning activities. This should include: a risk assessment; further evaluation of specific remediation technologies identified during the EA process; consultations with the GVN and other potential implementing partners to select an overall remediation strategy including roles and responsibilities, and develop full design packages for the chosen strategy; and incorporation of lessons learned from the implementation of remediation at Danang Airport. Stakeholders should also consider implementation of additional interim measures to reduce ongoing exposure risk to the local population both on and off of the Airbase, especially from consumption of contaminated fish and biota, regardless of how or when implementation occurs.

Section 1 Summary

1.1 Purpose and Procedure

This document is the Environmental Assessment (EA) prepared under Task Order AID-486-13-00009, Environmental Assessment at Bien Hoa Airbase (the Study), funded by the United States Agency for International Development (USAID). This document has been prepared by CDM International, Inc. (CDM Smith) and Hatfield Consultants (Hatfield) in compliance with Title 22 of the United States (U.S.) Code of Federal Regulations (CFR), Part 216.

The Bien Hoa Airbase (referred herein as the Airbase) is a prominent dioxin contamination hotspot due to past usage, storage, and handling of Agent Orange and other herbicides during the U.S.-Vietnam War. The overall objective of this EA is to inform potential future actions on the Airbase to address Agent Orange-related contamination. Specifically, the purpose of this EA is to:

- Understand the full nature and extent of dioxin contamination on and around the Airbase.
- Determine exposure pathways from dioxin contamination.
- Evaluate feasible environmental short-term mitigation and monitoring/interim measures.
- Evaluate potential long-term remediation alternatives.

In addition, a gender assessment was conducted and is included in this EA to:

- Determine if there are gender biases regarding exposure to dioxin in the home or workplace resulting from current exposure pathways or which might result from recommended dioxin containment and remediation at the Airbase.
- Develop measures to mitigate gender bias that would be incorporated into containment and remediation designs, if necessary.

The EA at Bien Hoa Airbase is subject to the environmental procedures established under Title 22 U.S. CFR Chapter 216 (22 CFR 216) and the Request for Categorical Exclusion (RCE) prepared as part of the Initial Environmental Evaluation (IEE), approved on September 6, 2012, and the IEE Amendment to the RCE, approved on March 2, 2015, which changed the EA categorization to a Negative Determination with Conditions. The purpose of this EA is to fulfill requirements for environmental remediation at the Airbase in accordance with 22 CFR 216.6(a) which states:

> "The purpose of the Environmental Assessment is to provide Agency and host country decision makers with a full discussion of significant environmental effects of a proposed action. It includes alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources."

The Bien Hoa EA began with a scoping phase, which included information gathering of historical environmental data and current site specific conditions; this scoping phase was documented in an Environmental Scoping Statement (ESS) as required under 22 CFR 216 and was approved by the USAID

Asia Bureau Environment Officer (BEO) in October 2014. The ESS determined the scope and significance of issues to be analyzed in the EA and identified and eliminated from detailed study those issues that were not significant or had been covered by earlier environmental reviews, thereby defining the scope of the EA. The scope of work for the EA at the Airbase included addressing significant potential adverse health-related, environmental, and social issues associated with implementing activities for remediation of dioxin- containing soil and sediment to GVN standards and enhancing beneficial use of the Airbase. The ESS determined that the EA would need to document stakeholder engagement discussions and consultations, applicable GVN standards for remediation, supplemental investigation sampling and analyses, the site conceptual model, evaluations of remediation alternatives, affected environment and environmental consequences of implementing remediation, consequences to social resources if they are indirectly affected through changes in the physical and natural environment from implementing remediation, approaches for environmental mitigation and monitoring, and resettlement. These key findings and recommendations of the ESS were reviewed and re-assessed as new information became available during the preparation of the EA regarding existing environmental and social resources and assets and details of the alternatives being considered.

Following the ESS, an extensive sampling program was developed and conducted in close collaboration with the GVN – in particular the Ministry of National Defense (MND) – between November 2014 and April 2015 to determine the current nature and extent of dioxin contamination at the Airbase. Based on the resultant data and the MND-approved dioxin limits for the Airbase, dioxin-contaminant volumes were calculated and remediation alternatives were conceptualized. At the same time, an environmental, social, and gender baseline of the Airbase and adjacent communities was developed using existing information. Each of the remediation alternatives was then assessed for potential environmental, social, and gender effects, cost, implementability, and effectiveness, and a conceptual Environmental Mitigation and Monitoring Plan (EMMP) was prepared.

As such, this EA provides the basis for selection of a preferred project alternative or alternatives for remediation of dioxin contamination at the Airbase. Vietnamese environmental law and its environmental compliance regulations require an Environmental Impact Assessment (EIA) for dioxin remediation activities once a preferred remediation alternative has been selected and a specific project defined. Therefore, this EA also represents a first step in the GVN EIA process, to be elaborated upon if and when a remediation alternative is selected and accompanying designs and cost estimates are prepared. If additional, potentially significant impacts on the environment are identified during the design process of a selected alternative, the EA will be amended to reflect these. Additional detail on the purpose, regulatory framework, and interaction with GVN is included in **Section 2**.

1.2 Project Area

The Airbase is located in Bien Hoa City (**Figure 1-1**), Dong Nai Province, approximately 30 kilometers (km) northeast of Ho Chi Minh City. Bien Hoa City has an average population density of approximately 3,400 persons per square kilometer (km^2) (Dong Nai Statistical Office 2013). The Airbase property is adjacent to Trung Dung, Quang Vinh, and Buu Long Wards and lies within Tan Phong Ward. Surrounding areas are densely populated, with most of the land used for housing, industrial facilities, transportation, and associated infrastructure. There were approximately 885,000 persons living in Bien Hoa City in 2013 (Dong Nai Statistical Office 2013); in 2012, approximately 111,000 persons lived in the city wards surrounding the Airbase and 1,200 persons lived on the Airbase (Canh 2012b). Current estimates provided by the Air Defense Air Force Command (ADAFC) indicate that there are up to

2,200 workers on the Airbase at peak times. Given recent population growth estimates of Dong Nai Province (Dong Nai Statistical Office 2013) it is estimated that the current population living in the city wards surrounding the Airbase and on the Airbase itself is approximately 120,000 persons[1].

The Airbase is an active military airbase and encompasses a total area of approximately 1,000 hectares (ha). Situated on low-lying land immediately to the east and northeast of the Dong Nai River, the Airbase has been used for agriculture, forestry, and aquaculture particularly in the northern part of the property. From 2007 to 2009, the Vietnam Public Health Association (VPHA) and, in 2013, the Office of National Steering Committee on Overcoming Consequences of Toxic Chemicals Used by U.S. during the War in Vietnam (Office 33) implemented awareness raising activities and interim measures to reduce exposure of airbase workers and the local communities to dioxin contamination (Vu-Anh et al 2010; Hatfield and Office 33 2011). The dangers associated with dioxin exposure were explained to residents, and signs were erected to warn people not to fish in the numerous aquaculture ponds. Aquaculture was banned by the Airbase authorities in 2010 per Office 33's recommendations and fences were constructed around the perimeter of key aquaculture ponds to restrict access. Despite these efforts, fishing activities continue to occur in Airbase waterbodies and have been observed as recently as December 2015 (Thien-Le Quan 2015).

With respect to land use on the Airbase property:

1. Approximately 1,200 people live on the Airbase (Canh 2012b), with up to 2,200 workers on the Airbase during peak times.
2. There are 20 units of army guards on the Airbase, which is enclosed by a perimeter wall/fence.
3. Air force training activities are extensive, and occur mainly in the east apron area.
4. There is a factory complex with an area of 50 ha southeast of the runways.
5. Part of the Airbase property is used for warehouses and storage.
6. The northern part of the Airbase property is used for agriculture (including family gardens and cattle grazing, which were noted as recently as April 2015) and contains rubber plantations.
7. There are a number of aquaculture ponds on the Airbase property (raising primarily Nile Tilapia, *Oreochromis niloticus*, but also ducks and other aquatic organisms); use of these ponds for aquaculture purposes was officially banned in 2010 by the Airbase (per Office 33's recommendation). However, enforcement of the fishing ban has been challenging. Reports from local residents indicate that the majority of fishing taking place since the ban is by migrants from other provinces, who have not benefited from the education programs implemented by Office 33 (Thien-Le Quan 2015).

[1] In 2012, approximately 111,000 persons lived in the city wards surrounding the Airbase, while approximately 1,200 persons lived on the Airbase itself (Canh 2012b). For the purposes of this EA a current population of 120,000 persons living in the vicinity of and on the Airbase is estimated, with 1,200 of these persons assumed to be living on the Airbase. This estimate is reflective of recent population growth estimates of Dong Nai Province reported in Dong Nai Statistical Office (2013) and Hatfield (2015).

1.3 Historical Use of Agent Orange and Other Herbicides at Bien Hoa Airbase

During the U.S.-Vietnam War, over 80 million liters of herbicides were sprayed over South Vietnam in a code-named mission called Operation Ranch Hand (Cecil 1986). Bien Hoa Airbase was the largest and most active Ranch Hand site in Vietnam. These herbicide mixtures were predominantly used to defoliate forests and crops, and many of them contained 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) as a contaminant by-product. The Airbase is recognized as a dioxin hotspot due to high TCDD concentrations remaining decades after the large volumes of Agent Orange and other herbicides were stored, handled, and spilled at the Airbase during the U.S.-Vietnam War (Dwernychuk et al. 2002; Dwernychuk 2005).

Three large storage tanks were used for herbicide storage at the Airbase; one each for Agent Orange, Agent White, and Agent Blue. According to U.S. military data, the Airbase was used to store and handle 98,000 45-gallon (170-liter) barrels of Agent Orange, 45,000 barrels of Agent White and 16,000 barrels of Agent Blue (U.S. Department of Defense [DOD] 2007). Agent Blue did not contain dioxin but organic arsenic was in the formulation. Additional herbicide formulations were also used at the Airbase included Agents Purple, Pink, Green and others. The Pacer Ivy mission was launched on September 15, 1971 to consolidate, re-drum, and ship all remaining Agent Orange herbicide and Ranch Hand herbicides in South Vietnam to Johnston Atoll in the central Pacific Ocean.

1.4 Potential Exposure Pathways and Site Conceptual Model

A site conceptual model (SCM) is a synthesis of available site data, and a critically important tool to explain and understand those data, identify gaps in site data, describe exposure pathways, develop short-term mitigation actions, develop and evaluate long-term remediation alternatives, and ultimately implement remedial actions effectively. The SCM is informed by historical land use information, the characteristics of site contaminants, and known site characteristics, such as surface water flow paths. A preliminary SCM was developed for the ESS.

Given results from historical sampling efforts, it is evident that contaminated soil and sediment exists as a result of past handling, storage, and disposal of Agent Orange and other herbicides. When released, these extremely hydrophobic compounds became associated with the organic fractions of Airbase soils and sediment. Contaminated surface soils and sediments have spread from their original sites of storage, handling, and spills through several primary transport and release mechanisms: runoff during rainfall events; excavation and movement of contaminated material during the course of Airbase activities, construction, and agriculture; and through wind erosion. The raising, harvesting, and transport of contaminated fish and other aquatic animals to consumers both inside and outside the Airbase results in a high potential for dioxin contamination in the general population.

1.5 Dioxin Contamination on and around Bien Hoa Airbase

Several sampling programs have been conducted within and around the Airbase since 1990 to determine concentrations exceeding national and international dioxin limits (**Section 3.2.1**). The known major dioxin source areas on the Airbase were identified as follows:

- **Z1 Area**: Located in the southern area of the Airbase, Z1 was the main storage area for Agent Orange, Blue, and White herbicides at the Airbase and initially contained the most heavily contaminated materials at the Airbase. A landfill (referred to as the Z1 Landfill) was constructed at the Airbase in 2009 to contain the contaminated soils from the area where the storage tanks were located.
- **Southwest Area:** Located west of the Z1 Area along residential areas abutting the boundary of the Airbase, dioxin contamination was discovered in this area during studies in 2008 and 2010. The area was suspected to be used as an herbicide storage area during the Pacer Ivy mission at the Airbase (Hatfield and Vietnam-Russia Tropical Centre [VRTC] 2009; Hatfield and Office 33 2011).
- **Pacer Ivy Area:** Located on the western end of the Airbase, the Pacer Ivy Area is close to the current runway. During the Pacer Ivy mission, this area was used to store, re-drum and package 11,000 containers of Agent Orange for shipping to Johnston Atoll in the central Pacific Ocean. Under the United Nations Development Programme (UNDP) Global Environment Facility (GEF) Dioxin Project in 2013, a series of drainage ditches were constructed around the perimeter of the Pacer Ivy Area to restrict flow into this area and outside of the Airbase. In addition, a ban on aquaculture in the area was also implemented.

In addition to the known major source areas, elevated dioxin concentrations have also been found in lake sediments in the Northwest Area, Northeast Area, and outside the Airbase (Gate 2 Lake, Bien Hung Lake, and in the drainage canal west of the Pacer Ivy Area). Whole fish, as well as fish fat, and muscle tissue samples analyzed from lakes and waterways within and outside of the Airbase have exceeded acceptable limits (Hatfield and Office 33 2009, 2011). Dioxin has also been recorded in blood serum and breast milk in the human population in Bien Hoa, with highest concentrations recorded in individuals who regularly consumed Tilapia and other fish species from the Airbase (Hatfield and Office 33 2009, 2011; Nguyen et al. 2011). These previous studies identified the potential for contamination of local Bien Hoa residents, and confirmed the main exposure pathway was through consumption of fish and other aquatic organisms on the Airbase (Durant et al. 2014).

In order to fully characterize the nature and extent of dioxin contamination across the Airbase, an extensive sampling program was implemented by the USAID in November-December 2014 and March-April 2015 as part of this EA (**Section 3.2.2**). Sampling locations were selected based on professional judgement, previous sampling programs, known gaps in knowledge, and input from the MND to ensure samples were collected from the perimeter of the Airbase. Sampling was completed in nine general areas of the Airbase (Z1 Area, Z1 Taxiway [ZT] Area, Southwest Area, Pacer Ivy Area, Northwest Area, Northern Forest Area, Northeast Area, Southeast Area, and Lakes Outside of the Airbase). The nine general areas were divided into decision units (DUs) that were considered a reasonable size to assess dioxin exposure and to estimate average dioxin concentrations. **Figure 1-2** shows the locations of these areas and identifies the specific locations of the DUs that were sampled during the 2014/2015 sampling program. Each DU was further divided into three screening level sub-decision units (sub-DUs) in order to further refine the contaminated volume estimate. Dioxin concentrations detected in samples were compared against the Vietnam National Standards on Allowed Limits of Dioxin in Soils (QCVN 45:2012/BTNMT) and MND-approved dioxin limits for each sampled area (**Section 3.2.4**). The allowable limit of dioxin contamination (parts per trillion [ppt] toxicity equivalent [TEQ] on a dry weight basis) is determined based on land use (**Table 1-1**).

The following are the main results from USAID's EA 2014/2015 sampling program (analytical results presented are in ppt by mass (which is picograms per gram [pg/g]) TEQ):

1. **General:** Results from the 2014/2015 sampling program indicated that dioxin contamination in soils at the Pacer Ivy Area is more extensive than other areas, followed by the Southwest Area and Z1 Area. However, the highest dioxin concentration in a sub-DU was recorded in the Southwest Area. Based on the sampling results and the MND-approved dioxin limits for each sampled area, the total estimated volume of dioxin-contaminated soils and sediments is approximately 408,500 to 495,300 cubic meters (m^3). This range in volume accounts for potential variability in site conditions during excavation and is explained in more detail in **Section 3.2.5**. The total volume consists of approximately 315,700 to 377,700 m^3 of contaminated soil and 92,800 to 117,600 m^3 of contaminated sediment. The estimated area of contamination encompasses about 522,400 square meters (m^2), of which approximately 369,600 m^2 is in soil areas and 152,800 m^2 is in sediment areas. Of the dioxin-contaminated baseline volume of 408,500 m^3, 42 percent (%)is in the Pacer Ivy Area, 24% is in the Z1 Area (including the Z1 Landfill), and 15% is in the Southwest Area. The remaining 19% is located in the ZT, Northwest, and Northeast Areas. Approximately 5% of the total dioxin-contaminated baseline volume is located off of the Airbase.
2. **Z1 Area:** With the exception of the landfill and sediment in the lakes in the Z1 Area (a maximum of 1,578 ppt in sediments at Z1-10 at 15-30 centimeter [cm] depth), overall dioxin concentrations were relatively low (especially in soils). Excavation of contaminated soils and construction of the landfill in 2009 appears to have been effective in significantly reducing overall dioxin concentrations in the Z1 Area (also reported by Hatfield and Office 33 2011). The maximum soil dioxin concentration recorded, excluding the landfill, was at Z1-16B (901 ppt). Tilapia from Z1-9 exhibited dioxin concentrations above guidelines for human consumption such as the European Union's (EU's) 3.5 ppt standard and the Canadian Food Inspection Agency [CFIA] guideline of 20 ppt (68.3 ppt in whole fish).
3. **Z1 Landfill:** Dioxin concentrations in the landfill (1,510 ppt) were lower than expected, given the amount of contaminated soil contained in this area and high concentrations reported from this area by Hatfield and VRTC (2009; maximum 262,000 ppt). Based on current understanding of how the Z1 Landfill was constructed with a waste thickness of about1.5 meters (m) over a measured area of approximately 4.0 ha, it is estimated to contain approximately 60,000 m^3 of contaminated soils. As discussed in **Section 3.2.1**, previous estimates indicated a volume of 94,000 m^3 (Hatfield 2013).
4. **ZT Area:** Located north of the Z1 Area, this was the former taxiway for transportation of herbicide, aircraft loading/unloading, and for moving equipment during the war, but had never been investigated prior to the 2014/2015 EA Study. Dioxin concentrations reported during this Study were low in this area (i.e., below the MND-approved dioxin limits), with the exception of one area in ZT-2B (3,440 ppt).
5. **Southwest Area:** This area exhibited the highest dioxin concentration of all sub-DU locations sampled on the Airbase (110,000 ppt at SW-1A, 30-60 cm depth). Contamination in the Southwest Area appears to be concentrated in the SW-1, SW-2A and B, and SW-3A and B DUs. However, dioxin concentrations exceeding the MND-approved dioxin limits were also recorded at SW-7A (674 ppt) and SW-7B (311 ppt).

6. **Pacer Ivy Area:** A number of DUs in the Pacer Ivy Area exhibited dioxin concentrations above the MND-approved dioxin limits, particularly along the western boundary of the Airbase (PI-2, PI-8, PI-10, PI-17, PI-18, and PI-20); the maximum soil dioxin concentration was recorded at PI-2 (11,400 ppt at 30-60 cm depth). Contamination extended outside the Airbase to PI-12, PI-15, and PI-16, especially along the drainage canal west of the Pacer Ivy Area (maximum 3,370 ppt at PI-15). The source of this dioxin contamination is transport of contaminated soil/sediment via drainage from the Pacer Ivy Area, which flows westward through a series of canals to the Dong Nai River. However, contamination was not found in the Dong Nai River sediments sampled downstream of the canal (maximum of 69.1 ppt at PI-21). Catfish from PI-20 exhibited high concentrations of dioxin (57.7 ppt in muscle; 3,550 ppt in fat; 69.5 ppt for the whole fish); previously this area was also used extensively for Tilapia aquaculture and for raising of ducks and other aquatic animals, but operations have ceased as of 2015.
7. **Northwest Area:** Sediment dioxin concentrations were above the MND-approved dioxin limits in NW-4A (477 ppt at 0-15 cm, and 262 ppt at 15-30 cm depth) and at NW-3C (385 ppt at 0-15 cm, and 587 ppt at 15-30 cm depth). Both of these ponds were being used for aquaculture at the time of the EA sampling program in March 2015; Tilapia collected from NW-4 had the highest dioxin concentration of all fish sampled and were above dioxin limits (49.9 ppt in muscle; 760 ppt in eggs; 3,780 ppt in fat).
8. **Northern Forest Area:** Dioxin concentrations measured in samples from this area were below MND-approved dioxin limits, except for NF-4A and B (a maximum of 465 ppt).
9. **Northeast Area:** Sediments in several lakes in this area had dioxin concentrations above MND-approved dioxin limits. The highest sediment dioxin concentrations were recorded at NE-7 (1,300 ppt at 0-15 cm; 765 ppt at 30-45 cm). Tilapia fat sampled from this lake also exhibited dioxin concentrations (837 ppt) above the dioxin limits. Bighead Carp sampled from NE-15 also had dioxin concentrations, particularly in fat, above the dioxin limit (1,440 ppt in fat; 33.9 ppt in muscle). This area is the site of the most extensive aquaculture operations on the Airbase, with several large lakes producing significant quantities of fish for consumption and sale both inside and outside the Airbase.
10. **Southeast Area:** This area had not been investigated prior to the 2014/20115 EA Study. Only low dioxin concentrations were measured in soils sampled in this area (a maximum of 64.5 ppt at SE-2) and are below the MND-approved dioxin limits.
11. **Outside the Airbase (Offsite Lakes):** Gate 2 Lake surface sediments (166 ppt) were above the GVN dioxin contamination standard for sediments (150 ppt); Bien Hung Lake sediments (83 ppt) were below the GVN standard for dioxin contamination. Dredging, or cleaning, of sediment from Bien Hung Lake occurred in 1995 (Nguyen et al 2005), and it appears to have been a very effective measure in reducing dioxin concentrations in sediment. However, fish from Bien Hung Lake had dioxin concentrations above the dioxin limit in fat (40.6 ppt), but below the guideline in other tissues (0.8 ppt in muscle and 9.4 ppt in eggs). No fish were caught from Gate 2 Lake; however, historical sampling results from this location indicated dioxin concentrations above dioxin limits in whole Tilapia (Hatfield and Office 33 2009; 2011).
12. **Drinking Water:** Samples from off-site groundwater production wells and on-site drinking water sources indicated no concentrations of dioxin above applicable U.S. Environmental Protection Agency (USEPA) or GVN drinking water standards.

13. **Other Onsite Groundwater:** In addition to the drinking water samples described above, unfiltered and filtered water samples were also collected from groundwater monitoring wells on the Airbase. Five of the groundwater monitoring wells are screened at depths of 3 to 15 m below ground surface and one well is screened at 2 to 6 m, all of which are too shallow to be a viable drinking water source. These samples contained concentrations of dioxin above the USEPA maximum contaminant level (MCL) and GVN discharge standard in unfiltered water, as well as the metal lead above its USEPA MCL. Picloram was detected in the most recent 2015 samples at concentrations below USEPA MCLs, but MCL exceedances have been observed during past studies (Dekonta 2014). In the filtered monitoring well water samples, dioxin concentrations were below the USEPA MCL, but remained above the GVN discharge standard of 10 parts per quadrillion (ppq). The groundwater from these locations is not utilized as a drinking water source. The decrease in dioxin in filtered samples is expected given dioxin is very insoluble in water, and much more likely to partition to suspended organic solids.

1.6 Risk Reduction Measures

Several measures (**Section 3.3.1**) have been implemented at the Airbase by the MND, Office 33, and the UNDP GEF Dioxin Project to reduce the risk of exposure to high levels of dioxin. The Z1 Landfill was constructed in 2009 by the MND in the Z1 Area and contains approximately 60,000 m^3 of contaminated soil excavated from the area. As discussed further in **Section 3.2.1**, previous studies had indicated a landfilled volume of 94,000m^3. In 2015, MND began construction of the XD-2 Landfill (located on the east side of the Z1 Landfill) to contain contaminated soil from the Southwest Area. In 2013 and early 2014, surface water controls were implemented in the Pacer Ivy Area, the Northwest Area, and the Northeast Area by Office 33, with funding from the GEF through the UNDP, to manage stormwater that could come in contact with contaminated soils or sediments. In addition, fencing and/or warning signs have been erected near several of the lakes to deter access and fishing, fishing bans have been enacted, and Office 33 has conducted communication programs regarding dioxin information. If these measures operate as intended, then controls are already in place to significantly reduce the exposure potential to dioxin contamination.

There are additional measures that should be considered to further limit exposure potential (**Section 3.3.2**), including: controlling or removing offsite contamination; removing all fish and biota within Airbase lakes, Gate 2 Lake, and Bien Hung Lake; erecting fencing, signage, and other appropriate access controls to limit future fishing activities; and continuation with the Office 33 communication programs.

1.7 Long-Term Remediation Alternatives

A list of potentially-applicable technologies was developed after researching previous technology evaluations and the scientific literature (**Section 4.2.1** and **Appendix C**). An initial screening of technologies was conducted to eliminate those technologies that did not meet the following three criteria (described in more detail in **Section 4.2.2**):

- Has the technology or strategy demonstrated dioxin destruction or containment on a scale larger than a lab study, and from the range of concentrations measured in soils and sediments at the Airbase to below the range of required land-use-based dioxin limits? If a particular technology has not been demonstrated to treat or contain materials to below land-use-based dioxin limits, it should not receive the same consideration as a technology or strategy that has demonstrated maturity and applicability.

- Would full-scale costs be prohibitive, or not competitive with what other comparable technologies could achieve? Technologies with available cost data, even if conceptual, were compared. Those without cost information or with only limited cost information, were assessed using professional judgment regarding expected cost drivers.
- Is the technology or strategy expected to be acceptable to Vietnamese stakeholders? This criterion is based on feedback from GVN stakeholders during early discussions regarding technology evaluation, or during past discussions.

A detailed description of all technologies and the screening process is presented in **Appendix C**. Alternatives for remediation were then developed using the technologies and strategies retained from the screening process. All alternatives (except for the No Action Alternative, Alternative 1) were designed to comply satisfactorily with GVN regulations (**Section 2.5.1**) and land use based MND-approved dioxin limits (**Section 3.2.4**), and to achieve acceptable environmental and social impacts. Further all actionable alternatives reduce risk of human exposure to dioxin contamination. Therefore, any of the actionable alternatives (Alternatives 2 through 5) presented herein are preferable to the No Action Alternative. All actionable alternatives also include removal of all fish and other aquatic animals at all lakes (**Section 4.4**). Alternatives were developed while also considering potential exposure pathways, DU area and volume considerations, general logistics and feasibility, and the advantages and limitations of each technology and/or strategy.

Within those constraints, alternatives were designed to cover a range of effort from no action through complete containment to complete treatment as shown in **Figure 1-3** and summarized as follows:

- <u>Alternative 1</u>: No Action (baseline; for comparison purposes).
- <u>Alternative 2</u>: Provide containment of all soil and sediment above the MND-approved dioxin limits established for the various areas of the Airbase:
  - Alternative 2A: Contain in a Passive or Active Landfill.
  - Alternative 2B: Contain using Solidification/Stabilization.
- <u>Alternative 3</u>: Treat all soil and sediment above 2,500 ppt; contain the soil and sediment between MND-approved dioxin limits and 2,500 ppt.
- <u>Alternative 4</u>: Treat all soil and sediment above 1,200 ppt; contain the soil and sediment between the MND-approved dioxin limits and 1,200 ppt.
- <u>Alternative 5</u>: Treat all soil and sediment above the MND-approved dioxin limits established for the various areas of the Airbase:
  - Alternative 5A: Treat using Incineration/*Ex Situ* Thermal Treatment.
  - Alternative 5B: Treat using *Ex Situ* Thermal Conductive Heating (TCH).
  - Alternative 5C: Treat using Mechano-Chemical Destruction (MCD).

Under Alternatives 2 through 5, all sediment that exceeds the GVN allowable limits for dioxin is excavated. There is no in place solidification/stabilization of sediments. The 2,500 ppt concentration threshold was selected for Alternative 3 based on a natural break point in the data but happens to separate the estimated volume of contaminated soil and sediment into approximately 75% containment and 25% treatment. The 1,200 ppt dioxin concentration threshold selected for Alternative 4 corresponds to the 1,200 ppt GVN standard for industrial land use.

Both Alternative 2A and 2B focus exclusively on dioxin containment, whereas Alternatives 5A, 5B, and 5C are designed to provide only dioxin destruction through treatment. Alternatives 3 and 4 are designed to provide a hybrid remediation approach that treats higher concentration material and contains lower concentration material. Because of this, the following evaluation first presents the containment alternatives (Alternative 2), then the treatment technologies (Alternative 5), then selects one containment and one treatment alternative to be utilized in the hybrid approaches (Alternatives 3 and 4). The selection of specific containment and treatment technologies for Alternatives 3 and 4 is not intended to indicate that these technologies are preferred or selected. Rather, Alternatives 3 and 4 were developed and evaluated against the other alternatives to assess varying combinations of containment and treatment, given the large difference in costs between containment and treatment technologies (i.e., treatment may cost 4 to 6 times as much as containment).

1.7.1 Alternative 1: No Action

The No Action alternative examines the potential environmental impacts of not addressing dioxin contamination at the Airbase (**Section 4.4.1**). This alternative establishes baseline information and estimates that existing routes of exposure would persist over a number of years/decades without action. This alternative provides a baseline against which other alternatives are compared.

1.7.2 Alternative 2: Containment Only

Two alternatives were developed following the initial technology screening that can be utilized to contain dioxin-impacted soils and sediments in order to reduce potential for exposure and to prevent migration in the environment. In all containment-only alternatives, all excavated soil DUs would be backfilled with imported clean material; sediment DUs would not be backfilled.

1.7.2.1 Alternative 2A: Landfill

In this alternative (**Section 4.4.2**), all soils and sediments above the MND-approved dioxin limits for the various areas of the Airbase (with the exception of the Z1 Landfill, which would remain intact) would be excavated and hauled to one of two new landfills constructed on the Airbase for disposal and containment. One landfill would be located in the Pacer Ivy Area and one would be located in the Z1 Area.

There are two types of landfills that could be constructed: passive and active. The two types of landfills have essentially the same major design and construction elements, with the difference being that an active landfill incorporates bioremediation with the goal of destroying dioxin inside the landfill. The EA evaluates a passive landfill with the option of converting to an active landfill pending future demonstrations to show effectiveness of dioxin removal via bioremediation.

1.7.2.2 Alternative 2B: Solidification/Stabilization

Solidification and stabilization of contaminated soil and sediment is a process used to prevent migration of contaminants from the material, thereby preventing exposure (**Section 4.4.3**). Solidification is a process that binds contaminated media in a solid form, decreasing the permeability of the material and encapsulating the contaminant. Stabilization is a chemical process used to immobilize contaminants and reduce the solubility and leachability of the contaminant from the waste material.

In a solidification/stabilization remedy, binders and admixtures are added to the soil and sediment and mixed, either *in situ* using augers or other excavation equipment, or *ex situ* using machine mixers such as a pug mill. Common admixtures used in solidification and stabilization include inorganic binders such as cement, fly ash, and lime, as well as organic binders and stabilizers such as activated carbon, asphalt, or organophilic clays. The addition of an organic carbon stabilizer is expected to be advantageous during solidification/stabilization of soils and sediments containing dioxins, as dioxin would tightly bind with the carbon. While limited data are available for long-term solidification/stabilization for dioxin-contaminated materials (e.g., leachability data 10 years after solidification/stabilization), information available from hazardous waste sites in the U.S. indicates reductions in leachability of dioxins from stabilized/solidified soil to levels below the USEPA MCL for drinking water (30 ppq, which is equivalent to picograms per liter [pg/L]).

1.7.2.3 Comparison of Containment Alternatives

Both of the containment alternatives described above (landfill and solidification/stabilization) are expected to be feasible and readily implementable at the site. Both technologies are effective at containment of dioxin-impacted materials, though solidification/stabilization is expected to be more effective at reducing mobility of dioxins. However, the costs associated with landfill implementation are lower than the solidification/stabilization alternative.

The landfill alternative (2A) was selected as the containment strategy for cost estimation purposes in Alternatives 3 and 4. The selection of landfill as the containment technology for use in Alternatives 3 and 4 was done only to allow relative comparison of varying combinations of treatment and containment, and not to identify it as the selected containment technology.

1.7.3 Alternative 5: Treatment Only

Three demonstrated treatment alternatives were retained during the initial technology screening. The following sections describe the alternatives developed using these treatment technologies. In all treatment-only alternatives, treated material would be used to backfill soil DUs, with the exception of soil that would be treated at the end of the project. Treated sediments and soils not used for backfill would be placed in a final treated material stockpile at a location approved by the Airbase and GVN.

1.7.3.1 Alternative 5A: Incineration/*Ex Situ* Thermal Treatment

Incineration is a well-established technology for dioxin remediation, as several applications of the technology have been implemented for remediation of dioxin-contaminated soils and sediments. In order to volatilize and destroy dioxins in an incinerator, high temperatures, ranging from approximately 870 to 1,200 degrees Celsius (°C), are required. Several types of incinerators have successfully been used to destroy dioxin (BEM Systems, Inc. [BEM] 2007), though rotary kiln incinerators have been most frequently utilized in the U.S. to remediate dioxin-contaminated soils (USEPA 1998a, USEPA 1998b). Destruction efficiencies (DEs) can be as high as 99.9999% for rotary kiln incinerators. Further, the throughput for rotary kiln incinerators used for large-scale treatment of dioxin in soil is documented to be as high as approximately 25 to 30 tons per hour (tph) (USEPA 1998a, USEPA 1998b). Based on observed performance and operational parameters from incinerators in the U.S., approximately 8,100

m^3 of contaminated soil can be processed in one month. All soils and sediments would be excavated and transported to a central location (either at Z1 or Pacer Ivy Areas) for incineration (**Section 4.4.5**).

1.7.3.2 Alternative 5B: *Ex Situ* TCH

TCH is a commonly used and mature remediation technology (USEPA 2010), and has also been demonstrated to be capable of generating and distributing sufficient heat to desorb and destroy dioxin from soils and sediments (ENSR 2000, Baker and La Chance 2003, Baker et al. 2007, Heron et al. 2010, USAID 2015c). TCH can be implemented either *in situ* or *ex situ*, but the distribution of dioxin at the Airbase over large areas and small thicknesses makes *in situ* treatment technically impracticable because of excessive heat losses. Conversely, excavating and placing contaminated material in an above-ground, insulated structure for *ex situ* treatment, as was done using IPTD® at the Danang Airport remediation project, would enable better management of heat losses and provide a more efficient heating environment. An *ex situ* TCH alternative would therefore include excavation of all contaminated soil and sediment exceeding the MND-approved dioxin limit in each DU, and transporting it to one of two areas for treatment (**Section 4.4.6**). Impacted soil and sediment would be placed in one of two insulated, capped pile structures (one located in the Z1 Area and one located in the Pacer Ivy Area), and heated to a target temperature of 335°C. Most of the dioxin would be oxidized or pyrolyzed in the pile, while the remainder would be volatilized and extracted. Extracted dioxin would be adsorbed in a treatment system prior to discharge of treated off-gas and steam condensate.

1.7.3.3 Alternative 5C: MCD

The MCD technology involves using mechanical energy to initiate chemical reactions and subsequent destruction of recalcitrant organic molecules. These mechanochemical reactions are very complex and may involve a variety of mechanisms. However, it is generally accepted that the primary destruction mechanism involves generation of free radicals formed during fragmentation of silica-rich soil particles and subsequent physical and chemical interaction of these high-energy oxidants with the organic compounds of interest that yields amorphous carbon and inorganic salts (Heineke 1984). The internationally-patented MCD reactors consist of special hard-wearing cast rotors that make continuous contact with thousands of stainless steel balls to create continuous and repetitive particle collisions. These collisions facilitate generation of the aforementioned free radicals capable of chemically transforming the dioxins to carbon and inorganic halides. Operated as a closed and scalable system, MCD technology has been demonstrated for treatment of dioxins with a DE of up to 99.99% under laboratory- and pilot-scale settings.

The MCD alternative would involve excavation of contaminated soil and sediment, removal of excess moisture, transport of materials to stockpile areas located in the Z1 and Pacer Ivy Areas, treatment using MCD reactors located in these areas, and confirmation sampling and subsequent backfilling of excavations with treated material and/or stockpiling of the leftover treated materials in a location agreeable to the Airbase and GVN (**Section 4.4.7**).

1.7.3.4 Comparison of Treatment Alternatives

All of the treatment alternatives described above are expected to be feasible and implementable at the Airbase, and are demonstrated capable of reducing dioxin concentrations in soil to below GVN standards (to levels below all standards for Alternatives 5A and 5B, and to below commercial/industrial standards for Alternative 5C). However, the costs associated with *ex situ* TCH are lower than the incineration or MCD alternatives. Therefore, *ex situ* TCH (5B) was selected as the treatment strategy for cost estimation purposes in Alternatives 3 and 4, which are described below. The selection of *ex situ* TCH as the treatment technology for use in Alternatives 3 and 4 was done only to allow relative comparison of varying combinations of treatment and containment, not to identify it as the selected treatment technology.

1.7.4 Alternative 3: Landfill Material < 2,500 ppt, *Ex Situ* TCH Material > 2,500 ppt

This alternative utilizes a combination of a containment strategy (landfills) and a treatment strategy (*ex situ* TCH) to address dioxin-impacted soils and sediments at the Airbase (**Section 4.4.9**). Under this alternative, soils and sediments with dioxin concentrations greater than 2,500 ppt TEQ would be treated using *ex situ* TCH, while soils and sediments with concentrations between the MND-approved dioxin limits and 2,500 ppt would be placed in landfills and contained. The Z1 Landfill would remain in place since it has an average dioxin concentration less than 2,500 ppt. The 2,500 ppt concentration threshold was selected for Alternative 3 based on a natural breakpoint in the data but happens to separate the volume of soil and sediment that exceeds GVN allowable limits for dioxin contamination into approximately 75% containment and 25% treatment.

1.7.5 Alternative 4: Landfill Material < 1,200 ppt, *Ex Situ* TCH Material > 1,200 ppt

This alternative utilizes the same general approach as Alternative 3, with a combination of a containment strategy (landfills) and a treatment strategy (ex situ TCH) to address dioxin-impacted soils and sediments at the Airbase. Under Alternative 4, soils and sediments with dioxin concentrations greater than 1,200 ppt TEQ (including the current Z1 Landfill) would be treated using *ex situ* TCH, while soils and sediments with a concentration between the MND-approved dioxin limits and 1,200 ppt would be placed in landfills and contained (**Section 4.4.10**).

1.8 EA Evaluation and Results

The EA included preparing conceptual designs for each alternative and used the following criteria to evaluate the alternatives: 1) effectiveness of the alternatives to achieve cleanup goals and/or to contain dioxin-impacted soils and sediments to reduce exposure; 2) implementability of each alternative at the Airbase; 3) cost of the alternatives; and 4) potential environmental impacts of each alternative. **Table 1-2** presents a summary of the evaluation of the alternatives against these criteria and a summary of the anticipated implementation schedule for each alternative. The following subsections describe the evaluation criteria.

1.8.1 Effectiveness

Effectiveness of an alternative can be evaluated based on several factors, including:

- Short-term effectiveness: the alternative should be able to reduce the short-term exposure to dioxins in the impacted media, including during implementation of the alternative.
- Long-term effectiveness: the alternative should be able to reduce the presence or likelihood of exposure over the long term. Long-term monitoring requirements to confirm the effectiveness may be necessary for some alternatives. Alternatives that destroy the dioxin would be more effective in the long term compared to alternatives that contain dioxin-impacted soils and sediments.

- Effectiveness for all media: the alternative needs to be able to be utilized on any of the impacted media at the Airbase, specifically soil and sediment of varying composition.
- Effective over a range of concentrations: the alternative needs to be effective whether the impacted soils and sediments contain relatively low or relatively high concentrations of dioxin.
- Effective at treatment of impacted soils to below the GVN standards based on land use: the alternative should be able to remove dioxins from the impacted soils and sediments to below the appropriate dioxin limit.

1.8.2 Implementability

The implementability of an alternative is dependent on numerous factors, including:

- Technology availability: are the specific technologies, equipment, supplies, and expertise readily available in the vicinity of the project, or would these items need to be imported or sourced from outside the country? Additionally, are multiple vendors or contractors available who can implement a particular technology, and are the technologies patented?
- Scalability: given the relatively large volumes of impacted soils at the Airbase, a technology needs to be able to operate effectively at a large scale.
- Site-specific limitations: issues such as climate (rainy and dry seasons), future land use, availability of utilities, and limitations on work in specific areas of the Airbase may make some alternatives more challenging to implement.
- Duration of treatment: the length of time required to adequately implement an alternative is important to evaluate, as longer implementation timeframes may require longer periods of operation and maintenance activities and temporary environmental controls and mitigation measures (i.e., stormwater controls during construction), and therefore may be less desirable for project stakeholders. In addition, an alternative that can be implemented faster would reduce potential exposure risk to the surrounding population sooner.
- Material handling requirements: alternatives requiring more handling of residual materials and by-products or generate waste materials might make them more challenging to implement.
- Long-term monitoring requirements: the need for long-term effectiveness monitoring or institutional controls might make an alternative more challenging to implement or maintain over the long term.

1.8.3 Cost

A preliminary estimated overall cost was developed for each alternative (with the exception of Alternative 1 – No Action) based on the conceptual-level design presented in the EA and in general accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, EPA 540-R-00-002 (USEPA 2000). At the alternatives evaluation stage, the designs for the remediation alternatives are still conceptual, not detailed, and the cost estimates are considered to be "order-of-magnitude." **The remediation alternative preliminary estimated overall costs were developed during the EA primarily for the purpose of comparing alternatives during the remediation selection process, <u>not</u> for establishing Project budgets.** Costs for remediation alternatives are expected to have accuracies between -40% to +75% of actual costs, based on the scope presented. Factors such as increased project duration and phased implementation that might require longer field implementation time may increase the cost, although by an undetermined amount. Another factor related to the cost evaluation of each alternative is the sensitivity of the cost to both the schedule for implementation and the volume of material to be addressed by the alternative.

Alternative 2A is the least expensive while Alternative 5A is the most expensive. Based on the contaminated volume estimate of 495,300 m^3 (including contingency volume), the preliminary estimated overall cost estimate for a passive landfill under Alternative 2A is $137 million (with an estimated cost range of $82 million to $239 million) over 5 to 6 years of implementation, while for incineration under Alternative 5A the preliminary estimated overall cost estimate is $794 million (with an estimated cost range of $476 million to $1.4 billion) over 8 to 10 years of implementation.

For Alternative 1 – No Action, there are no costs associated with implementation or long-term operation and maintenance (O&M). However, there could be significant externalized costs, such as the costs associated with illness that might result from exposure to elevated concentrations of dioxin. While these costs cannot be quantified, they are important to note and could be substantial.

1.8.4 Environmental and Social Consequences

The potential effects of each alternative on environmental and social resources were characterized using the following set of criteria: magnitude, geographic extent, duration and frequency of impact, and ability of the environmental or social resource in question to recover after each remedial alternative had been implemented. Both objective and subjective considerations were included in the application of these criteria. Objective considerations included the ability to meet statutory or regulatory requirements related to environmental protection and management such as ambient air quality objectives, water quality guidelines, effluent discharge limits, regional environmental objectives, and international environmental obligations. Professional judgment was applied when potential effects could not be predicted quantitatively due to limited data availability or when there are no benchmarks against which to compare predicted quantitative impacts.

All remedial alternatives have a number of positive environmental consequences as a result of removing dioxin exposure pathways and reducing exposure risk to dioxin, as well as removing dioxin concentrations on the Airbase as a constraint to land use changes and development. In addition, there are a number of environmental resources, notably protected areas and cultural, heritage, and tourism resources, for which all remedial alternatives are predicted to have no impact.

In general, however, the overall environmental and associated social and gender impacts of all remedial alternatives are potentially substantial. All alternatives require the excavation, transport, and deposition of a large volume of dioxin-contaminated soil from hotspots into a landfill or stockpile for either containment or treatment, and vegetated lowlands must be drained and dredged to remove contaminated sediments. In addition, any treatment component has significant energy requirements and, therefore, environmental impacts associated with the release of greenhouse emissions. **Environmental impacts are unavoidable over the short term in order to eliminate the possibility of future dioxin exposure to humans and the environment.**

However, there are mitigation and monitoring measures available to address all potential environmental and associated social and gender impacts. Properly implemented as part of the selected remedial alternatives, all potential environmental and associated social and gender impacts are determined as mitigable and a conceptual EMMP framework has been

developed as part of this EA. The residual, or remaining, environmental and associated social and gender impacts after the application of the EMMP are predicted to be as follows:

1. Residual effects are predicted to be local, occurring almost exclusively within the Airbase property. The exception to this is greenhouse gas (GHG) emissions which, by their very nature, are global in geographic extent.
2. The duration of all residual effects is predicted to be short-term and occurring during the construction and operation of the remediation alternative only, with the exception of risk of compromised integrity of landfills and solidification/stabilization structures for a number of the remedial alternatives, as well as the risk of re-contamination of selected Airbase lakes, both of which are predicted to be residual legacies of the remediation alternatives.
3. All residual effects for all remediation alternatives considered in this EA are predicted of low magnitude. Residual effects are predicted to be somewhat above typical background conditions, but well within established or accepted protective standards and normal socio-economic fluctuations, and will cause no detectable change in ecological, social or economic conditions.

There is a high level of confidence in the predicted environmental effects of the remediation alternatives because predicted effects are based on good understanding of cause-effect relationships and data and information from the Airbase, Bien Hoa City, and experience from the Danang Airport remediation project, as well as a set of proven and well-accepted mitigation and monitoring measures for effectively reducing or limiting potential environmental and related social and gender impacts of any of the remediation alternatives assessed in this EA.

The results of this EA suggest that environmental and social consequences of all remediation alternatives are similar: (i) all remediation alternatives evaluated in this EA have the same set of environmental and social issues requiring a determination; (ii) all potential environmental and social effects associated with any remediation alternative evaluated in this EA are mitigable; and (iii) the conceptual EMMP/EMMP framework developed in this EA is applicable to any remediation alternative evaluated in this EA. There was no significant difference in the preliminary estimated overall costs among mitigation measures necessary for each remediation alternative. Overall the cost estimates for mitigation measures is small relative to the costs of implementing any of the remediation alternatives.

Given the range of alternatives examined in this EA and the results of the environmental assessment described above, the same general conclusions regarding environmental and social consequences and conceptual scope of EMMP may be expected of any other remediation alternative that may be ultimately selected for Bien Hoa Airbase. This includes any variations on any of the remediation alternatives evaluated in this EA or any other remedial technology that might be selected and included in a remediation alternative. An entirely new EA for these sorts of situations (i.e., variation on any of the remediation alternatives evaluated in this EA or any other remedial technology that might be selected and included in a remediation alternative) would therefore not be required. Rather, an amendment to this EA should be sufficient for these situations, and would be an early step to be done in a detailed design phase for the selected remediation alternative. This amended EA would be the basis for an EIA for the selected remediation alternative that would need to be prepared by GVN in order to meet Vietnam's national environmental assessment regulations.

1.9 Stakeholder Engagement and Response

During this Study, six Stakeholder Engagement Meetings were held at key project milestones to engage the GVN stakeholders, provide updates and results, receive feedback, and obtain concurrence/acceptance. Details of the meetings (i.e., purpose, location, and date) are provided in **Section 2.4**.

At Stakeholder Engagement Meeting No. 5 in March 2016, the structure of the EA was explained to GVN stakeholders, and they were provided with a copy of the Draft Final EA for review and comment. In April 2016 at Stakeholder Engagement Meeting No. 6, GVN stakeholders provided comments on the Draft Final EA. Participants included the Academy of Military Science and Technology (AMST), ADAFC, Chemical Command (CC), VRTC, Military Science Department (MSD), Office 33, Dong Nai Department of Natural Resources and Environment (DONRE), USAID, CDM Smith, and Hatfield. A summary of the comments received from GVN stakeholders and associated responses are provided in **Table 1-3**.

As a result of these meetings, GVN perspectives were captured and consensus gained on the technical content associated with the major milestones of the EA, including historical sampling data, the supplemental sampling plan and results, the short list of technologies, and the remediation alternatives. Furthermore, the meetings resulted in significant information sharing that enabled a much more concise assessment.

1.10 Additional Considerations

To facilitate the next steps to be taken by project stakeholders and decision makers, this EA presents several considerations. These additional considerations are presented in more detail in **Section 8**, and summarized below:

- Additional Site Characterization Considerations: additional investigation activities may be useful to further understand dioxin concentrations in the Southwest Area, where excavation for the XD-2 Landfill occurred, to identify the bottom of contamination in a few DUs, understand arsenic speciation, and to increase understanding of site groundwater that may be encountered during any remediation activities. It may also be worthwhile to complete a biodiversity survey.
- Technology Evaluation Considerations: additional testing and/or evaluation of several potentially applicable treatment technologies (active landfill/bioremediation, solidification/stabilization, soil washing, and thermal desorption) may be appropriate. These technologies may be beneficial in reducing volumes of contaminated material, overall project costs, and uncertainty in design details.
- Pre-Implementation Considerations: a risk assessment to prioritize remediation activities and drive technical decisions on excavation depths and treatment goals, additional design and planning, approvals, and procurement will be necessary to proceed, and will help reduce cost uncertainty, but may take 3 to 5 years. It will also be necessary to develop further an overall implementation strategy, in consultation with GVN and other potential implementing partners. Confirmation of available utilities (power, water, and fuel for incineration) will also be necessary. It may also beneficial to consider dividing up or phasing the work as informed by the risk assessment and discussions with the GVN, and consider opportunities to improve energy efficiency. Special consideration is likely warranted regarding additional interim measures (**Section 3.3**) regardless of how or when implementation occurs, so as to reduce the high risk of exposure associated with consumption of contaminated fish and other biota from lakes on and around the Airbase. Additional

measures could include both social and institutional measures (e.g., enforcement and monitoring of fishing bans, awareness raising campaigns, etc.) and environmental controls (e.g., physical removal of fish populations from aquaculture ponds on the Airbase). Additionally, it may be useful to begin planning mitigation measures for communities outside the Airbase that may need resettlement, clear unexploded ordinance (UXO) from project areas, and plan further stakeholder engagement. Finally, lessons learned from planning for the Danang Airport remediation project should be considered, such as documentation of baseline conditions.

- Implementation Considerations: decision makers should consider technology transfer limitations with specialized vendors, applicable lessons learned from project implementation at the Danang Airport remediation project, and monitoring and institutional controls that will be necessary even after successful completion of remedial actions to keep land uses consistent and minimize risk of exposure to any dioxin that is not destroyed during remediation.

Table 1-1 GVN Dioxin Standards/Allowable Limits of Dioxin Contamination Specified in GVN National Technical Regulation on Allowed Limits of Dioxin in Soils (QCVN 45:2012/BTNMT)

Land Use Type	Allowable Limit of Dioxin Contamination (ppt TEQ dry weight)
Annual crop land	40
Forest land and perennial tree land	100
Rural residential land	120
Urban residential	300
Recreational	600
Commercial	1,200
Industrial	1,200

Table 1-2 Summary of Alternatives Evaluation

Alternative	Effectiveness Containment or Treatment to Below MND-Approved Dioxin limits	Implementability	Preliminary Estimated Overall Cost for Contamination Volume Range (Million USD) (-40% to +75%)		Implementation Schedule for Contamination Volume Range
			Baseline Volume	Baseline with Contingency Volume	
Alternative 1 No Action	Not Effective for Containment or Treatment	Implementable	Not applicable (Externalized)	Not applicable (Externalized)	Not applicable
Alternative 2A Landfill	Effective for Containment, but Not Effective for Treatment	Implementable with challenges: landfill siting, significant fill material required, long-term O&M	$126M ($76M to $221M)	$137M ($82M to $239M)	• 3 to 5 years for planning, approvals, and procurement • 5 to 6 years construction • 50-year long-term O&M and monitoring
Alternative 2B Solidification/ Stabilization	Effective for Containment, but Not Effective for Treatment	Implementable with challenges: treatability testing, stockpile siting, significant fill material required, long-term O&M	$202M ($121M to $354M)	$229M ($138M to $402M)	• 3 to 5 years for planning, approvals, and procurement • 6 to 7 years construction • 50-year long-term O&M and monitoring

Alternative	**Effectiveness** Containment or Treatment to Below MND-Approved Dioxin limits	**Implementability**	**Preliminary Estimated Overall Cost for Contamination Volume Range (Million USD) (-40% to +75%)**		**Implementation Schedule for Contamination Volume Range**
			Baseline Volume	**Baseline with Contingency Volume**	
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	***Landfilling*** - Effective for Containment, but Not Effective for Treatment ***TCH*** - Effective for Treatment (Demonstrated)	Implementable with challenges: ***Landfill*** - siting, fill required, long-term O&M ***TCH*** - Energy usage (moderate-high), infrastructure, monitoring during treatment	$226M ($135M to $395M)	$236M ($142M to $413M)	• 3 to 5 years for planning, approvals, and procurement • 7-year construction • 50-year long-term O&M and monitoring of landfill
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	***Landfilling*** - Effective for Containment, but Not Effective for Treatment ***TCH*** - Effective for Treatment (Demonstrated)	Implementable with challenges: ***Landfill*** - siting, fill required, long-term maintenance and institutional controls ***TCH*** - Energy usage (moderate-high), infrastructure, monitoring during treatment	$377M ($226M to $660M)	$390M ($234M to $683M)	• 3 to 5 years for planning, approvals, and procurement • 10-year construction • Long-term maintenance and institutional controls of landfill
Alternative 5A Incineration	Effective for Treatment (Demonstrated)	Implementable with challenges: Energy usage (high), infrastructure, monitoring during treatment	$666M ($400M to $1,166M)	$794M ($476M to $1,389M)	• 3 to 5 years for planning, approvals, and procurement • 8 to 10 years construction and operation • No long-term O&M

Alternative	**Effectiveness** Containment or Treatment to Below MND-Approved Dioxin limits	**Implementability**	**Preliminary Estimated Overall Cost for Contamination Volume Range (Million USD) (-40% to +75%)**		**Implementation Schedule for Contamination Volume Range**
			Baseline Volume	**Baseline with Contingency Volume**	
Alternative 5B *Ex Situ* TCH	Effective for Treatment (Demonstrated)	Implementable with challenges: Energy usage (moderate-high), infrastructure, monitoring during treatment	$539M ($323M to $943M)	$640M ($384M to $1,121M)	• 3 to 5 years for planning, approvals, and procurement • 14 to 16 years construction and operation • No long-term O&M
Alternative 5C MCD	Effective for Treatment (Demonstrated, but not to below all GVN standards)	Implementable with challenges: Energy usage (moderate), infrastructure, monitoring during treatment	$600M ($360M to $1,050M)	$712M ($427M to $1,247)	• 3 to 5 years for planning, approvals, and procurement • 8 to 10 years construction and operation • No long-term O&M

Table 1-3 Summary of Comments Received from GVN Stakeholders on EA Document

Comment Received from GVN Stakeholders	Response
General	
The EA is a well-structured document, providing abundant, updated, and highly indicative information. The methodology used is very scientific and comprehensive. The EA is the most comprehensive report prepared to date for Bien Hoa.	Acknowledged.
Since this is a joint project between the U.S. and Vietnam, please include Vietnamese partners in the list of preparers.	The Vietnamese partners have been added to **Section 10**.
Background Information and Regulations	
The Airbase area is approximately 1,000 ha, not 760 ha as identified in the Draft EA.	This has been revised throughout the document.
During peak hours, there are currently about 2,200 workers on the Airbase.	This clarification has been added to **Sections 1.2, 2.1, and 3.1**.
The regulations section should include QCVN 43:2012, which relates to dioxins/furans in sediment quality. The list of regulations should be checked and updated.	The regulation has been added to **Section 2.5.3.1**. Also, as mentioned in **Section 2.5.3**, the list of laws and regulations identified is not comprehensive. Once a remediation alternative is selected, this list will need to be updated and expanded during the development of the detailed design and EIA to reflect those that are specifically related to the selected alternative.
Explain the basis for applying the standard of 1,200 ppt instead of 1,000 ppt.	The 1,200 ppt is from the most current GVN regulation on the maximum allowable dioxin concentrations in soils, which is based on land-use. Portions of the Airbase have been identified as having an industrial land use (1,200 ppt), urban residential (300 ppt), and forest land (100 ppt). Please refer to **Sections 2.5.1 and 3.2.4**, and **Tables 2-1 and 3-7**.

Comment Received from GVN Stakeholders	Response
It appears that not all of the historical sampling data are presented in the EA, and some of those results indicated some very high concentrations.	As discussed in **Section 3.2.1** and presented in **Table 3-1**, eleven studies have been conducted at the Airbase prior to this Study to characterize dioxin. Seven of these studies were reviewed for the ESS; however, data from only five of these studies were provided by GVN for preparation of the EA. During consultations with GVN during the development of the ESS, there were comments from stakeholders regarding the validity of historical data: several sampling events were conducted more than 10 years ago; the sampling methodology and laboratory analytical procedures from that time may be quite different from what is acceptable today; and the results may not reflect the current status of the site, considering there might have been disturbance and/or construction on the site. Because of this, it was suggested that the older data be used as a "screening tool" to identify where dioxin could be present and additional sampling be performed to assess the areas. That recommendation was followed for this Study. Please also see the comment and response below regarding MIS sampling and high concentrations.
Current Landfills	
The volume contained in the Phu Cat Landfill should be approximately 11,000 m^3, not 7,500 m^3.	References to the Phu Cat landfill volume have been changed to 11,000 m^3 in **Section 2.1**.
Construction of the XD-2 Landfill has been ongoing. Please update to reflect the current status.	The status of the XD-2 Landfill has been updated in several areas of the EA, including **Sections 1.6, 3.3.1, and 8.2**.

Comment Received from GVN Stakeholders	Response
Please clarify the volume contained in the Z1 Landfill and why the volume is different from what has been identified in previous reports.	Previous reports have had conflicting information regarding the area and volume of the Z1 Landfill: an area of 4.3 ha and a volume of 43,000 m^3 was indicated in Hatfield and Office 33 (2011); and an area of 4.7 ha and a volume of 94,000 m^3 was indicated in the Bien Hoa Master Plan (Hatfield 2013). As part of this Study, measurements in the field and on aerial imagery have shown that area of the Z1 Landfill complex (including perimeter ditching, walls, stormwater treatment system, old concrete pad [Z1-17], and landfill) is 4.3 ha and that the lined portion of the complex (i.e., the area containing contaminated material) is approximately 4.0 ha. Also, review of landfill drawings and conversations with Chemical Command indicated the landfill was constructed with a waste thickness of about 1.5 m. These two factors would indicate a contamination volume of approximately 60,000 m^3. To account for potential variances in waste thickness, an additional 20,000 m^3 (0.5 m over an area of 4.0 ha) has been included in the contingency volume estimate. This has been clarified in several areas of the EA, including **Sections 1.5, 1.6, and 3.2.1**.
Sampling Methodology and Results	
Sampling in the Z1 Landfill was only performed in the upper 1 m and, as a result, may not reflect the contamination at deeper depths.	Based on review of the landfill drawings and conversations with Chemical Command, it was understood that portions of the landfill were built with waste thicknesses as low as 1.5 m. Taking into consideration potential settlement and consolidation of the waste since construction in 2009, it was decided to limit the sampling to the upper 1 m in order to provide separation from the bottom liner and eliminate potential for damage. This sampling approach was submitted to AMST for approval in February 2015 and subsequently approved in March 2015. It should be noted that for the remediation alternatives requiring treatment of the Z1 Landfill (Alternatives 4, 5A, 5B, and 5C), the entire depth of the landfill will be excavated and treated, and some contingency volume is included in case the landfill is deeper.

Comment Received from GVN Stakeholders	**Response**
Since the MIS methodology makes a composite sample from 30 incremental samples, won't this dilute the sample and lead to missing areas with contamination? Why are high concentrations from previous discrete samples not always included?	This is not a concern for a several reasons. First, the MIS sample provides a better representation of the actual TEQ of the soil from an exposure perspective, and is therefore more appropriate to dioxin limits compared to an aliquot that may not represent a significant amount of the soil. Therefore, the high concentrations from previous reports are not as directly comparable to dioxin limits. Second, with a heterogeneous distribution of soil, it will always be possible to select concentrations that are higher and lower than the representative result from the analysis of an MIS sample, but such variability may provide a false negative or positive compared to a repeatable and statistically defensible MIS sample. Third, if the data produced by a discrete sample is not replicated by the MIS samples, it is not expected it will affect the decision as to whether the material exceeds the action level. As demonstrated during the Danang Airport remediation project, the switch to MIS sampling during confirmation sampling significantly increased the amount of soils and sediments that required excavation. Fourth, and most importantly, it is not expected it would influence the selection of appropriate remediation technologies, or the implementation.
The EA should mention the scientific basis for doing the sampling using the MIS method.	The basis is referenced in several places throughout the document (such as **Section 3.2.1** and **Appendix A**); also, refer the guidance provided by the Interstate Technology and Regulatory Council (ITRC) in 2012.
During the sampling investigation, six DUs were not sampled. AMST has sampled these areas, in addition to several more areas, and these results should be included in the EA.	Reference to these results has been added to the end of **Section 2.3** in **Appendix A**, and the results have been added as **Appendix G**. Based on anticipated land use, the dioxin concentrations reported in the additional sampling are below the dioxin limits (i.e., dioxin contamination was not identified in these additional areas) and do not impact volume estimates.

Comment Received from GVN Stakeholders	**Response**
Volume Estimates	
Several DUs indicated contamination at the greatest depth sampled. For these areas, an estimation of the depth of contamination below these depths was performed in order to develop the contamination volume estimate. Can you please provide more explanation on how these depths and volumes were estimated?	**Section 3.2.5** provides an explanation of the methodology used to estimate the depth and volume for this situation. It should be noted that when any excavation is conducted, confirmation samples should be collected and analyzed to confirm the bottom of the excavation is below the dioxin limits.
A 15% Concentration Safety Factor (CSF) has been applied in calculating the contamination volume. Explain the rationale for this.	The 15% CSF is based on the computed relative percent difference from 30 duplicate and 15 split samples and has been applied to the dioxin limits to account for the inherent variability of the MIS sampling methodology and laboratory testing. **Section 3.2.5** provides additional information.
Please clarify what percentage of the total contamination volume is located off of the Airbase.	Approximately 5% of the contamination volume is located off of the Airbase. This has been clarified in **Sections 1.5 and 8.1**.
Technologies and Remediation Alternatives	
Groundwater at the Airbase is shallow and needs to be considered in the remedial alternatives.	Facilities for any remediation alternative, whether it be containment or treatment, would be constructed above ground to avoid groundwater impacts. Refer to **Section 4.4** for more information. Also, excavation activities would be limited to the dry season when the groundwater level is lower in order to minimize the amount of water to be managed. **Section 7.3** and **Table 7-7** provides a preliminary EMMP which addresses this item.
Selected technologies should be tested in specific conditions in Vietnam.	Some of the technologies identified herein have already been tested and used in Vietnam (i.e., landfills and *ex situ* TCH). Additional testing is not expected to be necessary for these technologies. MCD has been tested using soil from Bien Hoa (Cooke 2015) but some optimizations should be made, and verified, as described in **Section 4.4.7 and Section 8.3**. **Section 8** indicates that additional testing is necessary with regard to stabilization/solidification to verify the mix design. Incineration is one of the most mature technologies with regard to treatment of dioxin-contaminated soil, but also could be tested prior to implementation.

Comment Received from GVN Stakeholders	**Response**
For Alternative 3, what is the basis of selecting 2,500 ppt as the break point between using containment and treatment?	As mentioned in **Section 4.4.9**, the 2,500 ppt concentration threshold was selected for Alternative 3 based on a natural breakpoint in the data, but happens to divide the estimated volume of contaminated soil and sediment into approximately 75% containment and 25% treatment. Alternative 4, for example, roughly provides approximately 50% containment and 50% treatment.
For the cost estimates, explain the basis of the -40% to +75% applied to the actual cost.	At this stage of the alternatives evaluation, the design for the project alternatives are very conceptual and there are many uncertainties. To account for this, accuracy ranges are applied the estimated costs. The ranges applied to the Bien Hoa EA (-40% to +75%) are based on USEPA guidance for developing cost estimates for Superfund/remediation projects in the U.S. Refer to **Section 4.3.3** and **Appendix D** for more details.
The XD-2 Landfill is currently being constructed. How will the alternatives manage this material?	This contaminated material would likely be handled in the same fashion as the Z-1 Landfill (i.e., depending on the alternative selected). Additional sampling would be necessary to confirm the dioxin concentrations present inside the XD-2 Landfill.
Please discuss restoration activities for the alternatives.	Site restoration activities are discussed in **Section 4.4** for each alternative, and in **Section 7.1** for various environmental impact analyses.
EMMP	
Mitigation measures for activities outside of the Airbase should be presented.	The environmental mitigation and monitoring measures discussed in **Section 7.3** are for activities occurring on and off of the Airbase.
More detail needs to be provided on the EMMP.	The EMMP presented in **Section 7.3** is preliminary and conceptual at this stage of the project. After a remediation alternative is selected and designed, a more detailed EMMP can be developed that focuses specifically on the aspects of that alternative.
Biodiversity	
A biodiversity study has not been conducted for the site. One should be performed.	One of the suggested mitigation measures presented in **Table 7-7** and additional considerations presented in **Section 8.2** is to perform biological surveys (terrestrial and aquatic) prior to commencement of any construction to confirm there are no rare or endangered species on the Airbase and within the area of influence of the project.

FIGURE 1-1 OVERALL SITE MAP, BIEN HOA AIRBASE, VIETNAM

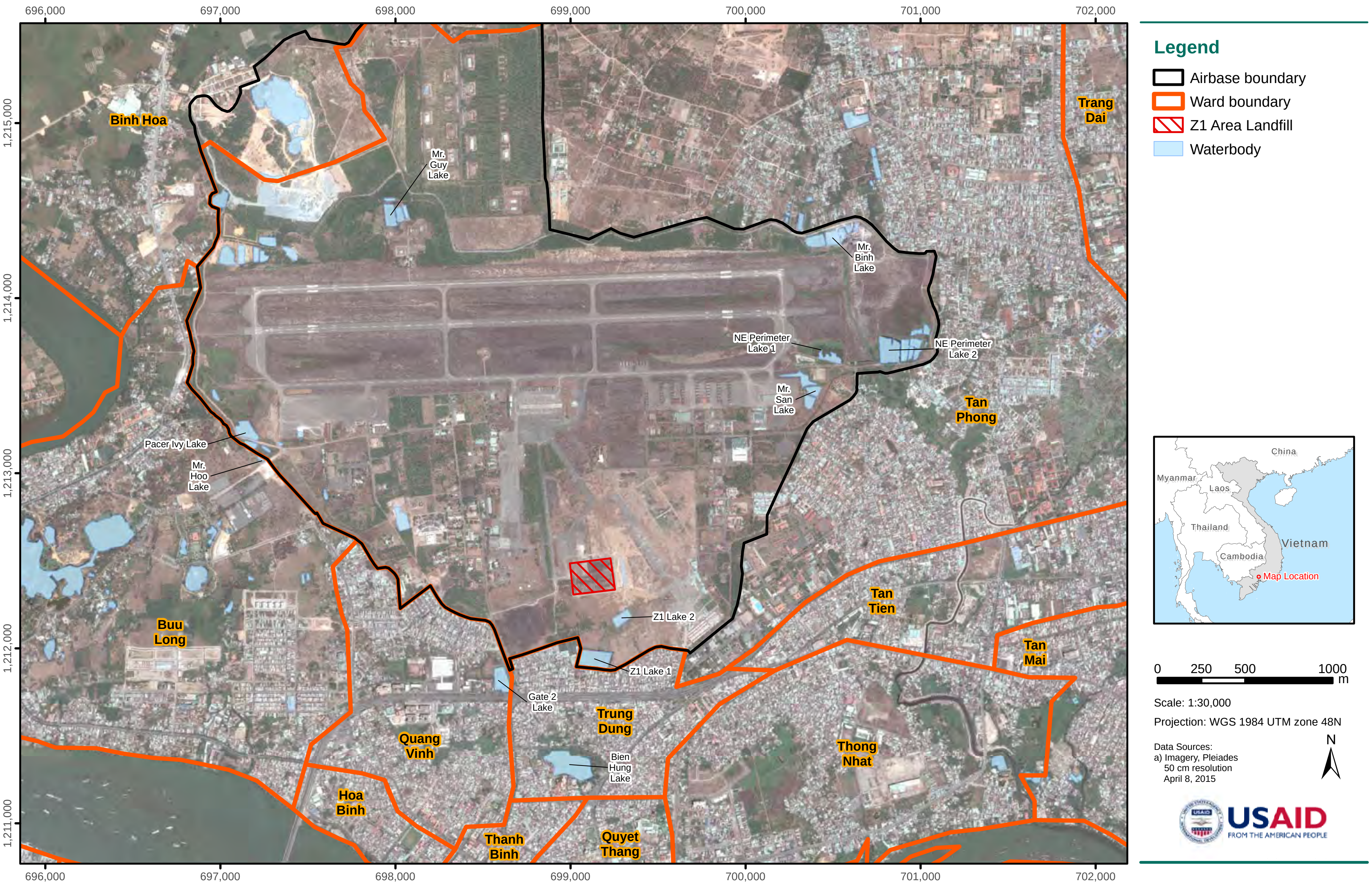

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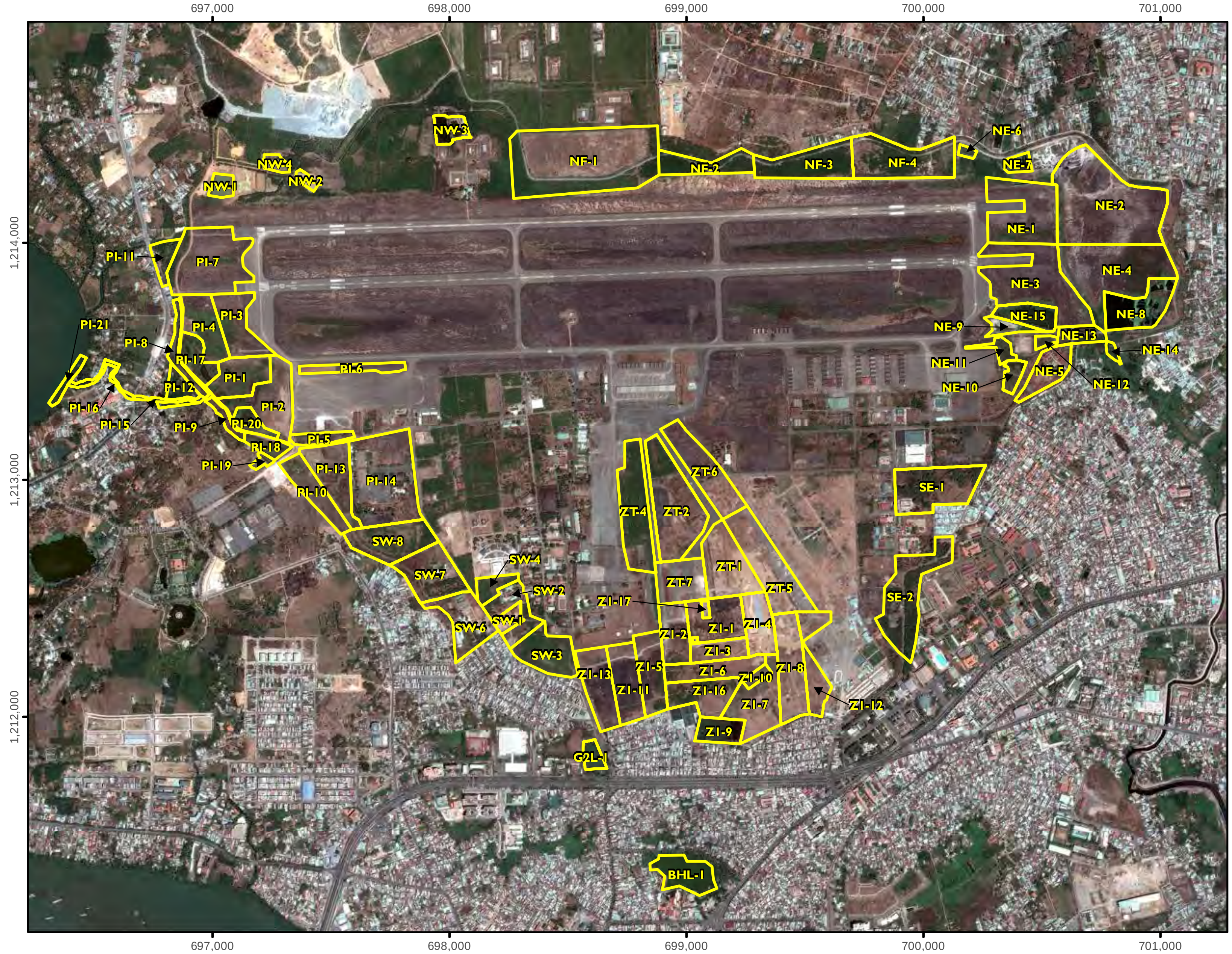
FIGURE 1-2 OVERALL SITE MAP WITH SAMPLING DECISION UNITS, BIEN HOA AIRBASE, VIETNAM



Legend

Decision unit

0 200 400 800 m

Scale: 1:24,000

Projection: WGS 1984 UTM zone 48N

N

Data Sources:
a) Imagery, Pleiades
50 cm resolution
April 8, 2015

USAID FROM THE AMERICAN PEOPLE

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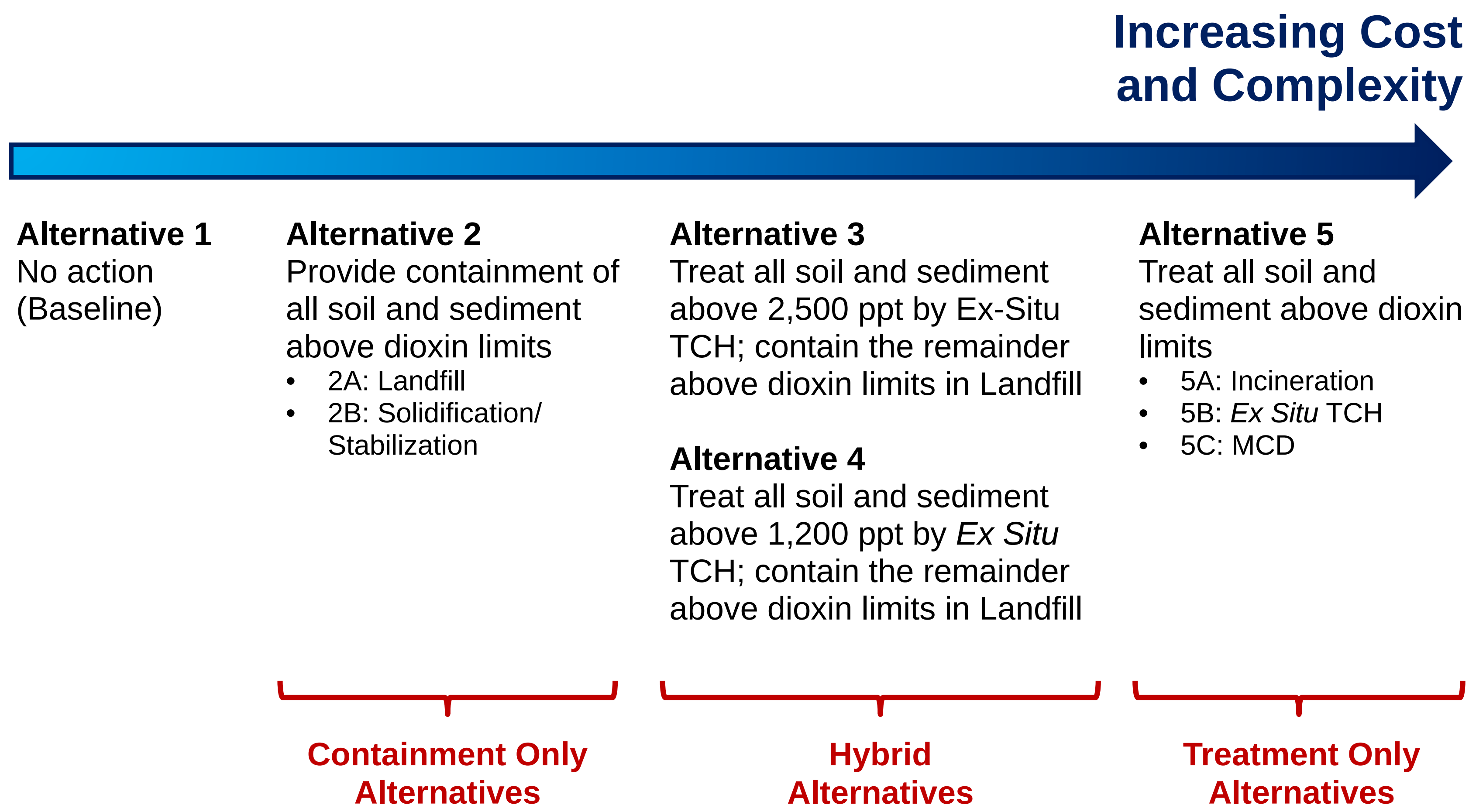
Figure 1-3 Range of Remediation Alternatives Considered for Bien Hoa EA



Section 2 Background

2.1 Need for the Development of Remedial Alternatives

The Airbases at Bien Hoa, Danang, and Phu Cat in Vietnam have been referred to as major dioxin "hotspots" due to high dioxin concentrations remaining decades after large volumes of Agent Orange and other defoliants were handled at these sites during the U.S.-Vietnam War (Dwernychuk et al. 2002; Dwernychuk 2005). The GVN has requested foreign assistance to support remediation efforts of these hotspots. The U.S. Government (USG) is currently supporting clean-up efforts at the Danang Airport. The UNDP GEF Dioxin Project supported activities at Phu Cat Airbase, including the construction of a landfill in 2012 to contain approximately 11,000 m^3 of dioxin contaminated soil. The creation of the Z3 landfill at Phu Cat Airbase has reduced the risk of dioxin exposure to local populations. The Airbase (Bien Hoa) is the largest of these dioxin hotspots and has yet to be fully addressed although the MND constructed a landfill in 2009 to address the former storage area and the UNDP GEF Dioxin Project implemented several short-term interim measures as further discussed in **Section 3.3.1**.

The Airbase is located within the urban part of Bien Hoa City and primarily comprises the Tan Phong District, with the districts of Trung Dung, Quang Vinh, and Buu Long adjoining the property along its southern border (**Figure 2-1**). Approximately 1,200 people live on the Airbase itself (Canh 2012b, Dekonta 2013) and approximately 120,000 people live immediately adjacent to the Airbase property (Hatfield 2015). ADAFC has indicated that up to 2,200 workers are on the Airbase during peak times. Previous studies have identified nine areas of known and potential dioxin contamination on the Airbase as well as outside the Airbase property (**Figure 2-1**).

2,3,7,8-TCDD (dioxin) is a toxic chemical that is associated with a range of health effects (Agency for Toxic Substances and Disease Registry [ATSDR] 1998). Historical studies show that dioxin concentrations within hotspot areas of the Airbase substantially exceed international standards and Vietnamese standards for dioxin (Hatfield and 10-80 Division of the Ministry of Health [10-80 Division] 2006, Hatfield and VRTC 2009, and Hatfield and Office 33 2011). Uncontrolled access to contaminated areas of the Airbase and transport of contaminated soils and sediments resulted in human exposures primarily through agricultural activities (including extensive aquaculture operations) and fish consumption; exposure has been recorded in human blood serum and breast milk from workers on the Airbase and the general population (Hatfield and Office 33 2011, Nguyen et al. 2011, Durant et al. 2014). The human exposure pathway was partly interrupted as a result of risk reduction measures summarized in **Section 3.3** (such as the construction of the Z1 Landfill in 2009 and surface water controls in 2013). While some of these measures could be considered permanent (such as the Z1 Landfill), others are interim and are reliant upon institutional controls and enforcement for effectiveness (such as bans on fishing). To date, these institutional controls have had limited success in preventing dioxin exposure, as fishing and aquaculture activities are known to continue on the Airbase despite the bans in place.

Dioxin contamination at the Airbase, coupled with the close proximity of large numbers of Airbase and Bien Hoa City residents to the areas of dioxin contamination, poses a risk to human health; therefore, institutional controls, containment, and/or remediation (e.g., cleanup) is required to protect human health and the environment. The GVN has requested U.S. assistance with environmental remediation at the Airbase; the USG has commissioned this Study to understand the full nature and extent of dioxin contamination on and around the Airbase, determine exposure pathways, evaluate feasible short-term mitigation measures, and consider and assess remediation alternatives (treatment and/or containment) for dioxin contamination at the Airbase.

This Study aligns with USAID/Vietnam's Country Development and Cooperation Strategy (CDCS) (USAID 2013a), Special Objective (SpO) 1: Legacies Addressed to Advance the U.S.-Vietnam Partnership, Intermediate Result (IR) SpO 1.1: Reduced Dioxin Contamination. Likewise, this Study aligns with the following specific objectives of the GVN's National Action Plan on Comprehensive Overcoming of Consequences of Toxic Chemicals used by the U.S. during the War in Vietnam to 2015 and Orientation towards 2020 (Prime Minister of the Government 2012) to:

1. Assess the spatial distribution, contamination level and long-term consequences of toxic chemicals on the human being and environment.
2. Determine and effectively deploy a system of measures for comprehensive treatment of contaminated environment.
3. Strengthen the domestic and international community's awareness and capacity in overcoming consequences of toxic chemicals.

It also aligns with the GVN's "Master Plan for Remediation of Bien Hoa Airbase, Vietnam" (finalized in May 2013 and approved by GVN; Hatfield 2013), which includes the specific objective to: contain and remediate dioxin contamination in core hotspot areas as well as soils and sediments within and around the Airbase; build capacity in the form of stakeholder engagement meetings, workshops and day-to-day transfer of knowledge; and ensure the health and safety (H&S) of remediation workers.

2.2 Threshold Determination and Study Purpose

This Study is subject to the environmental procedures established under 22 CFR 216 and the RCE prepared as part of the IEE, approved on September 6, 2012. The RCE determined this Study met the conditions for a Categorical Exclusion on the basis that the Study itself involves only detailed characterization of the nature and extent of dioxin contamination at the Airbase as well as research and assessment of feasible containment and remediation technologies, and does not include the remediation itself. The actual implementation of any alternative described in this Study will be considered a new activity by USAID. A change in determination from Categorical Exclusion to Negative Determination with Conditions was recommended during the preparation of the ESS (**Section 2.3**) in anticipation that USAID may decide to provide technical assistance and advice to the GVN on existing and on-going interim containment decision-making prior to EA approval. This change in determination was documented in an IEE Amendment to the RCE that was approved on March 10, 2015 (USAID 2015a).

The purpose of this EA is to fulfill requirements for environmental remediation at the Airbase in accordance with 22 CFR 216.6(a) which states:

> "The purpose of the Environmental Assessment is to provide Agency and host country decision makers with a full discussion of significant environmental effects of a proposed action. It includes alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources."

This EA provides the basis for selection of a preferred project alternative for remediation of dioxin contamination at the Airbase. Vietnamese environmental law and its environmental compliance regulations require an EIA for dioxin remediation activities once a preferred remediation alternative has been selected and a specific project defined. Therefore, this EA also represents a first step in the GVN EIA process, to be elaborated upon if and when a remediation alternative is selected and accompanying designs and cost estimates are prepared. If additional, potentially significant impacts on the environment are identified during the design process of a selected alternative, the EA will be amended to reflect these.

2.3 Environmental Scoping Statement

As required by 22 CFR 216.3 (4), the ESS determines the scope and significance of issues to be analyzed in the EA and identifies and eliminates from detailed study those issues that are not significant or have been covered by earlier environmental reviews. The ESS, which was approved by the USAID BEO for Asia in October 2014, identified the following environmental and social issues to be addressed in the EA:

- **Environmental and Social Issues Not Requiring Detailed Study:** It was determined that landforms and topography, nature reserves and protected areas designated in international conventions, cultural and historic sites, and tourism sites could be excluded from detailed study during the preparation of the EA because they would not be affected by any possible remediation alternative.
- **Significant Environmental and Social Effects that will Require Mitigation:** It was determined that effects of any selected containment/remediation alternative on surface water quality on and downstream of the Airbase property, air quality downwind of construction and remediation activities; noise levels around construction activities; and health of construction workers and local residents (which may pose greater risks for women of reproductive age) as a result of changes in air quality and noise levels would be significant in the absence of mitigation. For this group of environmental and social resources the magnitude of the effects would need to be assessed in the EA and appropriate mitigation measures specified.
- **Environmental and Social Issues Requiring Additional Study to Determine Significance of Potential Effects:** It was determined that the potential effects of any alternative on soils, surface water hydrology, groundwater resources, groundwater quality, terrestrial ecosystems and biodiversity, wetlands, aquatic ecosystems and biodiversity, nature reserves and protected areas (provincial and city level), domestic and drinking water supply, and natural or depletable resource requirements were uncertain at the time the ESS was prepared, and would therefore require detailed study in the EA.
- **Scope of EA:** The scope of work for the EA at the Airbase includes addressing significant potential adverse health-related, environmental, and social issues associated with implementing activities for remediation of dioxin- containing soil and sediment to GVN standards and enhancing beneficial use of the Airbase, such as commercial development. It was determined that the EA would need to document stakeholder engagement discussions and consultations, applicable GVN standards for remediation, supplemental investigation sampling and analyses, the SCM, evaluations of containment/remediation alternatives, affected environment and environmental consequences of implementing remediation, consequences to social resources if they are indirectly affected through changes in the physical and natural environment from implementing remediation, approaches for environmental mitigation and monitoring, and resettlement.

These key finding and recommendation of the ESS were reviewed and re-assessed as new information became available during the preparation of the EA regarding existing environmental and social resources and assets and details of the alternatives being considered.

2.4 Stakeholder Engagement and Host Government Consultations

Prior to the initiation of this Study, discussions regarding the Airbase were held with several of the project stakeholders through various media to inform the decision of developing an EA. Some examples include the U.S.-Vietnam Dialogue Group, the Joint Advisory Committee (JAC), and the Minister's Decision No. 651/QD-TTg (Prime Minister of the Government 2012).

During the period that the EA was under development (December 2013 to April 2016), numerous meetings, site visits, and workshops were held to discuss various aspects of the EA process and technical content. Stakeholders participating in workshops and meetings during this period typically included representatives from AMST, ADAFC, CC, VRTC, MSD, Regiment 935, Office 33, Dong Nai DONRE, UNDP, USAID, CDM Smith, and Hatfield.

The meetings, site visits, and workshops held during the development of the EA included the following:

- Progress Meetings with USAID, CDM Smith, and AMST to discuss and coordinate project activities and technical issues: 12/19/13, 02/24/14, 06/19/14, 07/17/14, 08/26/14, 01/28/15, 05/07/15, 07/30/15, 08/19/15, 09/15/15, and 12/18/15 (Hanoi).
- Office 33 workshop to provide overview of sampling performed in 2013 by VRTC on and adjacent to the Airbase, temporary stormwater containment structures and improvements recently constructed as part of the UNDP GEF Dioxin Project, monitoring results outside of the Airbase, and current land use at the Airbase: 03/10/14 (Hanoi).
- Stakeholder Engagement Meeting No. 1 to present preliminary work plan and solicit historical environmental sampling data packages for the EA: 03/19/14 (Hanoi).
- Meetings with Regiment 935 and Dong Nai DONRE to discuss ongoing dioxin monitoring programs conducted by DONRE, review existing information and preliminary work plan, and site visit to Airbase and areas outside of Airbase: 03/20/14 and 03/21/14 (Bien Hoa).
- Meeting with Dong Nai DONRE to provide an update on project activities and discuss DONRE dioxin monitoring: 09/29/14 (Hanoi).
- Stakeholder Engagement Meeting No. 2 to discuss the ESS, preliminary SCM, remediation goals, supplemental investigation strategy, and scope of the EA: 09/30/14 (Hanoi).
- Field visit to the Airbase: 10/01/14 (Bien Hoa).
- Office 33 workshop on "Dioxin Contamination in Bien Hoa Airbase; Status and Plan for the Future Work": 10/21/14 (Bien Hoa).
- Phase 1 Sampling at the Airbase: 11/03/14 to 12/05/14 (Bien Hoa).
- Meetings with Regiment 935 and Dong Nai DONRE to discuss and plan for Phase 2 sampling: 03/04/15 (Bien Hoa).
- Phase 2 Sampling at the Airbase: 03/09/15 to 04/17/15 (Bien Hoa).
- Field visit to the Airbase: 10/14/15 (Bien Hoa).

- Stakeholder Engagement Meeting No. 3 to present and discuss the development of alternatives to reduce risk exposure and screening of technologies: 09/25/15 (Hanoi).
- Stakeholder Engagement Meeting No. 4 to present and discuss the sampling results, estimated contamination volumes, short list of technologies and draft remediation alternatives, and detailed evaluations (effectiveness, implementability, and cost) performed on the remediation alternatives: 12/18/15 (Hanoi).
- Stakeholder Engagement Meeting No. 5 to present the environmental, social, and gender consequences of the remediation alternatives, discuss the structure of the Draft Final EA, and provide copies of the Draft Final EA to GVN stakeholders for review and comment: 03/18/16 (Hanoi).
- Field visit to the Airbase: 03/24/16 (Bien Hoa).
- Stakeholder Engagement Meeting No. 6 to solicit final GVN comments on the EA: 04/04/16 (Hanoi).

As a result of these meetings, GVN perspectives were captured and consensus gained on the technical content associated with the major milestones of the EA, including historical sampling data, the supplemental sampling plan and results, the short list of technologies, and the remediation alternatives. Furthermore, the meetings resulted in significant information sharing that enabled a much more concise assessment than might have otherwise been the case. In addition to the ongoing exchange with host government counterparts, USAID/Vietnam regularly consulted with USG stakeholders, including the U.S. Embassy, U.S. State Department, and USAID/Washington.

It should be noted that it is difficult in Vietnam to have direct engagement with community members due to GVN requirements and procedures for having public consultations. As a result, AMST and Dong Nai DONRE, as the technical representative of the Dong Nai People's Committee, were engaged and relied upon to conduct necessary on-Airbase and off-Airbase communications with military personnel and the local community, respectively.

2.5 Legal and Regulatory Considerations

This section describes the legal and regulatory requirements for Vietnam and the U.S. that were considered in developing the EA.

2.5.1 Vietnam

The Prime Minister's Decision No. 651/QD-TTg (Prime Minister of the Government 2012) is a national policy outlining the priorities, by 2020, for cleaning up dioxin contamination related to the U.S.-Vietnam War. This policy also contains requirements for habitat restoration, public awareness, and social services associated with the containment and remediation of dioxin contamination.

There are two main national regulations that guide the implementation of this national policy with respect to the Airbase. First, the 2009 *TCVN 8183:2009, Dioxin Thresholds in Soil and Sediment* (TCVN 2009) defines the maximum allowable concentration polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) as 1,000 ppt TEQ for soil, and 150 ppt TEQ for sediment. These standards were applied for the Environmental Remediation of Dioxin Contamination at Danang Airport project and the Phu Cat Airbase landfill project.

However, in 2012, the *QCVN 45:2012/BTNMT, National Technical Regulations on Allowed Limits of Dioxin in Soils* (QCVN 2012) was issued and defines maximum allowable concentrations of PCDDs and PCDFs in soil for various land-use types (**Table 2-1**). As directed by the GVN, this regulation will be used for soil areas inside and outside the Airbase.

QCVN 45:2012/BTNMT does not specify maximum allowable concentrations for sediments; therefore, the 150 ppt TEQ standard for sediments in TCVN 8183:2009 will be applied to sediments inside and outside the Airbase.

There is a wide range of national and international guidelines for TEQ in soils (varying by type land use in which the soil is found), sediments (varying by the type of receptor that is the focus of protection – ecological vs. human), food sources including fish, and for tolerable daily intake (TDI) by humans (varying by type of organism and level of restriction of consumption). A summary of these guidelines in comparison to Vietnamese guidelines is provided in **Table 2-2**.

2.5.2 United States

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), is the U.S. federal law promulgated to clean up abandoned hazardous waste sites and is commonly known as Superfund. CERCLA, as amended by SARA, directs the USEPA to select a permanent remedy or treatment whenever possible for Superfund hazardous waste sites. In practice, remedies are often selected and applied in combination (for example, over 30% of treatment remedies were selected with other types of remedies); and treatment remedies make up only 41% of Superfund remedies (USEPA 2013).

As described in **Section 2.2**, this Study is subject to the environmental procedures established under 22 CFR 216, the RCE, which was prepared and approved on September 6, 2012, and the IEE Amendment to the RCE, which was prepared and approved in March 2015 (USAID 2015a). Due to the nature of this assessment, this EA utilizes a hybrid approach that is intended both to follow the framework and requirements described in 22 CFR 216 and to be compatible with CERCLA. This EA has been aligned with key aspects of the CERCLA process, such as the Remedial Investigation and Feasibility Study steps, by following applicable guidance (USEPA 1988) during the project planning phase (USAID 2015b), implementation of the 2014/2015 field sampling program (USAID 2014), and evaluation of remedial alternatives for the Airbase (as presented in **Section 4**).

2.5.3 Consideration of Requirements of Both Countries

In preparing the EA, the site context and the legal and regulatory context of the U.S. and Vietnam were considered. The following laws and regulations were identified as having potential applicability either to the EA, or to the remediation of dioxin contamination at the Airbase; this list is <u>not</u> comprehensive.

2.5.3.1 Laws and Regulations

- U.S. Foreign Assistance Act (FAA) Section 117 and 22 CFR 216, Automated Directive System (ADS) 201.5 and 204 – Environmental Compliance.
- FAA 611(a)(1) – Adequate Planning.
- U.S. Brooks Act and U.S. Federal Acquisition Regulation (FAR) Part 36 – Engineering Integrity.
- USAID ADS 201.3.9.3 – Gender Considerations.

- Vietnamese Construction Regulation Standard Article 3.3.
- Vietnam Labor Code, Article 113 of Chapter X – Gender Restrictions on Employment at Hazardous Waste Sites.
- Vietnam National Law on Environmental Protection: No. 52/2005/QH11.
- Vietnam National Standard (TCVN) 8183: 2009 – Dioxin Thresholds in Soil and Sediment.
- Vietnam National Standard (TCVN) 9737: 2013 – Dioxin Discharge Standards in Wastewater and Air Waste from Dioxin Residue Treatment Activities
- Vietnam National Standard (QCVN) 45:2012/BTNMT – National Technical Regulations on Allowed Limits of Dioxin in Soils (see **Table 2-1**).
- Vietnam National Standards (QCVN) QCVN 03:2008/BTNMT – National Technical Regulation on the Allowable Limits of Heavy Metals in Soils.
- Vietnam National Standard (QCVN) 40:2011/BTNMT – National Technical Regulations on Industrial Wastewater
- Vietnam National Standard (QCVN) 43:2012/BTNMT - National Technical Regulation on Sediment Quality [Dioxin and Furan are also covered]
- Vietnam Law on Gender Equality Article 13, Section 1, 3a.
- Vietnam Law on Construction No. 16-2003-QH11.
- Vietnam Decree No 68/2005/ND-CP dated 20/5/2005 and Government Circular No. 12/2006/TT-BCN guiding the implementation of the Decree stipulate that unsafe chemicals must be treated appropriately.
- Vietnam Announcement No. 69/2002 of the Political Bureau directs the Government to strengthen international cooperation in preventing and overcoming consequences of the use of toxic chemicals in the War.
- Vietnam Decision 155/1999/QD-TTg of the Prime Minister of the Government on promulgating regulation of hazardous waste management.
- Vietnam Decision No. 64/2003/QD-TTg of the Prime Minister of the Government approving the plan for thoroughly handling establishments which cause serious environmental pollution.
- Vietnam Decision No. 67/2004/QD-TTg dated 27 April 2004 of the Prime Minister regarding the approval of the Action Plan for the Period of 2004-2010 in Overcoming Consequences of Toxic Chemicals.
- Vietnam Decision of the Prime Minister No. 184/2006/QD-TTg (8/2006) approving the National Implementation Plan (NIP) of the Stockholm Convention on Persistent Organic Pollutants.

2.5.3.2 Guidance

- U.S. Occupational H&S Administration (OSHA) Standards 29 CFR 1910 for H&S (monitoring activity).
- 40 CFR 264 Hazardous Waste Disposal Regulations.
- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA 540/P-91/001, OSWER 9355.3-11.
- United States Environmental Protection Agency, Regional Screening Levels (RSLs) for Contaminants in Soil

- United States Environmental Protection Agency Maximum Contaminant Levels (MCLs) for drinking water
- Vietnam Circular No. 05/2008/TT-BTNM – Guide to Strategic Environmental Assessment, Environmental Impact Assessment, and Environmental Protection Commitment.
- Vietnam Decree No. 21/2008/ND-CP – Amending and Supplementing a Number of Articles of Government Decree No. 80/2006/ND-CP, Detail and Guide to the Implementation of a Number of Articles of the Law on Environmental Protection.
- Vietnam Decree No. 29/2011/ND-CP – Amending Decree No. 80/2006/ND-CP and Decree No. 21/2008/ND-CP.
- Vietnam Circular No. 26/2011/TT-BTNMT – Detailing some clauses of Decree No. 29/2011/ND-CP.
- Vietnam Decree No. 80/2006/ND-CP – Detail and Guide to the Implementation of a Number of Articles of the Law on Environmental Protection.
- Vietnam Decision No. 60/2002/QD BKHCNMT - Guidance for the Design of Hazardous Waste Landfills.
- Guidance on maximum allowable dioxin/furan concentrations in fish tissues was taken from U.S., Canadian, and EU standards, given that no Vietnamese standards currently exist (see **Table 2-3**).

2.6 Obligations under International Environmental Conventions and Agreements

Vietnam is a signatory to a number of international conventions and agreements that are of direct or potential relevance to this Study (**Table 2-4**).

One of Vietnam's six Ramsar sites, the Bau Sau (Crocodile Lake) Wetlands and Seasonal Floodplains, is located in the province of Dong Nai, and a proposed United Nations Education, Scientific and Cultural Organization (UNESCO) World Heritage site (Cat Tien National Park) sits on the Dong Nai River. Both these sites are considerably upstream from the Airbase and will likely not be affected by any dioxin remediation alternative proposed for the Airbase as a result of this Study.

Table 2-1 GVN Dioxin Standards/Allowable Limits of Dioxin Contamination Specified in GVN National Technical Regulation on Allowed Limits of Dioxin in Soils (QCVN 45:2012/BTNMT)

Land Use Type	Allowable Limit of Dioxin Contamination (ppt TEQ dry weight)
Annual crop land	40
Forest land and perennial tree land	100
Rural residential land	120
Urban residential	300
Recreational	600
Commercial	1,200
Industrial	1,200

Table 2-2 Representative International Guidelines and Standards for PCDD and PCDF TEQ

Description	United States	Japan	Vietnam	Europe
Commercial Use Soil	730 ppt (USEPA RSL for Industrial Soil)	1,000 ppt[a]	1,200 ppt	240 μg kg^{-1} dry weight soil[b]
Residential Use Soil	51 ppt (USEPA RSL for Soil)	N/A	120 ppt for rural and 300 ppt for urban	8 μg kg^{-1} dry weight soil[b]
Sediment	N/A	150 ppt	150 ppt	5-10 ppt TEQ – Germany[c] 100 ppt – Netherlands[c]
Water	30 parts per quadrillion (ppq) (USEPA drinking water standard)	10 picogram (pg)-TEQ/L for wastewater emission 1 pg-TEQ/L for drinking water	10 pg-TEQ/L for wastewater discharge	N/A
Vapor Emission Discharge (not ambient air)	0.2 pg-TEQ/m^3	0.6 pg-TEQ/m^3	0.1 pg-TEQ/m^3	N/A
TDI	0.7 pg/kg-day (RfD)	4 pg-TEQ/kg-bw/day (derived from WHO TDI)	N/A	2 pg TEQ kg-bw/day (derived from WHO TDI)[d]

[a] Government of Japan. 2012. Dioxins. Council of Inter-Ministries and Agencies on Dioxin Policy: Member Ministries and Agencies, Government of Japan. Tokyo, Japan.

[b] Toxicology Department, PHE Centre for Radiation Chemical and Environmental Hazards. 2008. Dioxins (2,3,7,8-Tetrachlorodibenzo-*p*-dioxin): General Information, Incident Management and Toxicological Overview. Public Health England.

[c] European Commission DG Environment, UK Department of the Environment Transport and the Regions (DETR). 1999. Compilation of EU Dioxin Exposure and Health Data. Summary Report

[d] Environmental Agency. Soil Guideline Values for Dioxins, Furans and Dioxin-Like PCBs in Soil. Science Report SC050021/Dioxin SGV.2009. EA. Bristol, UK.

Table 2-3 Representative International Guidelines and Standards for Dioxin Concentrations in Fish Tissues

Country / Jurisdiction	Maximum Allowable Concentration – wet weight (pg/g)	Reference
EU	3.5 pg/g TEQ	Commission Regulation (EU) No 1259/2011[a]
Canada	20 pg/g TEQ	CFIA 2014[b]
U.S. Food and Drug Administration (FDA)	50 pg/g TEQ	The Food and Drug Administration (ATSDR 2008)[c]

[a] Commission Regulation (EU) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs Text with EEA relevance Retrieved Feb 15, 2016 from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32011R1259

[b] CFIA 2014. Fish Products Standards and Methods Manual: Appendix 3 Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products. NOTE: dioxin limit currently under review.

[c] ATSDR 2008. Public Health Statement for Chlorinated Dibenzo-P-dioxins (CDDs). In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). First published in the Encyclopedia of Earth November 13, 2007. Accessed at: http://www.eoearth.org/article/Public_Health_Statement_for_Chlorinated_Dibenzo-P-dioxins_(CDDs)

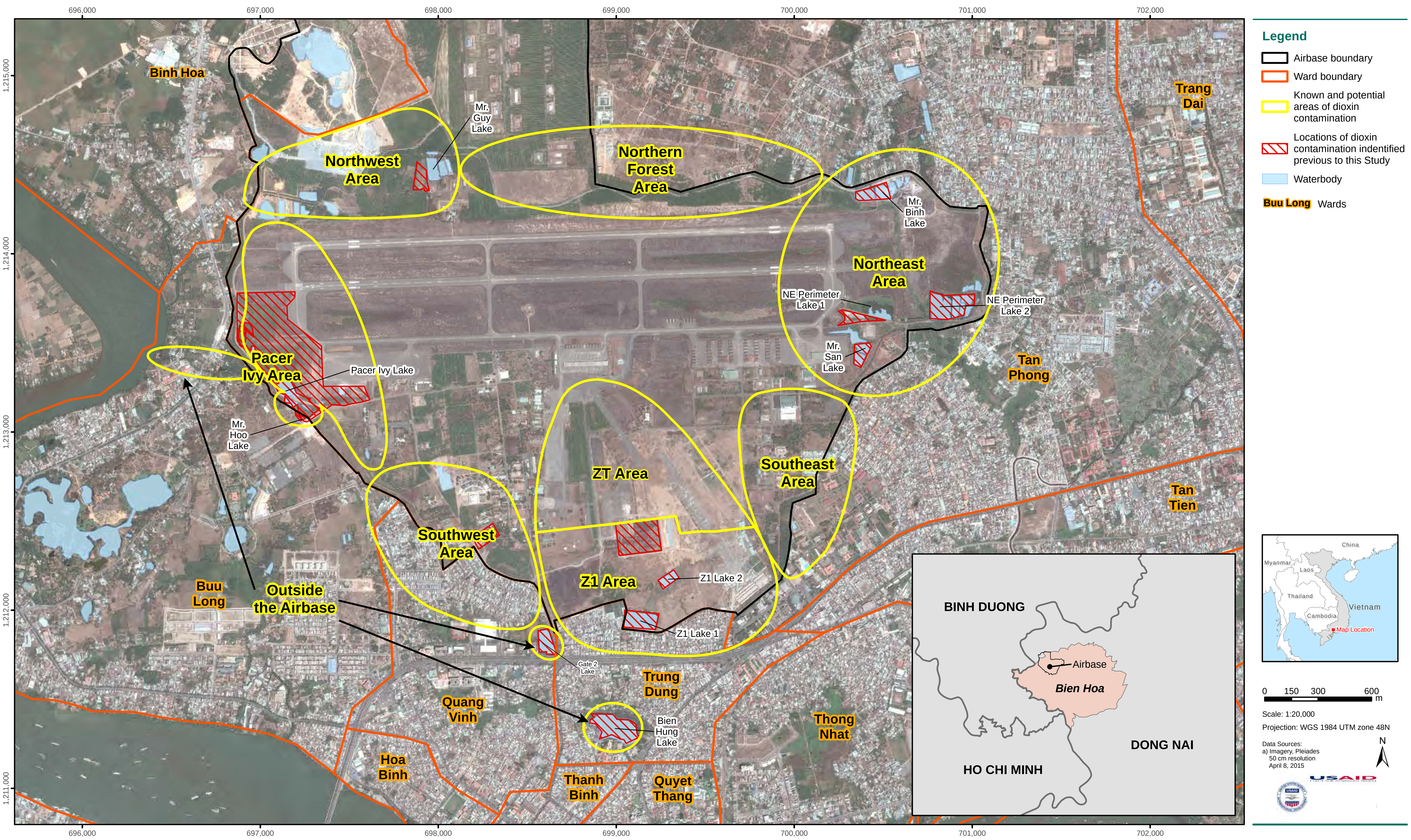
Table 2-4 International Conventions and Agreements to which Vietnam is a Signatory that are of Potential Relevance to this Study

Convention	Description	Key Stipulations and Obligations
Stockholm Convention on Persistent Organic Pollutants	Vietnam became a signatory to the Stockholm. Convention on Persistent Organic Pollutants (POPs) on May 23, 2001 and ratified the Convention on July 22, 2002. Vietnam prepared and adopted a National Implementation Plan under the Stockholm Convention in 2006.	**Article 6** requires the reduction of elimination of releases from stockpiles and wastes. **Article 7** requires the development of implementation plans to implement obligations under the Convention. **Article 10** requires the promotion of public information, awareness and education. **Article 11** stipulates the requirement for research, development, and monitoring regarding sources and releases into the environment, transport and fate, and effects on human health and environment. PCDD and PCDF are covered by the Convention under **Annex C**.
Rotterdam Convention	Promotes shared responsibilities regarding importation of hazardous chemicals. Vietnam accessioned the Rotterdam Convention on May 7, 2007.	**Article 5** covers procedures for banned or severely restricted chemicals. It requires GVN to notify the Secretariat in writing of regulatory actions which have taken effect. **Article 6** covers procedures for severely hazardous pesticide formulations and allows developing nations / economies in transition to propose a listing of a severely hazardous pesticide formulation. **Article 10 and 11** outline obligations in relation to imports and exports of chemicals listed in Annex III, requires GVN to ensure timely decisions with respect to the import of chemicals, and prevents GVN from exporting chemicals to any importing party which has failed to approve the import. **Articles 12, 13 and 14** stipulate requirements for providing export notification information to be included with exported chemicals and information exchange. Hexachlorobenzene and 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T), one of two main chemical components of Agent Orange, are covered by the Convention under **Annex III**.

Convention	Description	Key Stipulations and Obligations
Montreal Protocol	Provides a framework for the phasing out of the production of ozone depleting substances. Vietnam accessioned the Montreal Protocol on January 26, 1994.	GVN is required to report annually on its production, import and export of each substance it has committed to address.
Convention on Biological Diversity	Contains articles on various aspects of biodiversity conservation, identification, and monitoring that will need to be considered as part of the EA. Vietnam ratified the Convention on Biological Diversity on November 16, 1994.	**Article 7(c)** requires the GVN to identify processes and activities that have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity. **Article 14** requires the GVN to minimize adverse effects on biodiversity including environmental impact assessment of proposed projects that may affect biodiversity resources.
Convention on Wetlands of International Importance (Ramsar Convention)	Provides a framework for the maintenance of ecological character for wetlands[2] through national land-use planning, policies and legislation, management actions, and public education. Vietnam became a signatory to the Ramsar Convention on January 20, 2001.	**Article 3 No. 2:** Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.
Protection of the World Cultural and Natural Heritage	Defines the roles and obligations of ratified states in protecting and preserving areas of cultural and natural heritage. Vietnam became a signatory on October 19, 1987.	**Article 5** centers on effective and active measures for the protection and conservation of cultural and natural heritage and requires the GVN to take appropriate measures necessary for the identification, protection, conservation, presentation and rehabilitation of its cultural and natural heritage.

[2] Wetlands are defined in Vietnam in GVN Circular No. 18/2004/TT-BTNMT of August 23, 2004 *Guiding the Implementation of the Government's Decree No. 1099/2003/ND-CP of September 23, 2003 on Conservation and Sustainable Development of Wetlands* as "areas permanently or temporarily submerged in water, running or stagnant, fresh, alum, saline or brackish and are classified into coastal wetlands and inland wetlands."

FIGURE 2-1 BIEN HOA AIRBASE AND AREAS OF KNOWN AND POTENTIAL DIOXIN CONTAMINATION



Section 3 Summary of Current Situation

3.1 Bien Hoa Airbase and Surrounding Communities

The Airbase is located in Dong Nai Province northeast of Ho Chi Minh City. The province has an overall population of approximately 2.8 million people in an area of 5,907 km^2 and an average population density of 470 persons per km^2 (General Statistics Office [GSO] of Vietnam 2014a). The Province comprises eleven districts, including Bien Hoa City, with an average population density of approximately 3,400 persons per km^2 (Dong Nai Statistical Office 2013). The Airbase property is adjacent to Trung Dung, Quang Vinh, and Buu Long Wards and lies within Tan Phong Ward. Surrounding areas are densely populated, with most of the land used for housing, industrial facilities, transportation, and associated infrastructure. There are approximately 885,000 people living in Bien Hoa City (Dong Nai Statistical Office 2013). Approximately 120,000 persons are estimated to live in the city wards surrounding the Airbase as well as on the Airbase itself[3].

Bien Hoa City (and the province of Dong Nai) is an integral part of Vietnam's Southern Economic Development Zone, which contributes approximately 40% to the country's gross domestic product (GDP). While primary economic activities such as agriculture and forestry do occur, the industrial sector, and to a lesser extent the service sector, are the main economic drivers of Bien Hoa City. The city is characterized by high levels of urbanization, a decreasing amount of land allocated to agriculture, and an increasing amount of land allocated to industrial production (largely in industrial development zones, housing, and associated urban infrastructure).

The Airbase property is located within Bien Hoa City and is a military Airbase. It has a total area of approximately 1,000 ha and is situated on low-lying land immediately to the east and northeast of the Dong Nai River. The Airbase property is also used for agriculture and forestry, particularly in the northern part of the property. There are a number of aquaculture ponds on the Airbase property, particularly in the Northeast Area, and these have been in active use since at least 2010, with local people harvesting fish, ducks and other aquatic animals (Hatfield and Office 33 2011). Fish are sold to, and consumed by, local residents both on and off the Airbase. Interim measures implemented since 2009 are described in **Section 3.3**, including an awareness raising program conducted by Office 33 in October 2013 to warn residents of the dangers related to fishing on Airbase ponds, as well as fencing and warning signs. Fishing activities, including aquaculture, were observed on the Airbase as of December 2015 despite official fishing bans enacted by the Airbase authorities in 2010 (Thien-Le Quan 2015).

With respect to land use on the Airbase property:

1. Approximately 1,200 people live on the Airbase itself, with up to 2,200 workers on the Airbase during peak times.

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[3] In 2012, approximately 111,000 persons lived in the city wards surrounding the Airbase, while approximately 1,200 persons lived on the Airbase itself (Canh 2012b). For the purposes of this EA, a current population of 120,000 persons living in the vicinity of and on the Airbase is estimated, with 1,200 of these persons assumed to be living on the Airbase. This estimate is reflective of recent population growth in Dong Nai Province reported by the Dong Nai Statistical Office (2013) and by Hatfield (2015).

2. There are 20 units of army guards on the Airbase, which is enclosed by a perimeter wall/fence.
3. Air force training activities are extensive, and occur mainly in the east apron area.
4. There is a factory complex with an area of 50 ha southeast of the runways.
5. Part of the Airbase property is used for warehouses and storage.
6. The northern part of the Airbase property is used for agriculture (including family gardens and cattle grazing which were noted as recent as April 2015) and contains rubber plantations.
7. There are a number of aquaculture ponds on the Airbase property (raising primarily Tilapia, but also ducks and other aquatic organisms), primarily in the Northeast area; however, use of these ponds for aquaculture purposes was banned by the Airbase in 2010 per Office 33's recommendation. Enforcement of the fishing ban has been challenging to date.

3.2 Dioxin Contamination on and around Bien Hoa Airbase

During the U.S.-Vietnam war, over 80 million liters of herbicides were released over South Vietnam in a mission code-named Operation Ranch Hand (Cecil 1986). Bien Hoa Airbase was the largest and most active Ranch Hand site in Vietnam and handled the largest volume of herbicides (especially Agents Orange, White, and Blue but also other formulations including Agent Purple, Pink, and Green). These herbicide mixtures were predominantly used to defoliate forests and crops, and many of them contained TCDD as a contaminant by-product. The Airbase is recognized as a dioxin hotspot due to high TCDD concentrations remaining decades after large volumes of Agent Orange and other herbicides were stored, handled and spilled at the Airbase during the U.S.-Vietnam War (Dwernychuk et al. 2002; Dwernychuk 2005). Hotspots have high residual dioxin concentrations in soil, sediment, and other contaminated media (such as fish) as a result of storage, use, and spillage of concentrated versions of Agent Orange and other herbicides.

Three large tanks were used for herbicide storage at the Airbase during Operation Ranch Hand; one each for Agent Orange, Agent White, and Agent Blue. According to U.S. military data, the Airbase was used to store and handle 98,000 45-gallon (170-liter) barrels of Agent Orange, 45,000 45-gallon (170-liter) barrels of Agent White, and 16,000 45-gallon (170-liter) barrels of Agent Blue (DOD 2007). Agent Blue did not contain dioxin but organic arsenic was in the formulation. On April 17, 1970, the use of Agent Orange for military operations was formally halted in the Republic of Vietnam, and unused herbicides were placed in storage. The Pacer Ivy mission was launched on September 15, 1971 to consolidate, re-drum and ship all remaining Agent Orange and other Ranch Hand materials in South Vietnam to Johnston Atoll in the central Pacific Ocean.

Because of war-time conditions, demobilization from former Ranch Hand sites (including the Airbase) was not always undertaken with adequate precautions to minimize impacts to human health and the environment. At least four times between December 1969 and March 1970, major spills occurred at the Airbase (DOD 2007). These spills, estimated to be 25,000 liters of Agent Orange and 2,500 liters of Agent White (DOD 2007), likely resulted in releases to the environment.

Several scientific sampling programs have been conducted within the Airbase since 1990 to determine dioxin concentrations (**Table 3-1**). This section provides a summary of the key historical studies conducted at the Airbase, the main results from the 2014-2015 USAID EA sampling program, and the estimated amount of dioxin contaminated soil and sediment at the Airbase.

3.2.1 Summary of Previous Studies at Bien Hoa Airbase

Prior to 2000, there was limited information in the scientific literature on dioxin concentrations in and around the Airbase (Dwernychuk et al. 2002). The earliest recorded dioxin investigations at the Airbase and in the City of Bien Hoa were conducted by VRTC in 1990, by MND in 1995 and 1996, and by Dr. Arnold Schecter in 1999 (Schecter *et al.* 2001). More comprehensive studies were conducted between 2006 and 2011, including sampling of soils and sediments in suspected source areas on the Airbase and the dioxin exposure to local residents (Hatfield and 10-80 Division 2006, Hatfield and VRTC 2009, Hatfield and Office 33 2011). Studies conducted to date show that dioxin concentrations within source area areas of the Airbase, and in some locations outside the Airbase, exceed international and Vietnamese standards for dioxin. As a result of these studies, it is clear that dioxin has entered the aquatic environment and human food chain, and that levels in the human population are above World Health Organization (WHO) standards (WHO 1998). Eleven studies have been conducted at the Airbase to characterize the dioxin contamination (**Table 3-1**). Seven of these studies were reviewed for the ESS. However, data from only five of these studies were available for the preparation of this EA. These studies are summarized below:

- Data from studies conducted by MND from 1995 and 1996 were not available in published form.
- Schecter *et al.* (2001) reported high levels of 2,3,7,8-TCDD in Airbase area soils and human blood. Results of dioxin analyses of soil samples from Bien Hoa City and the Airbase varied from undetected to over 1 million ppt TEQ. However, the exact locations of samples collected by Schecter *et al.* (2001) on the Airbase are unknown. A total of 20 human blood samples were also collected from residents living within close proximity to Bien Hung Lake; 19 samples indicated levels above 6 ppt TEQ with the highest concentration detected at 271 ppt TEQ (Schecter *et al.* 2001).
- From 2003 to 2005, with funding from the Ford Foundation, Hatfield and the 10-80 Division (2006) conducted a review of all suspected dioxin hotspots in Vietnam, including the Airbase. The project, entitled "Identification of New Agent Orange/Dioxin Contamination Hotspots in Southern Vietnam," included: the identification of potentially contaminated sites that may pose a risk to human health; a field sampling program; and recommendations for future action. Soil and sediment sampling and dioxin analyses undertaken as part of this research included the eastern end of the runway (Northeast Area), Gate 2 Lake, Bien Hung Lake, and surrounding areas. Elevated dioxin concentrations in soils and sediments (per QVCN 2012 standards) were recorded in the Northeast Area. Based on these results, recommendations were made for further assessments on the Airbase (as well as the Danang Airport, Phu Cat Airbase, and other suspected hotspots identified in the study), to determine the extent of contamination and possible exposure of the local population to dioxin (Hatfield and 10-80 Division 2006, Dwernychuk et al. 2006).
- In 2008, Hatfield, VRTC and UNDP (Hatfield and VRTC 2009) completed an assessment of soils and sediments in the Southwest Area of the Airbase, Pacer Ivy Area, and the Z1 Area and its perimeter. Sampling was also conducted in the vicinity of the former herbicide storage tanks in the Z1 Area during construction of the landfill. Hatfield and VRTC (2009) was the first study to identify the Southwest Area as a dioxin source area on the Airbase (the highest dioxin concentration recorded was 65,500 ppt TEQ in surface soils 0-10 cm). Maximum dioxin concentration recorded in the Pacer Ivy was 22,800 ppt (0-10 cm) for soils and 5,970 ppt for sediments. Sampling was also conducted at the Z1 Landfill site during its construction, including the area below the former Ranch Hand herbicide storage tanks. Dioxin concentrations recorded below the former Agent Orange storage tank were 262,000 ppt TEQ in a sample analyzed by the VRTC laboratory (60-90 cm depth);

a sample analyzed by AXYS Analytical Services Ltd. (AXYS) in the same area but at greater depth (150-180 cm depth) was 185,000 ppt TEQ. These samples indicated high dioxin concentrations in materials placed in the landfill, from soil excavations conducted in the Z1 Area. Perimeter areas generally exhibited lower dioxin concentrations, with the exception of a drainage canal downslope of the Z1 Area (2,090 ppt). Hatfield and VRTC (2009) recommended further investigations of the Z1 Area, including potential dioxin contamination in wetlands and ponds downstream of the Z1 Landfill.

- The Vietnam Environment Administration (VEA) and Ministry of Natural Resources and Environment (MONRE) in 2011 conducted a dioxin characterization study in the Pacer Ivy Area, which added information on the extent and depth of contamination in this area of the Airbase (VEA and MONRE 2012). VEA and MONRE (2012) conducted soil, sediment and core sampling including sampling to a depth of 2.4 meters (m). Results of this study provided a better understanding of dioxin concentrations throughout the Pacer Ivy Area. However, highly variable dioxin concentrations were recorded at various depths, ranging from undetectable to 962,560 ppt TEQ.
- In 2013, a sampling survey was conducted by VRTC as part of the UNDP GEF Dioxin Project on lakes inside the Airbase and soils outside of the Airbase to assess the potential for dioxin outflow from the Pacer Ivy Area (MND unpublished data). From this study, 28 waterbodies in the Airbase area were identified as being potentially contaminated with dioxins above the Vietnamese guidelines and soil samples collected from outside the Airbase west of the Pacer Ivy Area were generally below the Vietnamese dioxin guidelines (MND unpublished data).
- Groundwater monitoring studies were conducted at the Airbase by Dekonta from the Czech Republic, in association with Dong Nai DONRE and Office 33 (Urban et al. 2012). These included installation of groundwater monitoring wells at seven strategic locations in and around the Airbase: four wells in the vicinity of the Z1 Area; one well in the Southwest Area; and two wells in the Pacer Ivy Area. The monitoring wells were generally screened at between 3 m and 15 m depth, with the exception of MW-6 in the Pacer Ivy Area, which was screened between approximately 2 m and 6 m depth (Dekonta 2014). Groundwater sampling results showed detectable yet low concentrations of dioxin in all but one of groundwater wells (Dekonta 2014). 2,3,7,8-TCDD concentrations in these wells ranged from 0.18 ppq [pg/L]) to 17 ppq. There is no GVN standard for surface water or groundwater, but all of these concentrations were below the USEPA MCL of 30 ppq for drinking water for 2,3,7,8-TCDD (USEPA 2009b). Picloram (a component of Agent Orange) was detected at all groundwater monitoring wells ranging from 0.484 micrograms per liter (µg/L) to 1,050 µg/L during Dekonta's monitoring effort in 2014 the USEPA MCL for picloram is 500 µg/L (USEPA 2009b). Dong Nai DONRE has also conducted dioxin monitoring for soil, sediments and groundwater at several locations around the Airbase between 2005 to present; however, detailed laboratory analytical results were not available for review as part of this EA.
- Soil sampling conducted as part of a remediation technology demonstration project under the UNDP GEF Dioxin Project revealed arsenic levels which exceeded the GVN limit for arsenic in soils (QCVN 03:2008/BTNMT) of 12 parts per million (ppm) in the Southwest Area and Pacer Ivy Area (Cooke 2013; 2015, and Hatfield 2013). Soil samples from five sites were found to have arsenic concentrations that ranged from 3.5 to 273 ppm. Elevated levels of hexavalent chromium, copper, lead and zinc were also detected. The VEA and MONRE (2012) study also identified elevated levels of arsenic in nine soil samples analyzed from the Pacer Ivy Area; concentrations ranged between 11.6 and 252 ppm.

- In 2010, Hatfield and Office 33 (2011) conducted environmental investigations of soils and sediments, fish tissues, human blood serum, and breast milk from community members deemed at high risk from dioxin exposure (i.e., Airbase workers, people who consume fish/aquatic organisms from lakes and ponds, etc.), including people who reside inside and outside of the Airbase. Three out of the 42 blood serum samples analyzed by Hatfield and Office 33 (2011) were found to have TCDD concentrations above the WHO (1998) standard of 30 ppt TEQ (cited in American Chemistry Council [ACC] 2003); the maximum was 1,970 ppt 2,3,7,8-TCDD (2,020 ppt TEQ) present in an Airbase worker (male) involved in aquaculture and fishing near the Pacer Ivy Area. Dioxin levels in blood serum in all but one person sampled exceeded the WHO 1998 standard. Dioxins were also recorded in breast milk samples analyzed from Bien Hoa residents; the average daily intake of breast milk per infant was calculated based on WHO/EURO (1989). Total TEQ ingested by infants ranged from 5 to 172 pg TEQ/kilograms body weight per day (kg bw/d) (the WHO standard is 4 pg TEQ/kg bw/d; WHO 1998). The highest levels were recorded in breast-feeding mothers who had consumed fish raised on the Airbase. These results indicated a risk for dioxin contamination in local Bien Hoa residents and confirmed that the main exposure pathway was through consumption of fish and other aquatic organisms on the Airbase (Hatfield and Office 33 2011, Nguyen et al. 2011, Durant et al. 2014).
- No ecological surveys are known to have been conducted at the Airbase that describe impacts to local biodiversity from dioxin contamination. However, fish tissue samples were collected and analyzed for dioxins in 2010 by Hatfield and Office 33 (2011), from fish collected both within the Airbase and in surrounding areas. Fish were collected from the Northeast Area, Northwest Area, Pacer Ivy Area, the Z1 Area, and from lakes outside of the Airbase. Samples had concentrations ranging between 1.4 and 32 ppt TEQ in fish muscle and between 4.54 and 4,040 ppt TEQ in fat (CFIA guideline is 20 ppt; Hatfield and Office 33 2011; CFIA 2014). Fish (and other sources of food) with concentrations above this threshold of dioxin are therefore a major concern for consumers in the Bien Hoa area. Due to the lipophilic properties of dioxin, this contaminant tends to bioaccumulate (i.e., accumulate in higher concentrations as one moves up a food chain). This places community members who consume these contaminated fish products at higher risk of dioxin exposure.

Based on these earlier studies, the key dioxin source areas and exposure pathways were identified on the Airbase and the general extent of contamination was known prior to commencement of this EA Study. However, key data gaps were filled during the EA process including collection and analysis of: a) soil samples around the entire perimeter of the Airbase, in several areas which had previously not been sampled; b) sediment samples from all known waterbodies on the Airbase, and in the drainage canal west of the Pacer Ivy area outside the Airbase; c) fish samples from all known aquaculture ponds and other aquatic habitats. The number of samples collected and analyzed as part of this study was unprecedented in Vietnam, and was the largest dioxin sampling program undertaken to date in the country.

It is important to note that these earlier studies relied on discrete soil sampling methods whereas this EA Study employed the multi-increment® sampling (MIS) methodology – an important lesson learned from the Danang Airport EA effort and volume estimation process. The MIS method was selected to generate results with significantly less variability and a higher statistically-defensible level of confidence than discrete sampling or less robust composite sampling methods (Interstate Technology and Regulatory Council [ITRC] 2012). Further, based on consultations with the GVN cited in **Section 2.4**, the GVN indicated that all previous studies should be considered screening level data quality only and requested an updated evaluation of the nature and extent of dioxin contamination.

Initial estimates of the volumes of contaminated soil and sediment requiring remediation as presented in the Bien Hoa Master Plan (Hatfield 2013) were 200,800 m^3 of soil and 29,200 m^3 of sediment. These initial volume estimates were established using the 2010 GVN National Standard (TCVN 8183:2009), where all soil, regardless of land use, was classified as contaminated when exceeding 1,000 ppt. These estimates differ widely from what is presented in later sections of this EA because: 1) previous volume estimates were based on the former GVN regulation for dioxin contamination in soil (1,000 ppt) versus the MND-approved dioxin limits which are based on the current land-use-based GVN regulation for dioxin contamination in soil, which varies from 40 ppt to 1,200 ppt depending on designated land use; and 2) the 2014/2015 USAID sampling efforts performed in support of this EA more clearly delineated the lateral and vertical extent of contamination on and around the Airbase and extended sampling to areas not previously sampled.

The known (and suspected) dioxin source areas on the Airbase, and potential exposure pathways to the local population, were identified as follows prior to the 2014/2015 EA sampling program:

- **Z1 Area**: Located in the southern corner of the Airbase, Z1 was the main storage area for Agent Orange, Blue, and White herbicides at the Airbase and initially contained the most heavily contaminated materials at the Airbase. During the U.S.-Vietnam war, three large herbicide storage tanks were present at this location (one for each main herbicide type used), and the area surrounding the Z1 was subjected to significant spillage. As a result, dioxin has been detected in soil, sediment, concrete and other construction materials, and aquatic organisms (mainly fish) in onsite lakes and lakes down-gradient and offsite of this former storage area. Dioxin contamination in soil has penetrated to a depth of at least 2 m, and possibly as deep as 4.5 m in some locations (Canh 2012b). Concentrations measured by Vietnamese scientists in this area have been as high as 409,818 ppt TEQ (Nyet 2012), 1,180,738 ppt TEQ (10-80 Committee as reported in Nyet 2012), and 5,800,000 ppt TEQ in a sample collected from the underground concrete sump used for waste at the aircraft rest area (Canh 2012b). Contamination has spread south of the original herbicide storage areas into both soils and lake sediments (Canh 2012b), with soil and sediment concentrations as high as 11,900 and 2,240 ppt TEQ, respectively (Hatfield and VRTC 2009; Nyet 2012). Interim containment measures were implemented in this area in 2009 with drainage ditches and containment of approximately 60,000 m^3 of contaminated soils in the Z1 Landfill [4].
- **ZT Area**: Located north of the Z1 Area, this was the former taxiway for transportation of herbicide, aircraft loading/unloading, and for moving equipment during the war. The area was

[4] This estimate is based on the understanding of the authors of this EA regarding the design of the Z1 Landfill and conversations the authors of this EA had with Chemical Command during EA preparation which indicated that the waste thickness was about1.5 m. As part of this Study, measurements in the field and on aerial imagery have shown that area of the Z1 Landfill complex (including perimeter ditching, walls, stormwater treatment system, old concrete pad [Z1-17], and landfill) is 4.3 ha and that the lined portion of the complex (i.e., the area containing contaminated material) is approximately 4.0 ha. When the thickness (1.5 m) is multiplied by the measured area of the landfill (4.0 ha), the resulting volume estimate is approximately 60,000 m^3. A higher estimate of 94,000 m^3 has been reported in the Bien Hoa Master Plan (Hatfield 2013) and assumes a thickness of 2 m and a landfill area of 4.7-ha. To account for the discrepancy in waste thickness, an additional 20,000 m^3 (0.5 m over an area of 4.0 ha) has been included in the contingency volume estimate (Section 3.2.5).

suspected to be contaminated due to transportation and spillage of herbicides during Operation Ranch Hand but had never been investigated prior to the 2014/2015 EA Study.

- **Southwest Area:** Located on the southwest side of the Airbase adjacent to residential areas abutting the boundary of the Airbase, this area was suspected to be used as an herbicide storage area during the Pacer Ivy mission (Hatfield and Office 33 2009; 2011). Dioxin contamination was first discovered in this area in 2008 with maximum levels measured at 65,000 ppt TEQ (Hatfield and VRTC 2009). The depth profile of contamination is complex, with higher concentrations of dioxin found between layers of less contaminated soils (Minh 2012). Contaminated materials include soil and some concrete used for infrastructure. A number of military barracks, other buildings and forest plantations are found in this area. Results of the 2014/2015 EA Study discovered expanded areas of contamination in this area, which were shared with MND to modify their plans to excavate this area and construct a second landfill (XD-2 Landfill) adjacent to the existing Z1 Landfill (see **Section 3.3** for more information).
- **Pacer Ivy Area:** Located on the western end of the Airbase and close to the current runway, this area was used to store, re-drum, and package 11,000 drums of Agent Orange for shipping to Johnston Atoll in the central Pacific Ocean during the Pacer Ivy Mission. The Pacer Ivy Area covers roughly 3.8 ha with many ponds and lakes, and may have also been a general waste dump area during the US-Vietnam War. This area receives drainage from the runway and Southwest Area of the Airbase and drains west to Buu Long Ward, Bien Hoa City, specifically through a canal in Buu Long Ward and eventually to the Dong Nai River. Both soils and sediments have been found to contain dioxin concentrations higher than the MND-approved limits for dioxin contamination. The maximum dioxin concentration measured in soil in this area is 962,560 ppt TEQ (VEA 2012). Sediment concentrations have been measured as high as 6,681 ppt TEQ in samples taken from ditches connecting the runway and ponds in this area (Hatfield and VRTC 2009). A number of aquaculture ponds were previously operating in this area, and high concentrations of dioxin in sediment and fish in these ponds have been recorded (Hatfield and Office 33 2011). As in the Southwest and Z1 Areas, the distribution of contamination over the area and at different depths is variable and complex (Hatfield 2013). Under the UNDP GEF Project, a series of drainage ditches were constructed around the perimeter of the Pacer Ivy Area to restrict and redirect flow outside of the Airbase; a ban on aquaculture in the area was also successfully implemented (see **Section 3.3** for more information).
- **Northwest Area:** Located between the runway and the northern boundary of the Airbase on the west side of the Airbase. Few sampling programs were conducted in the Northwest Area of the Airbase prior to the 2014/2015 EA sampling program, with the exception of sediment sampling in lakes by VRTC in 2013. VRTC (2013) recorded contaminated sediments (dioxin concentrations greater than 150 ppt TEQ) from ponds in the area, and subsequently a sediment control structure was constructed in this area as part of interim remediation measures under the UNDP GEF Dioxin Project (see **Section 3.3** for more information).
- **Northern Forest Area:** This area is located along the northern boundary of the Airbase and consists of extensive rubber plantation forests and some agriculture and livestock areas. VRTC (2013a; 2013b) conducted sampling in this area in 2013 and found dioxin concentrations above the GVN allowable limit for dioxin contamination in soil for forest land use (100 ppt).
- **Northeast Area:** Located immediately east of the runways, contaminated soil, sediments, and fish were identified in this area by Hatfield and Office 33 (2011). Of primary concern is the extensive aquaculture ponds in this area, which have been used to raise several hundred tons (t) of Tilapia and

other fish annually. Fish are moved from this area to other lakes on the Airbase property, and likely have been sold inside and outside the Airbase (possibly for decades), thereby increasing the risk of exposure to local residents through consumption of contaminated foods. Interim mitigation measures (see **Section 3.3**) conducted in this area under the UNDP GEF Dioxin Project included fencing and signage around the aquaculture ponds; however, this appeared to have little impact on fishing practices, which were observed in the area as late as March 2015. Controlling fishing and aquaculture activities in this area, and on the Airbase in general, has been challenging and largely ineffective to date.

- **Areas Outside the Airbase:** Historical data indicate dioxin contamination extends beyond the Airbase property boundaries resulting in contamination in soils, sediments, fish, and ultimately, the local population (Schecter et al. 2001, Hatfield and 10-80 Division 2006, Hatfield and Office 33 2011, Nguyen et al. 2011). Key areas are those located immediately outside the boundary of the Airbase, and downstream or down-slope from core sources of contamination such as the Z1 Area, Northeast Area, and Pacer Ivy Areas. The primary concern is overflow of water carrying contaminated-sediment during the rainy season from the Pacer Ivy Area into Bien Hoa City and potentially to the Dong Nai River. This includes: known contaminated lakes such as Gate 2 Lake, which is immediately south of the Airbase main gate, as well as Bien Hung Lake, a recreational area for Bien Hoa City residents; and the drainage canal west of the Pacer Ivy Area.
  - **South, Southwest, and West of the Pacer Ivy Area:** Soil samples collected south and southwest of the Pacer Ivy Area, outside of the Airbase property, have been found to have elevated concentrations of dioxin, indicating that contamination has spread offsite, likely primarily through rainwater runoff and air dispersion (Hatfield and 10-80 Division 2006; Hatfield and VRTC 2009; Hatfield and Office 33 2011; VRTC 2013a; and VRTC 2013b).
  - **Gate 2 Lake and Bien Hung Lake:** The lakes in the Z1 Area were originally hydraulically connected to Gate 2 Lake and Bien Hung Lake, outside the Airbase property (first through a connected series of wetlands, and later via storm sewers), which resulted in dioxin contamination spreading south of the Airbase (Hatfield and 10-80 Division 2006; Hatfield and Office 33 2011).
  - **South of the Northeast Area:** Concentrations of dioxin in sediment samples collected south of the Northeast Area, outside and downstream of the Airbase property, have been found to have dioxin concentrations greater than 150 ppt TEQ (Hatfield and 10-80 Division 2006; Hatfield and VRTC 2009; Hatfield and Office 33 2011; VRTC 2013a; and VRTC 2013b), suggesting that contamination has spread offsite, likely primarily through rainwater runoff and air dispersion.

A brief summary of historical sampling results from the Airbase is provided in **Table 3-2**. Data presented include results from studies that used high-resolution gas chromatography – mass spectrometry (HR-GCMS) for dioxin analyses, and for which acceptable quality assurance/quality control (QA/QC) data are available. Detailed historical data results are presented in **Appendix A**.

3.2.2 USAID Sampling at Bien Hoa Airbase

The analytical data collected prior to 2014 provided an understanding of dioxin contamination at the Airbase and identified key dioxin source areas and exposure pathways; however, as described in the ESS (USAID2015b), additional data were needed to refine the lateral and vertical extent of contaminated material requiring remediation; alternate characterization was needed to make a more refined contaminated volume estimate; and an updated review of technologies and alternatives was needed to guide decision-making related to site remediation. Further, the GVN considered all previous sampling efforts as screening level data only and requested a more current understanding of the full nature and extent of dioxin contamination on and around the Airbase (USAID 2015b).

The nine sampling areas (Z1 Area, ZT Area, Southwest Area, Pacer Ivy Area, Northwest Area, Northern Forest Area, Northeast Area, Southeast Area, and Lakes Outside of the Airbase) were selected based on professional judgement, results of previous sampling programs, known data gaps, and consensus to ensure samples were collected from the entire perimeter of the Airbase. The nine general areas were divided into DUs that were considered a reasonable size to assess dioxin exposure. Thirty aliquots were collected in each DU at a specific depth interval and composited into one MIS sample to estimate average dioxin concentrations. **Figure 3-1** shows the locations of these areas and identifies the specific locations of the DUs that were sampled during the 2014/2015 sampling program. Each DU was further divided by into three screening level sub-decision units (sub-DUs) based on a ten aliquot composite in order to further refine the estimate for contaminated volume.

A sampling and analysis plan (SAP) was prepared for the 2014/2015 EA sampling program to obtain additional dioxin contamination information for the Airbase (USAID 2014). The SAP included details on methodologies for collection of soil, sediment, water and fish tissue samples, as well as a description of the MIS technique that was applied for all soil and sediment sampling. The proposed sampling plan was presented at Stakeholder Engagement Meeting No. 2 in September 2014. MND provided approval of the sampling plan on October 30, 2014 (Letter No. 1470-KH-VKHCNQS).

The specific data quality objectives (DQOs) of this SAP were as follows:

1. Delineate the vertical and lateral extent of dioxin contamination on and around the Airbase.
2. Determine the nature of non-dioxin contamination in the areas of influence of dioxin.
3. Identify which lakes require remediation to prevent human exposure to dioxin contamination.
4. Determine the amount of soil, sediment, and groundwater that must be remediated in order to close dioxin exposure pathways.

To address each of these DQOs, a two-phase sampling program was implemented at the Airbase. Phase 1 was conducted over a 5-week period from November to December 2014; Phase 2 was conducted over a 6-week period from March to April 2015. Soil and sediment sampling at the Airbase was conducted at each of the nine areas using the MIS method. The MIS method is designed to provide an unbiased, statistically valid estimate of the mean value of an analyte within a designated sampling area, or DU, by compositing 30 or more increments or aliquots (i.e., individual sampling points) from the area into each MIS sample. The large number of increments in each MIS sample results in a greater density of sample aliquot locations when compared to typical composite sampling methods. The MIS sample will result in one representative sample concentration per depth, per DU. The MIS method reduces the fundamental error caused by the constitutional heterogeneity of a sample (i.e., represents the minimum sampling error that would be expected if all other error sources are negligible, such as sample delimitation, chemical analysis, potential contamination etc.). Additionally, the depth of contamination within each DU, as determined through MIS sampling at multiple depth intervals, will allow for a higher level of confidence in contaminated soil and sediment volume estimates, when compared to contaminant depths determined using discrete or less-robust composite sampling methods.

One potential concern with MIS sampling is the possibility that it will "dilute" or otherwise obscure high concentrations present in the soil that might be easier to see with a discrete sample. This is not a concern for several reasons. First, the MIS sample provides a better representation of the actual TEQ of the soil from an exposure perspective, and is therefore more appropriate to dioxin limits compared to an aliquot that may not represent a significant amount of the soil. Second, if the data produced by a discrete sample is not replicated by the MIS samples, it is not expected it will affect the decision as to whether the material exceeds the action level. As demonstrated during the Danang Airport remediation project, the switch to MIS sampling for use during confirmation sampling significantly increased the amount of soils and sediments that required excavation. Third, it is not expected it would influence the selection of appropriate remediation technologies.

As shown in **Figure 3-1**, a total of 76 DUs were sampled: 28 during Phase 1 and 48 during Phase 2. In each DU, MIS samples were taken at several depths. Soil MIS samples were collected at 30-cm intervals to depths ranging between 0.6 and 3.9 m. Sediment MIS samples were collected at 15-cm intervals to a maximum depth of 45 cm. Areas which had sampling depths of 100 cm or less were sampled using a soil corer, Ogeechee sampler or Ekman sampler. Drilling (via drill rig) was utilized for the areas with sampling depths greater than 100 cm. In addition to MIS samples, subsamples were also collected at each sampling depth in all but two of the DUs (Z1-1 and Z1-17). Each DU was divided into three sub-DUs (for a total of 222 sub-DUs) and a subsample was collected from each sub-DU.

Over 8,700 aliquots were collected to generate more than 1,300 soil/sediment dioxin samples. In addition, approximately 100 samples were collected for chemical and physical property testing of soil/sediment, and dioxin and chemical testing of groundwater and biota. In total, the sampling program generated more than 1,400 samples as summarized in **Table 3-3**. For the soil/sediment dioxin samples, it should be noted that not all subsamples were analyzed. Subsamples to be analyzed were selected based on prioritization of samples, results of analysis on MIS samples, and professional judgement. A summary of the number of samples analyzed is provided in **Table 3-4**. As indicated, over 700 samples of soil, sediment, groundwater, and biota were analyzed as part of this Study. More detailed lists of all samples collected, analyzed, and the analytes tested are included in **Appendix A, Tables A1.1a through A1.1i**.

Figures 3-2 through 3-10 present the areas sampled during the 2014/2015 EA sampling program, along with the dioxin analytic results. Additional details regarding the sample collection locations, areas and depths, DU and sub-DU boundaries, and dioxin analytical data are presented in **Appendix A. Appendix E** contains the analytical data for other environmental analyses. Areas sampled as part of the 2014/2015 EA sampling program and significant findings for each area are included in **Table 3-5.**

To analyze samples in a cost-effective manner and to meet project objectives, a tiered approach was implemented to decide which samples should be analyzed. MIS samples collected from areas of previously-identified dioxin contamination, as well as all surface soil and sediment samples, were categorized as Tier I and analyzed immediately following collection. Deeper soil samples from areas where dioxin contamination had not been previously identified were set aside for future analysis (Tier II and Tier III). Select Tier II samples were analyzed based on an evaluation of the results of the Tier 1 samples, and select Tier III samples were analyzed based on the Tier II results. All MIS soil and sediment samples for each DU were analyzed for dioxins and furans during one of the tiers. Subsamples from some areas under Tier II and Tier III were not analyzed if the MIS samples from these areas were below applicable soil concentration dioxin limits based on land use (see **Section 3.2.4** and **Table 3-7**). Select Tier I soil and sediment samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyl (PCBs), herbicides, metals, and physical properties.

Analytical results are presented in a series of tables and figures in **Appendix A**. This includes specific details on dioxin and furan concentrations found in soil, sediment, biota and groundwater samples. **Appendix E** provides analytical results for samples collected for VOCs, SVOCs, PCBs, herbicides, metals, and physical properties.

Results of the 2014/2015 EA sampling program, as organized by their respective DQO, are as follows:

DQO #1: Delineate the vertical and lateral extent of dioxin contamination on and around the Airbase

Samples collected and analyzed in the 2014/2015 EA sampling program provided significant new information about dioxin contamination in soil and sediment on the Airbase. More than 1,400 soil and sediment dioxin samples were collected, including 247 MIS samples, which represents the largest dioxin sampling program undertaken to date in Vietnam. Estimates of the vertical and lateral extent of dioxin contamination were determined using the results of the MIS sampling conducted and this information was used to determine more accurate estimates of area and volume of soil and sediment requiring remediation than were previously reported in the Bien Hoa Master Plan (Hatfield 2013). Several areas that were not previously known to be contaminated were identified, including the perimeter of the Southwest Area (SW-3, SW-7), the former taxiway leading to the Z1 Area (ZT-2), and the Northern Forest Area (NF-4). The vertical extent of contamination was also defined with greater precision than in previous sampling programs. Results of the sampling program and analytical results are presented in greater detail below and in **Appendix A**.

The following are key results of the delineation of contaminated soil/sediment areas on the Airbase (all values in ppt TEQ unless otherwise specified; dioxin limits mentioned below are based on the MND-approved limits, see **Section 3.2.4**):

1. **General:** Results from the 2014/2015 EA sampling program indicated that dioxin contamination in soils at the Pacer Ivy Area is more extensive than other areas, followed by the Southwest Area and Z1 Area. However, the highest dioxin concentration in a sub-DU was recorded in the Southwest Area. Z1 Area soils had the lowest dioxin concentrations among the three known source areas sampled on the Airbase (a maximum of 1,510 ppt was recorded in the landfill soils collected from 0-100 cm depth). Sixteen of the 25 sediment areas were found to have dioxin concentrations exceeding the sediment dioxin limit of 150 ppt.
2. **Z1 Area:** With the exception of the landfill and sediment in the lakes in this area (a maximum of 1,578 ppt was recorded in sediments at Z1-10 at 15-30 cm depth), overall dioxin concentrations in soils were slightly above or below the MND-approved dioxin limits. Excavation of contaminated soils and construction of the landfill in 2009 appears to have been effective in significantly reducing overall dioxin concentrations in the Z1 Area (also reported by Hatfield and Office 33 2011). Excluding the Z1 Landfill, the maximum soil dioxin concentration recorded was at Z1-16B (901 ppt) and dioxin concentrations exceeding the MND-approved dioxin limits were

only recorded at depths less than 60 cm. Tilapia from Z1-9 (68.3 ppt in whole fish) had dioxin concentrations above the dioxin limit.

3. **Z1 Landfill:** Dioxin concentrations in the landfill (1,510 ppt) were lower than expected, given the amount of contaminated soil contained in this area (and high concentrations reported from this area by Hatfield and VRTC [2009]), and the extensive Operation Ranch Hand activities conducted at the Airbase. One discrete sample was collected and analyzed from the bioremediation study area in the Z1 Landfill, which also exhibited low dioxin concentrations (3 ppt).
4. **ZT Area:** Dioxin concentrations were below MND-approved dioxin limits throughout this area, with the exception of ZT-2B (3,440 ppt). The field team reported strong chemical smells from this area during sample collection.
5. **Southwest Area:** This area exhibited the highest dioxin concentrations of all sub-DU locations sampled on the Airbase (110,000 ppt at SW-1A, 30-60 cm), down to the maximum depth sampled at SW-1 (2,680 ppt at SW01A, 120-150 cm). Contamination in the SW-1 area appears to be concentrated in the SW-1, SW-2A and B, and SW-3A and B areas. However, dioxin concentrations above the MND-approved dioxin limits were also recorded at SW-7A (674 ppt) and SW-7B (311 ppt). As discussed in **Section 3.3.1**, soils from SW-1 and SW-2 were excavated in the springs of 2015 and 2016 and placed in a new landfill (named XD-2) near the existing Z1 Landfill. The extent and depth of remaining soil contamination in the Southwest Area is therefore unknown.
6. **Pacer Ivy Area:** A number of DUs in the Pacer Ivy Area exhibited dioxin concentrations above the MND-approved dioxin limits, particularly along the western boundary of the Airbase (PI-2, PI-8, PI-10, PI-17, PI-18, and PI-20); PI-2 had the maximum soil dioxin concentration recorded (11,400 ppt at 30-60 cm depth) and the depth of contamination may extend to 2.5 m. Contamination extended outside the Airbase to PI-12, PI-15 and PI-16, along the drainage canal west of the Pacer Ivy Area (maximum 3,370 ppt at PI-15). The source of this dioxin contamination is drainage from the Pacer Ivy area, which flows westward through a series of canals to the Dong Nai River. However, contamination was not found in the Dong Nai River sediments sampled downstream of the canal (a maximum of 69.1 ppt at PI-21). Catfish from PI-20 exhibited high concentrations of dioxin (57.7 ppt in muscle; 3,550 ppt in fat; 69.5 ppt for the whole fish); previously this area was also used extensively for Tilapia aquaculture and for raising of ducks and other aquatic animals, but operations have ceased as of 2015.
7. **Northwest Area:** Sediment dioxin concentrations exceeded cleanup levels in NW-4A (477 ppt at 0-15 cm, and 262 ppt at 15-30 cm depth) and at NW-03C (385 ppt at 0-15 cm, and 587 ppt at 15-30 cm depth). Both these ponds were used for aquaculture at the time of the EA sampling program in March 2015; Tilapia collected from NW-4 had the highest dioxin concentration of all fish sampled (49.9 ppt in muscle; 760 ppt in eggs; 3,780 ppt in fat).
8. **Northern Forest Area:** Dioxin concentrations measured in samples from this area were below MND-approved dioxin limits, except for NF-4A and B (a maximum of 465 ppt).
9. **Northeast Area:** Sediments in several lakes in this area are contaminated with dioxins, to the maximum depth sampled (30-45 cm increment). The highest sediment dioxin concentrations were recorded at NE-7 (1,300 ppt at 0-15 cm; 765 ppt at 30-45 cm). Tilapia fat sampled from this lake had dioxin concentrations exceeding the dioxin limit (837 ppt), as did Bighead Carp from NE-15 (1,440 ppt in fat, 33.9 ppt in muscle). The Northeast Area is the location of the most extensive

aquaculture operations on the Airbase, with several large lakes producing significant quantities of fish for consumption and sale both inside and outside the Airbase (in the City of Bien Hoa).

10. **Southeast Area:** Low dioxin concentrations were recorded in this area (a maximum of 64.5 ppt at SE-2).
11. **Outside the Airbase (Offsite Lakes):** Gate 2 Lake surface sediments (166 ppt) were slightly above the GVN standard for sediments (150 ppt). Bien Hung Lake sediments (83 ppt) were below the standard and therefore dredging of this lake will not be required as part of any remedial alternative. However, fish from Bien Hung Lake had dioxin concentrations above the dioxin limit in fat (40.6 ppt), but below the guideline in other tissues (0.8 ppt in muscle; 9.4 ppt in eggs). No fish were caught from Gate 2 Lake; however, historical sampling results from this location indicated dioxin concentrations above dioxin limits in whole Tilapia (Hatfield and Office 33 2011; Durant et al. 2014).

DQO #2: Determine the nature of non-dioxin contamination in areas of influence of dioxin

In addition to analyses of dioxin- and furan-related compounds, analyses of metals (including arsenic), VOCs, SVOCs, herbicides, and PCBs were performed on select samples of soil and sediment to determine the nature of non-dioxin contamination in areas influenced by dioxin contamination, and to evaluate how the conceptual design of potential remediation technologies might be influenced by these other compounds. Only 22 samples were analyzed for these compounds, compared to approximately 550 samples analyzed for dioxin. In addition, analysis of particle size distribution, moisture content, pH, drainage curve, and organic content were performed in select areas of known dioxin contamination to determine if and how any physical property anomaly might affect the conceptual design of potential remediation technologies. Arsenic was detected in all samples, at concentrations ranging from 3.1 to 63 milligrams per kilograms (mg/kg). Each sample exceeded the USEPA risk-based screening level of 3 mg/kg (USEPA 2015), and some exceeded the GVN standard (QCVN 03:2008/BTNMT) of 12 mg/kg. One sample from PI-14 contained elevated PCBs, but no dioxin contamination was found in this DU. No SVOCs or herbicides were detected above USEPA risk-based screening levels for industrial soils. As described in **Appendix E**, to allow for measurement of VOCs from each sample aliquot without risking volatilization, a similar amount of soil from each MIS aliquot sampling location was immediately placed in a methanol preservative, which was analyzed. The results indicated a very small number of low-level detections, either from samples in Bien Hung Lake, where no dioxin contamination in excess of MND-approved dioxin limits exists, or from n-hexane, which has a very high USEPA risk-based screening level (USEPA 2015). These results indicate that remedial alternatives developed as part of this EA will need to consider the potential impact of arsenic in soils and sediments, but no other compounds were found to be collocated with dioxin contamination and present at concentrations above applicable GVN standards or appropriate USEPA screening levels at the subset of all locations sampled during the USAID EA sampling.

> Remedial alternatives will need to consider the potential impact of arsenic in soils and sediments, but no other compounds were found to be collocated with dioxin contamination and present at concentrations above applicable GVN standards or appropriate USEPA screening levels.

Groundwater samples were also collected from monitoring wells on the Airbase. Five of the monitoring wells are screened at depths of 3 to 15 m below ground surface and one well is screened at 2 to 6 m, all of which are too shallow for providing drinking water. These samples indicated concentrations of picloram (an herbicide) below its respective USEPA MCL, as well as lead above its USEPA MCL but below its QCVN criterion.

No anomalies in physical properties were identified in collected soil and sediment samples. All non-dioxin data are presented in **Appendix E**.

DQO #3: Identify which lakes require remediation to prevent human exposure to dioxin contamination

Extensive sediment sampling was conducted in March-April 2015 at 25 lakes/wetlands on and outside the Airbase; **Figure A1.3** in **Appendix A** shows all the lakes sampled and denotes those found to be above acceptable dioxin concentrations, as well as the results of analysis of fish sampling.

More than half (16 of 25) of the lakes and waterbodies sampled had sediment sample results above the GVN standard of 150 ppt and will require remediation to meet MND-approved dioxin limits. The exceptions were PI-19; PI-21; NW-1; NW-2; NE 6, NE-10; NE-13; NE-14; and BHL-1. Maximum dioxin concentrations were found in Pacer Ivy Area Lakes (5,410 ppt at PI-20 at 15-30 cm depth) and in the Northeast Lakes (1,300 ppt at NE-7).

Contaminated fish were reported in 9 of the 10 lakes for which the fish were sampled and analyzed (the exception was NE-10). BHL-1, which is located off the Airbase, and NW-2 both contained contaminated fish even though dioxin concentrations of sediment samples were below the GVN standard of 150 ppt. The highest concentrations were found in Tilapia fat (3,780 ppt at NW-4) and in Catfish fat (3,550 ppt at PI-20); snail tissues also contained elevated dioxin concentrations (>60 ppt) at both of these lakes. Therefore, the potential for bioaccumulation of dioxins in fish and other aquatic animal tissues in lakes on and around the Airbase extends to lakes with sediment dioxin concentrations that are below MND-approved dioxin limits.

> Recommended Remedial Actions for Lakes in Any Selected Remedial Alternative:
> 1. Sediments in a lake are to be remediated if sediments are found to have concentrations above the 150 ppt guideline.
> 2. Fish and other aquatic animals are to be collected and destroyed in all lakes on the Airbase as well as all lakes outside the Airbase in which fish have been found to be contaminated above the 20 ppt guideline.

It should be noted that during sampling activities prior to this Study, people were observed moving fish between lakes in the Northeast Area and lakes in the Pacer Ivy Area. It is not known if fish have been relocated over larger distances inside the Airbase, but none was observed (Hatfield and Office 33 2011). Because of the observed movement of fish between lakes, the difficulty in maintaining fishing bans, as a precautionary measure, all alternatives presented in **Section 4** require that all fish are to be collected and destroyed in all lakes on the Airbase as well as Bien Hung Lake and Gate 2 Lake so as to ensure the exposure pathway related to fish contamination is severed.

As discussed in more detail in **Section 4**, two types of remediation are therefore prescribed for the lakes:

1. Sediments in a lake are to be remediated if sediments are found to have concentrations above the GVN standard of 150 ppt.
2. Fish are to be collected and destroyed in all lakes on the Airbase as well as all lakes outside the Airbase in which fish have been found to be contaminated above the 20 ppt guideline.

DQO #4: Determine the amount of soil, sediment, and groundwater that must be remediated in order to close dioxin exposure pathways

Using the MIS sampling results from the 2014/2015 EA sampling program, the amount and extent of contaminated material requiring remediation may be calculated with improved levels of accuracy. Having a reasonably accurate estimate of the extent of dioxin-contaminated material at the Airbase at this stage of the Study is critical to ensure that excessive iterations of excavation will not be required, resulting in cost increases and schedule delays. Based on the MIS sampling and land use based MND-approved dioxin limits for the Airbase (**Section 3.2.4**), an estimated total area of 522,400 m^2 is believed to be contaminated with dioxins on the Airbase (**Table 3-6**); the largest areas requiring remediation include the Pacer Ivy Area (154,800 m^2), Z1 Area (122,600 m^2), and the Southwest Area (85,100 m^2). The total estimated volume of dioxin-contaminated soils and sediments is approximately 408,500 to 495,300 cubic meters (m^3). This consists of approximately 315,700 to 377,700 m^3 of contaminated soil and 92,800 to 117,600 m^3 of contaminated sediment. The basis for the volume estimate is discussed in detail in **Section 3.2.5**.

Estimated Volume of Dioxin-Contaminated Material at Bien Hoa Airbase:

- Total: 408,500 to 495,300 m^3
- Soil: 315,700 to 377,700 m^3
- Sediment: 92,800 to 117,600 m^3

Groundwater data collected as part of this analysis indicate that none of the groundwater sources used for drinking water at the Airbase, or in offsite wells used for water supply, exhibit dioxin concentrations in excess of the USEPA MCL (30 ppq [pg/L]) or GVN wastewater discharge criterion (10 pg/L). Only unfiltered groundwater samples from monitoring wells MW-5, in the Southwest Area, and MW-6, in the Pacer Ivy Area, had dioxin concentrations greater than 30 pg/L TEQ; filtered water from these wells were below the 30 pg/L MCL, but remained above the 10 pg/L GVN discharge criterion. All other filtered and unfiltered samples had concentrations below both criteria. Such differences in filtered and unfiltered samples are expected given dioxin is very insoluble in water, and much more likely to partition to suspended organic solids. All dioxin groundwater data are presented in in **Table A17,** in **Appendix A**.

Because the shallow groundwater at the Airbase is not utilized as a drinking water source, the only exposure pathway for contaminated groundwater would be contact to shallow groundwater during remedial activities such as excavation, dewatering, and treatment. Although these data indicate that groundwater in some portions of the Airbase (i.e., the Southwest and Pacer Ivy Areas) may contain suspended solids with dioxin, groundwater that may be encountered during construction in other portions of the Airbase that has not been as well characterized. For example, PI-2 is a large area, with shallow groundwater and deep dioxin contamination. Significant dewatering would therefore likely be necessary to excavate at this location, but there is only one monitoring well (MW-6) in the area, and the monitoring well may not be downgradient of the areas with highest concentrations, and/or representative of what may be encountered during construction. The amount of water expected to be encountered, and the treatment equipment needed, during excavation and dewatering is estimated based on available data and assumed excavation quantities and durations for each remediation alternative, and is detailed in the preliminary estimated overall costs provided in **Appendix D**.

3.2.3 Potential Exposure Pathways and Site Conceptual Model

An SCM is a synthesis of available site data, and a critically important tool to explain and understand those data, identify gaps in site data, describe exposure pathways and short-term mitigation actions, develop and evaluate all remedial alternatives, and ultimately implement remedial actions effectively. The SCM is informed by historical land use information, the characteristics of site contaminants, and known site characteristics, such as surface water flow paths. The preliminary SCM developed for the ESS was updated using knowledge gained during the 2014/2015 EA sampling program described in **Section 3.2.2**. Therefore, the SCM described herein presents the current understanding of the Airbase using all available information to identify key contaminated areas and potentially affected receptors and to provide the current understanding of exposure pathways. For potential health risks to be present, a contaminated site must exhibit at least three conditions or risk factors:

- Chemical Hazard: one or more chemical contaminants at concentrations capable of causing human or ecological health impacts.
- Exposure Pathway: a way for chemical contaminants to reach the receptors.
- Receptors: human, animals or plants.

If any of the above are missing, exposure cannot occur and there is no risk. If all three risk factors are present, two aspects of the risk should be considered: the probability the effect will occur, and the severity of the effect. If an effect has a very small chance of happening, the corresponding risk is reduced, and conversely, if the effect is more certain, the risk increases correspondingly. The manner in which the severity drives risk is similar: a severe effect will imply a much larger risk than a minor effect. One example of this is an effect that is felt by a large number of receptors will be more severe than one that exposes a smaller population. It is also important to assess to what degree a particular risk can be mitigated or has been mitigated (e.g., by interim measures), and what residual risk remains following that mitigation.

Given results from historical and the 2014/2015 EA sampling efforts, it is evident that contaminated soil and sediment exists as a result of past handling, storage, and disposal of Agent Orange and other herbicides. Contaminated surface soils at the Airbase are near to groundwater resources, multiple water bodies (including aquaculture ponds, canals, and the Dong Nai River), agricultural areas and areas used by livestock and other animals, and residential areas. Contaminated surface soils have spread from their original sites of storage, handling, and spills through three primary transport and release mechanisms: runoff during rainfall events; excavation and movement of contaminated material during the course of Airbase activities, construction, and agriculture; and through wind erosion.

Figure 3-11 illustrates and summarizes how contaminant sources, exposure pathways, and receptors are linked together to form the potential health risk associated with dioxin contamination at the Airbase. Detailed discussions of the contaminant source and distribution, contaminant transport and exposure, environmental setting and receptor identification, and potential exposure pathways are provided below.

Contaminant Sources and Current Contaminant Distribution

As described in more detail in **Section 3.2.2**, and shown in **Figures 3-2 through 3-10**, there are a number of distinct dioxin source areas at the Airbase. Dioxin concentrations exceeding the MND-approved dioxin limits were measured at several locations in the northern, western, southern, and eastern areas of the Airbase. A brief description of the contaminant source and distribution is provided as follows:

- The Z1 Area, which served as the main storage area for herbicides at the Airbase, is contaminated due to historical handling and spillage of Agents Orange, White, and Blue and possibly other herbicides. Based on results of the 2014/2015 EA sampling program, dioxin contamination in soil appears to be limited to the Z1 Landfill and portions of Z1-2, Z1-3, Z1-6, Z1-7, and Z1-16 (**Figure 3-2**). In addition, dioxin contamination was identified in downstream sediment at Z1-9 and Z1-10. Fish samples collected at the Z1-9 Lake exhibited dioxin concentrations of 68.3 ppt. GVN has no fish tissue standard; the EU guideline is 3.5 ppt (Bellona 2009), the Health Canada guideline is 20 ppt (CFIA 2014), and the U.S. FDA guideline is 50 ppt (ATSDR 2009). Much of the contamination likely present historically in this area appears to have been collected into the existing Z1 Landfill (Z1-1), which reduces the potential exposure to the local population. However, the risk of exposure to dioxin remains given that the concentrations measured during the 2014/2015 sampling still exceeded MND-approved dioxin limits in several DUs. It is likely that historical contamination originating in this area contributed to the sediment and biota contamination recorded in Gate 2 Lake and Bien Hung Lake outside the Airbase (although since dredging of Bien Hung Lake occurred, sediments now appear to be clean in this off-site lake based on the results of the 2014/2015 sampling effort). It should be noted that dioxin concentrations measured at the Z1 Landfill under the 2014/2015 EA sampling program were markedly lower than those from previous sampling programs which sampled soils placed in the landfill, including areas near the former herbicide storage tanks used during the US-Vietnam War (Hatfield and VRTC 2009). This discrepancy may be attributable to the different sampling methodologies employed (i.e., discrete sampling was used in previous sampling efforts while MIS was employed in the most recent one) and/or perhaps because the landfill was only sampled to a depth of 1m (for safety reasons).

> The 2014/2015 sampling conducted in support of this EA verified that much of the contamination likely present historically in the Z1 Area appears to have been collected into the existing Z1 Landfill which reduces the potential exposure to the local population.

- The Southwest Area, which is believed to have been a temporary storage area for herbicides (as part of the Pacer Ivy mission), was also likely the site of surface spillage, as evidenced by increased dioxin concentrations in soil. In fact, the highest dioxin concentrations detected during the 2014/2015 EA sampling program were found at the Southwest Area, specifically SW-1. Sediment areas were not present in the Southwest Area, and no biota samples were collected due to the lack of available aquatic habitats.
- The Pacer Ivy Area was used for herbicide storage and re-drumming, receives surface flow from the Southwest Area, and was also used for aquaculture in recent years. Samples collected from this area indicate high dioxin concentrations in soil, sediment, and fish tissues. As indicated by this Study, as well as historic studies (Hatfield and 10-80 Division 2006; Hatfield and VRTC 2009; Hatfield and Office 33 2011; VRTC 2013a; and VRTC 2013b), dioxin contamination appears to have migrated off the Airbase to areas south, southwest, and west of the Airbase via rainwater runoff and

air dispersion. The Pacer Ivy Area is likely the primary source of dioxin contamination to areas identified to the west outside the Airbase.

- Elevated dioxin concentrations were found in sediment and biota samples collected in the Northeast Area. Contamination transport likely occurred through rainwater runoff and perhaps air dispersion from other impacted areas.
- Similar to the Northeast Area, dioxin concentrations exceeding MND-approved dioxin limits were found in sediment (two sub-DUs) and biota samples (one DU) located in the Northwest Area. Contamination transport likely occurred through rainwater runoff and air dispersion, perhaps from the Pacer Ivy Area to the south.
- Dioxin was not detected in any of the drinking water source samples collected either on or off the Airbase; however, it was detected in unfiltered water samples collected from two onsite groundwater monitoring wells located adjacent to the Southwest Area (MW-5, screened between 3 and 15 m depth) and the Pacer Ivy Area (MW-6, screened between 2 and 6 m depth) in excess of 30 ppt TEQ, the EPA MCL for dioxin in drinking water. Filtered water samples were found to be below the EPA MCL for the same locations, but exceeded the GVN discharge standard of 10 pg/L. In general, as expected due to the high hydrophobicity of dioxins, much higher concentrations were found in the unfiltered samples versus the filtered samples, as presented in **Appendix A, Table A17**.

Contaminant Release, Transport and Exposure

Historical uses of Agent Orange and other herbicides at the Airbase, especially in the Z1 Area and the Pacer Ivy Area, resulted in surface spills and releases, whereby contaminants directly contacted soils, concrete, and other materials. When released, these extremely hydrophobic compounds became associated with the organic fractions of Airbase soils and sediment. These contaminated soils and sediments were then subjected to various physical transport mechanisms, including rain, surface water flow, wind-induced erosion and sedimentation. The northern portion of the Airbase is slightly more elevated, and drainage from the Airbase generally flows west from the Pacer Ivy Area, west and possibly south from the Southwest and Z1 Areas, and southeast from the Southeast and Northeast Areas, eventually flowing into the Dong Nai River. Anthropological disturbances associated with various land uses (e.g., agriculture, aquaculture, construction) also influenced contaminant transport. The raising, harvesting, and transport of contaminated fish to consumers both inside and outside the Airbase results in high potential for dioxin contamination in the general population. Specific contaminant transport and release mechanisms are provided below:

- Sampling results from DUs downstream from the Pacer Ivy and Z1 areas as well as outside the Airbase have indicated dioxin concentrations above MND-approved dioxin limits, particularly in sediment and/or biota samples collected in Gate 2 Lake and Bien Hung Lake. In these low-lying areas, contaminant transport via surface or rain water and subsequent sedimentation and bioaccumulation in biota species is likely the primary mechanism.
- There has also been movement of soils on the Airbase for various construction-related purposes and this may have also resulted in additional exposure of contaminated soils into the environment via the transport mechanisms listed above.
- The combined effect of these transport processes results in significant heterogeneity in contaminant distribution at the Airbase. These processes additionally contribute to the concentration of contaminated material in low-lying areas where eroded sediment has settled, and most importantly

in lakes and ponds where they are most likely to enter the food chain through fish and other aquatic animals. This drives the relatively high percentage of lake sediment that was found to exceed standards during the 2014/2015 EA sampling, as well as elevated levels in fish tissues also identified.

- Although dioxins do not volatilize, contaminants present in airborne soil, dust, and ash can result in additional human exposure via inhalation. Areas disturbed by construction or areas with high herbicide concentrations that do not support vegetative cover, are more likely to result in fugitive dust. This could include historical construction activities at the Airbase, as well as the recent construction activities associated with the new XD-2 Landfill in the Southwest Area and Z1 Area.
- Contaminants present in sediment and soil can also result in exposure to human and ecological receptors via direct dermal contact.
- Contaminants are also integrated into the ecosystem via natural biological processes (e.g., respiration) and aquaculture. As noted above, significant aquaculture activities have been taken place for years (and possibly decades) in the Northeast Area lakes and others around the Airbase including the Z1 Area, Pacer Ivy Area, and Northeast Area. Historical and the 2014/2015 EA sampling efforts have demonstrated that dioxin concentrations exceeding MND-approved dioxin limits were present in the majority of sampled waterbodies and almost all aquatic animals, thus indicating the scope of potential exposure that can occur via this pathway. Only one fish sample, from NE-10, did not exceed dioxin limits. Again, this is the most likely exposure pathway to human receptors.

Exposure Pathways

There are several potential exposure pathways identified at the Airbase:

- Dietary exposure/ingestion: once integrated into the food chain, dioxin exposure occurs primarily to human and ecological receptors via ingestion. According to the synthesis reviews of dioxin and exposure and health datasets from various parts of the world by AEA Technology (1999) and Srogi (2008), consumption of dioxin-contaminated food accounts for more than 90% of the human exposure to dioxins in the general population; this is likely to also be the case with respect to dioxin contamination at the Airbase. The lipophilic properties of dioxin cause bioaccumulation and exposure to those who consume contaminated food sources. Given the difficulties of enforcing fishing bans, it is likely that this exposure pathway has resulted in significant dioxin exposure, and is a high priority for remediation to address future potential exposure.
- Inhalation of fugitive airborne particulates: Dioxin-contaminated soils may become airborne due to wind erosion and/or vehicular and construction-related disturbances. This is particularly true in many contaminated areas at the Airbase that are minimally vegetated. In addition, bush burning has traditionally been carried out annually to clear the ground at the Airbase; this increases the risk of higher dioxin congeners (e.g., OCDD) entering the environment (Canh 2012a). Inhalation of these airborne substances containing dioxins represents the primary exposure pathway via inhalation.
- Dermal absorption: contaminants present in sediment and soil can result in exposure to human and ecological receptors via direct dermal contact. This poses a concern for anyone working in soils or sediments on the Airbase.
- Soil ingestion: people and/or children who come in close and regular contact with contaminated soils derived from the Airbase may ingest small amounts of the soil.

Environmental Setting and Receptor Identification

The Airbase is located adjacent to a primarily urban population, with an estimated 120,000 persons living in the immediate vicinity of or on the Airbase. The Airbase's current or recent land uses include cattle farming, rubber plantations, and aquaculture (tilapia and other fish species, ducks, and others) in addition to military activities. The Airbase and its immediate vicinity includes 32 lakes of varying permanence which fluctuate in depth seasonally, as well as secondary and planted forest and shrub vegetation. Land use plans associated with the different areas are presented in **Section 3.2.4**. Three key receptors have been identified:

- Local adults (particularly women of child-bearing age), children, and elderly: Residential areas are close to several contaminated areas, especially south of the Z1 Area, west of the Pacer Ivy Area and southeast of the Northeast Area. Buildings in these areas were mostly constructed post-war (older housing may be found south of the Z1 Area, which likely pre-dates the war). Areas not occupied by residential communities are used as transportation routes and/or may be used for raising livestock, cultivation of food and/or products for sale (e.g., vegetables, rubber trees). Local residents have used the areas surrounding the Airbase to rear fish, livestock, and poultry and to cultivate land. Fish and ducks raised on contaminated ponds and lakes on the Airbase have been sold in markets in Bien Hoa City; this practice has likely taken place for decades, since at least the end of the war, and possibly during the war years as well. Local residents are currently or historically have been potentially exposed to dioxin through contact with contaminated soils through agriculture, construction, and forestry; consumption of food such as fish and ducks raised in areas with elevated dioxin concentrations; ingesting contaminated soil particles that adhere to vegetables and other cultivated food items; and through respiration of potentially contaminated fugitive airborne particulates.
- Airbase workers and residents: Until 2008, the Southwest Area of the Airbase housed a residential area for military staff and their families (Hatfield and VRTC 2009). When dioxin contamination was confirmed in the area, families were moved elsewhere; new residential areas were constructed west of the Southwest Area. TCDD concentrations in human blood serum collected from Airbase workers and aquaculture farmers exhibited elevated TCDD and TEQ levels; elevated levels were also recorded in human breast milk, especially in individuals who had consumed fish raised on the Airbase (Hatfield and Office 33 2011). Airbase workers and residents may potentially be exposed in a similar manner to local adults and children through consumption of contaminated food items (especially fish), dermal contact, ingestion and inhalation.
- Fish, ducks, snails, and other aquatic animals: Due to its physical and chemical characteristics, dioxins tend to bioaccumulate in the food chain. Dredging, flooding, agricultural practices, and construction activities may disturb the contaminated soil and sediment, which in turn may increase the bioavailability and bioaccumulation of dioxins in aquatic animals. Consumption of these contaminated materials represents a significant human exposure pathway to dioxins, as demonstrated by the results of the 2014/2015 efforts to sample fish and other biota.

In summary, past storage, handling, and disposal activities have resulted in several dioxin source areas at the Airbase. Based on historical and the most recent sampling efforts, dioxin concentrations exceeding MND-approved dioxin limits were observed in soil and sediment samples at the Z1 Area, Southwest Area, and Pacer Ivy Area, and other areas to a lesser extent. Sediment and biota samples exceeding their respective dioxin limits were also seen at almost all locations where samples were collected. A variety of natural and, to some extent, anthropological transport mechanisms contribute to the contaminant transport at the Airbase, resulting in dioxin exposure to key environmental receptors including nearby residents, Airbase workers, and aquatic animals through dermal absorption, ingestion, and inhalation of contaminated materials.

The most important dioxin exposure pathway to the general population within and outside the Airbase likely occurs via consumption of dioxin-bioaccumulated fish and other aquatic animals that are illegally caught and sold to nearby street marketplaces (Hatfield and Office 33 2011, Durant et al. 2014). Due to the difficulties in enforcing existing fishing bans and incomplete site security, additional measures should be considered to sever this most important exposure pathway. Information regarding the existing and interim measures is provided in **Section 3.3**.

3.2.4 Land Use Planning for Bien Hoa Airbase

It is important to take into consideration development plans during the preparation of the EA to ensure the remedial alternatives that are considered in this Study are compatible with future land uses and development planned for the Airbase. Information on the land uses is critical to determining the allowable limit of dioxin concentration for any particular area per QCVN 45:2012/BTNMT (**Table 2-1**) and determining whether specific areas are impacted above that limit, and in turn, enable an estimation of the volume of soils and sediments at levels that require mitigation.

MND has indicated that the Airbase will be used for combined military and civilian purposes (i.e., activities such as parachuting, model plane flying, and light aircraft for tourists). Due to security concerns and on-going planning efforts, a land use map for the Airbase has not been provided by MND; however, AMST developed a table with proposed dioxin limits for each sampled area of the Airbase. In Letter No. 8308/VP-TH dated September 17, 2015, MND approved dioxin limits for the Airbase, which are summarized in **Table 3-7**, and directed that a formal land use plan for Bien Hoa Airbase be expedited. As indicated, the MND-approved dioxin limits and corresponding land uses include the following:

Soils (QCVN 45:2012/BTNMT)

- Industrial (1,200 ppt): 24 DUs in the Z1, ZT, Pacer Ivy, and Northeast Areas.
- Urban Residential (300 ppt): 23 DUs in the Z1, Southwest, Pacer Ivy, and Southeast Areas.
- Forest Land and Perennial Tree Land (100 ppt): Four DUs in the Northern Forest Area.

Sediments (TCVN 8183:2009)

- Sediment (150 ppt): 23 DUs in the Z1, Pacer Ivy, Northwest, and Northeast Areas and two DUs outside the Airbase (Gate 2 Lake and Bien Hung Lake).

The USEPA has developed RSLs for soils, air, and water as a tool to determine whether contamination found at a site deserves additional investigation or remediation. The RSLs are not final remediation standards, but can serve as preliminary remediation goals that can be adjusted based on site specific exposure conditions into final remediation standards. However, GVN has already established standards or requirements regardless of site specific exposure conditions. Therefore, the EA utilized the MND-approved dioxin limits, which are based on the GVN standards for allowable limits of dioxin by land use type, to develop volume estimates and preliminary cost estimates. USEPA RSLs were used in evaluation of other COPCs, as a point of comparison in cases where a relevant standard was available from Vietnamese regulations.

3.2.5 Volume of Contaminated Material to be Remediated

Using the results of the 2014/2015 EA sampling program (**Section 3.2.2**) and the MND-approved dioxin limits for each sampled area in **Table 3-8**, the volumes of contaminated soils and sediment were estimated. The following approach and assumptions were used in performing the volume estimate calculations:

- The contamination volume for each DU was calculated based on the area of the DU and the depth of contamination. The area of each DU was estimated using a combination of global positioning system (GPS) coordinates collected during the 2014/2015 EA sampling program and evaluation of site features identified on the project-specific web-based geographic information system (GIS).
- If triplicate samples were collected for a DU, then the 95% upper confidence limit (UCL) was used for that area instead of the MIS sample concentration. The UCL is calculated using the ITRC 2012 guidance (http://www.itrcweb.org/ism-1/4_2_2_UCL_Calculation_Method.html).
- To account for the inherent variability of the MIS sampling methodology and laboratory testing, a 15% concentration safety factor (CSF) was used in the volume calculations. The 15% CSF is based on the computed relative percent difference (RPD) from laboratory duplicates and split samples, excluding outliers (additional information is presented in **Appendix A**). Areas that had a concentration below the dioxin limit, but within 15% of the dioxin limit, were conservatively assumed to be impacted above the dioxin limit, and therefore added to the volume estimate. For example, in areas where the dioxin limit is 150 ppt, the calculations included any laboratory result indicating a concentration above 127.5 ppt (i.e., 150 ppt less 15%).
- If a contaminated layer was found below clean soil, the clean soil was conservatively included in the volume estimate.
- If the MIS result for a sampled DU exceeded its respective dioxin limit, the sub-DU sample results were used to refine the area of contamination (i.e., only the sub-DUs exceeding the dioxin limit were accounted for in the volume estimation). In the cases where the MIS result for a sampled DU exceeded its respective dioxin limit and the sub-DU samples were not analyzed, the entire DU was included in the volume estimation as a conservative approach.
- In some locations, the deepest collected sample exceeded the dioxin limit and an estimation of additional contamination depth was made. (Specifically, in 15 of the 76 sampled DUs, the deepest samples collected exceeded the MND-approved dioxin limits. These include Z1-9, Z1-10, SW-1, SW-3, PI-12, PI-15, PI-16, PI-17, PI-18, PI-20, NW-3, NF-4, NE-8, NE-9, and NE-11.) The additional estimated depth was calculated by multiplying the sampling interval (15 cm for sediment and 30 cm for soil) by the square root of the ratio of the total TEQ for the deepest sample to the dioxin limit, representing an assumed decline in concentration with the square of the depth. For example, if the total TEQ value associated with the deepest sampled depth of a soil DU exceeded its dioxin limit by a factor of 5, then the additional depth included in the volume estimation was 67 cm ($\sqrt{5}$ multiplied by 30 cm).
- Information from the Z1 Landfill design drawings and conversations with CC indicated that the thickness of contaminated material placed into the landfill is approximately 1.5 m. To avoid potentially damaging the bottom liner system, the Z1 Landfill was sampled only to a depth of 1 m.

For the volume estimates, however, a depth of 1.5 m is used. In addition, the area of the entire Z1 Landfill, including the bioremediation test area, is being included in the volume estimate. It should be noted that measurements in the field and on aerial imagery indicate that the lined area of the landfill is approximately 4.0-ha. Previous reports (Bien Hoa Master Plan, Hatfield 2013) have indicated an area of 4.7 ha and a volume of 94,000 m^3, which would correspond to a waste thickness of 2 m. To account for the discrepancy in reported waste thickness (1.5 m versus 2 m), a 0.5-m thickness over 4.0-ha has been included in the contingency volume estimate.

- A volume contingency was added to account for potential variability in site conditions during excavation. A systematic approach was used to identify areas where it might be necessary to perform an extra layer of excavation and took into consideration the dioxin concentrations in the vicinity of the layer or the practicality of excavation practices. These layers would only be excavated if confirmation sampling performed after excavation of the overlying material indicated that it was necessary.

The DUs exceeding the MND-approved dioxin limits and the estimated contaminated volumes of soils and sediments are summarized in **Table 3-8**, and provided in more detail in **Appendix B**. As indicated, the total estimated volume of dioxin contaminated soils and sediments is approximately 408,500 to 495,300 m^3. This consists of approximately 315,700 to 377,700 m^3 of contaminated soil and 92,800 to 117,600 m^3 of contaminated sediment. Breakdowns of the estimated contamination volume with depth is provided in **Table 3-9.** It is estimated that approximately 83,600 m^3 of material exceeds a dioxin concentration of 2,500 ppt TEQ and 216,000 m^3 exceeds a dioxin concentration of 1,200 ppt TEQ.

3.3 Risk Reduction Measures

Until remediation and/or containment activities are implemented in the future, measures should be in place to significantly reduce the risk of exposure to elevated levels of dioxin. Depending on the nature of the measures, these could be viewed as interim (or temporary) or permanent. It is therefore necessary to determine if the measures that are currently in place are adequate and, if appropriate, provide recommendations for any new interim, containment, mitigation, and/or monitoring measures for the Airbase and any nearby off-base areas of significant dioxin influence.

3.3.1 Current Measures

Measures to reduce exposure to dioxin contamination have been implemented since 2009 to some degree at all of the known areas of dioxin contamination on the Airbase. The current measures include the following:

- **Z1 Landfill:** In 2009, MND constructed a landfill in the Z1 Area that is just over 4 ha in size. Dioxin-contaminated soil was excavated from the area and placed in the landfill with thickness of approximately 1.5 m, which corresponds to a volume of approximately 60,000 m^3. The landfill is divided into eight cells and is provided with a composite liner system on the bottom and top that contains a single, high density polyethylene (HDPE) geomembrane as the primary barrier layer. A 0.5-m thick and relatively flat soil cover has also been placed on the landfill to provide added physical protection. A concrete drainage ditch was constructed around the perimeter of the landfill to collect and convey surface water drainage. As part of a long-term groundwater monitoring plan designed for the Airbase with development assistance provided by the Czech Republic (Dekonta

2014), four monitoring wells were installed around the perimeter of the landfill (one upgradient and three downgradient). Contaminated material in the Z1 Landfill is effectively enclosed through the presence of a bottom liner and cap system, thus eliminating any exposure potential. As discussed in **Section 4.4**, the Z1 Landfill would remain in place as a permeant measure for Alternatives 2 and 3. For Alternatives 4 and 5, the contents of the landfill would be excavated and treated.

- **XD-2 Landfill:** In 2015, MND began construction of the XD-2 Landfill to contain contaminated soil from the Southwest Area. The new landfill is located on the east side of the Z1 Landfill and is understood to have a similar design. Construction is ongoing and has involved excavation and subsequent movement of contaminated materials across the Airbase from the Southwest Area during the 2014/2015 sampling efforts. To inform MND during their excavation activities, USAID provided the sampling results from the Southwest Area (SW-1, SW-2, and SW-3) in May 2015. Additional material was excavated and placed in the XD-2 landfill in 2016. Because the volume estimates reported in **Section 3.2.5** are based on sampling conducted prior to excavation of contaminated material from the Southwest Area and its transport to the XD-2 Landfill, the volume of contaminated material to be remediated reported in **Section 3.2.5** and forming the basis for the remediation alternatives in **Section 4** includes the contaminated material destined for the XD-2 Landfill.
- **Bien Hung Lake Dredging:** Dredging, or cleaning, of sediment from Bien Hung Lake occurred in 1995 (Nguyen et al 2005). Sampling performed on Bien Hung Lake sediment as part of this Study indicated a dioxin concentration of 83 ppt, which is below the MND-approved dioxin limit for sediment. As a result, the dredging performed in 1995 appears to have been a very effective measure in reducing the risk of exposure to dioxin via contaminated sediment. However, as mentioned in **Section 3.2.2**, fish sampled from the lake as part of this Study did indicate dioxin concentrations above the dioxin limit and, as a result, the risk of exposure through consumption of fish still exists.
- **Surface Water Controls:** In 2013 and early 2014, surface water controls were implemented in the Pacer Ivy Area, the Northwest Area, and the Northeast Area by Office 33 through the UNDP GEF Dioxin Project. The goals of the newly constructed surface water controls are to:
  - Divert stormwater runoff before contacting dioxin contamination;
  - Contain any stormwater that contacts dioxin contamination; and/or
  - Trap sediment before discharging stormwater runoff from the Airbase.

  To achieve these goals, diversion ditches, berms, deepened catchment basins, and weir structures were constructed in the Pacer Ivy Area, Northwest Area, and Northeast Area. At present, there is no known monitoring plan in place to assess the performance of these surface water controls.
- **Fencing and/or Signage:** While the entire Airbase is walled/fenced, additional fencing has been erected around several lakes to inhibit access, and in 2013, Office 33 posted fabric signage to prohibit fishing and warn of health risks from consumption of fish from Airbase lakes. Signs were posted near at least one lake in each of the Northeast Area, Pacer Ivy Area, and Z1 Area, as well as offsite at Bien Hung Lake. Signage was not placed at all lakes, including all lakes in the Northwest Area, and most lakes in the Northeast Area, where most aquaculture is conducted. The condition of these signs in 2015 was observed to be very poor with faded wording, degraded and torn fabric, and overgrown or knocked down posts.

- **Fishing Bans:** Bans on fishing from the lakes have been enacted; however, enforcement of these bans has been challenging given the long history of aquaculture on the Airbase lakes and less stringent access control in some areas within the Airbase.
- **Communication Program:** Office 33, with funding from the UNDP GEF Dioxin Project, implemented a communication program to provide information on the status of dioxin contamination at the Airbase, explain exposure pathways, and describe how to prevent dioxin exposure. Community meetings were held, and a number of awareness raising activities were conducted for Airbase personnel and their families (posters, brochures, videos and meetings).

Despite these interim measures to control fishing activities, this exposure pathway remains. Illegal catching and selling of fish to nearby street marketplaces is not uncommon and was observed during the 2014/2015 EA sampling program. On November 29, 2015, it was reported that a group of 20 men entered the Airbase and caught more than 100 kilograms of fish from Airbase lakes that were subsequently sold on a sidewalk in Bien Hoa City (Thien-Le Quan 2015). As described in **Section 3.2.3**, consumption of dioxin-contaminated food accounts for more than 90% of the human exposure to dioxins in the general population; this is likely to also be the case with respect to dioxin contamination at the Airbase. Considering that concentrations observed in all but one fish sampled from the Airbase in 2015 exceeded the standard (as noted in **Section 3.2.2**) and that fish from the Airbase are still be consumed despite the interim measures already enacted, it is clear that this represents the largest risk from dioxin contamination and focusing on this exposure pathway is critical to reducing ongoing exposure.

3.3.2 Recommendations for Additional Interim Measures

As discussed above, several risk reduction measures have already been implemented at the Airbase to address exposure concerns. If these measures operate and continue to be maintained as intended, then controls are already in place to significantly reduce the potential exposure to dioxin contamination for Airbase personnel and the general public; however given the importance of aquatic animal consumption as an exposure pathway, the residual risk is likely still too large with the existing interim measures.

Alternatives are presented in **Section 4** of this EA that would effectively reduce exposure risks to dioxins to acceptable levels through containment and/or treatment. However, the process to select, fund, design, permit, and implement any of the identified alternatives may take considerable time. As a result, it is worth considering additional interim measures to further limit exposure and reduce risk, such as:

- **Control Offsite Contamination:** Contaminated soils and sediments were found outside the Airbase to the west of the Pacer Ivy Area (PI-12, PI-15, and PI-16) and in Gate 2 Lake (G2L-1). It is estimated that these areas contain approximately 10,400 to 13,500 m^3 of contaminated soil and 10,900 to 14,000 m^3 of contaminated sediment. While fishing bans, signage, and fencing at offsite lakes and channels would be a less-costly measure compared to remediation, without adequate institutional controls such an approach would not sever the exposure pathways shown on **Figure 3.11**. This contaminated material could be excavated, hauled, and contained in a contaminated area of the Airbase (such as the Z1, ZT, and/or Pacer Ivy Areas) to remove the exposure risk to residents. In addition, contaminated areas immediately upstream of these areas, such as PI-8A and PI-17A&B, should also be excavated and contained (approximately 11,000 to 14,200 m^3). Temporary or interim containment measures could involve stockpiling the material and covering with a HDPE geomembrane and clean soil cover. In total, approximately 32,300 to 41,700 m^3 of contaminated material would need to be contained to remove this offsite exposure risk.

- **Limit Exposure to Contaminated Fish and Biota**: As noted in **Section 3.2.2**, all but one of the fish samples collected during the 2014/2015 EA sampling program exceeded the dioxin standard. Because of the ineffectiveness of current fishing bans and incomplete site access control (Thien-Le Quan 2015), and the high likelihood that exposure to contaminated fish drives exposure (AEA Technology 1999, Srogi 2008), the following fishing-related interim measures are strongly recommended:
  - **Removal of fish and other aquatic animals:** All fish and other aquatic animals within the Airbase lakes, Gate 2 Lake, and Bien Hung Lake should be physically or chemically destroyed, removed from the lakes, and disposed (for example, buried in the Pacer Ivy Area or other areas of known dioxin contamination). Depending on overall project schedule, it may even be appropriate to implement fish removal at a reasonable frequency to keep exposure reduced. Physical methods for implementing this are presented in **Section 4.4** and are included in all remedial alternatives. These methods include complete dewatering of all lakes, and therefore may be expensive and challenging to implement, especially on a repeated basis. However, if complete dewatering of the lakes is not feasible, the use of other physical or chemical methods to remove fish would also be worth consideration. This could include a combination of fishing methods, including gillnetting, seine nets, and electrofishing. Use of chemicals such as rotenone should also be considered, provided these are acceptable under Vietnamese law.
  - **Fishing and aquatic animal harvesting bans and access control:** Prior to removal of all fish, fencing and other appropriate access controls should be constructed to help limit future fishing and aquatic animal harvesting activities. Permanent security personnel should also be hired to monitor the lakes and enforce the fishing ban.
  - **Signage:** Adequate and durable signage should be posted to prohibit fishing and warn of health risks from consumption of fish. To ensure this happens, an inventory should be conducted at all Airbase lakes, the drainage canal to the west of Pacer Ivy Area, Gate 2 Lake, and Bien Hung Lake to assess the current status of posted signage. Information to be collected at each area should include: the number and location of each sign; information displayed; physical characteristics of the sign material (i.e., metal, wood, plastic, fabric, etc.) and lettering (i.e., professional lettering and graphics, hand-drawn, etc.); and the physical condition of the sign. Based on the results of this inventory, durable signs should be installed at locations without signage and signs that are in poor condition or not properly worded should be replaced.
- **Communication Program:** Communication programs and public awareness campaigns initiated by Office 33 should be continued in order to provide updated information on the status of dioxin contamination, exposure pathways, and ways to prevent exposure. Priority should be given to those residents living in close proximity to contaminated areas, as well as to new migrants to Bien Hoa who may be unaware of the dioxin issue. The communication programs would likely be conducted through Vietnamese institutions and organizations such as Dong Nai DONRE, Regiment 935, or other local entities.

Table 3-1 Characterization Studies of Dioxin Contamination Conducted at Bien Hoa Airbase

Source of Information[1]	Year Study Conducted	No. of Samples Collected	No. of Samples Analyzed	Type of Sample	Analytical Technique	Laboratory Location (Name)
VRTC	1990	unknown	1	Soil	--	--
MND (2)	1995 to 1996	unknown	84	Soil	GCMS low resolution	Vietnam (VRTC)
Schecter et al. (2001) (2)	1999	unknown	35	Soil, Sediment, Blood	GCMS high resolution	Vietnam and Japan (ERGO)
VRTC	2000 to 2001	unknown	115	Soil, Sediment, Biological	--	--
Hatfield and 10-80 Division (2006)	**2004 to 2005**	**36**	**36**	**Soil, Sediment**	**GCMS high resolution**	**Canada (AXYS)**
Hatfield and VRTC (2009)	**2008**	**125**	**79**	**Soil, Sediment**	**GCMS high resolution**	**Canada (AXYS) and Vietnam (VRTC)**
Military Institute of Chemistry and Environment	2008 to 2012	unknown	121	Soil, Sediment	--	--
Hatfield and Office 33 (2011)	**2010**	**183**	**162**	**Soil, Sediment, Fish, Human Blood Serum, Breast Milk**	**GCMS high resolution**	**Canada (AXYS)**
VEA and VRTC	2011	unknown		Soil	--	--
Dong Nai DONRE	2011	unknown	162	Soil, Sediment, Biological	--	--
VEA and MONRE (2012)	**2012**	**130**	**111**	**Soil, Sediment**	**--**	**Vietnam (DXL) with QA/QC in Canada (AXYS)**
VRTC (2013a, 2013b)	**2013**	**unknown**	**155**	**Soil, Sediment**	**--**	**Vietnam (VRTC)**

Notes:

1. Data/reports in **bold** were available during preparation of this EA; others were not made available to USAID.
2. The study was reviewed during preparation of the ESS and EA; however, data from the study was not available.

Table 3-2 Summary of Sampling Results of Dioxin Source Areas of Bien Hoa Airbase 1990-2013

Media and Location	Number of Samples	Minimum TCDD Concentration (ppt TEQ)	Maximum TCDD Concentration (ppt TEQ)	Number of Samples Exceeding GVN Dioxin Standards[1]	Percentage of Samples Exceeding GVN Dioxin Standards
Hatfield and 10-80 Division (2006)					
Z1 Area	1 Soil 3 Sediment	294 80.2	294 833	0 2	0 66.7
Northeast Area	1 Soil 2 Sediment	424 48.9	424 101	1 0	100 0
Outside of the Airbase	7 Soil 9 Sediment	2.8 1.19	287 130	0 0	0 0
Hatfield and VRTC (2009)					
Z1 Area and Perimeter around Z1 Area	40 Soil 1 Sediment	6.15 413	262,000 413	12 100	31.6 100
Southwest Area	18 Soil	4.12	65,500	5	31.3
Pacer Ivy Area	11 Soil 4 Sediment	80.3 1,090	22,800 5,810	2 4	18.2 100
Outside of the Airbase (Lakes downstream of Z1 Area)	5 sediment	15.2	2,200	2	40
Hatfield and Office 33 (2011)					
Z1 Area	13 Soil 3 Sediment	1.46 125	3,210 219	2 1	15.4 33.3
ZT Area	2 Soil	34.8	113	0	0
Southwest Area	6 Soil	8.77	5,150	1	16.7
Pacer Ivy Area	22 Soil 7 Sediment	2.79 68.5	61,800 2,020	9 6	40.9 85.7
Northwest Area	1 Sediment	5.66	5.66	0	0
Northern Forest Area	2 Soil	8.47	459	1	50
Northeast Area	6 Soil 5 Sediment	17.1 6	1,160 633	2 2	33.3 40
Outside of the Airbase	10 Soil 5 Sediment	0.836 26.9	347 372	0 0	0 0

Media and Location	**Number of Samples**	**Minimum TCDD Concentration (ppt TEQ)**	**Maximum TCDD Concentration (ppt TEQ)**	**Number of Samples Exceeding GVN Dioxin Standards[1]**	**Percentage of Samples Exceeding GVN Dioxin Standards**
Fish	42	19.3	2020	41[3]	97.6
Blood Serum	22	1.55	39.6	22[2]	100
Breast Milk	21	0.0782	4040	12	57.1
VEA and MONRE (2012)					
Pacer Ivy Area	116 Soil	0.118	962,559	69	59.5
Outside of the Airbase	1 Soil	68.8	68.8	0	0
VRTC (2013a, 2013b)					
Pacer Ivy Area	1 Soil 10 Sediment	64.342 19.254	64.342 1,053.99	0 4	0 40
Northwest Area	5 Sediment	5.099	544.555	3	60
Northern Forest Area	15 Soil	0	181.74	4	26.7
Northeast Area	20 Sediment	13.186	8,043.2	11	55
Outside of the Airbase	91 Soil 29 Sediment	0 0.562	1,208.35 1,105.2	0 0	0 0

Notes:

1. QCVN 2012
2. Based on WHO Daily Intake Standard of 4 pg TEQ/kg bw/d
3. Values exceed the WHO Acceptable Exposure Guidelines (1998) for TCDD in Serum Lipid – 30 ppt corresponding to a chronic intake of 4 pg TEQ/kg bw/d

Table 3-3 Summary of Samples Collected during 2014/2015 EA Sampling Program

Media and Analyses	Z1 Area	ZT Area	SW Area	Pacer Ivy Area	NW Area	N. Forest Area	NE Area	SE Area	Offsite Lakes	Other	Total
Soil/Sediment											
Depths Sampled (cm)	0-390	0-150	0-150	0-300	0-45	0-60	0-60	0-60	0-45	NA	-
Dioxin (subtotal)	330	102	121	380	63	44	224	21	21	0	1,306
MIS Samples	64	20	23	72	12	8	40	4	4	0	247
Sub-DU Samples	168	60	69	216	36	24	120	12	12	0	717
Triplicates	20	0	2	8	0	2	16	0	0	0	48
Duplicates	8	1	3	8	2	2	4	1	1	0	30
Discrete Sample[1]	1	0	0	0	0	0	0	0	0	0	1
Split Samples (AXYS)	4	1	1	4	1	0	4	0	0	0	15
Split Samples (VRTC)[2]	65	20	23	72	12	8	40	4	4	0	248
VOCs, SVOCs, Metals, PCBs, Herbicides	7	1	3	8	0	0	1	0	2	0	22
Physical Properties	2	0	1	1	0	0	2	0	0	0	6
Groundwater											
Dioxin	8	2	2	2	0	0	0	0	0	8[3]	22
Herbicides	4	1	1	1	0	0	0	0	0	8[3]	15
VOCs, SVOCs, Metals, PCBs	4	1	1	1	0	0	0	0	0	1[4]	8
Biota (Fish / Snails)											
Dioxin	4	0	0	4	6	0	16	0	3	0	33
Totals	**359**	**107**	**129**	**397**	**69**	**44**	**243**	**21**	**26**	**17**	**1,412**
Aliquots for Soil/Sediment											
MIS and Triplicate Samples	2,320	600	750	2,400	360	300	1,740	120	120	0	8,710

Notes:
1. One discrete sample was collected from the bioremediation study area in Z1 Landfill.
2. VRTC received a split of all MIS samples and the one discrete sample.
3. Groundwater samples were collected from six offsite locations and at the Airbase water supply tower (before and after treatment).
4. Groundwater samples were collected at the Airbase water supply tower after treatment.

Table 3-4 Summary of Samples Analyzed

Media	Number of Samples Analyzed						
	Dioxin / Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical Properties
Soil/Sediment	507	22	22	22	22	22	6
MIS	*247*	*22*	*22*	*22*	*22*	*22*	*6*
Sub-DU	*181*	*0*	*0*	*0*	*0*	*0*	*0*
Other[1]	*79*	*0*	*0*	*0*	*0*	*0*	*0*
Water	22	8	8	15	8	8	0
Biota	22	0	0	0	0	0	0
Totals	**551**	**30**	**30**	**37**	**30**	**30**	**6**

Note:
1 Includes one discrete sample collected from the bioremediation study area in Z1 Landfill, 48 triplicates, and 30 duplicates.

Table 3-5 Areas Sampled as Part of the 2014/2015 EA Sampling Program and Significant Findings for Each Area

Location	Description	Estimated Area (ha)	DUs	Significant Findings
Z1 Area (Figure 3-2)	Former storage area for herbicides at the Airbase. Includes the Z1 Landfill.	85.2	• Identified: 17 • Sampled: 15 (13 soil, 2 sediment)	• Dioxin concentrations above MND-approved dioxin limits in 5 soil and 2 sediment DUs. • Excavation of contaminated soils and construction of the Z1 Landfill appears to have been effective in significantly reducing overall dioxin concentrations outside of the landfill. • Approximately 24% of the total estimated contamination volume is located in the Z1 Area, of which more than half is currently contained in the Z1 Landfill. • Fish exhibited dioxin concentrations above dioxin limits.
ZT Area (Figure 3-3)	Former taxiway leading to the Z1 Area. Not previously sampled.	69.3	• Identified: 7 • Sampled: 6 (soil)	• Dioxin concentrations above MND-approved dioxin limits in 1 soil DU.
Southwest Area (Figure 3-4)	Located in southwest portion of Airbase, suspected to have been used as an herbicide storage area.	67.1	• Identified: 8 • Sampled: 7 (soil)	• Dioxin concentrations above MND-approved dioxin limits in 4 soil DUs. • Highest dioxin concentration of all sub-DUs analyzed as part of this Study were found in SW-1A. • Approximately 15% of the total estimated contamination volume is located in the Southwest Area. • Some excavation occurred after sampling as part of new XD-2 Landfill, adding some uncertainty as to what material remains

Location	Description	Estimated Area (ha)	DUs	Significant Findings
Pacer Ivy Area (Figure 3-5)	Former herbicide storage and re-drumming location and is situated at the western end of the Airbase, close to the current runway	76.3	• Identified: 21 • Sampled: 21 (14 soil, 7 sediment) • 6 located offsite between the Airbase and Dong Nai River	• Dioxin concentrations above MND-approved dioxin limits in 5 soil and 5 sediment DUs. • Dioxin contamination is most extensive of any areas sampled on the Airbase and accounts for 42% of the estimated contamination volume. • Depth of contamination in PI-2 may extend to 2.5 m. • Contamination extends outside the Airbase to the Dong Nai River along a drainage canal. • Fish exhibited dioxin concentrations above dioxin limits.
Northwest Area (Figure 3-6)	Located between runway and northern boundary of Airbase on its west side	55.5	• Identified: 5 • Sampled: 4 (sediment)	• Dioxin concentrations above MND-approved dioxin limits in 2 sediment DUs. • Fish exhibited dioxin concentrations above dioxin limits.
Northern Forest Area (Figure 3-7	Located along northern limits of Airbase, contains rubber tree plantations	82.6	• Identified: 4 • Sampled: 4 (soil)	• Dioxin concentrations above MND-approved dioxin limits in 1 soil DU.
Northeast Area (Figure 3-8)	Located immediately east of the runway, with the highest concentration of aquaculture ponds on the Airbase	133.2	• Identified: 16 • Sampled: 15 (5 soil, 10 sediment) • 1 located off the Airbase to the south	• Dioxin concentrations above MND-approved dioxin limits in 6 sediment DUs and below for all soil DUs. • Fish exhibited dioxin concentrations above dioxin limits.
Southeast Area (Figure 3-9)	Located between the Z1 Area and the Northeast Area. Not previously sampled.	53.2	• Identified: 2 • Sampled: 2 (soil)	• Dioxin concentrations are all below the MND-approved dioxin limits.

Location	Description	Estimated Area (ha)	DUs	Significant Findings
Lakes Outside the Airbase (Figure 3-10)	Includes Bien Hung Lake and Gate 2 Lake. Located off of the Airbase.	9.8	• Identified: 2 • Sampled: 2 (sediment)	• Dioxin concentrations in Bien Hung Lake are below MND-approved dioxin limits. • Dioxin concentrations in Gate 2 Lake are above MND-approved dioxin limits. • Fish in Bien Hung Lake exhibited dioxin concentrations above dioxin limits. No fish were sampled from Gate 2 Lake, but historical sampling results indicated dioxin concentrations above dioxin limits.

Table 3-6 Estimated Area of Contaminated Soil and Sediment at Bien Hoa Airbase

Location	DUs with Dioxin Concentrations above MND-Approved Dioxin Limits[1]	Estimated Contaminated Area (m²)		
		Soil	Sediment	Total
Z1 Area	***Soil:*** Z1-1, Z1-2A, Z1-3, Z1-7C, Z1-16B ***Sediment:*** Z1-9, Z1-10	97,600	25,000	122,600
ZT Area	***Soil:*** ZT-2B	36,400	0	36,400
Southwest Area	***Soil:*** SW-1, SW-2A&B, SW-3A&B, SW-7A&B	85,100	0	85,100
Pacer Ivy Area (On the Airbase)	***Soil:*** PI-2, PI-8A, PI-10, PI-13A ***Sediment:*** PI-17A&B, PI-18, PI-20	92,800	37,000	129,800
Pacer Ivy Area (Outside the Airbase)	***Soil:*** PI-12 ***Sediment:*** PI-15, PI-16	14,500	10,500	25,000
Northwest Area	***Sediment:*** NW-3C, NW-4A	0	10,900	10,900
Northern Forest Area	***Soil:*** NF-4A&B	43,200	0	43,200
Northeast Area	***Soil:*** none ***Sediment:*** NE-7, NE-8A&B, NE-9, NE-11, NE-12, NE-15C	0	60,600	60,600
Southeast Area	***Soil:*** none	0	0	0
Outside the Airbase (Gate 2 Lake and Bien Hung Lake)	***Sediment:*** G2L-1	0	8,800	8,800
	Totals	**369,600**	**152,800**	**522,400**

Note:

1. Only DUs with dioxin concentrations exceeding the MND-approved dioxin limits are identified. If a DU is not listed, then the dioxin concentration in the DU is below the dioxin limits.

Table 3-7 MND-Approved Allowable Dioxin Concentration Limits for Sampling Decision Units

Location/DU	Media	Land Use Type	Allowable Limit of Dioxin Contamination (ppt TEQ dry weight)
Z1 Area			
Z1-1	Soil	Industrial	1,200
Z1-2	Soil	Urban residential	300
Z1-3	Soil	Urban residential	300
Z1-4	Soil	Industrial	1,200
Z1-5	Soil	Urban residential	300
Z1-6	Soil	Urban residential	300
Z1-7	Soil	Urban residential	300
Z1-8	Soil	Urban residential	300
Z1-9	Sediment	Sediment	150
Z1-10	Sediment	Sediment	150
Z1-11	Soil	Urban residential	300
Z1-12	Soil	Industrial	1,200
Z1-13	Soil	Urban residential	300
Z1-16	Soil	Urban residential	300
Z1-17	Soil	Industrial	1,200
ZT Area			
ZT-1	Soil	Industrial	1,200
ZT-2	Soil	Industrial	1,200
ZT-4	Soil	Industrial	1,200
ZT-5	Soil	Industrial	1,200
ZT-6	Soil	Industrial	1,200
ZT-7	Soil	Industrial	1,200
Southwest Area			
SW-1	Soil	Urban residential	300
SW-2	Soil	Urban residential	300
SW-3	Soil	Urban residential	300
SW-4	Soil	Urban residential	300
SW-6	Soil	Urban residential	300
SW-7	Soil	Urban residential	300
SW-8	Soil	Urban residential	300
Pacer Ivy Area			
PI-1	Soil	Industrial	1,200

Location/DU	Media	Land Use Type	Allowable Limit of Dioxin Contamination (ppt TEQ dry weight)
PI-2	Soil	Industrial	1,200
PI-3	Soil	Industrial	1,200
PI-4	Soil	Industrial	1,200
PI-5	Soil	Industrial	1,200
PI-6	Soil	Industrial	1,200
PI-7	Soil	Industrial	1,200
PI-8	Soil	Industrial	1,200
PI-9	Soil	Industrial	1,200
PI-10	Soil	Urban residential	300
PI-11	Soil	Urban residential	300
PI-12	Soil	Urban residential	300
PI-13	Soil	Urban residential	300
PI-14	Soil	Urban residential	300
PI-15	Sediment	Sediment	150
PI-16	Sediment	Sediment	150
PI-17	Sediment	Sediment	150
PI-18	Sediment	Sediment	150
PI-19	Sediment	Sediment	150
PI-20	Sediment	Sediment	150
PI-21	Sediment	Sediment	150
Northwest Area			
NW-1	Sediment	Sediment	150
NW-2	Sediment	Sediment	150
NW-3	Sediment	Sediment	150
NW-4	Sediment	Sediment	150
Northern Forest Area			
NF-1	Soil	Forest land and perennial tree land	100
NF-2	Soil	Forest land and perennial tree land	100
NF-3	Soil	Forest land and perennial tree land	100
NF-4	Soil	Forest land and perennial tree land	100
Northeast Area			
NE-1	Soil	Industrial	1,200

Location/DU	Media	Land Use Type	Allowable Limit of Dioxin Contamination (ppt TEQ dry weight)
NE-2	Soil	Industrial	1,200
NE-3	Soil	Industrial	1,200
NE-4	Soil	Industrial	1,200
NE-5	Soil	Industrial	1,200
NE-6	Sediment	Sediment	150
NE-7	Sediment	Sediment	150
NE-8	Sediment	Sediment	150
NE-9	Sediment	Sediment	150
NE-10	Sediment	Sediment	150
NE-11	Sediment	Sediment	150
NE-12	Sediment	Sediment	150
NE-13	Sediment	Sediment	150
NE-14	Sediment	Sediment	150
NE-15	Sediment	Sediment	150
Southeast Area			
SE-1	Soil	Urban residential	300
SE-2	Soil	Urban residential	300
Outside Airbase			
BHL-1	Sediment	Sediment	150
G2L-1	Sediment	Sediment	150

Table 3-8 Estimated Volume of Contaminated Soil and Sediment at Bien Hoa Airbase

Location	DUs with Dioxin Concentrations above MND-Approved Dioxin Limits[1]	Estimated Contaminated Volume (m^3)		
		Soil	Sediment	Total
Z1 Area	***Soil:*** Z1-1, Z1-2A, Z1-3, Z1-7C, Z1-16B ***Sediment:*** Z1-9, Z1-10	81,800	17,800	99,600
ZT Area	***Soil:*** ZT-2B	10,900	0	10,900
Southwest Area	***Soil:*** SW-1, SW-2A&B, SW-3A&B, SW-7A&B	60,600	0	60,600
Pacer Ivy Area (On the Airbase)	***Soil:*** PI-2, PI-8A, PI-10, PI-13A ***Sediment:*** PI-17A&B, PI-18, PI-20	117,700	32,500	150,200
Pacer Ivy Area (Outside the Airbase)	***Soil:*** PI-12 ***Sediment:*** PI-15, PI-16	10,400	9,600	20,000
Northwest Area	***Sediment:*** NW-3C, NW-4A	0	6,600	6,600
Northern Forest Area	***Soil:*** NF-4A&B	34,300	0	34,300
Northeast Area	***Soil:*** none ***Sediment:*** NE-7, NE-8A&B, NE-9, NE-11, NE-12, NE-15C	0	25,000	25,000
Southeast Area	***Soil:*** none	0	0	0
Outside the Airbase (Gate 2 Lake and Bien Hung Lake)	***Sediment:*** G2L-1	0	1,300	1,300
	Subtotals	***315,700***	***92,800***	***408,500***
	Contingency	62,000	24,800	86,800
	Totals	**377,700**	**117,600**	**495,300**

Note:

1. Only DUs with dioxin concentrations exceeding the MND-approved dioxin limits are identified. If a DU is not listed, then the dioxin concentration in the DU is below the dioxin limits.

Table 3-9 Estimated Contamination Volume Distribution by Depth

Location	Sediment (m³)			Soil (m³)				
	0 to 0.5 m	**0.5 to 1.0 m**	**> 1.0 m**	**0 to 0.5 m**	**0.5 to 1.0 m**	**1.0 to 1.5m**	**1.5 to 2.0 m**	**> 2.0 m**
Z1 Area	12,500	5,300	0	40,100	21,500	20,200	0	0
ZT Area	0	0	0	10,900	0	0	0	0
Southwest Area	0	0	0	35,600	17,800	4,400	2,800	0
Pacer Ivy Area (On the Airbase)	18,500	10,700	3,300	37,900	25,100	25,100	25,100	4,500
Pacer Ivy Area (Off the Airbase)	5,200	3,400	1,000	7,200	3,200	0	0	0
Northwest Area	4,400	2,200	0	0	0	0	0	0
Northern Forest Area	0	0	0	21,600	12,700	0	0	0
Northeast Area	22,500	2,500	0	0	0	0	0	0
Southeast Area	0	0	0	0	0	0	0	0
Outside the Airbase (Gate 2 Lake)	1,300	0	0	0	0	0	0	0
Total	**64,400**	**24,100**	**4,300**	**153,300**	**80,300**	**49,700**	**27,900**	**4,500**

Note:
Volumes do not include the estimated contingency volume of 86,800 m^3.

FIGURE 3-1 OVERALL SITE MAP WITH SAMPLING DECISION UNITS, BIEN HOA AIRBASE, VIETNAM

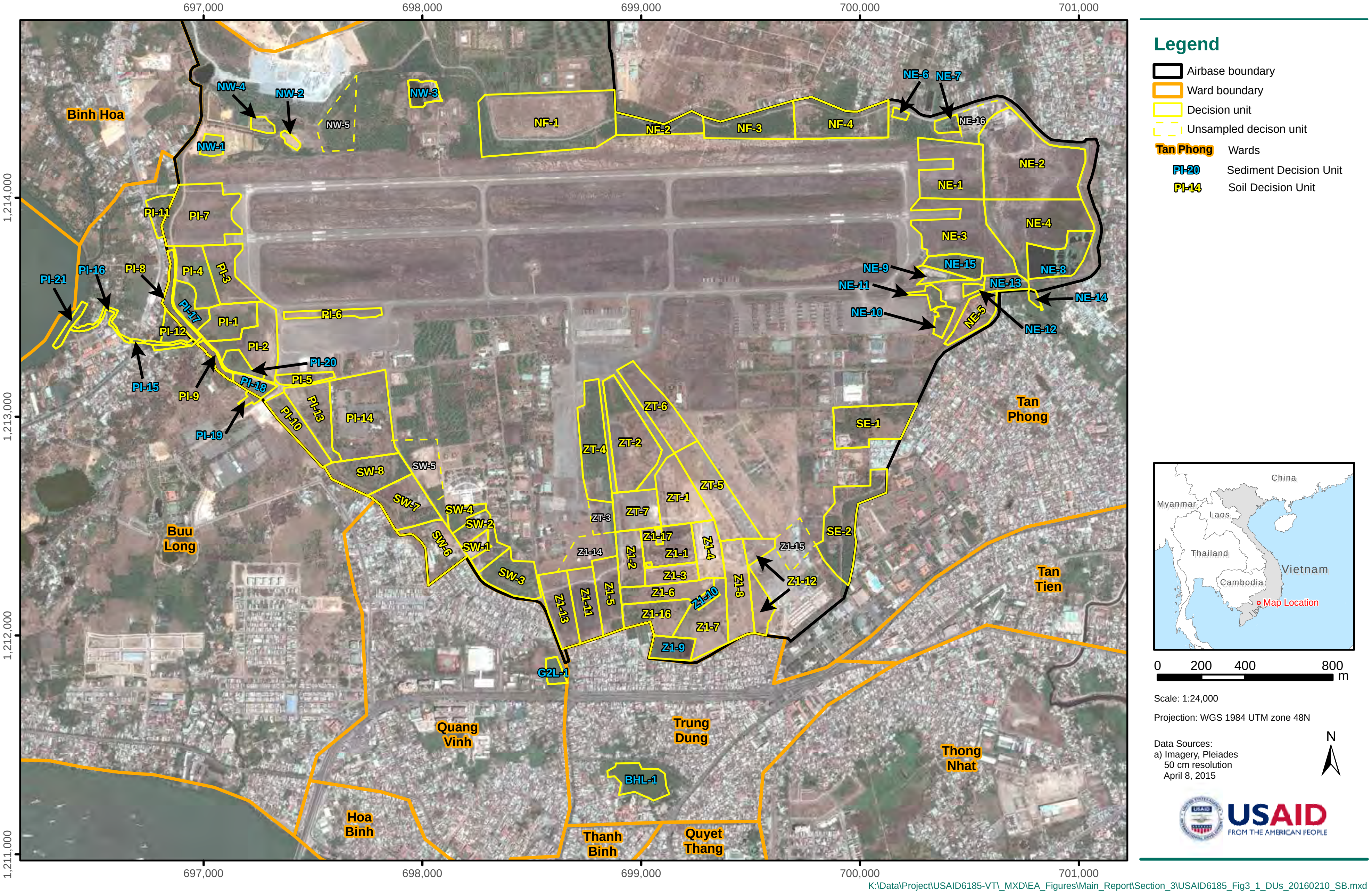
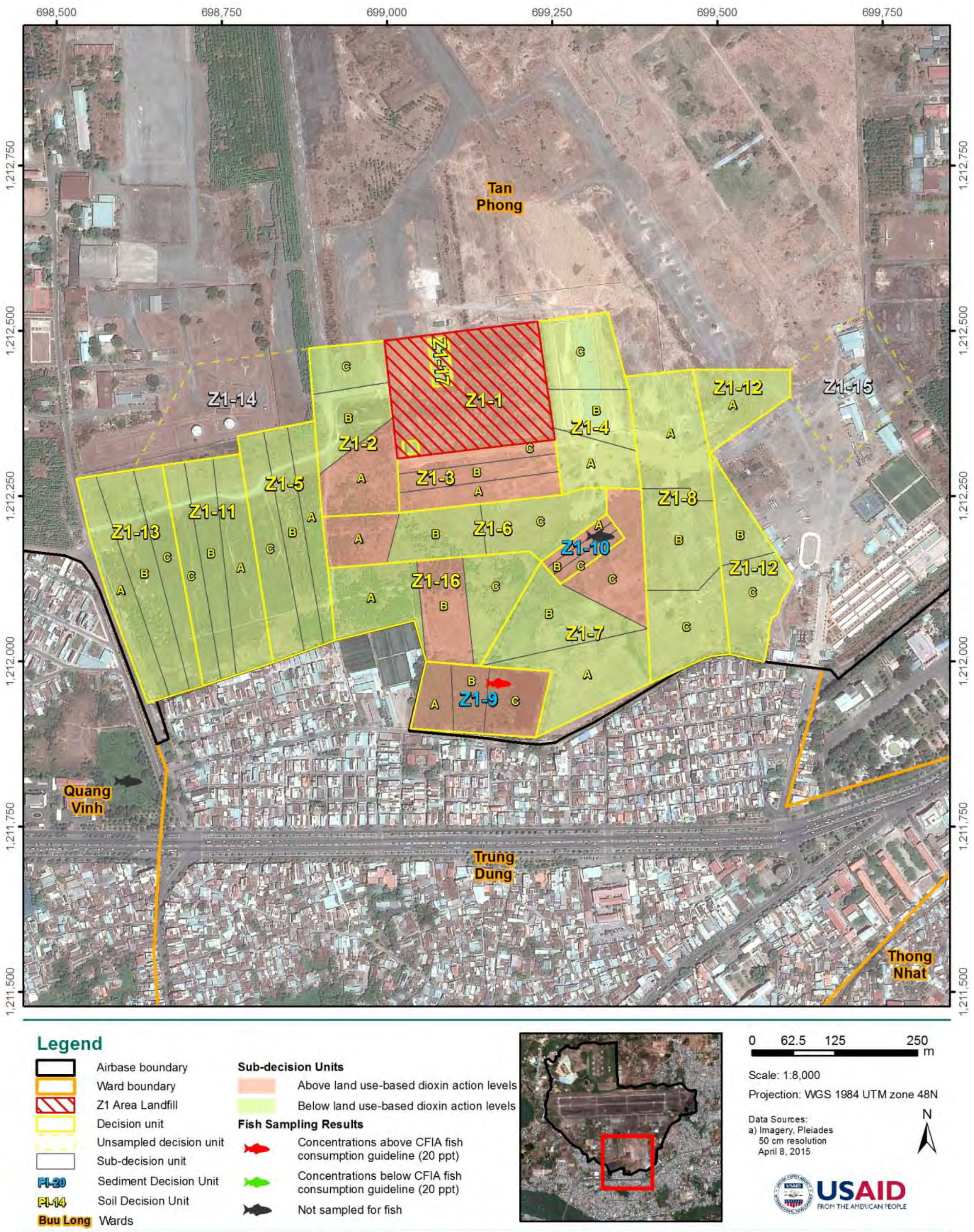


FIGURE 3-2 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS – Z1 AREA



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95% upper confidence limit calculations for triplicate samples.

Sub-DU	Depth (cm)	Media	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
Z1-3	0-30	Soil	207	180.9814	2.91998558	512.1
	60-90	Soil	46	26.6664	2.91998558	90.5
	120-150	Soil	4	0.7746	2.91998558	5.6
Z1-10	0-15	Sediment	1,074	249.4634	2.91998558	1494.6
	15-30	Sediment	900	402.4279	2.91998558	1578.8
	30-45	Sediment	124	71.5747	2.91998558	244.8
Z1-13	0-30	Soil	82	12.2880	2.91998558	103.2
Z1-16	0-30	Soil	329	63.4157	2.91998558	435.6
	30-60	Soil	112	65.0961	2.91998558	222.2

Biota Sampling Results

Sample Location	Sample Type	Sub-Sample Type	Total TEQ (pg/g)
Z1-9	Fish (Tilapia)	Whole	68.3

DU	Sub-DU	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
Z1-1-BIO	MIS	0-100	3 2 ppt (reanalysis)	-	-
Z1-1-Landfill	MIS	0-100	1,510 1,700 ppt (reanalysis)	40,457	60,685
Z1-2	MIS	0-30	333	12,382	3,715
	A	0-30	865	12,382	3,715
	B	0-30	162		
	C	0-30	28.4		
	MIS	60-90	206		
	A	60-90	452		
	B	60-90	82.4		
	C	60-90	44.9		
	MIS	120-150	20.8		
	MIS	180-210	25.8		
	MIS	240-270	34.2		
	MIS	300-330	25.6		
	MIS	360-390	33.2		
Z1-3	MIS	0-30	512.1	20,153	6,046
	MIS	60-90	90.5		
	A	60-90	86.5		
	B	60-90	95.8		
	C	60-90	3.25		
	MIS	120-150	5.6		
	MIS	180-210	4.03		
	MIS	240-270	0.702		
	MIS	300-330	0.728		
	MIS	360-390	3.08		
Z1-4	MIS	0-30	49.9		
	MIS	60-90	7.30		
	MIS	120-150	7.53		
	MIS	180-210	9.41		
	MIS	240-270	4.17		
	MIS	300-330	10.8		
	MIS	360-390	4.26		
Z1-5	MIS	0-30	48.2		
	MIS	30-60	11.3		
	MIS	60-90	4.00		
Z1-6	MIS	0-30	205		
	A	0-30	325		
	B	0-30	152		
	C	0-30	237		
	MIS	30-60	12.8		
	MIS	60-90	31.7		
	MIS	120-150	14.0		
	MIS	180-210	16.4		

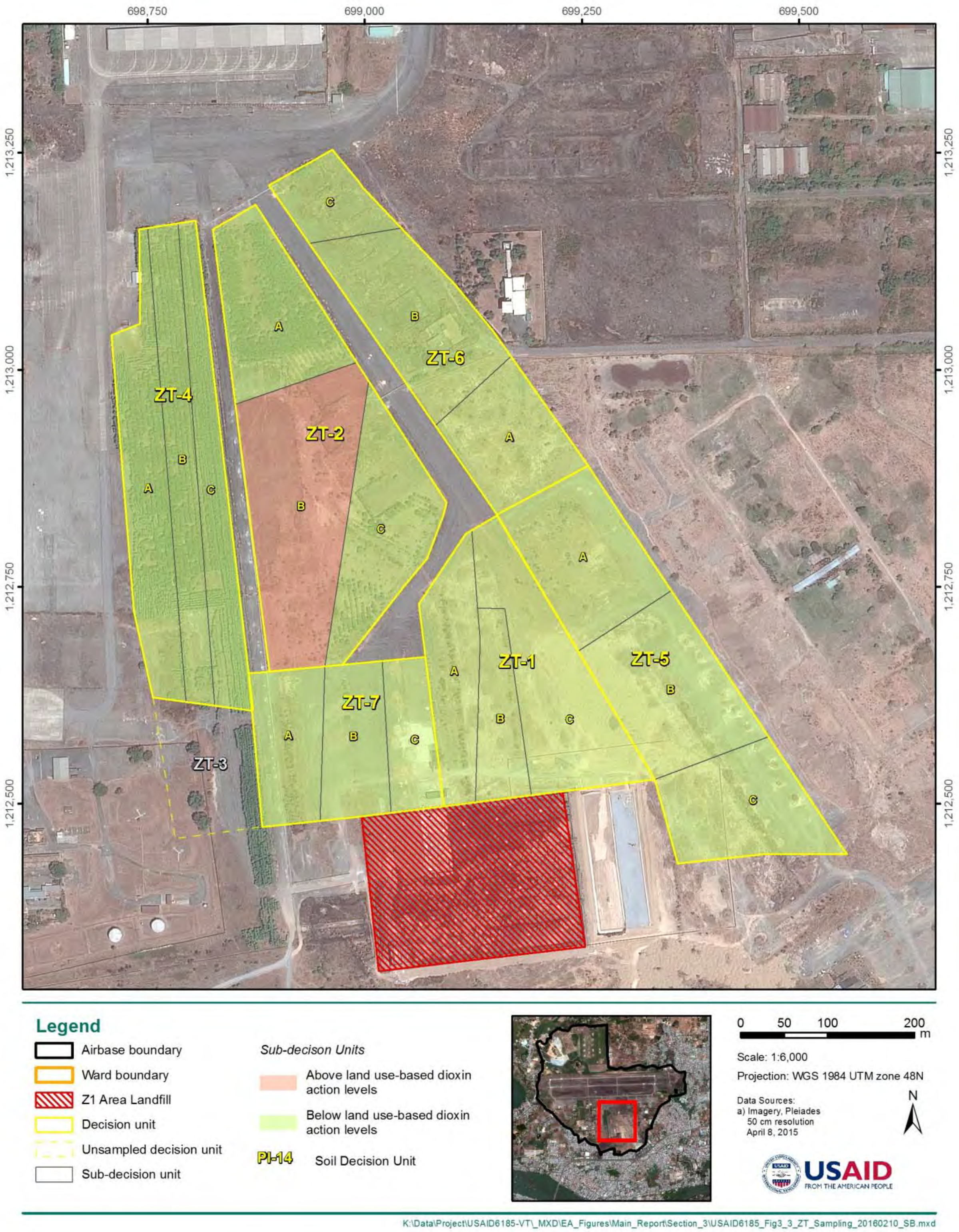
DU	Sub-DU	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
Z1-7	MIS	0-30	168	13,363	4,009
	A	0-30	129		
	B	0-30	184		
	C	0-30	175	13,363	4,009
	MIS	30-60	274	13,363	4,009
	A	30-60	233		
	B	30-60	53.5		
	C	30-60	438	13,363	4,009
	MIS	60-90	13.9		
	MIS	120-150	8.92		
	MIS	180-210	4.06		
Z1-8	MIS	0-30	107		
	A	0-30	104		
	B	0-30	16.1		
	C	0-30	10.3		
	MIS	30-60	17.4		
	MIS	60-90	18.5		
Z1-9	MIS	0-15	413	19,456	2,918
	MIS	15-30	260	19,456	2,918
	MIS	30-45	444	19,456	8,364
Z1-10	MIS	0-15	1,494.6	5,506	826
	MIS	15-30	1,578.8	5,506	826
	MIS	30-45	244.8	5,506	1,970
Z1-11	MIS	0-30	93.9		
	A	0-30	151		
	B	0-30	75.7		
	C	0-30	49.9		
	MIS	30-60	31.1		
	MIS	60-90	8.88		
Z1-12	MIS	0-30	7.18		
	MIS	30-60	3.47		
Z1-13	MIS	0-30	103.2		
	A	0-30	90.8		
	B	0-30	85.0		
	C	0-30	47.8		
	MIS	30-60	20.5		
	MIS	60-90	7.82		
Z1-14	Not sampled				
Z1-15	Not sampled				
Z1-16	MIS	0-30	435.6	11,199	3,360
	A	0-30	150		
	B	0-30	900	11,199	3,360
	C	0-30	130		
	MIS	30-60	222.2		
	MIS	60-90	91.4		
	MIS	120-150	21.2		
	MIS	180-210	14.6		
Z1-17	MIS	0-30	13.6		
	MIS	60-90	4.08		
	MIS	120-150	2.10		
	MIS	180-210	6.47		
	MIS	240-270	0.697		
	MIS	300-330	1.93		
	MIS	360-390	0.697		

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter; MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation; TEQ – toxic equivalency; UCL – upper confidence limit

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

FIGURE 3-3 2014/2015 SOIL SAMPLING RESULTS – ZT AREA



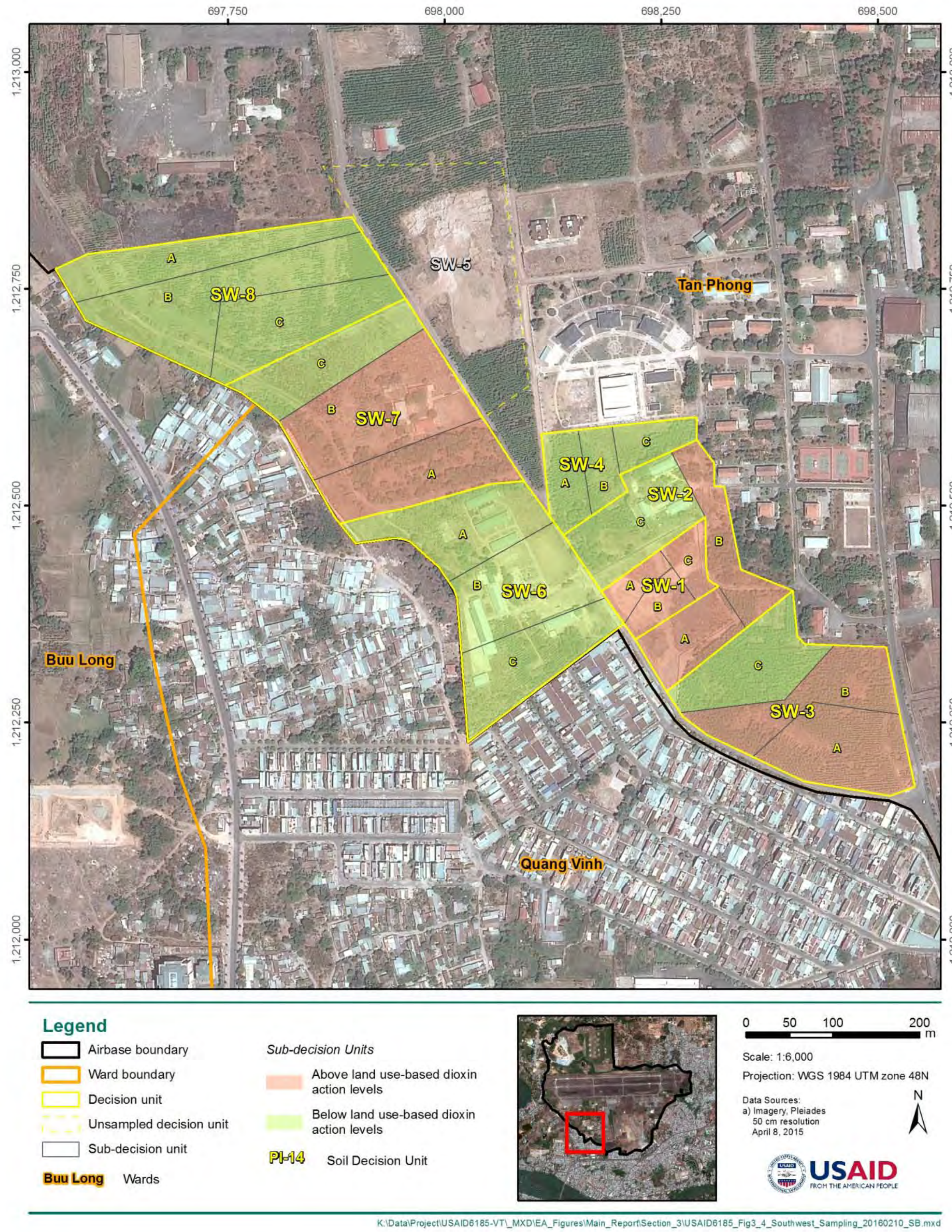
Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m²)	Contaminated Vol (m³)
ZT-1	MIS	0-30	48.8		
	MIS	30-60	4.59		
	MIS	60-90	64.7		
	MIS	120-150	43.6		
ZT-2	MIS	0-30	1,080	36,415	10,925
	A	0-30	312		
	B	0-30	3,440	36,415	10,925
	C	0-30	178		
	MIS	30-60	181		
	A	30-60	73.2		
	B	30-60	429		
	C	30-60	46.9		
	MIS	60-90	86.1		
ZT-3	Not sampled				
ZT-4	MIS	0-30	15.3		
	MIS	30-60	6.24		
	MIS	60-90	1.32		
ZT-5	MIS	0-30	10.5		
	MIS	30-60	1.18		
	MIS	60-90	2.02		
ZT-6	MIS	0-30	23.8		
	MIS	30-60	4.93		
	MIS	60-90	0.939		
ZT-7	MIS	0-30	86.4		
	MIS	30-60	40.6		
	MIS	60-90	9.42		
	MIS	120-150	0.785		

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m² – square meter; m³ – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

FIGURE 3-4 2014/2015 SOIL SAMPLING RESULTS – SOUTHWEST AREA



95% upper confidence limit calculations for triplicate samples.

Sub-DU	Depth (cm)	Media	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
SW-4	0-30	Soil	36	2.9428	2.91998558	41.4

Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
SW-1	MIS	0-30	10,900	8,793	2,638
	A	0-30	20,000	2,627	788
	B	0-30	21,800	3,153	946
	C	0-30	1,240	3,012	904
	MIS	30-60	41,000	8,793	2,638
	A	30-60	111,000	2,627	788
	B	30-60	26,600	3,153	946
	C	30-60	359	3,012	904
	MIS	60-90	4,880	5,780	1,734
	A	60-90	13800	2,627	788
	B	60-90	499	3,153	946
	C	60-90	25.6		
	MIS	90-120	62.0	5,780	1,734
	MIS	120-150	1,370	5,780	7,356
	A	120-150	2,680	2,627	3,343
	B	120-150	1,230	3,153	4,012
	C	120-150	14.2		
SW-2	MIS	0-30	2,560	15,806	4,742
	A		7,880	7,338	2,202
	B		170	8,468	2,540
	C		115		
	MIS	30-60	332	15,806	4,742
	A		830	7,338	2,202
	B		311	8,468	2,540
	C		12.7		
	MIS	60-90	71.6		
SW-3	MIS	0-30	746	25,590	7,677
	A	0-30	1,880	13,572	4,072
	B	0-30	641	12,018	3,605
	C	0-30	142		
	MIS	30-60	550	13,572	4,072
	A	30-60	1,680	13,572	4,072
	B	30-60	114		
	C	30-60	10.1		
	MIS	60-90	445	13,572	12,830
	A	60-90	1,180	13,572	12,830
	B	60-90	38.4		
	C	60-90	6.81		

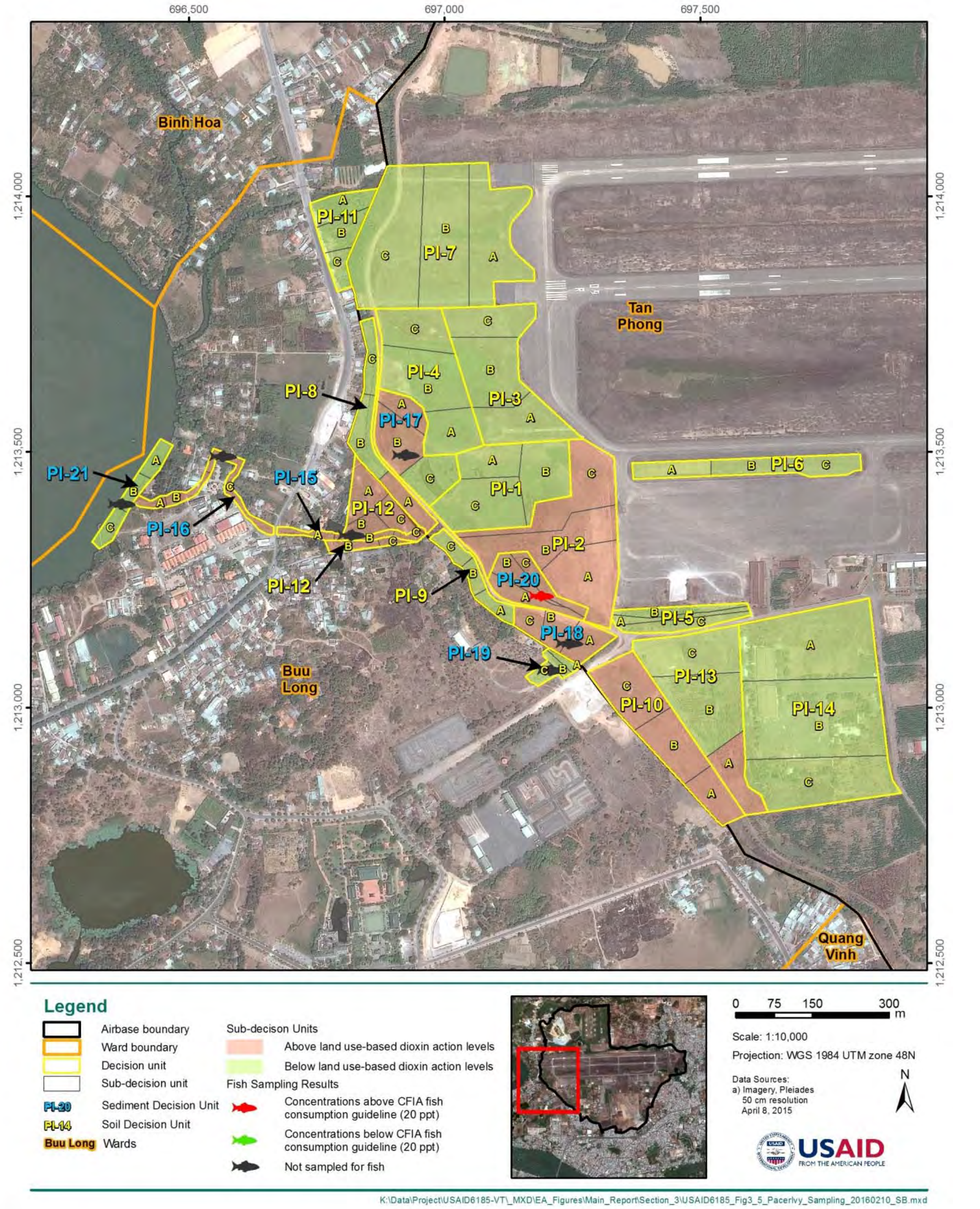
Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
SW-4	MIS	0-30	41.4		
	MIS	30-60	15.0		
	MIS	60-90	12.2		
SW-5	Not sampled				
SW-6	MIS	0-30	62.8		
	A	0-30	57.3		
	B	0-30	52.4		
	C	0-30	71.0		
	MIS	30-60	20.1		
	MIS	60-90	49.2		
SW-7	MIS	0-30	406	34,930	10,479
	A	0-30	674	14,543	4,363
	B	0-30	311	20,388	6,116
	C	0-30	210		
	MIS	30-60	169		
	A	30-60	231		
	B	30-60	192		
	C	30-60	81.4		
	MIS	60-90	129		
	A	60-90	219		
	B	60-90	168		
	C	60-90	64.5		
SW-8	MIS	0-30	60.8		
	MIS	30-60	171		
	A	30-60	149		
	B	30-60	216		
	C	30-60	44.4		
	MIS	60-90	40.7		

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

FIGURE 3-5 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS – PACER IVY AREA



95% upper confidence limit calculations for triplicate samples.

Sub-DU	Depth (cm)	Media	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
PI-1	0-30	Soil	151	19.4822	2.91998558	183.5
	30-60	Soil	84	53.6961	2.91998558	174.6
PI-8	0-30	Soil	1,903	397.4362	2.91998558	2573.4
PI-13	0-30	Soil	173	55.1382	2.91998558	266.3

Biota Sampling Results

Sample Location	Sample Type	Sub-Sample Type	Total TEQ (pg/g)
PI-20	Fish (Catfish)	Muscle	57.7
		Fat	3,550.0
	Snail	Whole	69.5

Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m²)	Contaminated Vol (m³)
PI-1	MIS	0-30	183.5		
	MIS	30-60	174.6		
	MIS	60-90	39.6		
	MIS	90-120	12.4		
	A	90-120	0.986		
	B	90-120	0.813		
	C	90-120	29.8		
	MIS	150-180	23.2		
	A	150-180	21.0		
	B	150-180	17.1		
	C	150-180	30.3		
	MIS	210-240	4.66		
	MIS	270-300	2.33		
PI-2	MIS	0-30	9,230	50,212	15,064
	MIS	30-60	11,400	50,212	15,064
	MIS	60-90	3,160	50,212	15,064
	MIS	90-120	2,900	33,132	9,940
	A	90-120	2,280	16,759	5,028
	B	90-120	6,610	16,372	4,912
	C	90-120	66.2		
	MIS	150-180	733	33,132	9,940
	A	150-180	782	16,759	5,028
	B	150-180	1,320	16,372	4,912
	C	150-180	101		
	MIS	240-270	1,120	33,132	9,940
	A	240-270	1,920	16,759	5,028
	B	240-270	1,120	16,372	4,912
	C	240-270	68.3		
	MIS	270-300	566		
PI-3	MIS	0-30	23.7		
	MIS	30-60	9.96		
	MIS	60-90	3.42		
	MIS	90-120	0.913		
	MIS	120-150	0.728		
PI-4	MIS	0-30	243		
	MIS	30-60	166		
	MIS	60-90	14.1		
	MIS	90-120	21.1		
	MIS	120-150	119		
PI-5	MIS	0-30	259		
	MIS	30-60	193		
	MIS	60-90	158		
PI-6	MIS	0-30	245		
	MIS	30-60	261		
PI-7	MIS	0-30	15.1		
	MIS	30-60	6.91		
	MIS	60-90	3.77		
PI-8	MIS	0-30	2,573	4,306	1,292
	A	0-30	3,040	4,306	1,292
	B	0-30	536		
	C	0-30	864		
	MIS	30-60	377		
	MIS	60-90	253		
PI-9	MIS	0-30	372		
	MIS	30-60	139		
	MIS	60-90	69		

Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m²)	Contaminated Vol (m³)
PI-10	MIS	0-30	637	30,310	9,093
	A	0-30	316	6,545	1,964
	B	0-30	395	10,685	3,205
	C	0-30	2,200	13,080	3,924
	MIS	30-60	117		
	A	30-60	118		
	B	30-60	79.1		
	C	30-60	153		
	MIS	60-90	54.5		
	A	60-90	80.7		
	B	60-90	39.1		
	C	60-90	11.7		
PI-11	MIS	0-30	221		
	MIS	30-60	32.6		
	MIS	60-90	36.3		
PI-12	MIS	0-30	2,170	14,482	4,345
	A	0-30	1,290	5,667	1,700
	B	0-30	2,870	4,414	1,324
	C	0-30	2,340	4,401	1,320
	MIS	30-60	560	8,815	2,645
	A	30-60	175		
	B	30-60	759	4,414	1,324
	C	30-60	1,000	4,401	1,320
	MIS	60-90	288	4,401	3,438
	A	60-90	40.0		
	B	60-90	207		
	C	60-90	656	4,401	3,438
PI-13	MIS	0-30	266.3	8,038	2,411
	A	0-30	299	8,038	2,411
	B	0-30	20.9		
	C	0-30	22.1		
	MIS	30-60	73.7		
PI-14	MIS	0-30	48.1		
	MIS	30-60	5.01		
PI-15	MIS	0-15	1,910	4,059	609
	A	0-15	693	1,564	235
	B	0-15	3,370	1,435	215
	C	0-15	2,180	1,060	159
	MIS	15-30	1,360	4,059	609
	A	15-30	801	1,564	235
	B	15-30	1,240	1,435	215
	C	15-30	2,750	1,060	159
	MIS	30-45	1,670	4,059	3,715
	A	30-45	809	1,564	1,431
	B	30-45	1,250	1,435	1,314
	C	30-45	3,320	1,060	970

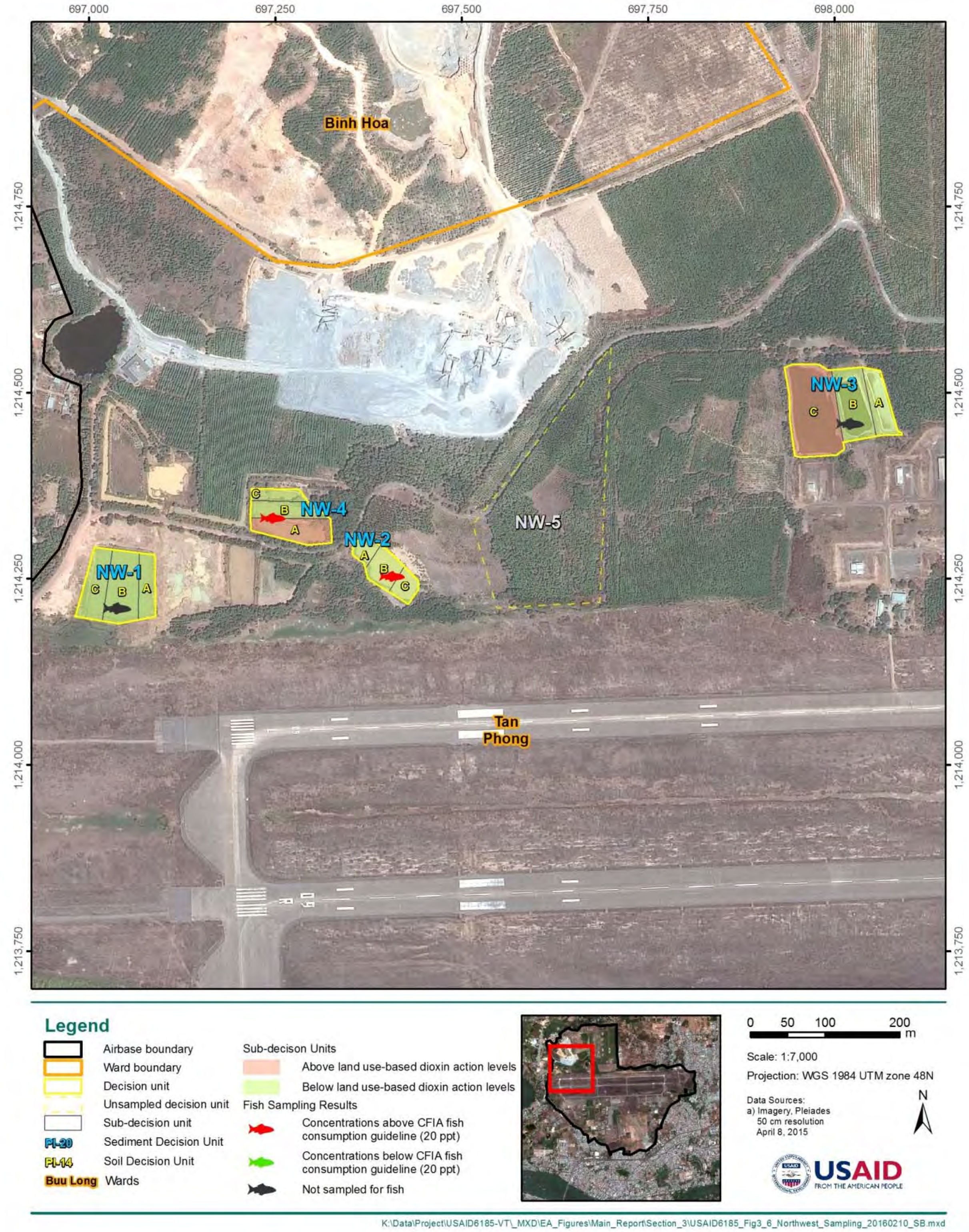
Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m²)	Contaminated Vol (m³)
PI-16	MIS	0-15	395	6,487	973
	A	0-15	211	1,169	175
	B	0-15	171	1,677	252
	C	0-15	889	3,641	546
	MIS	15-30	403	6,487	973
	A	15-30	164	1,169	175
	B	15-30	212	1,677	252
	C	15-30	1,120	3,641	546
	MIS	30-45	276	4,810	2,688
	A	30-45	321	1,169	653
	B	30-45	102		
	C	30-45	947	3,641	2,034
PI-17	MIS	0-15	431	12,935	1,940
	A	0-15	318	4,083	612
	B	0-15	1,300	8,852	1,328
	C	0-15	16.2		
	MIS	15-30	264	12,935	1,940
	A	15-30	370	4,083	612
	B	15-30	613	8,852	1,328
	C	15-30	4.09		
	MIS	30-45	172	12,935	5,806
	A	30-45	267	4,083	1,832
	B	30-45	506	8,852	3,973
	C	30-45	2.34		
PI-18	MIS	0-15	1,080	11,959	1,794
	MIS	15-30	349	11,959	1,794
	MIS	30-45	169	11,959	3,919
	A	30-45	146	4,983	1,633
	B	30-45	149	3,952	1,295
	C	30-45	179	3,024	991
PI-19	MIS	0-15	34.1		
	MIS	15-30	18.3		
	MIS	30-45	8.01		
PI-20	MIS	0-15	3,080	12,092	1,814
	MIS	15-30	5,410	12,092	1,814
	MIS	30-45	3,820	12,092	11,742
PI-21	MIS	0-15	26.6		
	MIS	15-30	18.4		
	MIS	30-45	69.1		

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m² – square meter; m³ – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

FIGURE 3-6 2014/2015 SAMPLING RESULTS – NORTHWEST AREA



Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
NW-1	MIS	0-15	96.8		
	MIS	15-30	104		
	MIS	30-45	69.7		
NW-2	MIS	0-15	72.4		
	MIS	15-30	46.5		
	MIS	30-45	23.7		
NW-3	MIS	0-15	**155**	7,810	1,172
	A	0-15	4.11		
	B	0-15	16.8		
	C	0-15	**385**	7,810	1,172
	MIS	15-30	**177**	7,810	1,172
	A	15-30	0.766		
	B	15-30	6.71		
	C	15-30	**587**		
	MIS	30-45	**194**	7,810	3,804
	A	30-45	0.742		
	B	30-45	4.87		
	C	30-45	**644**	7,810	3,804
NW-4	MIS	0-15	**199**	3,087	463
	A	0-15	**477**	3,087	463
	B	0-15	82.6		
	C	0-15	34.6		
	MIS	15-30	108		
	A	15-30	**262**		
	B	15-30	32.7		
	C	15-30	37.6		
	MIS	30-45	37.0		
NW-5	Not sampled				

LEGEND

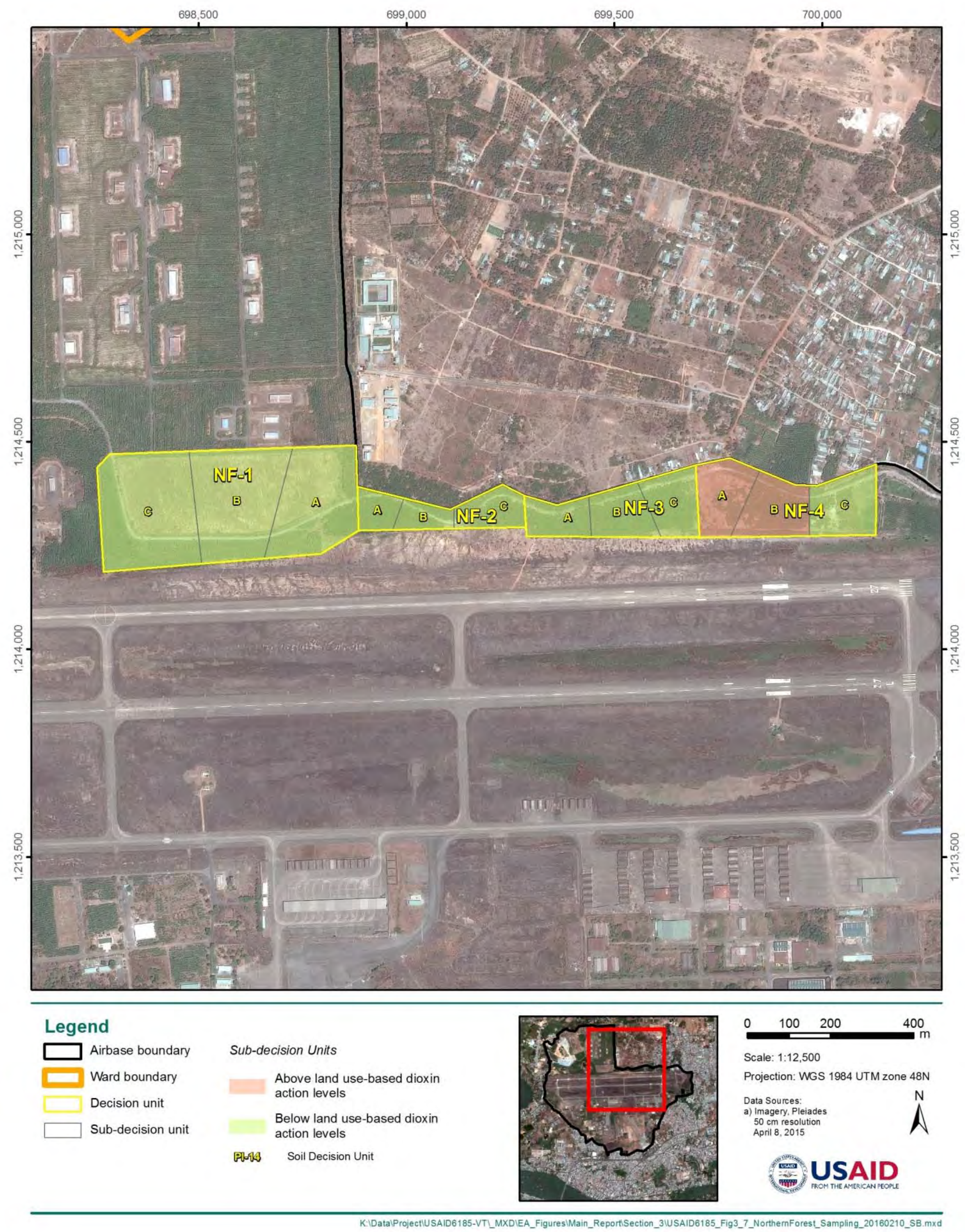
Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter; MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation; TEQ – toxic equivalency; UCL – upper confidence limit

Biota Sampling Results

Sample Location	Sample Type	Sub-Sample Type	Total TEQ (pg/g)
NW-2	Fish (Basa)	Muscle	4.1
		Fat	942.0
NW-4	Fish (Tilapia)	Muscle	49.9
		Fat	3,780.0
		Eggs	760.0
	Snail	Whole	61.6

FIGURE 3-7 2014/2015 SOIL SAMPLING RESULTS – NORTHERN FOREST AREA



Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
NF-1	MIS	0-30	35.5		
	MIS	30-60	6.27		
NF-2	MIS	0-30	60.0		
	MIS	30-60	4.02		
NF-3	MIS	0-30	19.0		
	MIS	30-60	1.00		
NF-4	MIS	0-30	**171**	43,173	12,952
	A	0-30	**349**	21,293	6,388
	B	0-30	**125**	21,881	6,564
	C	0-30	20.1		
	MIS	30-60	**159**	21,293	21,328
	A	30-60	**465**	21,293	21,328
	B	30-60	21.4		
	C	30-60	25.9		

LEGEND

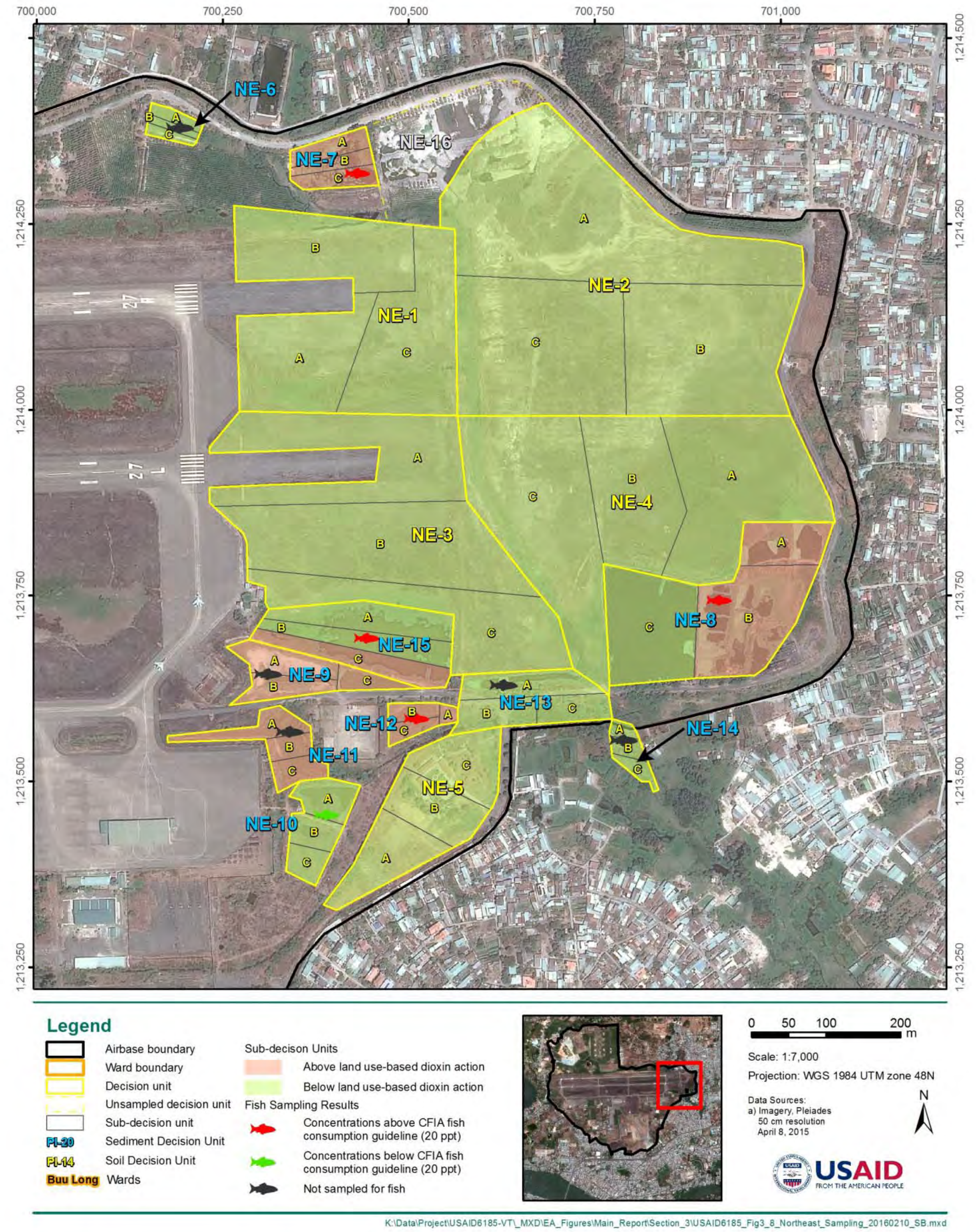
Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

95% upper confidence limit calculations for triplicate samples.

Sub-DU	Depth (cm)	Media	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
NF-1	0-30	Soil	30	3.3360	2.91998558	35.5

FIGURE 3-8 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS – NORTHEAST AREA



95% upper confidence limit calculations for triplicate samples.

Sub-DU	Depth (cm)	Media	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
NE-4	0-30	Soil	549	27.2764	2.91998558	595.0
	30-60	Soil	195	94.8086	2.91998558	354.8
NE-5	0-30	Soil	46	16.9306	2.91998558	74.7
NE-10	0-15	Sediment	22	3.0880	2.91998558	26.9
	15-30	Sediment	32	1.0209	2.91998558	33.7
	30-45	Sediment	35	8.3731	2.91998558	49.0
NE-11	0-15	Sediment	109	9.2783	2.91998558	124.7
	15-30	Sediment	188	105.8689	2.91998558	366.8
	30-45	Sediment	137	21.7613	2.91998558	174.0

Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
NE-1	MIS	0-30	10.6		
	MIS	30-60	3.78		
NE-2	MIS	0-30	794		
	A	0-30	981		
	B	0-30	542		
	C	0-30	1,020		
	MIS	30-60	63.3		
NE-3	MIS	0-30	34.7		
	MIS	30-60	20.5		
NE-4	MIS	0-30	595.0		
	A	0-30	666		
	B	0-30	706		
	C	0-30	236		
	MIS	30-60	354.8		
NE-5	MIS	0-30	74.7		
	MIS	30-60	40.9		
NE-6	MIS	0-15	71.5		
	MIS	15-30	44.8		
	MIS	30-450	74.5		
NE-7	MIS	0-15	**1,300**	7,372	1,106
	MIS	15-30	**765**	7,372	1,106
	MIS	30-45	54.0		
NE-8	MIS	0-15	**179**	24,794	3,719
	A	0-15	**223**	6,608	991
	B	0-15	**215**	18,187	2,728
	C	0-15	48.8		
	MIS	15-30	**202**	24,794	3,719
	A	15-30	**157**	6,608	991
	B	15-30	**265**	18,187	2,728
	C	15-30	52.7		
	MIS	30-45	128	6,608	2,284
	A	30-45	**217**	6,608	2,284
	B	30-45	122		
	C	30-45	39.9		
NE-9	MIS	0-15	**448**	10,140	1,521
	MIS	15-30	**334**	10,140	1,521
	MIS	30-45	**216**	10,140	3,501

Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
NE-10	MIS	0-15	26.9		
	MIS	15-30	33.7		
	MIS	30-45	49.0		
NE-11	MIS	0-15	124.7	7,950	1,193
	MIS	15-30	**366.8**	7,950	1,193
	MIS	30-45	**174.0**	7,950	2,586
NE-12	MIS	0-15	**185**	3,639	546
	A	0-15	**259**	596	89
	B	0-15	**148**	1,581	237
	C	0-15	**133**	1,462	219
	MIS	15-30	64.5		
	MIS	30-45	47.1		
NE-13	MIS	0-15	77.6		
	MIS	15-30	89.7		
	MIS	30-45	63.9		
NE-14	MIS	0-15	35.8		
	MIS	15-30	39.2		
	MIS	30-45	34.8		
NE-15	MIS	0-15	**154**	6,699	1,005
	A		50.0		
	B		127		
	C		**225**	6,699	1,005
	MIS	15-30	24.6		
	MIS	30-45	9.81		
NE-16	Not sampled				

LEGEND

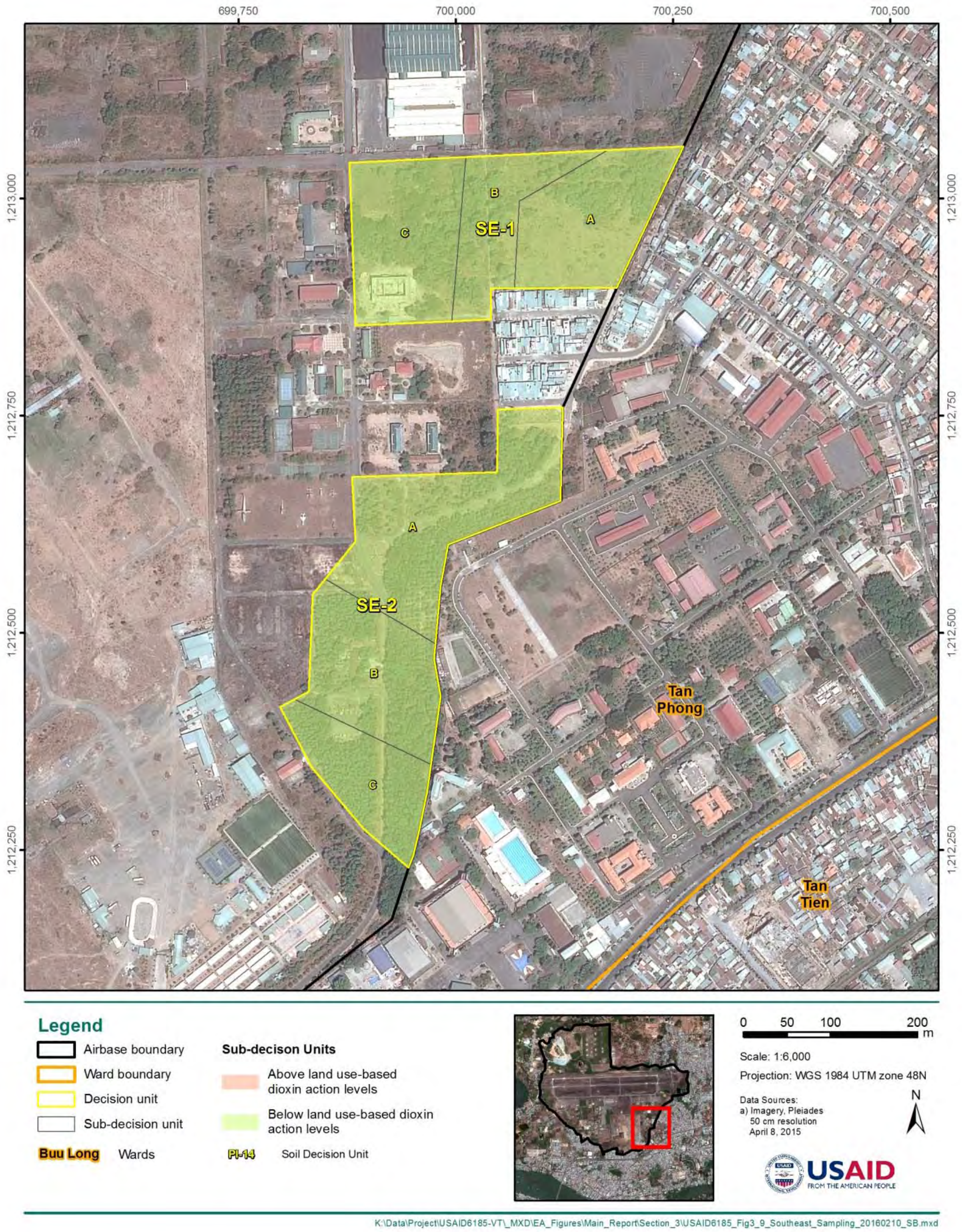
Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

Biota Sampling Results

Sample Location	Sample Type	Sub-Sample Type	Total TEQ (pg/g)
NE-7	Fish (Tilapia)	Fat	837.0
NE-8	Fish (Tilapia)	Muscle	3.4
		Fat	141.0
		Eggs	65.2
NE-10	Fish (Tilapia)	Whole	1.6
NE-12	Fish (Tilapia)	Muscle	3.7
		Eggs	233.0
NE-15	Fish (Bighead Carp)	Muscle	33.9
		Fat	1,440.0

FIGURE 3-9 2014/2015 SOIL SAMPLING RESULTS – SOUTHEAST AREA



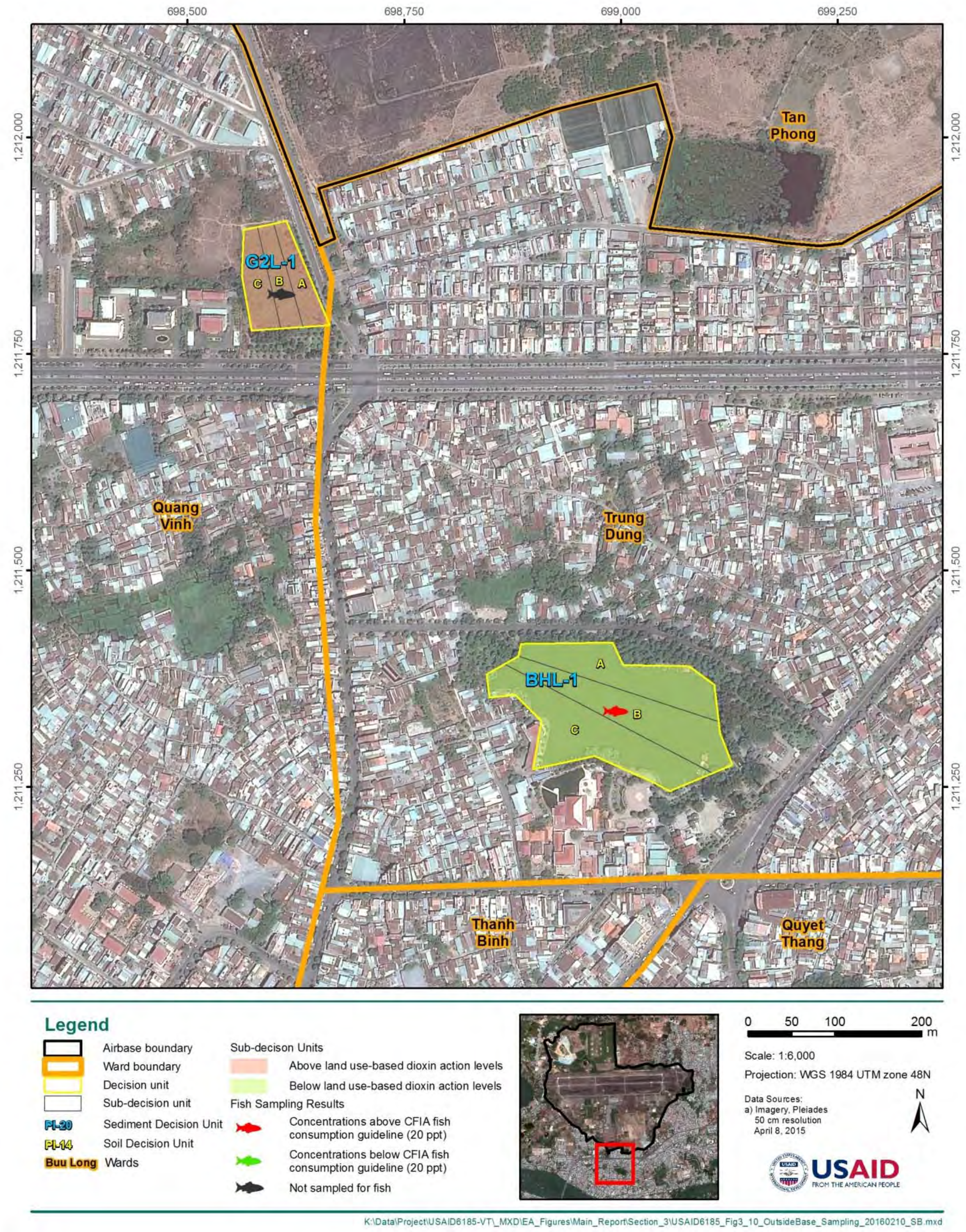
Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m²)	Contaminated Vol (m³)
SE-1	MIS	0-30	36.9		
	MIS	30-60	34.5		
SE-2	MIS	0-30	64.5		
	MIS	30-60	31.7		

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

FIGURE 3-10 2014/2015 SEDIMENT SAMPLING RESULTS – OUTSIDE OF THE AIRBASE



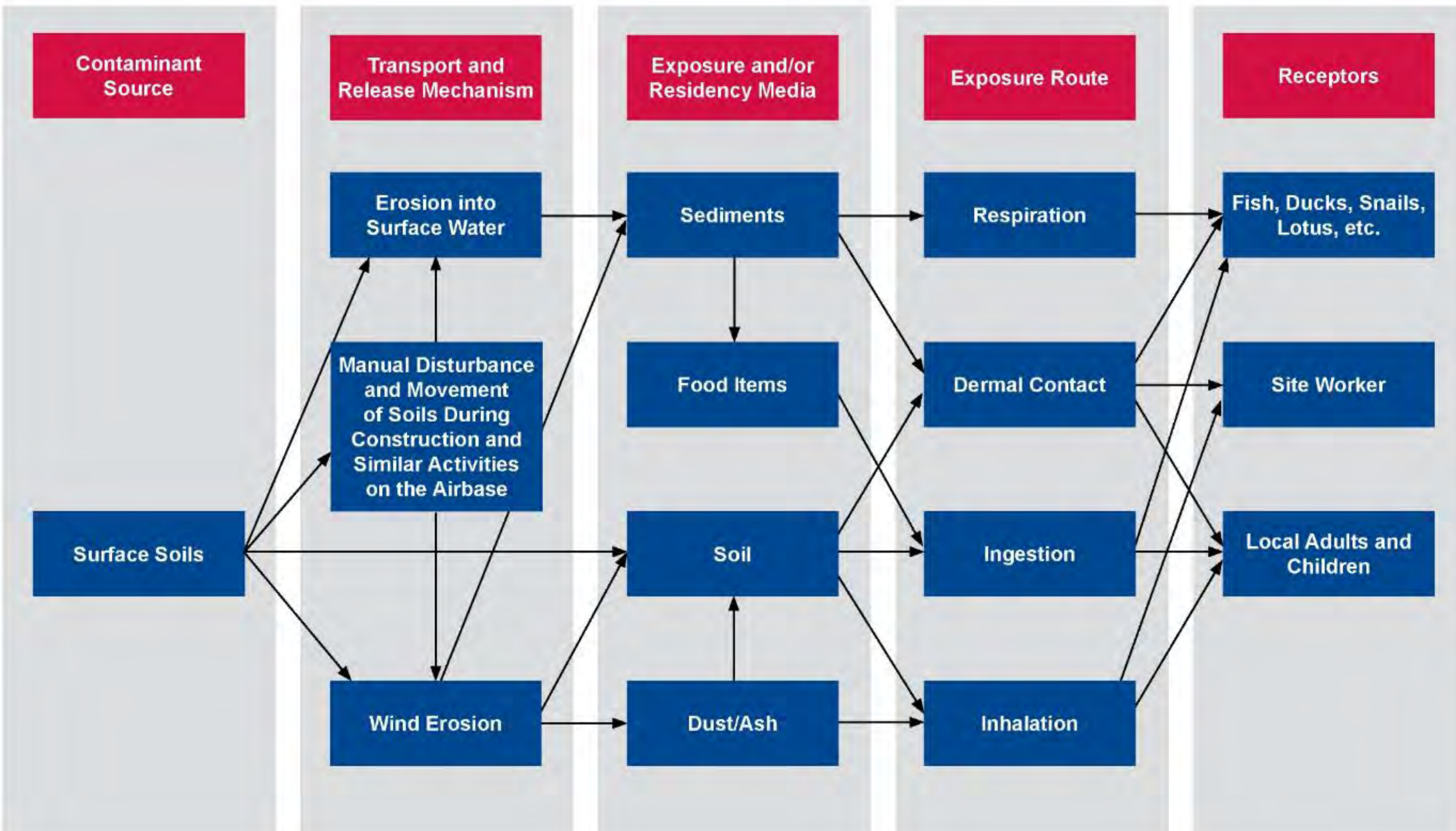
Area	Sub-Area	Depth (cm)	TEQ (ppt)	Contaminated Area (m^2)	Contaminated Vol (m^3)
G2L-1	MIS	0-15	**166**	8,789	1,318
	MIS	15-30	100		
	MIS	30-45	56.5		
BHL-1	MIS	0-15	83.0		

LEGEND

Color	Concentration	Excavated?	Treated?
Black	< Action Levels	No	No
Yellow	Between Action Levels and 1,200 ppt	Yes	Alt. 5
Blue	Between 1,200 and 2,500 ppt	Yes	Alts. 4 and 5
Red	Above 2,500 ppt	Yes	Alts. 3, 4 and 5

cm – centimeter; DU – decision unit; m^2 – square meter; m^3 – cubic meter;
MIS – multi-increment sampling; ppt – part per trillion; Stdev – standard deviation;
TEQ – toxic equivalency; UCL – upper confidence limit

Figure 3-11 Conceptual Transport and Exposure Pathway Model for Human and Ecological Receptors from Contaminant Sources



Section 4 Evaluation of Alternatives

4.1 Potentially Applicable Technologies/Strategies

A number of technologies and/or management strategies have potential applicability for remediation (treatment or containment) of dioxin contamination in soil and sediments at the Airbase. Previous studies that evaluated applicable technologies were reviewed, and recent scientific literature was also searched to identify any promising recent advances. Only those technologies and strategies that did not meet the initial screening criteria described in **Section 4.2.1** were discarded; all others were retained, including destructive treatment technologies and applicable containment technologies and strategies. **Table 4-1** lists the technologies and strategies identified. Additional details regarding each of these technologies are presented in **Appendix C**.

4.2 Screening of Technologies and Description of Alternatives

4.2.1 Technologies and Strategies

Identified technologies and strategies were subjected to a screening process before being considered for detailed evaluation within a remedial alternative. This initial screening utilized three criteria, all of which had to be met for the strategy or technology to be retained:

- Has the technology or strategy demonstrated dioxin destruction or containment on a scale larger than a lab study, and from the range of concentrations measured in soils and sediments at the Airbase to below the range of required MND-approved dioxin limits? In other words, has the technology or strategy been demonstrated to be sufficiently mature to be applied at the Airbase? If a particular technology has not been demonstrated to treat or contain materials to below MND-approved dioxin limits, it should not receive the same consideration as a technology or strategy that has demonstrated maturity and applicability.
- Would full-scale costs be prohibitive or not competitive with other comparable technologies? Technologies with available cost data, even if conceptual, were compared. Those without cost information or with only limited cost information, were assessed using professional judgment regarding expected cost drivers. For example, if a particular technology had significantly higher expected energy requirements versus another comparable technology that was already known to be effective, it was not retained. Additionally, if a particular technology required significant preprocessing and pretreatment prior to its application compared to others, it was not retained.
- Is the technology or strategy expected to be acceptable to Vietnamese stakeholders? This criterion is based on feedback from GVN stakeholders during early discussions regarding technology evaluation or during past discussions. This includes technologies which GVN stakeholders have indicated are not expected to be sufficiently protective or which would have significant waste streams that would require additional management.

These screening criteria are different than the primary alternative evaluation criteria (effectiveness, implementability, cost, and environmental consequences) presented in **Section 4.3** below, but were designed to retain only those that would be worth further evaluation for potential implementation at the

Airbase. **Table 4-1** lists the technologies and strategies identified for this screening step, as well as whether each was retained for more detailed evaluation. For each technology or strategy that was screened out, the criterion that it did not meet is identified. Additional technical details regarding each of these technologies, and the screening process and results, are presented in **Appendix C**.

The following technologies and strategies were retained:

- **Landfills:** This commonly used containment strategy achieves containment of contaminated soil and sediment by isolating it from the surrounding environment using layers of clean fill, polyethylene liners, and low-permeability materials. Landfills were used to isolate contamination in the Z1 Area at the Airbase and at the Phu Cat Airbase.
- **Stabilization/Solidification:** Using this containment technology, contaminated material is mixed with stabilization agents (cement, lime, fly ash, additives, and/or proprietary organophilic clays) to reduce leachability, erosion, and other transport mechanisms.
- **Incineration:** High temperatures (870 to 1,200°C) generated by rotary kiln incinerators are commonly used to volatilize dioxin from contaminated soil and sediment, and then oxidize it in the gaseous phase.
- ***Ex Situ* TCH:** Soil is heated to approximately 300°C in an *ex situ* pile so that dioxin is either oxidized or pyrolyzed in the pile, or volatilized and extracted for further treatment as needed. An example of *ex situ* TCH is IPTD®, which was used at the Danang Airport remediation project.
- **MCD (also known as Ball Milling):** Vibration-induced soil crystal damage generates free radicals, which in turn can dechlorinate dioxin molecules and react with other organics.

4.2.2 Alternatives

Using the retained technologies and strategies, alternatives for remediation were then developed. All alternatives (with the exception of Alternative 1) were designed to comply with GVN regulations and MND-approved dioxin limits, and achieve acceptable environmental and social impacts. Alternatives 2 through 5 (described below) would also meet the objective of the Prime Minister's Decision No. 651/QD-TTg (Prime Minister of the Government 2012) for cleaning up dioxin contamination related to the U.S.-Vietnam War. However, due to the time associated with implementation, none of the alternatives would be completed by 2020.

Complete excavation of all soil or sediment exceeding a dioxin limit in a DU is included in every alternative. Alternatives were developed while also considering potential exposure pathways, DU area and volume considerations, general logistics and feasibility, and the advantages and limitations of each technology and/or strategy.

Within those constraints, alternatives were designed to cover a range of potential aggressiveness with regard to treatment versus containment, ranging from the most passive alternative (containment) to most aggressive alternative (treatment) as shown in **Figure 4-1** and summarized as follows:

- <u>Alternative 1</u>: No Action (baseline; for comparison purposes).
- <u>Alternative 2</u>: Provide containment of all soil and sediment above MND-approved dioxin limits:
  - Alternative 2A: Contain in a Passive or Active Landfill.
  - Alternative 2B: Contain using Solidification/Stabilization.

- Alternative 3: Treat all soil and sediment above 2,500 ppt; contain the soil and sediment between MND-approved dioxin limits and 2,500 ppt.
- Alternative 4: Treat all soil and sediment above 1,200 ppt; contain the soil and sediment between the MND-approved dioxin limits and 1,200 ppt.
- Alternative 5: Treat all soil and sediment above MND-approved dioxin limits:
  - Alternative 5A: Treat using Incineration.
  - Alternative 5B: Treat using *Ex Situ* TCH.
  - Alternative 5C: Treat using MCD.

Both Alternative 2A and 2B focus exclusively on dioxin containment, whereas Alternatives 5A, 5B, and 5C are designed to provide complete dioxin destruction through treatment. Alternatives 3 and 4 are designed to provide a combination of the benefits of both containment and treatment. The 2,500 ppt concentration threshold was selected for Alternative 3 based on a natural breakpoint in the data but happens to separate the volume of soil and sediment that exceeds GVN allowable limits for dioxin contamination into approximately 75% containment and 25% treatment. The 1,200 ppt concentration threshold selected for Alternative 4 corresponds to the 1,200 ppt GVN standard for industrial land use.

During the development of the alternatives, it was determined that given the number of containment and treatment options, it would not be feasible to evaluate every possible combination as a distinct alternative. Therefore, in the evaluation that follows, the two containment technologies were first compared against each other as two separate alternatives (2A and 2B). Similarly, the three treatment technologies were compared against each other as separate alternatives (5A, 5B, and 5C). Finally, for the purposes of comparison, two alternatives that include a mixture of containment and treatment technologies were evaluated (3 and 4). The selection of specific containment and treatment technologies for Alternatives 3 and 4 is not intended to indicate that these technologies are preferred or selected. Rather, Alternatives 3 and 4 were developed and evaluated against the other alternatives to assess varying mixtures of containment and treatment, given the large difference in costs between containment and treatment technologies.

4.3 Description of Evaluation Criteria

The alternatives retained after initial screening were further evaluated based on several criteria that allow for direct comparison of the alternatives in terms of costs and environmental benefits. The evaluation is based on a preliminary conceptual design for each alternative as described in the following sections. The specific criteria utilized for this evaluation are effectiveness, implementability, cost, and environmental consequences. These criteria are described in greater detail as follows.

4.3.1 Effectiveness

Effectiveness of an alternative can be evaluated based on several factors, including:

- Short-term effectiveness: the alternative should be able to reduce the short-term exposure to dioxins in the impacted media, including during implementation of the alternative.
- Long-term effectiveness: the alternative should be able to reduce the presence or likelihood of exposure over the long term. Long-term monitoring requirements to confirm the effectiveness may

be necessary for some alternatives. Alternatives that destroy the dioxin would be more effective in the long term compared to alternatives that contain dioxin-impacted soils and sediments.

- Effectiveness for all media: the alternative needs to be able to be utilized on any of the impacted media at the Airbase, specifically, soil and sediment of varying composition.
- Effective at a range of concentrations: the alternative needs to be effective whether the impacted soils and sediments contain relatively low or relatively high concentrations of dioxin.
- Effective at treatment of impacted soils to below the GVN standards based on land use: the alternative should be able to remove dioxins from the impacted soils and sediments to below the appropriate dioxin limit.

4.3.2 Implementability

The implementability of an alternative is dependent on numerous factors, including:

- Technology availability: are the specific technologies, equipment, supplies, and expertise readily available in the vicinity of the project site or would these items need to be imported or sourced from outside the country? Additionally, are multiple vendors or contractors available who can implement a particular technology, and are the technologies patented?
- Scalability: given the relatively large volumes of impacted soils at the Airbase, a technology needs to be able to operate effectively at a large scale.
- Site-specific limitations: issues such as climate (rainy and dry season), future land use, other site-specific COPCs, availability of utilities, and limitations on work in specific areas of the Airbase may make some alternatives more challenging to implement.
- Duration of treatment: the length of time required to adequately implement an alternative is important to evaluate, as longer implementation timeframes may require longer periods of operation and maintenance activities and temporary environmental controls and mitigation measures (i.e., stormwater controls during construction), and therefore may be less desirable for project stakeholders. In addition, an alternative that can be implemented faster would reduce potential exposure risk to the surrounding population sooner.
- Material handling requirements: alternatives requiring more handling of residual materials and by-products or generate waste materials might make them more challenging to implement.
- Long-term monitoring requirements: the need for long-term effectiveness monitoring or institutional controls might make an alternative more challenging to implement or maintain over the long term.

4.3.3 Cost

Identification and evaluation of potential costs for remedial alternatives is integral to the evaluation process to help determine the most feasible remedial alternative. The remedial alternative costs presented in this EA were developed in general accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, EPA 540-R-00-002 (USEPA 2000). Although the EA process is distinct from the CERCLA (i.e., Superfund) feasibility study (FS) process, the objectives and intent (as well as project concept development) for this EA are sufficiently similar to the CERCLA process to warrant use of this guidance.

At the alternatives evaluation stage, the designs for the remedial alternatives are still conceptual, not detailed, and the preliminary estimated overall costs are considered to be "order-of-magnitude." **The remedial alternative preliminary estimated overall costs were developed during the EA primarily for the purpose of comparing alternatives during the remedial selection process, not for establishing Project budgets**. As a remedial alternative moves from the planning stage into the design and implementation stages, the level of project definition increases, thus allowing for a more accurate cost estimate. An "early" estimate of the remedial alternative's life cycle costs is made during the EA process to make a remedy selection decision. The levels of detail employed in making these estimates are conceptual, but are considered appropriate for making choices between alternatives. The information provided in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives.

Costs for remedial alternatives are expected to have varying accuracies depending on the level of project definition. For example, the recommended cost accuracy is from -50% to +100% of actual costs at the remedial investigation or feasibility stage and from -30% to +50% at the remedy selection stage. Since the Bien Hoa EA lies between these two stages, cost accuracies of -40% to +75% of actual costs are being used. Factors such as increased project duration and phased implementation that might require longer field implementation time may increase the cost, although by an undetermined amount. It is important to note that the costs were valued consistently across alternatives, and therefore, the estimates allow for reliable comparisons between alternatives.

Another factor related to the cost evaluation of each alternative is the sensitivity of the cost to both the schedule for implementation and the volume of material to be addressed by the alternative. For example, an alternative with a high capital cost to install, but low cost to operate or maintain, is relatively insensitive to the volume of material to be contained or treated, meaning that increasing the volume treated does not drastically increase the total project costs. An alternative which has significant operational or maintenance costs based on the volume of material contained or treated would have costs that increase more substantially if the volume of material increases beyond the estimates presented herein. Assumptions of the Project scope and duration are defined for each alternative to provide preliminary estimated overall costs for the various remedial alternatives. Important assumptions specific to each remedial alternative are summarized in the description of the alternative. Additional assumptions are included in the detailed preliminary estimated overall cost backup, which can be found in **Appendix D**. As discussed further in this section for each alternative, and presented in more detail in the backup in Appendix D, costs include estimated design costs and other construction costs that may not be associated with the remedial contractors (e.g., energy costs, oversight costs, and waste disposal). Information is also presented on expected labor sources (local or expatriate).

For comparison purposes in the EA, net present value costs are not presented for comparison of project alternatives because the project funding mechanism is assumed to be through annual Congressional appropriations without use of an interest-bearing account. Thus the current costs (total project costs excluding net present value discounting) were used for project alternative comparisons.

4.3.4 Environmental and Social Consequences

Detailed analyses of the potential environmental and social impacts associated with each alternative were conducted. Compliance with the requirements of 22 CFR 216 was maintained throughout the EA. The issues that formed the scope of the assessment of environmental consequences were derived from the ESS, the conceptual designs of each alternative, and additional environmental baseline information obtained during the 2014/2015 EA sampling.

For each issue, one of the following impact ratings was determined:

- **NO IMPACT:** This determination is made when there is no impact of the remedial alternative on the environmental resource of concern. This assessment is made if the activities associated with the remedial alternative are to be spatially or temporally removed from the environmental resource being assessed.
- **SIGNIFICANT AND UNMITIGABLE IMPACT:** This determination is made when there is expected to be an impact of a given remedial alternative on the environmental resource of concern and there are either no known mitigations or it is uncertain whether the significant impact can be effectively mitigated with available mitigation activities.
- **MITIGABLE IMPACT:** The potential impact is Significant, as described above, but it can be effectively mitigated using well-accepted and proven mitigation measures.
- **INSIGNIFICANT IMPACT:** This determination is made when there is expected to be an impact of a given remedial alternative on the environmental resource of concern but the impact is assessed to be too negligible to require intervention in the form of either mitigation or monitoring.
- **POSITIVE IMPACT:** This determination is made when the effect of a given remedial alternative will be to improve the condition and integrity of the environmental resource of concern.

The determination of significance was based upon applying the following set of criteria to each potential environmental effect: magnitude; geographic extent; duration and frequency of impact; and ability of the environmental or social resource in question to recover after each remedial alternative had been implemented. Both objective and subjective considerations were included in the application of these criteria. Objective considerations included the ability to meet statutory or regulatory requirements related to environmental protection and management such as ambient air quality objectives and water quality guidelines, effluent discharge limits, regional environmental objectives, and international environmental obligations. Professional judgment was applied when potential effects could not be predicted quantitatively due to limited data availability or when there are no benchmarks against which to compare predicted quantitative impacts. The determination of significance integrated quantitative impact analysis (where possible) and professional judgment that took into account the assessments of each of the criteria listed above (i.e., magnitude, geographic extent, duration and frequency of impact; and ability of the environmental or social resource in question to recover after each remedial alternative had been implemented). Gender-specific differences in the potential impacts were also noted.

4.4 Alternatives Evaluation and Findings

As described in **Section 4.2**, the retained alternatives for remediation of dioxin at the Airbase range from alternatives that are solely containment of contaminated soils and sediments (Alternative 2A – Landfill and Alternative 2B – Solidification/Stabilization), to alternatives that consist of treatment of all soils to remove and destroy dioxin (Alternative 5A – Incineration, Alternative 5B – *Ex Situ* TCH, and Alternative 5C – MCD/Ball Milling). Alternatives 3 and 4 are combinations of the optimal containment strategy with the optimal treatment strategy, with a dioxin concentration threshold to determine the materials to be contained or treated. For this reason, the containment alternatives (Alternative 2) are discussed first, followed by the treatment alternatives (Alternative 5). Alternatives 3 and 4 are discussed after evaluation of the respective containment and treatment components that would be combined in these alternative approaches.

With the exception of Alternative 1 (No Action), there would be several common elements among the alternatives including: mobilization and project preparation; excavation and hauling of contaminated soil and sediment; and removal and destruction of contaminated fish and other aquatic animals. These elements are discussed below.

Project Planning, Approval, and Procurement

All remediation alternatives require project planning, including development of detailed designs and an EIA, approvals by GVN, and procurement of implementation contractors. There will be unbudgeted USAID administrative costs during this period. It is anticipated that the time required to perform these activities would be 3 to 5 years and that this time would be in addition to the implementation time identified under each alternative.

Mobilization and Project Preparation

Clearing all Project Areas of UXO: All existing UXO within the Project area (excavation areas, temporary storage and dewatering areas, and containment/treatment areas) would be detected and cleared prior to the commencement of any onsite Project activities.

Project Setup, Equipment, Facilities: Several activities need to be completed prior to the start of construction, such as the finalization of contractual items (i.e., contracts, subcontracts, waivers, etc.), conducting pre-construction meetings, submittal and approval of required pre-construction plans, mobilization of contractor personnel, establishment of project site offices with necessary licenses and/or registrations, obtaining appropriate site access and land management agreements, provision of site utilities (i.e., water, electricity, etc.), and procurement and mobilization of material and equipment.

Excavation and Hauling of Contaminated Soil and Sediment

For Alternatives 2 through 5, a common element is the excavation and transportation of contaminated soil and sediment to centralized locations for containment and/or treatment. In each DU where dioxin concentrations exceed the applicable land use based dioxin limit, contaminated soil/sediment would be excavated (with the exception of the Z1 Landfill for Alternatives 2 and 3) to the limits and depths indicated on **Figures 3-2 through 3-10**. **Table 4-2** presents the estimated haul distances from each DU being excavated to the respective centralized location in the Pacer Ivy or Z1 Areas for containment and/or treatment. The excavation areas, depths, volumes, and haul distances are the same for all alternatives, with the exception of the Z1 Landfill which is not excavated in Alternatives 2 and 3. Since the Z1 Landfill is effectively containing dioxin contaminated material and, thus eliminating any exposure potential, it will remain for Alternatives 2 and 3. However, since the measured dioxin concentration in the landfill (1,510 ppt) is greater than the 1,200 ppt threshold that defines the action in Alternatives 4, it would be excavated and treated. Similarly, the Z1 Landfill would be excavated for Alternative 5 since the objective of that alternative is to treat all dioxin contaminated material above the MND-approved dioxin limits. Contaminated soil and sediments from the Pacer Ivy, Northwest, Northern Forest, and Northeast Areas would be excavated and stockpiled in the Pacer Ivy Area near PI-

> In Alternatives 2 through 5, dioxin-contaminated soil and sediment would be excavated and transported to centralized locations for containment and/or treatment.

5, PI-10, and PI-13, and contaminated soils and sediments from the Z1 Area, Southwest Area, ZT Area, and Gate 2 Lake would be excavated and stockpiled in the Z1 Area to the north of the Z1 Landfill. Excavated materials from the Northeast Area are planned to be hauled to the Pacer Ivy Area for containment or treatment, rather than to the Z1 Area, due to more restricted haul route access between the Northeast and Z1 Areas. Contaminated material would be transported to the identified containment and/or treatment locations in the Pacer Ivy and Z1 Areas by truck or other suitable means.

It should be noted that for Alternative 3, all material designated for treatment would be hauled to the Pacer Ivy Area for treatment, as only one treatment area is included in the conceptual design for this alternative to minimize capital cost and avoid relocating project facilities.

The following activities would be completed for each excavation area identified:

- Erosion and sediment controls would be constructed to prevent sediment migration from the excavation areas, as well as to prevent run-on of storm water.
- Vehicle decontamination facilities would be established at the exit point of each excavation area to decontaminate vehicles and prevent tracking of contaminated soils on haul roads.
- Sediment DUs and any areas with ponded water would be dewatered prior to commencing excavation. Pumped water would be treated and discharged. Treatment would likely consist of two steps: primary filtration to remove suspended solids and granular activated carbon (GAC) to remove organics (including dioxin). Treatment effectiveness would be confirmed via sampling.
- A temporary dewatering area would be established at the sediment DUs, where excavated sediments would be allowed to drain prior to loading into trucks for hauling.
- Following excavation to the limits and depths indicated, confirmation samples would be collected from each DU excavation area to determine whether the remaining material in the DU meets the respective dioxin limit based on the land use.
  - If the sampling results indicate that a DU does not meet the criteria, excavation would continue until the criteria are met.
  - Backfilling of DUs would be completed following receipt of confirmation samples which are below the applicable criteria for the respective excavation area.
- For purposes of evaluating the alternatives and preparing this EA, it has been assumed that excavated areas would be backfilled using either clean offsite fill material or treated material, depending on the alternative, to restore grades and facilitate drainage. Sediment DUs would not have sediment replaced after excavation.

Excavation activities are anticipated to be conducted during the dry season to the extent practical. Excavation would be completed using conventional excavation equipment, including bulldozers, track excavators, and front-end loaders, and soil transportation is anticipated to be completed using dump trucks. Primary truck haul routes to the Pacer Ivy and Z1 Areas are presented on **Figure 4-2**. The haul roads located in the Northern Forest, Northeast, and Northwest Areas would likely require improvement prior to hauling contaminated materials to the Pacer Ivy Area and costs for efforts to repave these roads are included in the preliminary estimated overall costs.

During excavation, several areas on the Airbase would likely require dewatering due to groundwater infiltration, particularly PI-2. Dewatering during excavation would be completed by pumping water from low points in the open excavation and by installation of temporary well points in the vicinity of the excavation, and pumping, treating, and discharging water as it accumulates in the excavation.

Backup information for the locations to be excavated and depths to which excavation would be required are described in **Appendix A** and **Appendix B**.

Removal and Destruction of Fish and Other Aquatic Animals

For Alternatives 2 through 5, a common element is the need for removal and destruction of fish and other aquatic animals currently found in Airbase lakes, as well as in Gate 2 Lake and Bien Hung Lake outside the Airbase. As described in **Section 3.2.2**, given that all fish samples collected on and off the Airbase (with the exception of NE-10) were contaminated, that most sediment DUs were impacted above MND-approved dioxin limits, and that fish may have been moved by aquaculture activities or natural processes, it would be difficult to identify a fish population that is considered safe for consumption. Furthermore, given the difficulty in implementing fishing bans (Thanh 2015) and the exposure risk posed by further consumption of contaminated fish (Durant et al. 2014), all fish and aquatic animals should be destroyed in all lakes. This includes areas where sediments would be remediated and areas where no sediment remediation is necessary. Furthermore, fish in Bien Hung Lake and NW-2 should also be removed and destroyed, even though these lakes did not contain contaminated sediments. Dioxins in these fish likely remain due to bioaccumulation through the food chain over time, and can be expected to remain a problem in future unless they are removed from the biological system. It is important to note that following remediation, and recreation of aquatic habitats, new populations of fish would inhabit the lakes. Therefore, institutional controls are an important component of ensuring contaminated fish and other aquatic animals are not consumed by the local population until sediment remediation and complete fish removal are both complete.

> The removal and destruction of fish and other aquatic animals currently found in Airbase lakes, as well as in Gate 2 Lake and Bien Hung Lake outside the Airbase, is a common feature of Alternatives 2 to 5.

In each DU where dioxin concentrations in fish or other aquatic animals exceed the applicable criterion (20 ppt) in lakes to be remediated (as well as Bien Hung Lake and NW-2), contaminated fish would be removed and placed in the treatment pile/landfill along with contaminated sediment. The numbers and total weight of fish and other aquatic animals is unknown and would vary between lakes. Contaminated fish and aquatic animals would be transported to the identified containment and/or treatment locations in the Pacer Ivy and Z1 Areas by truck or other suitable means. For some alternatives, destruction of the fish would be incorporated into the containment or treatment approach (e.g., landfills or incinerators). For stabilization/solidification or MCD, biota disposal would constitute another waste stream that would require management.

The following activities would be completed for each lake:

- Any ducks or other waterfowl residing on the lakes would be captured, killed, and moved to a separate holding facility for transport to the treatment area. Every precaution would be taken to minimize potential exposure of workers to avian flu or other potential diseases associated with waterfowl.

- As per the procedures stated above for sediment DUs and any areas with ponded water, these would be dewatered. Prior to commencing sediment excavation, fish would be captured, killed, and moved to a separate holding facility for transport to the treatment area.
- Aquatic vegetation would be removed from each lake, and would be transported to the treatment area along with any aquatic animals (e.g., snails) that might be living in the vegetation.
- Following removal of all fish and aquatic animals, a search of adjacent ponds and wetted areas would be made for any remaining fish, ducks, etc. that might have escaped the pond.
- The area would be secured and guarded prior to removal of fish and other aquatic animals. Care would be taken to ensure that workers or local people do not remove the fish and/or aquatic animals for consumption.
- The bans on fishing and aquaculture at all Airbase lakes need to be strictly enforced following removal of contaminated sediments, until sufficient data can be collected to demonstrate that fish consumption does not pose an unacceptable risk.
- Additional signage and/or fences should be erected around all Airbase lakes and offsite lakes with known contamination to deter further fishing and aquaculture.
- A communication program and public awareness campaign would be implemented to inform local residents of fishing bans on all Airbase lakes, Gate 2 Lake, and Bien Hung Lake.
- For all lakes where sediment treatment is not required, removal of fish would require the following:
  - Preferably, the lakes would be drained (or partially drained), and fish and other aquatic animals removed according to the procedures outlined above for all sediment DUs.
  - If dewatering is not possible, then it is more challenging to remove all fish from any given waterbody. A combination of fishing methods may be used to remove fish, including gillnetting, seine nets, and electrofishing. Use of chemicals such as rotenone should also be considered, provided these are acceptable under Vietnamese law.
  - Fishing bans would need to be strictly enforced, especially on Bien Hung Lake which is a recreational lake accessible to the general public.

4.4.1 Alternative 1: No Action

Under Section 6 of 22 CFR 216(c)(3), the EA must include the alternative of No Action. The No Action alternative examines the potential environmental impacts of not addressing dioxin contamination at the Airbase. This alternative establishes baseline information and estimates the continuing routes of exposure that could persist over a number of years without action. This alternative provides a baseline against which other alternatives are assessed.

4.4.1.1 Conceptual Design

Under the No Action alternative, the contaminated soil/sediment would be left in place and no new mitigation measures would be implemented. The only mitigation measures in this alternative would be the current interim measures presented in **Section 3.3**.

4.4.1.2 Effectiveness

The No Action alternative would not effectively reduce dioxin concentrations to meet GVN cleanup standards, nor would it provide containment for soils/sediments containing dioxin to reduce exposure. The interim measures currently in place have limited, unknown or insufficient effectiveness in preventing exposure. As a result, exposure pathways would remain that pose a potential threat to environmental, biological, and human receptors. Without action and given current levels of contamination and the nature of dioxin, existing dioxin pathways would likely persist for several decades or longer including the largest risk from dioxin contamination due to consumption of fish and other aquatic animals.

4.4.1.3 Implementability

The No Action alternative is implementable, as it does not require any action.

4.4.1.4 Cost

The No Action alternative has no cost associated with implementation or long-term O&M, with the exception of maintenance of current interim measures. However, there could be significant externalized costs, such as the costs associated with illness that might result from exposure to elevated concentrations of dioxin. While these costs cannot be quantified, they are important and could be substantial.

4.4.1.5 Environmental and Social Consequences

Under the No Action alternative, the contaminated soil and sediment would be left in place, and no remedial measures would be implemented other than the existing interim measures. The existing situation as described in **Section 3.2.3** would persist:

1. Contaminated surface soils at the Airbase that are near to groundwater resources, multiple water bodies (including aquaculture ponds, canals, and the Dong Nai River), agricultural areas and areas used by livestock and other animals, and residential areas would persist and continue to spread from their original sites of storage, handling, and spills by runoff during rainfall events, excavation and movement of contaminated material during the course of Airbase activities, construction, and agriculture, and through wind erosion.
2. The potential exposure pathways identified at the Airbase would persist: dermal absorption; dietary exposure and ingestion of dioxin; soil ingestion; and inhalation of fugitive airborne particles.
3. The Airbase is located adjacent to a primarily urban population in the middle of a densely-population city in the heart of one of Vietnam's primary economic zones, and with current or recent land uses that include cattle farming, rubber plantations, and aquaculture. In addition, there are 32 lakes of varying permanence on and in the immediate vicinity of the Airbase which fluctuate in depth seasonally, all of which maintains conditions for high risk of exposure to dioxin contaminated material.
4. The exposure of identified receptors to dioxin, aquatic biota, local residents, and Airbase workers would persist, along with the continued elevated levels of dioxin in these receptors.
5. The ability to generate economic benefits by creating development opportunities and implementing the future land use plan for the Airbase cannot proceed under the No Action Alternative.

Therefore, the No Action alternative is not considered an appropriate alternative for the Bien Hoa Airbase because:

- Concentrations of dioxin substantially exceed the allowable limits established by GVN for dioxin in soil and sediment.

- Exposure pathways described in **Section 3.2.3** remain open, continuing to put environmental resources at risk of dioxin contamination and continuing the risk of human exposure to dioxin contamination, particularly through the consumption of fish and other aquatic animals.
- There are significant gender-specific differences in the continued risk of human exposure to dioxin contamination, with risks associated with human exposure to dioxin contamination on the Airbase greater for women and children than for men.
- Under the No Action alternative, contaminated material could be dispersed beyond its current distribution on the Airbase as a result of potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.2 Alternative 2A: Landfill

In this alternative, all soils and sediments above the dioxin cleanup levels (with the exception of the Z1 Landfill) would be excavated and hauled to one of two landfills for disposal and containment. One landfill would be located in the Pacer Ivy Area as shown in **Figure 4-3** and one is located in the Z1 Area as shown in **Figure 4-4**. The Pacer Ivy Area Landfill would receive contaminated soils and sediments from the Pacer Ivy Area, Northwest Area, Northern Forest Area, and the Northeast Area. The Z1 Area Landfill would receive contaminated soils and sediments from the Z1 Area, ZT Area, Southwest Area, and Gate 2 Lake. Since the Z1 Landfill is adequately containing material and eliminating and exposure potential, it would remain intact for this alternative. This would also be true of material currently being placed in the new XD-2 Landfill, which is under construction at the time of the preparation of the EA. A summary of the volume of material to be excavated, hauled, and contained in the Pacer Ivy and Z1 Areas is provide in **Table 4-3**.

It should be noted that during the technology screening, dioxin bioremediation technologies were closely examined, especially those that could be implemented as part of an Active Landfill (USAID 2010a). An Active Landfill would be a standard landfill, with all the containment benefits provided by a typical landfill, but would also facilitate degradation of the dioxin, thus reducing the long-term risk. Degradation would occur via the addition of an undetermined mixture of solid bulking agents added to the soil (which would lead to an increase in landfill volume of up to 30%), liquid-phase nutrients and amendments required to stimulate bioremediation, and/or oxygen (to keep conditions in the landfill aerobic). As summarized in the EA prepared for the Danang Airport remediation project and as described in more detail in Field and Sierra-Alvarez (2008), studies thus far have been confined to lab-scale experiments, which have shown mixed results. No studies available at the time of the Danang EA had demonstrated bioremediation of 2,3,7,8-TCDD to below 1,000 ppt in soil and 150 ppt in sediment. In addition, neither the BEM (2007) report nor the UNDP (2009b) report identified any documented studies in which biodegradation was shown to treat dioxins below GVN cleanup standards. USEPA's Technology Innovation Program website notes:

> "Bioremediation is regarded as an attractive possibility for cleaning up dioxin-contaminated soil, but its real applicability and effectiveness is unknown. The following technical obstacles continue to limit the application of bioremediation: 1) only very specialized biological systems can be effective against the high toxicity, low volubility, and high absorptivity of dioxin; 2) a very stringent cleanup standard must be met; and 3) it may be difficult to find a microorganism that

can effectively deactivate dioxins under the different conditions present at existing dioxin contaminated sites."

However, as part of the effort to develop the list of potential technologies and strategies, a scientific literature search was conducted to gather any new information regarding dioxin bioremediation. Studies described in the literature indicate progress, but still no successful bioremediation of 2,3,7,8-TCDD beyond the lab scale and over the range of concentrations required at the Airbase. Chen and Wu (2013) reported biodegradation of near-fully and fully chlorinated dibenzo-p-dioxins and dibenzofurans, but observed stall at less-chlorinated congeners (e.g., TCDD). Combined technologies have also been recently explored. For example, potential for degradation of 2,3,7,8-TCDD had been previously reported by Kao (2000) in lab-scale aqueous-phase slurry reactors, where partial oxidation was followed by bioremediation. Bokare et al. (2012) reported complete dechlorination of 2,3,7,8-TCDD to dibenzo-p-dioxin using a combination abiotic and biotic mechanisms: palladized iron nanoparticles (for initial reductive dechlorination) and subsequent oxidative biomineralization by *Sphingomonas wittichii RW1*. Although this is promising, it was performed in an ideal aqueous-phase lab-scale environment, and further investigation would be necessary before full-scale effectiveness, implementability, cost, and environmental impact could be evaluated.

Vietnamese scientists working at the Institute of Biotechnology (IBT) within the Vietnamese Academy of Science and Technology (VAST) have continued potentially promising lab-scale experiments, including metagenomics and metatranscriptomics to improve understanding of potential microbial populations and degradation mechanisms, and pilot scale testing at the existing Z1 Landfill. However, the amount of information available during this EA was not sufficient to address concerns regarding technology maturity and cost, and to our knowledge, no information has been published in a peer-reviewed journal. Significant questions remain regarding the Z1 Landfill pilot test, including the methods and materials used and how they could be implemented full-scale, the soil sampling methodology, the degradation mechanism, and the cost. Without this information, it is not possible to develop and then evaluate bioremediation as a complete stand-alone alternative. Additionally, GVN researchers have indicated that soils and sediments with contamination greater than 5,000 ppt TEQ may not be well treated or may require additional handling; the estimated contamination volume at the Airbase above 5,000 ppt TEQ is approximately 37,000 m^3.

As a result, the landfills presented and evaluated in this EA (Alternatives 2A, 3, and 4) focus on passive technology. However, if there are advances in the bioremediation technology and the issues identified in the screening process are addressed, it would be possible to convert the passive landfill into an active landfill in the future. If the decision was made to convert to an active landfill, it would be necessary to consider additional factors such as bulking agents and volumetric expansion, conveyance piping for liquid injection, aeration, and/or vapor recovery, and access for interim soil sampling. These considerations, along with implications for conceptual design and all alternative evaluation criteria (effectiveness, implementation, cost, environmental impact) are presented in **Section 4.4.2.6**.

4.4.2.1 Conceptual Design

The conceptual design of the landfill was developed from GVN Decision No. 60/2002/QD-BKHCNMT, and similar USEPA regulations, which provide technical guidance for the design of hazardous waste landfills. **Figure 4-5** provides a conceptual cross section of the Landfill alternative to show key components of the landfill.

Mobilization and project preparation for this alternative would be required as described in **Section 4.4**. Following those activities, the main activities required to implement this alternative are discussed below.

Excavation and Hauling of Contaminated Material

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4** to the landfill locations. If necessary, excavated contaminated material (soil and sediments) would be dewatered in temporary storage areas. Project-affected water generated from the temporary storage and dewatering areas would be returned to natural drainages when GVN discharge standards are met after treatment. In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed.

Landfill Construction

<u>Clean Soil Fill:</u> Approximately 163,200 m^3 of clean fill from offsite borrow sources would be needed to establish a landfill subgrade and would be used for construction, operation, and closure of the landfills. This clean fill would be hauled to the landfill site from borrow pits off the Airbase property.

<u>Functional Components:</u> The conceptual design for the Landfill alternative includes three major functional components: 1) the bottom liner system; 2) the leachate collection and removal system; and 3) the final cap system.

<u>*Bottom Liner System*</u>

The bottom liner prevents offsite migration of any liquids and leachate (water that comes in contact with the contained waste) from the contaminated soil and sediments in the landfill to the surrounding subsurface. Typically, landfill bottom liners are a combination of several layers, each designed to stop leachate migration and/or allow its extraction. The layers included in this design are as follows, from bottom to top:

- A compacted soil subgrade which provides a firm foundation for the landfill.
- A geosynthetic clay liner (GCL), which provides the last barrier for migration of leachate outside the landfill.
- A 1.5-millimeter (mm) thick HDPE geomembrane, referred to as the secondary liner, which has extremely low permeability and strong chemical resistance.
- A geocomposite layer, where any leaks through the primary geomembrane would be detected and removed by a collection system.
- Another 1.5-mm thick HDPE geomembrane (the primary liner), which forms the primary barrier to leachate migration.

This conceptual arrangement (referred to as a double liner system) is typically used to provide the functional redundancy and additional measures of safety desired for hazardous waste landfills.

<u>*Leachate Collection and Removal System*</u>

The primary function of the leachate collection and removal system is to collect and remove leachate before it can permeate the liner layers. In this design, the leachate collection system is located immediately above the bottom liner system and consists of a geocomposite layer overlain by a 60-cm layer of sand. The sand serves as a drainage layer and a protective cover for the liner system. The leachate is collected within pipes wrapped in gravel that are spaced at intervals across the bottom of the landfill. The pipes would convey the leachate to a treatment system, likely consisting of a concrete vault or chamber containing activated carbon, where it is treated prior to discharge.

Final Cap System

Once all the contaminated soil and sediment has been hauled to and placed in the landfill, a final cap would be constructed to fully encapsulate the landfill. The landfill cap is designed to prevent liquid from infiltrating the landfill and becoming leachate. The components of the landfill final cap design, from bottom to top, are:

- A GCL layer, as a last barrier to prevent infiltration.
- A 1-mm thick linear low-density polyethylene (LLDPE) geomembrane, which offers good ultraviolet and chemical resistance and high tensile strength without sacrificing flexibility.
- A geocomposite layer to protect the geomembrane and provide drainage of the overlying soil cover.
- A 60-cm soil cover.
- Grass, which is designed to prevent surface erosion.

Similar to the bottom liner system, the final cap system is designed to prevent downward migration of water. However, rather than collect the water, the cap is designed to shed the water. The cap would have a minimum slope in all areas of 5% to minimize infiltration. During filling of the landfill (i.e., prior to construction of the final cap system), a temporary cap would be used to minimize infiltration during the rainy season. The sides of the landfill would be sloped at 4 horizontal to 1 vertical (4H:1V or 25%) to minimize the required footprint.

Stormwater that drains off the cap would be collected by perimeter ditches and routed to ponds prior to discharge. An access road would encircle the landfill and also provide access to the top of the landfill.

Placement of Contaminated Material into Landfill: Contaminated material would be placed within cells in the landfill, with the landfill cells being filled sequentially. Depending on the amount of soil and sediment excavated, it is expected that the height of each landfill would be between 5 and 8 m.

Clean Soil Fill

Approximately 315,700 m^3 of clean fill from offsite borrow sources would be needed to backfill excavations resulting from the removal of contaminated soil. This clean fill would be hauled to the excavations from borrow pits off the Airbase property. It is assumed that excavations resulting from the removal of contaminated sediments would not be backfilled.

Site Restoration

Site restoration activities would be decided in consultation with the Airbase and would generally consist of returning project-affected areas to pre-project conditions. It should be noted that completion of remedial activities as per MND-approved dioxin limits will mean that land uses should not change (i.e., an industrial area should not be converted for use as farmland or for aquaculture). Therefore, implementation of institutional controls will be required of all DUs to verify that land uses remain as intended, and that site drainage activities do not result in erosion of materials into lakes.

Project Demobilization

All project equipment and facilities would be removed from the project area.

Footprint

The area of the total footprint for the Landfill alternative is estimated to be approximately 611,600 m^2, consisting of:

- 481,900 m^2 of area of contaminated soils and sediments to be excavated.
- 100,000 m^2 for the Pacer Ivy Area landfill, with approximately one-half required for the landfill footprint and one-half for support area (some of this area is also included in the area to be excavated at PI-10).
- 60,000 m^2 for the Z1 Area landfill, with approximately one-half required for the landfill footprint and one-half for support area.

Construction and Operation Schedule

It is expected that the Landfill alternative would be constructed in 5 years (**Figure 4-6**) for a contamination volume of 347,800 m^3, which excludes the current Z1 Landfill. This is based on the assumption that the project would start at the beginning of the rainy season, which would enable mobilization and project preparation activities to be completed during the rainy season and, thus, enabling construction to start at the beginning of the dry season. Beginning the project at a different time of the year would likely lengthen the construction schedule. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). For cost estimation purposes, it is assumed that the Landfill would require long-term O&M for 50 years after closure, according to GVN requirements.

After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation of the Landfill alternative are as follows:

- Year 1: Mobilization and project preparation; UXO clearance; equipment, facilities, and project area setup; Pacer Ivy Area Landfill bottom liner and leachate collection system construction; excavation and placement of material in the Pacer Ivy Area Landfill; and backfilling of excavations.
- Year 2: Excavation and placement of material in the Pacer Ivy Area Landfill; and backfilling of excavations.
- Year 3: Excavation and placement of material in the Pacer Ivy Landfill; construction of Pacer Ivy Area Landfill final cap; Z1 Area Landfill bottom liner and leachate collection system construction; excavation and placement of material in Z1 Area Landfill; and backfilling of excavations.
- Year 4: Construction of Pacer Ivy Area Landfill final cap; excavation and placement of material in Z1 Area Landfill; construction of Z1 Area Landfill final cap; backfilling of excavations; and site restoration.
- Year 5: Construction of Z1 Area Landfill final cap; site restoration; and demobilization.

For the upper contamination volume estimate of 414,400 m^3 (excluding the current Z1 Landfill), it is anticipated that an additional year of construction would be necessary.

4.4.2.2 Effectiveness

Effective for containment: Hazardous waste landfills have been used successfully for decades worldwide to contain a variety of contaminants, including dioxins, furans, and other persistent organic pollutants. Design guidance and regulations for such landfills are readily available in the U.S., Vietnam, and in many other countries. This is a proven containment strategy.

Ineffective for treatment: The environmental half-life for chlorinated dioxins without some form of active treatment is generally thought to be measured in decades. The dioxins contained in the landfill would be expected to persist for many decades and would require eventual treatment.

4.4.2.3 Implementability

Landfill Siting Concerns

In this alternative, landfills would be constructed that occupy a footprint of about 30,000 m^2 in the Z1 Area and 45,500 m^2 in the Pacer Ivy Area. A suitable location for a landfill should not only have the necessary size, but also consider site drainage features, topography, potential wetland features or floodplains, surface geologic features, and buffer and height restriction criteria as it relates to the runways at the Airbase. The Z1 Area does have a suitable location and sufficient space to contain the landfill.

Only two locations were found to have adequate size in the Pacer Ivy Area. However, there are siting challenges for each location:

- Location 1: This location is situated in the main part of the Pacer Ivy Area (PI-1 to PI-4, PI-17, and PI-20) adjacent to the runways and taxiways. Since this area is contaminated, construction of a landfill here would require double handling of the material prior to placement in the landfill. It is understood that fill and other material/debris has been placed in the area over the years; this material would need to be removed and replaced with clean fill to provide a suitable foundation for the landfill. The area is also prone to wet conditions and/or flooding in the rainy season, which would require site drainage improvements. Finally, its proximity to the runways would limit the height of the landfill, which in turn would require a larger footprint to contain the necessary volume.
- Location 2: This site is located on the south side of Pacer Ivy Area (PI-5, PI-10, and PI-13) and would be adjacent to the Airbase boundary. While there is contamination in PI-10, double handling of material can be avoided by starting construction of the landfill in PI-13 (i.e., contaminated soil in PI-10 can be hauled directly to a completed portion of the landfill in PI-13). A landfill in this area would require the relocation of a drainage channel in PI-5 and a small road. Adequate buffers would need to be established with the Airbase boundary to the west and barracks to the east in PI-14. However, since the location is more than 300 m south of the taxiway, reasonable landfill heights can be achieved and not encroach upon the Airbase height restrictions.

Due to the limitations and issues with Location 1, it was decided to utilize Location 2 for the purposes of this evaluation.

Fill Material

A significant amount of fill material (~478,900 m^3) would be required for the landfill alternative. The fill material would be used to establish a landfill subgrade, to construct the landfill leachate collection system and final cap system, and backfill excavations resulting from the removal of contaminated soils. This is primarily a cost issue, but also requires additional labor, equipment, and an adequate offsite borrow source to implement.

Construction Material and Equipment Availability

Landfills have been constructed in Vietnam to contain dioxin contaminated soils and sediments. The materials and equipment necessary to construct the landfills are largely available in-country, though some importation may be necessary.

Long-Term O&M Requirements

Since a landfill would only provide containment, it would be necessary to perform O&M and long-term monitoring activities after the landfills are constructed.

Impact of Site COPCs

This containment technology is not very sensitive to other COPCs in the soil, including arsenic. The landfill design would be capable of containment of all types of material, regardless of specific constituents. Other COPCs might influence safety precautions, and result in varying constituents in the landfill leachate described immediately below, but no other impacts would be expected. Arsenic speciation and toxicity would not be expected to change significantly.

Waste Streams

There is the potential of leachate (e.g., water which has come in contact with contaminated soils and sediments) generation from the landfill. The amount of leachate generated and collected by the leachate collection system would be a function of the moisture content at which the soils and sediments were placed into the landfill (i.e., dryer material would produce less leachate) and the amount of precipitation during landfill construction. Following completion of the landfill cap system, leachate generation would be expected to decline significantly as the source of water would be prevented from entering the landfill by the cap system.

Technology Availability

As with all alternatives, no specialized technical expertise would be required to perform the dig and haul portion of this work. The construction of landfills would not be anticipated to require any specialized technology or knowledge. Expertise with landfill design and construction would be required, but these skills would not significantly limit implementation of this alternative to a small number of vendors. In addition, it is expected that any aspects of this technology not already known to Vietnamese stakeholders could be transferred during this work. Therefore, the alternative assumes that most construction labor would be provided by Vietnamese contractors. However, it is assumed that expatriate labor would be involved to provide management and third-party oversight.

4.4.2.4 Cost

The preliminary estimated overall cost for this alternative is $126M to $137M for the estimated contamination volume range of 347,800 m^3 to 414,400 m^3 (excluding the current Z1 Landfill). As indicated in **Tables D.1 and D.2** in **Appendix D**, with a 19% increase in volume, the estimated cost increase for Alternative 2A is only approximately 8.3%. The landfill alternative cost is less sensitive to increases in volume when compared to other alternatives, assuming that the overall landfill footprint remains the same and the additional volume results in a taller landfill. This assumption is valid for the anticipated volume range; however, if a greater volume is for some reason placed in the landfill, then this assumption may no longer be valid and the cost sensitivity will increase. A summary of the overall Landfill alternative cost is provided in **Table 4-4**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.2.5 Environmental and Social Consequences

Alternative 2A - Landfill will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.
- Lowering dioxin concentrations in soils and sediments on the Airbase to lower than the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 2A – Landfill are assessed as Mitigable:

1. Alternative 2A is assessed as having significant potential environmental impact with respect to surface water quality due to the need for dewatering stockpiles of contaminated material prior to the contaminated material being placed in the landfills, although the potential effects are predicted to be lower than any of the other alternatives.
2. There would be potential environmental impacts with respect to air quality because of temporary storage and dewatering areas and the landfills themselves in which dioxin-contaminated material would be exposed to the environment for an extended period of time. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. There would be significant potential effects on the generation of GHGs.
4. There would be significant potential environmental effects associated with Alternative 2A related to noise generated from extended heavy equipment use.
5. Alternative 2A is one of the remedial alternatives that would require an amount of clean fill that, if obtained from a single source, would require a full GVN EIA specifically for the provision of clean fill.
6. There are significant long-term environmental risks associated with Alternative 2A because successful operation of the landfills under this alternative would require long-term institutional controls to be effective.
7. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

The long-term integrity of the landfills in Alternative 2A would be at risk of being compromised by potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.2.6 Active Landfill

Considerations have been included in this alternative for potential conversion to an active landfill. As described in **Section 4.4.2**, given the state of the science in scientific literature and lack of engineering data, the information presented herein is speculative.

Conceptual Design

As introduced above, the main conceptual design changes that would be needed for an active landfill are assumed to be as follows:

- Additional volume: It is assumed that approximately 30% more volume would be needed in the landfill to accommodate bulking agents and other solid-phase additives to the soil. The dimensions of the landfills included in this alternative are such that such additional volume would require taller landfills and a slightly larger footprint as a passive landfill (i.e., approximately 10-m increase in width for the Z1 Area Landfill and 10-m increase in length and width for the Pacer Ivy Area Landfill). For the purposes of this analysis, it is assumed that such bulking agents would be added at the same time as the soil/sediment, but it would be possible to mix these in after the initial construction, albeit at a higher cost.
- Conveyance piping: It is assumed that some conveyance piping would be necessary to allow for injection of liquid-phase amendments and nutrients, injection of air to keep biological activity aerobic, and/or recovery of generated vapors. As with the bulking agents, it is assumed that this piping would be added during initial construction, but they could be added later if necessary. This would likely involve removing the landfill cap, installing a piping network with horizontal and/or vertical injection wells, and repairing the landfill cap.
- Additional provisions may be beneficial to incorporate into the cap system to facilitate sampling after construction in order to monitor the dioxin concentrations in the landfill, for the purpose of tracking progress.

The remaining aspects of the landfill would otherwise be as described in **Section 4.4.1** above. It is assumed that construction of an active landfill could be performed in the same schedule as a passive landfill.

Effectiveness

<u>Effective for containment:</u> The effectiveness of an active landfill with regard to containment would be the same as with a passive landfill.

<u>Effective for treatment:</u> For the purposes of this evaluation, it is assumed that an active landfill would be effective at reducing the persistence of dioxins in the soil; otherwise, it would not be implemented. As described above, further demonstration and pilot testing is necessary to confirm this assumption and treatment effectiveness.

Implementability

The major differences with regards to implantation of an active landfill are mainly uncertain, given the current lack of science and engineering data regarding this technology. It is expected that the construction effort involved in adding bulking agents, conveyance piping, and other items would not be challenging, especially if the components were added during initial construction. However, it is not known how straightforward it would be to implement active bioremediation in the landfill, and what challenges may be faced by contractors. It is likely that implementation would be more challenging than a more mature technology. It is also not known if it would be challenging to obtain the necessary bulking agents, and the nutrient, amendments and/or reagents in sufficient quantities for this project.

If successful in reducing dioxin concentrations in the landfill, long-term O&M effort would no longer be necessary, and would be replaced with greater short-term O&M effort to monitor and optimize bioremediation.

Given the degree to which this technology has been proven, it is expected that implementation would require participation and technical direction from those who had demonstrated the technology. The remainder of the construction and oversight work would be performed as described in **Section 4.4.2.2**.

Cost

The preliminary estimated overall cost for modification to this alternative is $141M to $154M for the estimated contamination volume range of 347,800 m^3 to 414,400 m^3 (excluding the current Z1 Landfill). The same cost sensitivity factors described for the passive landfill apply here; costs are not as sensitive to volume as other alternatives until the landfill footprint requires expansion. As indicated in **Table D2** in **Appendix D**, with a 19% increase in volume, the estimated cost increase for this option is only approximately 9%. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.3 Alternative 2B: Solidification/Stabilization

Solidification and stabilization of contaminated soil and sediment is a process used to prevent migration of contaminants from the material, thereby preventing exposure. Solidification is a process which binds contaminated media into a solid form, decreasing the permeability of the material and encapsulating the contaminant. Stabilization is a chemical process used to immobilize contaminants and reduce the solubility and leachability of the contaminant from the waste material.

In a solidification/stabilization remedy, binders and admixtures are added to the soil and mixed, either *in situ* using augers or other excavation equipment, or *ex situ* using machine mixers such as a pug mill. Common admixtures used in solidification and stabilization include inorganic binders such as cement, fly ash, and lime, as well as organic binders and stabilizers such as activated carbon, asphalt, or organophilic clays. The addition of an organic carbon stabilizer is expected to be advantageous during solidification/stabilization of soils and sediments containing dioxins, as dioxin would tightly bind with the carbon. While limited data are available for long-term solidification/stabilization for dioxin-contaminated materials (i.e., leachability ten years after solidification/stabilization), information available from sites in the U.S. has indicated reductions in leachability of dioxins from stabilized/solidified soil to levels below the USEPA MCL for drinking water (30 ppq [pg/L]).

4.4.3.1 Conceptual Design

The conceptual solidification/stabilization design for the Airbase would include excavation of contaminated soils and sediment exceeding MND-approved dioxin limits, and transporting and consolidating the material in the Pacer Ivy and Z1 Areas. Two potential mixing strategies can be employed for the contaminated materials at the Airbase:

- Mechanical mixing using a pug mill or similar machinery to add binders and stabilizers, and stockpiling of the mixed material at a location near the consolidated treatment areas.
- Stockpiling soil/sediment in a designated area, and mixing the binders and stabilizers with the soil using large-diameter auger or other mechanical means to stabilize within the stockpile.

While potentially more expensive on a unit basis, the pug mill alternative for mixing materials is advantageous to allow for more uniform mixing and distribution of the admixtures into the soil, allowing for more effective stabilization and solidification/binding of the mixture. Also, specialized large-diameter augers used for *in situ* mixing for solidification/stabilization projects may not be readily available in Vietnam. If not, other *in situ* mixing equipment may be usable. However, modifications may be required and this can affect how quickly the material would be processed.

Following solidification and stabilization of the soils and sediments at the Airbase, the solidified material would be stockpiled in the vicinity of the centralized treatment areas, in the same general locations as the landfills described in Alternative 2A, and are presented on **Figures 4-7 and 4-8.** Similar to the previous alternative, construction of a cap system equivalent to Alternative 2A (from bottom to top: GCL, LLDPE liner, geocomposite, 60 cm of soil, and grass) would be necessary for storage of the stabilized materials to minimize infiltration. However, it would not be necessary to collect leachate underneath the stockpiled material. It is not anticipated that stabilized materials would be returned to the excavation areas, as it would be necessary to monitor the long-term effectiveness and integrity of the stabilized materials, and institutional controls would need to be utilized to prevent disturbing the stabilized materials. In addition, it is not expected that vegetation would grow on top of the stabilized/solidified materials, therefore a soil cover would be required in order to re-establish vegetation. Overall, the expected footprint of the solidification/stabilization alternative would be expected to be similar but slightly larger than the landfill in Alternative 2A, due to the area required for solidification/stabilization mixing equipment. The additives incorporated into the soil and sediment during the stabilization/solidification process would be expected to increase the volume of material by approximately 10%: however, since the stockpile would not require a bottom liner system and leachate collection system like a landfill, the net change in height of the stockpile relative to the landfill alternative would be negligible.

Treatability Study

Prior to completing design of the solidification/stabilization remedy, a treatability study would need to be conducted using contaminated soils and sediments from the Airbase to determine the appropriate admixtures and binders to use, as well as the ratios of the mixture components, to obtain the optimal physical properties and greatest reduction in leachability of Airbase contaminants. Several mixtures and varying proportions of admixtures would be tested in a laboratory and evaluated for physical properties (e.g., compressive strength, hydraulic conductivity) and leachability tests for contaminants of interest using Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP). Long-term leachability of the material would also be tested to evaluate expected long-term performance of the stabilized/solidified material. Completion of these tests would allow a more appropriate design, and facilitate decisions regarding appropriate mixing techniques and other construction details.

Mobilization and Project Preparation

Mobilization and project preparation for this alternative would be required as described in **Section 4.4**. Installation of the solidification/stabilization equipment at Pacer Ivy and Z1 Areas would require preparation of adequate subgrade and installation of appropriate foundations for the equipment. The general types of equipment assumed for the solidification/stabilization system include:

- Stockpile/staging areas with stormwater controls and decontamination facilities.
- Installation of utilities (water and electricity).
- Structures for housing of equipment and raw materials (admixtures – cement, fly ash, lime, carbon, etc.).
- Soil mixing equipment (a pug mill is conservatively assumed).
- Conveyance/transportation of mixed materials to stockpile areas for curing.

The setup would include establishing surface water runoff diversions around the work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages.

Excavation and Hauling of Contaminated Materials

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4** to one of two areas for solidification/stabilization. Similar to Alternative 2A, the existing Z1 Landfill would remain since it is adequately containing material and eliminating and exposure potential, A summary of the volume of material to be excavated, hauled, and contained in the Pacer Ivy and Z1 Areas is provide in **Table 4-3.** If necessary, excavated contaminated material (soil and sediments) would be dewatered in temporary storage areas. Project-affected water generated from the temporary storage and dewatering areas would be returned to natural drainages when GVN discharge standards are met after treatment. In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed.

Solidification and Stabilization of Contaminated Soil and Sediment

Contaminated material would be loaded into the pug mill system at a rate of approximately 200 tph, based on the performance of commercially available pug mill systems used for contaminated soil stabilization. In the pug mill, the admixtures (anticipated to include cement, fly ash, activated carbon, and others), would be added and allowed to mix with the contaminated material. Following mixing, the mixture would be conveyed to the designated stockpile location via conveyor belt or other machinery, and would be placed in the designated stockpile and allowed to cure.

Following curing of the stabilized material, periodic samples would be collected of the stabilized material for physical property and leachability testing to verify that the stabilized soils and sediments meet the project requirements. After stockpiles of solidified/stabilized soils are created to the specified dimensions, the stockpiles would be covered with a cap system similar to a landfill. Periodic monitoring of runoff from the stockpiles would be necessary following completion of solidification/stabilization for monitoring purposes to ensure the long-term stability of the material. Institutional controls would be necessary to ensure that the stabilized soils and sediments are not disturbed.

Clean Soil Fill

Approximately 315,700 m^3 of clean fill from offsite borrow sources would be needed to backfill excavations resulting from the removal of contaminated soil. This clean fill would be hauled to the excavations from borrow pits off the Airbase property. It is assumed that excavations resulting from the removal of contaminated sediments would not be backfilled.

Site Restoration

Site restoration activities would generally consist of returning project-affected areas to pre-Project or better conditions. It should be noted that completion of remedial activities as per MND-approved dioxin limits will mean that land uses should not change (i.e., an industrial area should not be converted for use as farmland or for aquaculture). Therefore, implementation of institutional controls will be required of all DUs to verify that land uses remain as intended, and that site drainage activities do not result in erosion of materials into lakes.

Project Demobilization

All project equipment and facilities would be removed from the project area.

Footprint

The area of the total footprint for the alternative is estimated to be 627,600 m^2, consisting of:

- 481,900 m^2 of area of contaminated soils and sediments to be excavated.
- 100,000 m^2 for the Pacer Ivy Area stabilization/solidification operations, with approximately one-half required for the mixing and temporary stockpiling area, and one-half for final solidified/stabilized stockpile area (some of this area is also included in the area to be excavated at PI-10).
- 76,000 m^2 for the Z1 Area stabilization/solidification operations, with approximately one-half required for the mixing and temporary stockpiling area, and one-half for final solidified/stabilized stockpile area.

Schedule

It is expected that the solidification/stabilization alternative would be constructed in 6 years for the contamination volume estimate of 347,800 m^3 (excluding Z1 Landfill) as presented on **Figure 4-9**. This schedule is based on the assumption that the project would start at the beginning of the rainy season, which would enable mobilization and project preparation activities to be completed during the rainy season and, thus, enabling construction to start at the beginning of the dry season. Beginning the project at a different time of the year would likely lengthen the construction schedule. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). For cost estimation purposes, it is assumed that the solidified/stabilized soil piles would require long-term O&M for 50 years after closure, similar to the landfill alternative, but the effort during those 50 years is expected to be less.

After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation of the solidification/stabilization alternative include the following components:

- Year 1: Mobilization and project preparation; UXO clearance; equipment, facilities, and project area setup; Pacer Ivy Area solidification/stabilization equipment installation; excavation and hauling of material for mixing in Pacer Ivy and Z1 Areas; solidification/stabilization and stockpiling of stabilized materials; and backfilling of excavations.
- Years 2-5: Excavation and hauling of material for mixing in Pacer Ivy and Z1 Areas; solidification/stabilization and stockpiling of stabilized materials; and backfilling of excavations.
- Year 6: Site restoration and demobilization.

For the upper contamination volume estimate of 414,400 m^3 (excluding the current Z1 Landfill) it is anticipated that an additional year of construction would be necessary.

4.4.3.2 Effectiveness

<u>Effective for containment:</u> Solidification/stabilization would reduce the mobility of dioxin and would reduce the risk of future exposure to a greater extent than the landfill alternative, due to the physical binding of the dioxin within the stabilized/solidified matrix. Therefore, solidification/stabilization is expected to be more effective for containment than the landfill alternative. Solidification and stabilization of dioxin-impacted materials has been demonstrated to be effective for reducing the leachability and availability of dioxin in the short term. However, long-term studies have not been completed at dioxin sites which have used stabilization as a containment strategy, therefore the ability to stabilize dioxins in the long term (i.e., longer than ten years) is currently uncertain. It is expected that some of this uncertainty could be reduced during treatability testing. As a result, long-term monitoring of the ability of the solidification/stabilization alternative to reduce the leachability of dioxin would be necessary.

<u>Ineffective for treatment:</u> Solidification and stabilization is not effective for treatment or destruction of dioxins. As with the landfill alternative, dioxins would be expected to persist for many decades. However, unlike the landfill alternative, with stabilized/solidified soils and sediments, eventual treatment of the dioxin would likely be more challenging given the physical properties of the solidified material.

4.4.3.3 Implementability

Siting

The solidification/stabilization alternative would occupy a footprint approximately the same size as the landfills described in Alternative 2A, with stockpiles of solidified/stabilized soils placed at the same locations identified for landfills, based on the same factors mentioned in the siting discussion for Alternative 2A. These locations were selected as they are above levels which are typically subject to flooding and relatively far from nearby residential uses. Stockpiles of stabilized soils and sediments in these locations can be constructed with adequate buffer zones to prevent conflict with future development. The soil stockpile locations would be limited in height due to proximity to the runways, similar to the landfill described in Alternative 2A.

Fill Material

A significant amount of clean backfill material would be necessary for excavation areas. A total of approximately 434,000 m^3 of soil is required to be placed in excavation areas and as soil cover over the solidified soil stockpiles. Sediment areas would not be backfilled following excavation. The approach to backfilling excavation areas is the same as described for Alternative 2A. While fill material is not anticipated to be necessary to construct the subgrade for storage of solidified/stabilized materials, cover soil and vegetative cover would be necessary following construction of the stabilized soil stockpiles.

Equipment Availability

The equipment necessary for the solidification/stabilization alternative (excavation equipment, pug mills, and admixtures such as cement, fly ash, and activated carbon) are largely available in-country, though some importation may be necessary. Some specialized equipment and expertise may not be readily available in-country.

Impact of Site COPCs

The stabilization/solidification mix design would be sensitive to variability in general soil properties, but would not be expected to be sensitive to the presence of other organic COPCs in the soil. The mix design would also be able to reduce mobility of arsenic from the matrix.

Waste Streams

No contaminated waste streams are expected to be generated as part of this alternative. There may be leftover stabilization reagents and concrete, but those would not be impacted with any compounds from the Airbase.

Technology Availability

As with all alternatives, no specialized technical expertise would be required to perform the dig and haul portion of this work. The stabilization and solidification work would require sufficient knowledge and expertise to implement the mix design, but would not be expected to limit implementation of this alternative to a small number of vendors, and it is expected that this technology would be transferred to Vietnamese stakeholders. Therefore, the alternative assumes that most construction labor would be provided by Vietnamese contractors. However, it is assumed that expatriate labor would be involved to provide management and third-party oversight.

4.4.3.4 Cost

The preliminary estimated overall cost for this alternative is $202M to $229M for the estimated contamination volume range of 347,800 m^3 to 414,400 m^3, excluding the current Z1 Landfill. Solidification/stabilization costs are more sensitive to the soil volume than the landfill option, due to the operating costs and admixture material requirements for the solidification/stabilization process, which are both directly tied to the volume. As indicated in **Tables D.1 and D.2** in **Appendix D**, with a 19% increase in volume, the estimated cost increase for Alternative 2B is approximately 13.4%. While there is a cost associated with the cap on top of the stabilized/solidified pile, costs will be more sensitive to volume increases if the footprint of the stabilized pile increases, but the change in sensitivity is not as high as the landfill in Alternative 2A, given the cap for that pile represents a smaller portion of the overall project cost. However, for the estimated volume range, it is anticipated that the pile can be accommodated within the same footprint; it would only be necessary to expand the footprint if a greater volume than the estimated range were necessary to be contained. A summary of the overall solidification/stabilization alternative cost is provided in **Table 4-5**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.3.5 Environmental and Social Consequences

Alternative 2B will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.
- Lowering dioxin concentrations in soils and sediments on the Airbase to lower than the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 2B are assessed as Mitigable:

1. Alternative 2B is assessed as having significant potential environmental impacts with respect to surface water quality as a result of constructing and maintaining temporary stockpiles for dewatering, and for use of large quantities of concrete and S/S reagents that could be spilled.
2. Alternative 2B is assessed as having significant potential environmental impacts with respect to air quality because the mixing of binders and admixtures into and throughout the contaminated material prior to stabilization would create significant potential exposure to dioxin for construction workers. Conducting this activity in the dry season would increase the risk of exposure of residents living to the south of the Airbase, although this risk would be tempered by the distance between both the Pacer Ivy and Z1 Areas to the southern perimeter of the Airbase. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this alternative.
3. There would be significant potential effects on the generation of GHGs.
4. There would be significant potential environmental effects associated with Alternative 2B related to noise generated from extended heavy equipment use.
5. Alternative 2B is one of the remedial alternatives that would require an amount of clean fill that, if obtained from a single source, would require a full GVN EIA specifically for the provision of clean fill.
6. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

The long-term integrity of the stockpiles of stabilized/solidified material in Alternative 2B would be at risk of being compromised by potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.4 Comparison of Containment Alternatives

Both of the containment alternatives described above are expected to be feasible and readily implementable at the Airbase. Both technologies are effective at containment of dioxin-impacted soils, though solidification/stabilization is expected to be more effective at reducing mobility of dioxins. However, the costs associated with landfill implementation are lower than the solidification/stabilization alternative. Therefore, the landfill alternative (2A) will be utilized as the containment strategy for cost estimation purposes in Alternatives 3 (**Section 4.4.9**) and 4 **(Section 4.4.10**). The selection of landfills as the containment technology for use in Alternatives 3 and 4 was done only to allow relative comparison of varying combinations of treatment and containment, and not to identify it as the selected containment technology.

4.4.5 Alternative 5A: Incineration/*Ex Situ* Thermal Treatment

Dioxins are particularly recalcitrant to remediation, as they do not partition well into either gas or groundwater from soil. However, at higher temperatures, the dioxins can be volatilized and either completely oxidized or pyrolyzed. Dioxins still present in the aqueous phase can be destroyed via hydrolysis or hydrous pyrolysis at higher temperatures. Therefore, thermal treatments can be effective for dioxins (BEM 2007, Kulkarni et al 2008, UNDP 2009b).

Incineration is a well-established technology for dioxin remediation, as several applications of the technology have been implemented for remediation of dioxin-contaminated soils and sediments. In order to volatilize and destroy dioxins in an incinerator, high temperatures, ranging from approximately 870 to 1,200°C, are required. Several incinerator types have successfully been used to destroy dioxin (BEM 2007), though rotary kiln incinerators have been most frequently utilized in the U.S. to remediate dioxin-contaminated soils (USEPA 1998a, USEPA 1998b). DEs for incinerators can be as high as 99.9999% for rotary kiln incinerators, and the throughput for rotary kiln incinerators used for large-scale treatment of dioxin in soil has been as high as approximately 25 to 30 tph (USEPA 1998a, USEPA 1998b); based on observed performance and operational parameters from incinerators in the U.S., approximately 8,100 m^3 of contaminated soil can be processed in one month.

4.4.5.1 Conceptual Design

Similar to the other alternatives, the incineration alternative would include excavation of contaminated soil and sediment, and transport to stockpile areas located at a designated area within the Pacer Ivy and Z1 Areas. A summary of the volume of material to be excavated, hauled, and stockpiled for treatment in the Pacer Ivy and Z1 Areas is provide in **Table 4-3.** Since the objective of this alternative is treat all dioxin-contaminated material that is above the MND-approved dioxin limits, the Z1 Landfill would be excavated and treated. With the incineration/*ex situ* thermal treatment alternative, the treatment system operation would be completed in two locations. Contaminated soil and sediments from the Pacer Ivy, Northwest, Northern Forest, and Northeast Areas would be excavated and stockpiled in the Pacer Ivy Area near PI-5, PI-10, and PI-13, and contaminated soils and sediments from the Z1 Area, Southwest Area, ZT Area, and Gate 2 Lake would be excavated and stockpiled in the Z1 Area to the north of the Z1 Landfill. Under Alternative 5A (and under 5B and 5C)), the existing Z1 Landfill would be excavated and treated unlike under Alternatives 2A and 2B, where the Z1 Landfill would be left in place.

For Alternative 5A, the total soil and sediment volume to be consolidated and treated in the Pacer Ivy Area is approximately 236,100 m^3 (approximately 350,000 t), and the soil and sediment volume to be consolidated and treated in the Z1 Area is approximately 172,400 m^3 (approximately 260,000 t). The general locations of the components (contaminated soil and sediment stockpile and incinerator equipment) are shown on **Figures 4-10 and 4-11**.

There are two potential ways to sequence the incineration alternative at the Airbase. Given that consolidation and treatment is expected to occur in two areas of the Airbase (Pacer Ivy and Z1 Areas), two incinerators could be constructed and operated simultaneously, which would shorten the overall project timeframe, or a single modular incinerator system could be constructed and moved to each area in order to complete the treatment activities. The schedule presented later in this section assumes that a single incinerator would be utilized, first at the Pacer Ivy Area and then at the Z1 Area.

Mobilization and Project Preparation

Mobilization and project preparation for this alternative would be required as described in **Section 4.4**. Equipment for incineration would be supplied by a specialized vendor. Installation of the incineration system would require preparation of adequate subgrade and installation of appropriate foundations for the structures associated with the incinerator equipment. The general types of equipment assumed for the incineration system include:

- Stockpile/staging areas with stormwater controls and decontamination facilities.
- Structures for housing of incineration equipment.
- Soil pretreatment equipment (soil drying and/or lime addition, soil blending and processing);
- Incinerator (rotary kiln is assumed).
- Secondary combustion chamber for off-gas treatment.
- Vapor treatment (gas scrubber, baghouse/particulate scrubber, activated carbon);
- Liquid treatment (activated carbon).
- Ash handling equipment.

A conceptual process flow diagram for an onsite incinerator is presented in **Figure 4-12**. The incinerator can be constructed as either a modular (mobile) system or a fixed incinerator.

As part of mobilization, it would be necessary to establish surface water runoff diversions around the work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages.

Excavation and Stockpiling of Contaminated Materials

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4** to the staging area adjacent to the incinerator. In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed. It is assumed that excavation activities would be completed only during the dry season, therefore a stockpile of material should be staged at the incinerator to allow for the incinerator to continue operation during the rainy season.

Based on an assumed throughput of 8,100 m^3 of contaminated material per month, the maximum stockpile size located adjacent to each incinerator would contain approximately 50,000 m^3 and cover an area of approximately 10,000 m^2. Stockpiles may be covered with temporary plastic tarps or other material to avoid introducing excess moisture to the stockpiled soil prior to incineration, as that would increase treatment time and energy.

Placement of Clean Fill During Incineration Implementation

Following treatment, the treated soil would be used as backfill for excavations. Because incineration is a continuous treatment process that produces treated soil at a consistent rate, the total quantity of clean fill material required to backfill excavations is less than some other alternatives (e.g., Alternatives 2A and 2B). However, in order to avoid ponding of water in excavation areas during the first rainy season before treatment is complete, some clean fill material would need to be placed in some excavation areas. The quantity of clean fill material required would be equivalent to the soil material which would be stockpiled for treatment during the first rainy season, or approximately 40,000 m^3. Sediment areas would not require backfill.

Incineration of Contaminated Soil and Sediment

Contaminated material would be loaded into the incinerator at a rate of approximately 25 tph, based on the performance of similar incinerators used for dioxin-contaminated soil treatment. Contaminated material would be dried using a rotary drum dryer or other suitable equipment to lower the moisture content. Following drying, soil would enter the rotary kiln incinerator, which would operate at a temperature between 900 and 1,200°C, and would volatilize and destroy dioxins and other organics. The kiln would be designed such that the residence time of the material within the incinerator is approximately 40 to 60 minutes. Treated material would exit the opposite end of the incinerator and be conveyed to stockpiles for subsequent backfilling. Confirmatory sampling of treated soils and sediments would be necessary prior to backfilling. Ash from the incinerator would be quenched and stockpiled separately from the treated soil. Off-gas generated during incineration would be passed through a secondary combustion chamber to ensure that all organics are destroyed. Following secondary combustion of off-gas from the incinerator, the gases would pass through several treatment systems, such as bag filters or particulate separators, acid gas scrubbers, and quenchers to remove particulates and vapor-phase contaminants, and lower the temperature of the off-gas, prior to discharge to the atmosphere. Continuous monitoring of the off-gas wound be conducted to ensure pollutants (i.e., particulate matter, nitrous oxides, etc.) are not released in significant quantities.

Treated soil and sediment would be transported from the treated stockpile to the excavated areas of the Airbase and placed as clean fill into soil DUs only. It is not anticipated that sediment DUs would be backfilled. It is anticipated that transportation and backfilling of treated soils would occur primarily during the dry season. As such, it is expected that DUs excavated during the first dry season would require backfilling prior to the soil treatment being complete. Clean import fill would be used to backfill those DUs excavated first. It is estimated that 132,400 m^3 of treated material would not be used as backfill (39,600 m^3 of treated soil replaced by clean fill, and 92,800 m^3 of sediment not replaced), and instead would be placed in a permanent stockpile location selected by GVN (but assumed to be located in the Z1 Taxiway area, for purposes of this evaluation).

Site Restoration

Site restoration activities would generally consist of returning project-affected areas to pre-Project or better conditions. It should be noted that completion of remedial activities as per MND-approved dioxin limits will mean that land uses should not change (i.e., an industrial area should not be converted for use as farmland or for aquaculture). Therefore, implementation of institutional controls will be required of all DUs to verify that land uses remain as intended, and that site drainage activities do not result in erosion of materials into lakes.

Project Demobilization

All project equipment and facilities would be removed from the project area.

Footprint

The area of the total footprint for the incineration alternative is estimated to be 740,100 m^2, consisting of:

- 522,400 m^2 of area of contaminated soils and sediments to be excavated.
- 100,000 m^2 for the footprint for the incinerator equipment, temporary untreated and treated soil stockpiles, and other facilities at the Pacer Ivy Area (some of this area is also included in the area to be excavated).
- 148,000 m^2 for the footprint for the incinerator equipment, temporary untreated and treated soil stockpiles, the final treated soil stockpile and other facilities at the Z1 Area.

Construction and Operation Schedule

It is expected that the incineration alternative would be constructed and operated over an 8-year period for the estimated contamination volume of 408,500 m^3, assuming one incinerator system is constructed and operated sequentially at the Pacer Ivy Area followed by the Z1 Area. Incinerator operation is expected to be continuous (i.e., 24-hour operation) with periods of down time for equipment maintenance. If incineration in these areas is conducted simultaneously rather than sequentially, the anticipated project schedule would be expected to be approximately 5 years. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). Dioxin concentrations would be reduced to or below GVN cleanup standards by the end of operation; therefore, no long-term O&M would be required.

After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation of the incineration alternative are presented on **Figure 4-13**, and the main components are described below:

- Year 1: Mobilization and project preparation; UXO clearance; equipment, facilities, and project area setup; Pacer Ivy Area incineration equipment installation; excavation and hauling of material for incineration; and backfilling of excavations.
- Years 2 -4: Excavation and hauling of material to Pacer Ivy Area; incineration of soils in Pacer Ivy Area; maintenance of incineration equipment; and backfilling of excavations.
- Year 5: Excavation and hauling of material to Z1 Area; mobilization of incinerator to Z1 Area; incineration of soils in Z1 Area; maintenance of incineration equipment; and backfilling of excavations.

- Years 6-7: Excavation and hauling of material to Z1 Area; incineration of soils in Z1 Area; maintenance of incineration equipment; and backfilling of excavations.
- Year 8: Backfilling of excavations; site restoration; and demobilization.

For the upper contamination volume estimate of 495,300 m^3, it is anticipated that two additional years of construction and operation would be necessary.

4.4.5.2 Effectiveness

Incineration is a proven technology for dioxin remediation, with very high destruction efficiencies. The technology has been applied numerous times for treatment of soils and wastes impacted with persistent organic pollutants, including dioxin, in the U.S. and other countries. DEs for dioxins in soil have been demonstrated to be between 99.99% and 99.9999% at sites in the U.S., such as Times Beach and Baird and McGuire (USEPA 1998a, USEPA 1998b), using rotary kiln incinerators with air pollution controls and secondary combustion chambers as described previously.

Incineration technologies are effective at dioxin remediation even when high concentrations are present in the feed material. For example, the maximum soil dioxin concentrations successfully treated at the Times Beach and Baird and McGuire sites were 1,800,000 ppt and 28,700 ppt, respectively (USEPA 1998a, USEPA 1998b). These soils were treated using rotary kiln incineration to levels below the respective treatment criteria. Treated soils, with dioxin concentrations below the respective land use based dioxin limits, would not require long-term monitoring to evaluate the effectiveness of the treatment.

4.4.5.3 Implementability

Incineration is a demonstrated and implementable technology at the Airbase, with the associated challenges described in the subsections below.

Fill Material

Relative to the containment alternatives described previously, significantly less clean backfill material would be necessary for excavation areas using the incineration alternative, as the alternative is anticipated to provide a source of clean soil for backfilling of excavations. The necessary amount of clean backfill material is based on the quantity needed to backfill the first excavation areas (excavated prior to the first rainy season), which constitutes a maximum of approximately 40,000 m^3 of soil to be placed in excavation areas. Sediment areas would not be backfilled following excavation. A total of 50,000 m^3 of fill material is estimated to be required, including fill for construction of temporary treatment facilities. While it is likely that the soil following incineration is anticipated to be suitable for fill material, in the event that fill materials are unsuitable for backfilling, due to either unsuitable geotechnical properties or other reasons, additional offsite fill materials may be necessary for backfilling.

Energy Usage

The anticipated incinerator sizes necessary for treatment of the contaminated soils and sediments at the Airbase would require approximately 32 million British Thermal Units (MMBTU) per hour to operate, assuming a natural-gas fueled incinerator. Given the anticipated feed rate of 25 tph of operation, natural gas usage is expected to be at least 960,000 MMBTU. In addition, electrical power is required to run the incinerator facilities, which would amount to approximately 1,000,000 kilowatt-hours (kWh), assuming 40 horsepower (hp) is required to operate the rotary kilns. The availability of a natural gas supply in the vicinity of the Airbase which is sufficient to power the incinerator is unknown, and significant infrastructure improvements may be necessary to provide the appropriate fuel gas supply to the Airbase.

Mobilization

Much of the specific technical expertise for utilizing incineration for treatment of dioxin-impacted soils would have to come from overseas (such as the U.S.). While some specialized equipment may need to be imported, some components of the incinerator system are likely available or can be manufactured in-country. The preliminary estimated overall costs included herein are based largely on implementation of incineration technology at similar sites in the U.S.

Air Monitoring

Significant air monitoring would be required to ensure emissions do not exceed designated limits. Monitoring would need to include dioxins and other organics, as well as particulate matter and gases such as nitrous oxides (NOx).

Impact of Site COPCs

The presence of other organic COPCs in soils which are incinerated is not anticipated to adversely impact the incineration process. The high temperatures required for destruction of dioxin during incineration (870 to 1,200 °C) are sufficiently high to destroy VOCs, SVOCs, PCBs, and other organic compounds. The presence of certain metals (including arsenic, lead, cadmium, and mercury) in the incinerated material may lead to elevated metals concentrations in the resulting ash from incineration and in the waste streams associated with off-gas treatment (USEPA 2010).

Waste Streams

This alternative is expected to generate the following waste streams which would require management:

- Ash: Noncombustible materials would be turned into ash, which would require disposal offsite, such as in a landfill.
- Treatment residuals: It is expected that the vapor-phase treatment system would generate wastewater requiring treatment. This treatment process would be expected to generate additional residuals, which may include GAC to remove any residual organics, granular ferric hydroxide (GFH) to treat arsenic (if necessary), precipitated/filters solids, spent bag filters, and/or other residuals.

Technology Availability

As with all alternatives, no specialized technical expertise would be required to perform the dig and haul portion of this work. However, incineration systems are relatively complex to construct and operate, and require specialized contractor knowledge to implement. Therefore, it is anticipated that some level of expatriate labor may be required to design and implement the incineration alternative. For example, one company that has been identified as potentially capable of providing this technology, Holcim, is a Vietnamese branch of an international company, LafargeHolcim. Therefore, it is likely that design and installation of an incinerator for soil remediation at the Airbase could be utilized as an opportunity for capacity-building and technology transfer to GVN and/or Vietnamese companies for future implementation. It is expected that this technology would be limited mainly by the number of vendors licensed to use it or able to become licensed in Vietnam; however, there may be opportunities for technology transfer. Therefore, the alternative assumes that most construction labor would be provided by Vietnamese contractors. However, it is assumed that expatriate labor would be involved to provide management and third-party oversight.

4.4.5.4 Cost

The preliminary estimated overall cost for this alternative is $666M to $794M for the estimated contamination volume range of 408,500 m^3 to 495,300 m^3. Incineration costs are more sensitive to volume of material treated than the containment alternatives (2A and 2B) because the majority of the cost is associated with incinerator operation. As indicated in **Table D2** in **Appendix D**, with a 21% increase in volume, the estimated cost increase for Alternative 5A is approximately 19.1%. No long-term O&M beyond the 8 to 10-year operating timeframe would be required. A summary of the overall incineration alternative cost is provided in **Table 4-6**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.5.5 Environmental and Social Consequences

Alternative 5A will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.
- Lowering dioxin concentrations in soils and sediments on the Airbase to below the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 5A are assessed as Mitigable:

1. Alternative 5A is assessed as having significant potential environmental impacts with respect to surface water quality. Most of this would be generated from handling of contaminated soil and sediments, both during excavation and then stockpiling and handling at the incineration facilities.
2. Alternative 5A is assessed as having significant potential environmental impacts with respect to air quality. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. Alternative 5A is assessed as having the greatest potential effects of any of the remedial alternatives considered in this EA on the generation of GHGs due to the large energy requirements for the incineration process.
4. There would be significant potential environmental effects associated with Alternative 5A related to noise generated from extended heavy equipment use.
5. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

Because Alternative 5A involves treating the contaminated material on the Airbase, this alternative has no long-term risk associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province or from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.6 Alternative 5B: *Ex Situ* TCH

As described in more detail in **Appendix C**, thermal energy can be used in a large number of pretreatment and treatment technologies to either desorb dioxin from contaminated materials, or desorb and thermally degrade dioxin. TCH is one example of a technology that can desorb and achieve destruction of dioxin, wherein soils and sediments are directly heated for a sufficient duration to destroy and/or extract dioxins until target concentrations are reached. TCH can be implemented either *in situ* or *ex situ*. *In situ* TCH is a mature technology that could be applied to treat dioxin under favorable site conditions; however, it would be technically impracticable at the Airbase. As described in **Appendix C**, this is primarily because the distribution of contamination over the large areas and small depth intervals identified at the Airbase would result in prohibitively excessive heat losses. Conversely, excavating and placing contaminated material in an above-ground, insulated structure for *ex situ* treatment would enable better management of heat losses and provide a more efficient heating environment. An *ex situ* TCH technology, specifically IPTD®, was utilized during the first phase of treatment at the Danang Airport remediation project and was capable of treating dioxin-impacted soils and sediments to well below GVN standards and the project treatment level of 150 ppt (USAID 2015c). Post-treatment concentrations from the first *ex situ* TCH pile, which included soils from some of the most heavily contaminated portions of the airport, were reduced to an average of 9.3 pg TEQ/g. Therefore, ex situ TCH was used to develop an alternative for evaluation.

An *ex situ* TCH alternative would include excavation of all contaminated soil and sediment exceeding the dioxin limit in each DU, and transporting it to one of two areas for treatment. Similar to Alternative 5A, soils and sediments from the Z1 Area, ZT Area, Southwest Area, and Gate 2 Lake would be treated at the Z1 Area, and all other material would be treated at the Pacer Ivy Area. Since the objective of this alternative is treat all dioxin-contaminated material that is above the MND-approved dioxin limits, the Z1 Landfill would be excavated and treated. A summary of the volume of material to be excavated and hauled for treatment in the Pacer Ivy and Z1 Areas is provided in **Table 4-3**. Impacted soil and sediment would be placed in one of two insulated pile structures (one located in the Z1 Area and one located in the Pacer Ivy Area), capped to keep water out and steam in, and heated to a target temperature of 335°C. Dioxin would be oxidized or pyrolyzed in the pile, or volatilized and extracted. Any extracted dioxin would be adsorbed in a treatment system prior to discharge of off-gas and condensed steam. After treatment, treated soils and sediments would be placed in a location agreeable to GVN.

4.4.6.1 Conceptual Design

The conceptual design of an *ex situ* TCH alternative for the purposes of this EA would be very similar to the implementation at the Danang Airport remediation project, which used IPTD®. Given the amount of available space at the Airbase, the primary constraint regarding the size of the pile is likely to be the electrical infrastructure required to provide power to the TCH system. For the purposes of this analysis, it is assumed that infrastructure of similar capacity to the Danang project (approximately 13 megawatts) can be provided, but no more. As such, only piles of similar size to those used at the Danang project (approximately 50,000 m^3) are presumed to be feasible and operational at any given time (based on an assumption of power limitations). Given the amount of time required to load, treat, and unload each pile structure, this alternative includes two piles each with capacity of approximately 50,000 m^3 (70-m wide by 120-m long by 6-m high) – one in the Z1 Area and one in the Pacer Ivy Area. While one pile is being heated, the other pile would be loaded and unloaded. This would maximize throughput and reduce schedule. For a total treatment volume of approximately 408,500 m^3, it is assumed that four phases of treatment would be performed at each location. If the amount of material to be treated under this alternative was closer to 495,300 m^3, it would be necessary to conduct five phases of treatment at each location.

The piles would be encased with a combination of HDPE liners to shed water, lightweight insulating concrete (LWIC) to retain heat, and structural support provided by sheet pile and concrete slabs and blocks. A treatment system capable of handling liquids and vapors extracted from the pile during operations would be positioned adjacent to each pile structure. The general location of all components associated with the *ex situ* TCH system are shown on **Figures 4-14 and 4-15**.

Mobilization and Project Preparation

Mobilization and project preparation for this alternative would be required as described in **Section 4.4**. Equipment for *ex situ* TCH would be supplied by a specialized vendor. Installation of the *ex situ* TCH systems would require preparation of adequate subgrade and installation of appropriate foundations for the structures associated with the equipment. The general types of equipment assumed for the TCH system include:

- Material and equipment laydown areas with stormwater controls and decontamination facilities.
- Structures for housing of electrical distribution equipment.
- Structures for housing pile off-gas/condensate treatment equipment.

As part of mobilization, it would be necessary to establish surface water runoff diversions around the work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages.

Excavation and Hauling of Contaminated Material

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4** to one of two pile structures for treatment. In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed. As with some of the other alternatives, excavation would be staggered to minimize the total footprint of disturbed soil (to minimize environmental impact) and the amount of clean fill required. If necessary, excavated contaminated material (soil and sediments) would be dewatered in temporary storage areas. Project-affected water generated from the temporary storage and dewatering areas would be returned to natural drainages when GVN discharge standards are met after treatment.

Construction of Ex Situ TCH System

Construction of the Pile Structure: Prior to pile structure construction, each pile location would be leveled and covered with a crushed stone base to facilitate construction activities. Pile construction would then include: installation of the sheet pile walls; pouring of the LWIC around the edges; placement of concrete blocks around the edges; installation of an access road to the top of the pile; and preparation of drainage at the base of the pile. The bottom of the pile would be filled with layers of LWIC, a concrete slab above the LWIC, and crushed stone/filter sand in case pile leachate must be removed prior to heating. A schematic of each pile structure is shown as **Figure 4-16**.

Construction of the Treatment System: While each pile is being constructed, a treatment system would be installed adjacent to each pile. A conceptual process flow diagram is shown in **Figure 4-17**. This process is modeled after the liquid vapor treatment plant (LVTP) in use at the Danang Airport remediation project. The treatment systems would have the following functionality:

- Extract steam and vapors from the pile to minimize fugitive emissions.
- Cool vapors and remove condensate, using heat exchangers and vapor/liquid separators.
- Treat vapors prior to discharge; it is expected that this can be accomplished using only GAC to adsorb dioxin and other VOCs (e.g., benzene) generated during heating.
- Cool and treat any leachate and steam condensate prior to discharge; it is assumed this can be done with an oil-water separator to remove non-aqueous phase liquid (NAPL), macroporous-polymer extraction (MPPE) and GAC media to adsorb dioxin and other organics, and vessels filled with GFH to control arsenic (if necessary).

Filling the Pile Structure: As soon as the pile construction is complete, the pile would be loaded with contaminated soil and sediment for treatment. Soil and sediment moisture would be controlled to balance heating costs against compaction and to get as much material in the pile as feasible. Temporary waterproof tarps and pumps would be employed to keep free moisture from accumulating in the pile prior to heating.

Capping and Completing the Pile Structure: Once each pile is full, the cap would be constructed. A vapor recovery plenum would be installed first, with permeable backfill and horizontal vapor recovery piping. The vapor cover and the vacuum applied there would be used to minimize to the extent feasible to escape of vapors from the piles. Heater boreholes would be spaced approximately 2.5 m apart and vapor recovery wells spaced approximately 10 to 15 m apart. The top of each pile would be covered with layers of concrete and LWIC. The top of each pile would be sealed with a HDPE liner with standing seams to shed rain beyond the lateral edges of the sheet pile. The cover would be designed to prevent water from entering the pile and representing an additional heat sink that would waste energy being applied for heat treatment, and prolong treatment. While the top of the cover would be warm, its thickness and exposure to the atmosphere would be designed to prevent it from being so hot that it would boil water. Thus, steam generation from rainfall on the cover would be insignificant.

Thermal Treatment of Contaminated Soil and Sediment

The following steps would be required to thermally treat the contaminated soil and sediment in the pile structure: heating and treatment system shakedown; heating to boiling temperature; boiling and drying (to reduce water content in the pile); heating to target temperature for the target duration; sampling and analysis; and cooldown and quenching (if needed). Successful treatment of dioxins requires temperatures to be elevated to approximately 335°C for approximately 21 days. It is expected that the majority of the dioxins would be destroyed in the piles by the mechanisms of oxidation, hydrolysis, and/or hydrous pyrolysis. Recovery of the remaining dioxins would be accomplished via heated vapor extraction wells. This would be accomplished via the heater boreholes, which would raise the temperature of adjacent soil or sediment within the stockpile. Soil temperature near the heater boreholes would be approximately 700 to 800°C so as to achieve sufficient heating between boreholes. Once in-pile monitoring confirmed that the target temperatures had been achieved for the target duration, sampling would be conducted to confirm that the pile was successfully treated.

Pile Unloading and Backfilling

Once sample data indicated successful treatment, power application to the pile would cease. Power would be routed to the other pile structure for treatment in that location. During that time, in-pile equipment would be removed and the cap would be removed. Soil removal would then begin. Water would be applied to quench the material to facilitate handling either before or during soil removal. The treated material would then be allowed to cool further in nearby temporary stockpiles prior to being transported to the final location.

When cooled, approximately 276,100 m^3 of the treated soil would be returned to the soil DUs, where it would be placed, graded, and seeded as appropriate based on the DU. At this time, it is anticipated that sediment DUs would not be backfilled. In addition, because DUs would not be left without being backfilled for the length of time required to treat the material, and because the first DUs to be excavated would need backfill before any treated soil is generated, approximately 39,600 m^3 of clean import fill would be needed as backfill. Given it would therefore not be planned to place treated soils and sediments into these DUs or any sediment DUs, there would be approximately 132,400 m^3 of treated material that could not be used as backfill (39,600 m^3 of treated soil replaced by clean fill, and 92,800 m^3 of sediment not replaced). This material would be placed in a permanent stockpile location selected by GVN (but assumed to be located in the Z1 Taxiway area, for purposes of this evaluation).

Site Restoration

All Project equipment and facilities would be removed from the project area. Site restoration activities would be decided upon in consultation with the Airbase and would generally consist of returning project-affected areas to pre-Project or better conditions. It should be noted that completion of remedial activities as per MND-approved dioxin limits will mean that land uses should not change (i.e., an industrial area should not be converted for use as farmland or for aquaculture). Therefore, implementation of institutional controls will be required for all DUs to verify that land uses remain as intended, and that site drainage activities do not result in erosion of materials into lakes.

Project Demobilization

All project equipment and facilities would be removed from the project area.

Footprint

The area of the total footprint for the *ex situ* TCH alternative is estimated to be 740,100 m^2, consisting of:

- 522,400 m^2 of area of contaminated soils and sediments to be excavated.

- 100,000 m^2 for the footprint for the *ex situ* TCH equipment, and other facilities at Pacer Ivy Area (some of this area is also included in the area to be excavated).
- 148,000 m^2 for the footprint for the *ex situ* TCH equipment, the final treated soil stockpile and other facilities at Z1 Area.

Schedule

It is expected that the *ex situ* TCH alternative would be constructed and operated over a 14-year period for the estimated contamination volume of 408,500 m^3. This schedule assumes a staggered construction schedule, wherein one pile would be treated while the other pile was filled or capped. For this alternative, four piles or batches would be treated in each location (8 total). It is assumed that both piles cannot operate simultaneously because of electrical capacity constraints, and it is assumed that the only significant activity that could occur during the rainy season would be pile sampling and unloading. This assumption complicates and extends the schedule somewhat; it is expected that the schedule could be condensed to approximately 10 years if just one of the major operations (pile filling, pile capping and pile heating) could be conducted during the rainy season. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.).

Dioxin concentrations would be reduced to or below GVN cleanup standards by the end of operation; therefore, no long-term O&M would be required.

After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation of the incineration alternative are presented on **Figure 4-18**, and the main components are described below:

- Year 1: Mobilization and project preparation; UXO clearance; equipment, facilities, and project area setup.
- Pacer Ivy Area
  - Year 1: Treatment equipment installation and pile structure construction in the Pacer Ivy Area.
  - Years 2 to 4 (Pacer Ivy Phase I): Capping of the Pacer Ivy pile (Year 2); Operation of the Pacer Ivy pile (Year 3); Unloading and loading of the Pacer Ivy pile (Year 4).
  - Years 5 to 7 (Pacer Ivy Phase II): Capping of the Pacer Ivy pile (Year 5); Operation of the Pacer Ivy pile (Year 6); Unloading and loading of the Pacer Ivy pile (Year 7).
  - Years 8 to 10 (Pacer Ivy Phase III): Capping of the Pacer Ivy pile (Year 8); Operation of the Pacer Ivy pile (Year 9); Unloading and loading of the Pacer Ivy pile (Year 10).
  - Years 11 to 13 (Pacer Ivy Phase IV): Capping of the Pacer Ivy pile (Year 11); Operation of the Pacer Ivy pile (Year 12); Unloading of the Pacer Ivy pile (Year 13).
- Z1 Area
  - Year 2: Treatment equipment installation and pile structure construction in the Z1 Area.
  - Years 3 to 5 (Z1 Phase I): Capping of the Z1 pile (Year 3); Operation of the Z1 pile (Year 4); Unloading and loading of the Z1 pile (Year 5).
  - Years 6 to 8 (Z1 Phase II): Capping of the Z1 pile (Year 6); Operation of the Z1 pile (Year 7); Unloading and loading of the Z1 pile (Year 8).

- Years 9 to 11 (Z1 Phase III): Capping of the Z1 pile (Year 9); Operation of the Z1 pile (Year 10); Unloading and loading of the Z1 pile (Year 11).
- Years 12 to 14 (Z1 Phase IV): Capping of the Z1 pile (Year 12); Operation of the Z1 pile (Year 13); Unloading of the Z1 pile (Year 14).
- Year 14: Site restoration and demobilization.

For the upper contamination volume estimate of 495,300 m^3, it is anticipated that two additional years of construction and operation would be necessary.

4.4.6.2 Effectiveness

Effective for treatment (no long-term containment required): Previous well-documented case studies (ENSR 2000, Baker and La Chance 2003, Baker et al. 2007, Heron et al. 2010), and more importantly, full-scale work at the Danang Airport remediation project (USAID 2015c), have shown that *ex situ* TCH can treat chlorinated dioxins, including TCDD, to concentrations well below the cleanup goals for either soil or sediment. As noted above, post-treatment concentrations from the first *ex situ* TCH pile, which included soils from some of the most heavily contaminated portions of the airport, were reduced to an average of 9.3 pg TEQ/g.

Expectations regarding effectiveness are also supported by previous *in situ* work at other sites. Multiple studies have demonstrated that over 95% of dioxins and other high-boiling point compounds are destroyed *in situ* using TCH technologies, such as ISTD/IPTD®. For example, the Rocky Mountain Arsenal Hex Pit Treatability Study, which was overseen by the USEPA Superfund Innovative Technology Evaluation (SITE) Program, included a mass balance for PCDD/furans. The SITE program report stated, "These data further suggest that the application of the ISTD thermal well technology at the Hex Pit site will reduce the mass of these contaminants by greater than 95% *in situ*, while producing process condensate and process vapor with relatively low contaminant concentrations" (ENSR 2000). In other examples, treatability testing has shown that PAH-contaminated soils treated at 300°C (572 degrees Fahrenheit [°F]) for three days achieved much lower residual contaminant concentrations than soils treated at 400°C (752°F) for just one day (Baker et al. 2007). There are two primary reasons for the successful treatment of high-boiling point compounds such as polycyclic aromatic hydrocarbons (PAHs), PCBs, and PCDD/furans at temperatures significantly lower than their respective boiling points. First, heating the subsurface to above 300°C increases the contaminants' vapor pressures over one million-fold. Second, longer residence times in the heated zone have resulted in significantly higher removals of various PCB Aroclors (Heron et al. 2010), and the same was seen for PAHs (Baker et al. 2007).

Concentrations of dioxins and benzene in pile off-gas at the Danang Airport remediation project required treatment, and it is expected that the same treatment would be required in this alternative. As long as the off-gas is sufficiently cooled, dioxin adsorption on GAC would be expected to be successful. GAC is considered a Best Available Technology for removal of compounds like dioxins and furans (PCDD/furans) that have a high octanol-water partitioning coefficient. PCDD/furans are bound tenaciously to GAC, and especially with a lead-polish configuration of GAC vessels, cannot break through. If detailed design calculations were to show that use of serial GAC vessels alone would not meet the standards, then the need for a thermal oxidizer would be considered, but this is not expected based on Danang project experience. It is more likely that GAC replacement would be driven by the breakthrough of smaller compounds that adsorb more poorly than dioxin, and would be present in a larger quantity as thermal degradation byproducts of other materials in the soil and sediment.

Dispersion between the stack and property boundaries or locations of other receptors would be considered in this analysis.

Data collected during treatment of the first pile treated at the Danang Airport remediation project do suggest a high degree of in-pile destruction occurred, but concentrations of dioxins have been present in off-gas condensate and leachate from the pile. As such, this liquid stream would also require treatment prior to discharge to surface water. As described above, a treatment system of medium complexity would be needed, at a minimum, and could be refined during the design process. Regardless, this type of treatment approach would be expected to be effective in preventing release of dioxin to the environment.

4.4.6.3 Implementability

As demonstrated at the Danang Airport, *ex situ* TCH technologies, such as IPTD®, are implementable with the associated challenges described in the subsections below.

Fill Material

The quantity of clean fill required for *ex situ* TCH includes approximately 40,000 m^3, similar to the quantity required for incineration, to backfill excavated materials from the first year of implementation. Additional fill is also needed to construct the *ex situ* TCH treatment piles. This is estimated to be another 46,000 m^3, for a total of 96,000 m^3.

Energy Usage

It is estimated that approximately 21,000,000 kWh would be required for each of the eight stockpiles to be treated, for a total of 168,000,000 kWh. Over the duration of this project, this is on the order of a light to medium-sized industrial facility. This energy cost is included in the preliminary estimated overall cost.

Mobilization

Much of the equipment and technical expertise for this technology would have to come from overseas (probably the U.S.). This will impact cost and has been included in the preliminary estimated overall cost. There may be a potential to reuse some equipment from the Danang Airport remediation project, depending on when this project commences.

Air Monitoring

Significant air monitoring would be required to ensure emissions do not exceed designated limits and to protect workers.

Soil Integrity

For the Danang Airport remediation project (USAID unpublished data), it was concluded that treatment did not significantly affect the geotechnical properties of the soil and the treated material could be used as common fill material. It is currently assumed that treated soils would be used to backfill excavations.

Impact of Site COPCs

Given the small number of other COPCs identified at the site, it is not expected that any specialized treatment equipment or processes would be required to perform the *ex situ* TCH treatment. Even if present, other organic COPCs in soils and sediments would not be expected to have a significant impact compared to the naturally-occurring organic matter present in all soils. Arsenic present in treated materials may require removal from waste streams using a GFH media in order to meet discharge requirements.

Waste Streams

This alternative is expected to generate the following waste streams which would require management:

- GAC: Liquid-phase and vapor-phase GAC would be generated as part of this alternative, and would require offsite destruction, regeneration, or disposal.
- GFH: If required, arsenic removal media would also require offsite disposal.
- MPPE media: Based on experience at the Danang Airport remediation project, MPPE media may need to be disposed following use.
- NAPL: It is expected that NAPL would be concentrated at both the oil-water separator and via MPPE treatment. NAPL would require offsite management and disposal, likely at an incinerator permitted to handle dioxin-laden waste.

Technology Availability

As with all alternatives, no specialized technical expertise would be required to perform the dig and haul portion of this work. However, the implementation of the *ex situ* TCH portion of the work would require specialized expertise and equipment, and is a patented technology in many countries. At the present time, it is understood that there are two vendors that are capable of implementing this technology via two different approaches: the vendor who implemented this technology for the Danang Airport project via IPTD®, a technology that relies on electricity to generate heat, and another vendor that generates heat for TCH using combustion. It is not expected that either vendor, or any new vendor, would allow any substantial technology transfer. It should be noted that although this alternative assumes the power to perform *ex situ* TCH would be provided electrically, that should not be taken as a pre-selection or endorsement of the contractor who performed IPTD® at Danang. Regardless, this alternative assumes that most construction labor would be provided by Vietnamese contractors, and expatriate labor would be involved to provide management and oversight.

4.4.6.4 Cost

The preliminary estimated overall cost for this alternative is $539M to $640M for the estimated contamination volume range of 408,500 m^3 to 495,300 m^3. The cost for *ex situ* TCH is highly dependent on the volume of soil being treated due to the relatively high operating costs, and only slightly less sensitive than incineration. As indicated in **Table D2** in **Appendix D**, with a 21% increase in volume, the estimated cost increase for Alternative 5B is approximately 18.8%. No long-term O&M beyond the 14 to 16-year operating timeframe would be required. A summary of the overall *ex situ* TCH alternative cost is provided in **Table 4-7**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.6.5 Environmental and Social Consequences

Alternative 5B will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.
- Lowering dioxin concentrations in soils and sediments on the Airbase to below the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 5B are assessed as Mitigable:

1 Alternative 5B is assessed as having significant potential environmental impacts with respect to surface water quality due to the construction and operation of dewatering stockpiles of contaminated material and creation of the thermal piles.
2. Alternative 5B is assessed as having significant potential environmental impacts with respect to air quality. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. Alternative 5B is assessed as having significant potential effects on the generation of GHGs because of the very high amounts of electricity that would be required for pile treatment and the fact that a high percentage of Vietnam's electricity is generated from the burning of hydrocarbons.
4. There would be significant potential environmental effects associated with Alternative 5B related to noise generated from extended heavy equipment use.
5. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

Because Alternative 5B involves treating the contaminated material on the Airbase, this alternative has no long-term risk associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province or from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.7 Alternative 5C: MCD

MCD is a proprietary and internationally-patented technology that involves using mechanical energy to initiate chemical reactions and subsequent destruction of recalcitrant organic molecules. These mechanochemical reactions are very complex and may involve a variety of mechanisms. However, it is generally accepted that that the primary destruction mechanism involves generation of free radicals formed during fragmentation of silica-rich soil particles and subsequent physical and chemical interaction of these high-energy molecules with the organic compounds of interest that yields amorphous carbon and inorganic salts (Heinke 1984). MCD of a variety of recalcitrant compounds including pesticides, herbicides, PAHs, and dioxins has been demonstrated under both laboratory-scale and, to a limited extent, field-scale settings with minimal pre-treatment except for the drying of the contaminated materials. The internationally patented MCD reactors consist of special hard-wearing cast rotors that make continuous contact with thousands of stainless steel balls to create continuous and repetitive particle collisions. These collisions facilitate generation of aforementioned free radicals capable of oxidizing the dioxins to simple carbon compounds and inorganic halides. Operated as a closed and scalable system, MCD technology has been demonstrated for treatment of dioxins with a DE of up to 99.99%. Potential waste streams associated with the MCD technology include residuals from treatment of off-gases and fugitive dust generated by the MCD reactors.

The MCD alternative would involve excavation of contaminated soil and sediment, removing excess moisture, transport of materials to stockpile areas located in the Z1 and Pacer Ivy Areas, treatment using MCD reactors located in these areas, and confirmation sampling and subsequent placement of the treated materials into soil excavations or stockpiles. A summary of the volume of material to be excavated, hauled, and treated in the Pacer Ivy and Z1 Areas is provided in **Table 4-3.**

4.4.7.1 Conceptual Design

With the MCD alternative, similar to Alternatives 5A and 5B, contaminated materials from the Z1 Area, ZT Area, Southwest Area, and Gate 2 Lake would be excavated, dried, stockpiled, and treated in MCD reactors located near the Z1 Area. Since the objective of this alternative is treat all dioxin-contaminated material that is above the MND-approved dioxin limits, the Z1 Landfill would be excavated and treated. Treatment of contaminated materials excavated from the Pacer Ivy Area, Northwest Area, Northern Forest Area, and Northeast Area would be performed using MCD reactors located within the Pacer Ivy Area. The conceptual layouts of the MCD treatment in these areas are presented in **Figures 4-19 and 4-20**.

Mobilization and Project Preparation

Mobilization and project preparation for this alternative would be required as described in **Section 4.4**. Equipment for MCD would be supplied by a specialized vendor, and supported by expatriate technical experts. The general types of equipment assumed for MCD include:

- Pretreatment equipment for soil drying.
- Pug mills.
- MCD reactors.
- Vapor treatment (gas scrubber, baghouse/particulate scrubber, activated carbon).
- Fugitive dust and air monitoring equipment.
- Structures for housing MCD reactors and associated equipment.

As part of mobilization, it would be necessary to establish surface water runoff diversions around the work areas to minimize the amount of project-affected water requiring treatment before being returned to existing drainages.

Excavation and Hauling of Contaminated Material

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4** to one of the two MCD areas for staging and treatment. It is assumed that excavation activities would be completed only during the dry season, therefore a stockpile of material should be staged at each MCD treatment area to allow for the system to continue operation during the rainy season. In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed.

Based on an assumed throughput of 5,000 m^3 of contaminated material per month, the maximum stockpile size located adjacent to each MCD treatment system would contain approximately 50,000 m^3 of impacted soils and sediments, covering an area of approximately 10,000 m^2. Stockpiles may be covered with temporary plastic tarps or other material to avoid introducing excess moisture to the stockpiled soil prior to treatment.

Placement of Clean Fill During MCD Implementation

The total quantity of clean fill material required is similar to the incineration treatment option. In order to avoid ponding of water in excavation areas during the rainy season, the quantity of clean fill material required would be equivalent to the material which would be stockpiled for treatment during the rainy season, or approximately 40,000 m^3. A total of 50,000 m^3 of fill material is estimated to be required, including fill for construction of temporary treatment facilities.

MCD Treatment of Contaminated Materials

<u>Installation of MCD Reactors:</u> The MCD reactors would be installed at the Z1 and Pacer Ivy Areas during excavation, transport, and drying of the contaminated areas. Installation of the MCD system would require preparation of adequate subgrade and installation of appropriate foundations for the structures associated with the MCD equipment.

<u>MCD Treatment of Contaminated Materials:</u> **Figure 4-21** presents a conceptual process flow diagram of the MCD treatment process. MCD treatment would proceed in batches once the excavated materials were sufficiently dried. The following steps would be required during MCD treatment: equipment warmup, loading of contaminated materials into the reactors, MCD treatment of the materials, cool down, and treated material discharge. It is anticipated that the MCD setup would consist of an in-feed vibrating screen to remove any oversized materials (that would also be treated after crushing), a rotary dryer using an indirect hot water heater to further dry the feed material, MCD reactors to destroy the dioxins, and a rotary pug mill to allow for discharge of treated materials. The heat generated during the mechanical destruction of the contaminated materials would result in a pressure increase inside the MCD reactors. Off-gas relieved from the MCD treatment reactors would be sent to a comprehensive air quality monitoring and treatment system that is conceptually depicted in **Figure 4-21**.

Previous bench- and field-scale demonstrations suggest that up to 99.99% of the dioxins would be destroyed using MCD treatment methodology (UNDP 2009b). Off-gas generated during the treatment processes would be continuously monitored and treated using aforementioned treatment train. Upon confirmation sampling, the treated materials may be used as backfill materials or stockpiled in locations in consultation with GVN. MCD treatment can result in an increase in the mobility and leachability of heavy metals that are present in soil and sediments. However, based on the total metals concentrations measured from recent Airbase samples, which indicated relatively low concentrations, and based on the results of MCD treatability testing work conducted at Bien Hoa (UNDP 2009b), which did not indicate concern, it is not expected that the treatment process would drive an increased risk of exposure to heavy metals.

In the event that the post-treatment materials did contain elevated heavy metals concentrations that exceeded GVN regulations, solidification/stabilization, as described for Alternative 2B (**Section 4.4.3**), could be implemented. It should be noted that since this is not expected to be necessary for this alternative, the costs associated with any solidification/stabilization work that may be required to supplement the MCD treatment were not included in the preliminary estimated overall cost.

Treated Material Management and Backfilling

Following receipt of soil confirmation sampling results, the treatment materials temporarily stockpiled near the MCD reactors would be used for DU backfill or placed in a permanent treated soil stockpile. Treated soil and sediment would be transported from the treated stockpile to the excavated areas of the Airbase and placed as clean fill into soil DUs only. It is not anticipated that sediment DUs would be backfilled. It is anticipated that transportation and backfilling of treated soils would occur primarily during the dry season. As such, it is expected that DUs excavated during the first dry season would require backfilling prior to the soil treatment being complete. Clean import fill would be used to backfill those DUs excavated first. It is estimated that 132,400 m^3 of treated material would not be used as backfill (39,600 m^3 of treated soil replaced by clean fill, and 92,800 m^3 of sediment not replaced), and instead would be placed in a permanent stockpile location selected by GVN (but assumed to be located in the Z1 Taxiway area, for purposes of this evaluation).

Site Restoration

Site restoration activities would generally consist of returning project-affected areas to pre-Project or better conditions. It should be noted that completion of remedial activities as per MND-approved dioxin limits will mean that land uses should not change (i.e. an industrial area should not be converted for use as farmland or for aquaculture). Therefore, implementation of institutional controls will be required of all DUs to verify that land uses remain as intended, and that site drainage activities do not result in erosion of materials into lakes.

Project Demobilization

All project equipment and facilities would be removed from the project area.

Footprint

The area of the total footprint for the MCD alternative is estimated to be 740,100 m^2, consisting of:

- 522,400 m^2 of area of contaminated soils and sediments to be excavated.
- 100,000 m^2 for the footprint for the rotary heaters and other MCD equipment, temporary untreated and treated soil stockpiles, and other facilities at Pacer Ivy Area (some of this area is also included in the area to be excavated).
- 148,000 m^2 for the footprint for the rotary heaters and other MCD equipment, temporary untreated and treated soil stockpiles, the final treated soil stockpile, and other facilities at Z1 Area.

Construction and Operation Schedule

It is expected that the MCD alternative would be constructed and operated over a period of approximately 8 years for the estimated contamination volume of 408,500 m^3. This expectation was based on potential treatment throughput estimated by Environmental Decontamination, Ltd. (EDL). However, a 5-year project schedule could be feasible with two sets of reactors operating simultaneously. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). Dioxin concentrations would be reduced to or below GVN cleanup standards by the end of operation; therefore, no long-term O&M would be required.

After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation of the MCD alternative are presented in **Figure 4-22** and summarized below:

- Year 1: Mobilization and project preparation; UXO clearance; equipment, facilities, and project area setup; installation of MCD treatment systems at Pacer Ivy and Z1 Areas, excavation and hauling of contaminated material; and MCD treatment.
- Year 2 to 7: MCD treatment; excavation and hauling of contaminated material; and backfilling of excavations.
- Year 8: MCD treatment; backfilling of excavations; site restoration; and demobilization

For the upper contamination volume estimate of 495,300 m^3, it is anticipated that two additional years of construction and operation would be necessary.

4.4.7.2 Effectiveness

Effective for treatment (no long-term containment required): Several bench- and field-scale studies have shown that MCD technology can treat dioxins to below cleanup goals. Of particular interest is the demonstration of MCD by EDL in South Africa using soil from the Airbase in 2012. This demonstration program was funded primarily by the UNDP GEF Dioxin Project with additional support from the Government of New Zealand and EDL as part of a project entitled "Environmental Remediation of Dioxin Contaminated Hotspots in Vietnam".

The technology demonstration involved the use of MCD technology to treat contaminated soil collected from the Airbase. Three ranges of dioxin contamination were targeted, including high (greater than 100,000 ppt TEQ), medium (2,000 to 10,000 ppt TEQ), and low (less than 2,000 ppt TEQ). A basic MCD treatment configuration was used as part of this demonstration where contaminated soil excavated from target locations were processed in 42 batches across the aforementioned concentration ranges at approximately 2 to 6 t of materials per batch. The target cleanup level for this pilot demonstration was 1,000 ppt TEQ.

Results from this technology demonstration indicated that treatment performance is sensitive to in-feed soil dioxin concentrations and that the 99.99% DE was not always satisfactorily met (Cooke 2015). Specifically, incomplete dioxin destruction was seen in the high concentration soil. On the other hand, the target cleanup goal was achieved in 33 out of 43 results in the medium concentration soil. Similarly, the cleanup goal was met in 30 out of the 40 results in the low concentration soil. It should be noted that the demonstrated technology appeared to produce diminishing returns in terms of treatment effectiveness at low concentrations. However, it is believed that incomplete MCD treatment in high concentration soil can be mitigated by increased residence times and greater collision frequencies.

Assessment of secondary contamination associated with this MCD technology demonstration at the Airbase was incomplete (Cooke 2015). Results from a single dryer exhaust air and a condensate water indicated that the treatment process met provisional national and comparable international benchmarks.

Sampling results of the dust bag and GAC materials within the air pollution control system showed that these components were effective in capturing the airborne dioxins, but their relatively high levels indicated that a more robust pollution control system would be required for commercial applications of the technology. In addition, fugitive dust and VOC emissions were observed at concerning levels; this suggested that comprehensive environmental monitoring must be implemented in a full-scale configuration.

4.4.7.3 Implementability

MCD is a demonstrated and implementable technology at the Airbase, with the associated challenges described in the subsections below.

Fill Material

The quantity of clean imported backfill material required for this alternative is the same as that required for incineration or *ex situ* TCH (approximately 40,000 m^3).

Energy Usage

It is estimated that about 46,000,000 kWh would be required for the preliminary heating and subsequent MCD treatment of the contaminated materials. This cost is included in the preliminary estimated overall cost.

Mobilization

Much of the equipment and technical expertise for this technology would have to come from overseas (such as New Zealand, Japan, France, and the U.S.). This would impact cost and has been included in the preliminary estimated overall cost.

Dust and Air Monitoring

Significant air monitoring would be required to ensure fugitive dust generated during pre-treatment activities and off-gas emissions during treatment do not exceed designated limits. Based on the previous case studies, it is anticipated that the use of multiple GAC units and a comprehensive pollution control and monitoring system would be sufficient to meet all air emissions regulations. However, air emissions control would still need to be verified through strict stack testing.

Soil Integrity

Limited quantitative data are available regarding the impact of MCD on geotechnical properties of soil. The MCD technology demonstration by EDL at the Airbase (UNDP 2009b) indicated that the process tends to generate fine-grained materials that require control to avoid windblown particulate generation. It is likely that the treated materials could be used as fill for a variety of purposes but geotechnical testing would be performed to make that determination. It should also be noted that heavy metal mobilization and concentration, although unlikely based on observed metals concentrations in collected soil samples and previous treatability testing, may occur upon MCD treatment. If heavy metals concentrations in the treated materials exceed the applicable GVN regulations, then the treated materials would be subject to solidification/stabilization prior to being used as fill materials. It is currently assumed that treated soils and sediment would simply be used to backfill materials, but post-treatment testing would be performed to determine if additional treatments are necessary.

Impact of Site COPCs

The presence of other organic COPCs in soils is not anticipated to adversely impact the MCD process. Releases of volatile compounds during MCD implementation will be captured and treated by the off-gas treatment system. Presence of heavy metals such as arsenic in materials requiring treatment may result in mobilization/concentration and thus further treatment following MCD, as previously discussed.

Waste Streams

This alternative is expected to generate treatment residuals which would require management. It is expected that the vapor-phase treatment necessary to control off-gas from the MCD reactors would generate additional contaminated residuals. This may include vapor-phase GAC, baghouse filters and associated dust, and other components, depending on the detailed design of such an off-gas treatment system. Residuals would potentially be expected to contain dioxins and furans, intermediate degradation products from dioxins/furans (such as chlorophenols), heavy metals, and other compounds.

Technology Availability

As with all alternatives, no specialized technical expertise would be required to perform the dig and haul portion of this work. However, the implementation of the MCD portion of the work would require specialized expertise and equipment as MCD is a proprietary and patented technology in many countries. There are two known vendors who can provide this technology, one of which has performed pilot testing at Bien Hoa (Cooke 2015). It is not expected that either vendor would allow any substantial technology transfer. Regardless, this alternative assumes that most construction labor would be provided by Vietnamese contractors, and expatriate labor would be involved to provide management and third-party oversight.

4.4.7.4 Cost

The preliminary estimated overall cost for this alternative is $600 M to $712M for the estimated contamination volume range of 408,500 m^3 to 495,300 m^3. Costs for MCD are highly dependent on the volume of material treated, and only slightly less dependent than incineration and *ex situ* TCH. As indicated in **Table D2** in **Appendix D**, with a 21% increase in volume, the estimated cost increase for Alternative 5C is approximately 18.7%. No long-term O&M beyond the 8 to 10-year operating timeframe would be required. A summary of the overall MCD alternative cost is provided in **Table 4-8**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.7.5 Environmental and Social Consequences

Alternative 5C will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.
- Lowering dioxin concentrations in soils and sediments on the Airbase to below the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 5C are assessed as Mitigable:

1. Alternative 5C is assessed as having significant potential environmental impacts with respect to surface water quality. Most of the project-affected water is predicted to be generated as a result of scheduling excavation and stockpiling in the rainy season.
2. Alternative 5C is assessed as having significant potential environmental impacts with respect to air quality. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. Alternative 5C is assessed as having significant potential effects on the generation of GHGs. The greatest proportion of the predicted GHG emissions under this alternative would be generated by pre-heating contaminated material and operation of the MCD facilities.
4. There would be significant potential environmental effects associated with Alternative 5C related to noise generated from extended heavy equipment use.
5. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

Because Alternative 5C involves treatment of the contaminated material on the Airbase, this alternative has no long-term risk associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province or from an increased frequency and intensity of extreme weather events as a result of climate change.

4.4.8 Comparison of Treatment Alternatives

All of the treatment alternatives described above are expected to be feasible and implementable at the Airbase, and are demonstrated capable of reducing dioxin concentrations in soil and sediment to below GVN standards (to levels below all standards for Alternatives 5A and 5B, and to below commercial/industrial standards for Alternative 5C). Although each of the alternatives are similarly sensitive to changes in treatment volume, the costs associated with *ex situ* TCH are lower than the incineration or MCD alternatives. Therefore, *ex situ* TCH (5B) is utilized as the soil treatment strategy for cost estimation purposes in Alternatives 3 (**Section 4.4.9**) and 4 (**Section 4.4.10**). The selection of *ex situ* TCH as the treatment technology for use in Alternatives 3 and 4 was done only to allow relative comparison of varying combinations of treatment and containment, not to identify it as the selected treatment technology.

4.4.9 Alternative 3: Containment of Materials Less than 2,500 ppt TEQ, Treatment of Materials Greater than 2,500 ppt

This alternative utilizes a combination of a containment strategy (landfills) and a treatment strategy (*ex situ* TCH) to address dioxin-impacted soils and sediments at the Airbase. Under this alternative, soils and sediments with dioxin concentrations greater than 2,500 ppt TEQ would be treated using *ex situ*

TCH, while soils and sediments with a concentration between the MND-approved dioxin limits and 2,500 ppt would be placed in landfills and contained. The 2,500 ppt concentration threshold was selected for Alternative 3 based on a natural breakpoint in the data but happens to divide the estimated volume of contaminated soil and sediment into approximately 75% containment and 25% treatment. **Table 4-9** presents a summary of the specific soil and sediment DUs which would be landfilled or treated using *ex situ* TCH under this alternative. Under this alternative, the Z1 Landfill would remain in place since it has an average dioxin concentration less than 2,500 ppt.

4.4.9.1 Conceptual Design

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4**. Similar to Alternative 2A and 2B, the existing Z1 Landfill would remain since it has a dioxin concentration less than 2,500 ppt and is adequately containing material, thus eliminating and exposure potential. All material designated for treatment would be hauled to the Pacer Ivy Area, and all material designated for containment would be hauled to the same locations as in Alternative 2A (i.e., the Z1 and Pacer Ivy Areas). In addition to excavation of all contaminated soil and sediment, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed.

The conceptual design for the landfill portion of this alternative is the same as the landfills described in **Section 4.4.2**, with the same subgrade, bottom liner, leachate collection, and cap requirements. Landfills would be constructed in both the Z1 and Pacer Ivy Areas and at the same general locations as described in Alternative 2A, but the overall size and footprint of the landfills would be slightly smaller in area due to less volume being contained. **Figures 4-23 and 24** presents the approximate locations and sizes of the landfills to be constructed under this alternative. The overall footprint required for this alternative is relatively large (approximately 681,700 m^2), as the required footprint needs to include both landfill construction, *ex situ* TCH operations, and a final treated soil stockpile from the final TCH treatment pile.

Similarly, the implementation of TCH would be the same as described for Alternative 5B in **Section 4.4.6**. Under Alternative 3, the total quantity of soil and sediment requiring treatment using *ex situ* TCH is approximately 83,600 m^3, which would correspond to two treatment phases in a single pile structure having a maximum capacity of 50,000 m^3. Based on the locations of the majority of soils and sediments with concentrations greater than 2,500 ppt TEQ, the *ex situ* TCH portion of this remedy would be completed in the Pacer Ivy Area, as the soils and sediments in this area of the Airbase are more heavily impacted. Therefore, the division of areas from which soil would be placed into landfills and/or treated in the Pacer Ivy and Z1 Areas is the same as described in the previous alternatives, with the exception that the impacted soils from the Southwest Area which require treatment using TCH would be hauled to the Pacer Ivy Area for treatment. The location of the *ex situ* TCH components are shown on **Figure 4-23**.

It is expected that Alternative 3 would be constructed and operated over a period of approximately 7 years for the estimated contamination volume estimate of 408,500 m^3. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation Alternative 3 are presented in **Figure 4-25**. The landfilling component of the alternative would occur during Year 1 to Year 4 and *ex situ* TCH treatment would occur during Year 1 to Year 7. If it is necessary to excavate additional contaminated material to the upper contamination volume estimate of 495,300 m^3, it is anticipated that this material would be below 2,500 ppt and be placed in the landfill. While this would add one year of construction to the landfill, it would not impact the overall project schedule of 7 years.

4.4.9.2 Effectiveness

Alternative 3 would be effective in containing all soils and sediments on the Airbase which currently exceed applicable land use based MND-approved dioxin limits. The highest concentration soils and sediments onsite would be treated to destroy dioxins, resulting in a significant reduction in the amount of dioxin present on the Airbase. However, because dioxin-impacted soils and sediments present in the landfills would remain in place, long-term monitoring and O&M of the landfills would be required to ensure that containment remains effective in the long term.

4.4.9.3 Implementability

The landfill portion of this alternative is implementable, given the same landfill siting limitations as described for Alternative 2A. The Pacer Ivy and Z1 Area landfills under this alternative would be in the same locations as those described under Alternative 2A, but would have somewhat smaller footprints. The *ex situ* TCH portion of this remedy is also implementable as described under Alternative 5B. With less material requiring treatment, the energy requirements (42,000,000 kWh) and treatment requirements for off-gas and leachate are less, so the *ex situ* TCH portion of this alternative is easier to implement than that described in Alternative 5B.

Overall, the amount of clean fill material required for Alternative 3 is approximately 379,000 m^3, significantly more than the treatment alternative, but less than the containment alternatives, as a portion of soil on Airbase is treated and used as backfill for excavation areas.

4.4.9.4 Cost

The preliminary estimated overall cost for this alternative is $226M to $236M for the estimated contamination volume range of 347,800 m^3 to 414,400 m^3, excluding the current Z1 Landfill. As indicated in **Table D2** in **Appendix D**, with a 19% increase in volume, the estimated cost increase for Alternative 3 is approximately 4.6%. As it is assumed that the contingency soil volume will likely have dioxin concentrations below 2,500 ppt and will be landfilled under this alternative, the overall cost for implementing this alternative is relatively insensitive to volume of soil due to the relatively low incremental cost of landfilling versus treatment. The total cost sensitivity with this alternative is much lower than almost all other alternatives because of this assumption; the total cost increase is similar to Alternative 2A (Landfill), but because the total cost for Alternative 3 is higher than Alternative 2A, given it includes some treatment via *ex situ* TCH, the percentage increase due to the additional landfilled volume is smaller. Long-term monitoring of the landfills would be required after construction. A summary of the overall alternative cost is provided in **Table 4-10**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.9.5 Environmental and Social Consequences

Alternative 3 will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.

- Lowering dioxin concentrations in soils and sediments on the Airbase to lower than the dioxin limits set by GVN thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 3 are assessed as Mitigable:

1. Alternative 3 is assessed as having significant potential environmental impacts with respect to surface water quality; these effects are assessed as being potentially less than for most of the other alternatives considered in this EA because of the relatively low amount of project-affected water that is predicted to be generated from landfills.
2. Alternative 3 is assessed as having significant potential environmental impacts with respect to air quality. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. Alternative 3 is assessed as having significant potential effects on the generation of GHGs because of the generation of GHGs as a by-product of electricity generation for supplying the power to operate the piles.
4. Alternative 3 is assessed as having potential effects on noise levels.
5. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

Because it is a combination of containment and treatment, the long-term risk of the integrity of the constructed landfills for Alternative 3 associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province or from an increased frequency and intensity of extreme weather events as a result of climate change would be intermediate to that for Alternatives 2A and 2B (100% containment) and Alternatives 5A, 5B, and 5C (100% treatment).

4.4.10 Alternative 4: Containment of Materials Less than 1,200 ppt TEQ, Treatment of Materials Greater than 1,200 ppt

This alternative utilizes the same general approach as Alternative 3, with a combination of a containment strategy (landfills) and a treatment strategy (*ex situ* TCH) to address dioxin-impacted soils and sediments at the Airbase. Under Alternative 4, soils and sediments with dioxin concentrations greater than 1,200 ppt TEQ would be treated using *ex situ* TCH, while soils and sediments with a concentration between the MND-approved dioxin limits and 1,200 ppt would be placed in a landfill and contained. It should be noted that the actual concentration threshold selected for Alternative 4 corresponds to 1,020 ppt, which is the 1,200 ppt GVN standard for industrial land use, minus the 15% CSF used in the volume estimates. **Table 4-9** presents a summary of the specific soil and sediment DUs which would be landfilled or treated using *ex situ* TCH under this alternative.

4.4.10.1 Conceptual Design

Contaminated soils and sediments would be excavated and hauled as described in **Section 4.4**. Unlike Alternative 3, there would be two containment areas and two treatment areas. Contaminated soil and sediments from the Pacer Ivy, Northwest, Northern Forest, and Northeast Areas would be excavated and stockpiled in the Pacer Ivy Area, and contaminated soils and sediments from the Z1 Area, Southwest Area, ZT Area, and Gate 2 Lake would be excavated and stockpiled in the Z1 Area. The only other difference between this alternative and Alternative 3 is that the existing Z1 Landfill would be excavated for treatment since it has an average dioxin concentration greater than 1,020 ppt. As with Alternative 3, the removal and destruction of fish and other aquatic animals described in **Section 4.4** would also be performed.

The conceptual design for the landfill portion of this alternative is the same as the landfills described in **Section 4.4.2**, with the same subgrade, bottom liner, leachate collection, and cap requirements. Landfills would be constructed in both the Z1 and Pacer Ivy Areas, at the same locations as described in Alternative 2A. The overall size and footprint of the landfills, *ex situ* TCH piles, support facilities, and final stockpile of treated soil would be 751,700 m^2, which is larger than those described for Alternative 3, because *ex situ* TCH piles would be constructed in both locations and the final stockpile of treated soil would therefore be twice as large (equivalent to two *ex situ* TCH piles instead of one). **Figures 4-26 and 4-27** presents the approximate locations and sizes of the landfills to be constructed under this alternative.

Similarly, the implementation of TCH will be the same as described for Alternative 5B in **Section 4.4.6**. Under Alternative 4, the total quantity of soil and sediment requiring treatment using *ex situ* TCH is approximately 216,000 m^3, which would correspond to five treatment phases in a pile structure having a maximum capacity of 50,000 m^3. Based on the location of contaminated soils and sediments above 1,020 ppt, one pile structure would be constructed in the Pacer Ivy Area and be used 3 times for treatment and one pile structure would be construction in the Z1 Area and be used 2 times for treatment. The location of the *ex situ* TCH treatment areas are provided on **Figures 4-26 and 4-27**.

It is expected that Alternative 4 would be constructed and operated over a period of approximately 10 years for the estimated contamination volume of 408,500 m^3. It should be noted that this schedule does not include the time required for activities prior to start of construction (i.e., design, permitting, contractor procurement, etc.). After 3 to 5 years for planning, approvals, and procurement, the main schedule components for implementation Alternative 4 are presented in **Figure 4-28**. With two piles, the same types of schedule constraints as described in **Section 4.4.6.1** would apply here, as thermal treatment would occur during two out of every three years in the middle of the project. The landfilling component of the alternative would occur during Year 1 to Year 4 and *ex situ* TCH treatment would occur during Year 1 to Year 10. If it is necessary to excavate additional contaminated material to the upper contamination volume estimate of 495,300 m^3, it is anticipated that this material would be below 1,020 ppt and be placed in the landfill. While this would add one year of construction to the landfill, it would not impact the overall project schedule of 10 years.

4.4.10.2 Effectiveness

Alternative 4 would be effective in containing all soils and sediments on the Airbase which currently exceed applicable land use based MND-approved dioxin limit. The highest concentration soils and sediments onsite would be treated to destroy dioxins, resulting in a significant reduction in the amount of dioxin present on the Airbase. However, because dioxin-impacted soils and sediment present in the landfills (<1,200 ppt) would remain in place, long-term maintenance and institutional controls would be required to ensure that containment remains effective in the long term. The amount of material contained long-term in this alternative would be lower than Alternative 3.

4.4.10.3 Implementability

The landfill portion of this alternative is implementable, given the same landfill siting limitations as described for Alternative 2A. The Pacer Ivy and Z1 Area landfills under this alternative would be in the same locations as those described under Alternative 2A, but would have somewhat smaller footprints. The *ex situ* TCH portion of this remedy is also implementable as described under Alternative 5B, and with less soil requiring treatment, lower energy requirements (105,000,000 kWh), less treatment requirements for off-gas and leachate, and smaller footprint. The *ex situ* TCH portion of this alternative is easier to implement than that described in Alternative 5B, but more difficult than Alternative 3.

Overall, the amount of clean fill material required for Alternative 4 is approximately 357,000 m^3, significantly more than the treatment only alternatives, but less than the containment only alternatives, and less than Alternative 3, as a greater proportion of soil on the Airbase is treated and used as backfill for excavation areas under Alternative 4.

4.4.10.4 Cost

The preliminary estimated overall cost for this alternative is $377M to $390M for the estimated contamination volume range of 408,500 m^3 to 495,300 m^3. As indicated in **Table D2** in **Appendix D**, with a 21% increase in volume, the estimated cost increase for Alternative 4 is approximately 3.5%. As it is assumed that the contingency volume will likely have dioxin concentrations below 1,200 ppt and will be landfilled under this alternative, the overall cost for implementing this alternative is relatively insensitive to the total volume of material, due to the relatively low incremental cost of landfilling versus treatment. The total cost sensitivity with this alternative is much lower than all other alternatives because of this assumption; the total cost increase is similar to Alternative 2A (Landfill) and contingency volume is less than for Alternative 3, but because the total cost for Alternative 4 is higher than Alternative 2A, given that Alternative 4 includes a large amount of treatment via *ex situ* TCH, the percent increase in cost is smaller. Long-term maintenance and institutional controls of the landfills would be required after construction. A summary of the overall alternative cost is provided in **Table 4-11**. The detailed preliminary estimated overall cost backup is provided in **Appendix D**. It should be noted that there will be unbudgeted USAID administrative costs during the 3 to 5 year planning, approval, and procurement period.

4.4.10.5 Environmental and Social Consequences

Alternative 4 will have positive environmental and social consequences with respect to:

- Cutting off dioxin exposure pathways and reducing exposure risk to dioxin.

- Lowering dioxin concentrations in soils and sediments on the Airbase to below the dioxin limits set by GVN, thereby enabling land use changes and development on the Airbase to occur.

In addition, there will be no impact of this remedial alternative on protected areas and cultural, heritage, and tourism resources. With respect to all other environmental and social resources, the environmental consequences of Alternative 4 are assessed as Mitigable:

1. Alternative 4 is assessed as having significant potential environmental impacts with respect to surface water quality; as with Alternative 3, these effects are assessed as being potentially less than for most of the other alternatives considered in this EA because of the relatively low amount of project-affected water that is predicted to be generated from landfills.
2. Alternative 4 is assessed as having potential environmental impacts with respect to air quality. There would be gender differences in potential effects of exposure of residents living on and near the Airbase as well as construction workers implementing this remedial alternative if it were selected. Potential environmental effects related to air quality would also extend to airborne COPCs and dust that would be generated as a result of the construction activities associated with this remedial alternative.
3. Alternative 4 is assessed as having significant potential effects on the generation of GHGs because of the generation of GHGs as a by-product of electricity generation for supplying the power to operate the piles.
4. Alternative 4 is assessed as having significant potential effects on noise levels.
5. There would be an ongoing risk of recontamination of lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits.

All these potential environmental effects can be effectively mitigated with well-accepted, proven mitigation measures implemented as part of an EMMP.

Because it is a combination of containment and treatment, the long-term risk of the integrity of the constructed landfills for Alternative 4 associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province or from an increased frequency and intensity of extreme weather events as a result of climate change would be intermediate to that for Alternatives 2A and 2B (100% containment) and Alternatives 5A, 5B, and 5C (100% treatment). The consequences of the long-term risk to the integrity of the landfills under Alternative 4 would be lower than for Alternative 3 given the lower threshold of contamination to trigger treatment associated with Alternative 4.

4.4.11 Summary of Evaluation

Tables 4-12 through 4-15 present a comparative analysis of the alternatives presented above against the criteria described in **Section 4.3**. These tables allow for a direct comparison of all alternatives based on each of the evaluation criteria on a qualitative basis to assist with determination of the optimal remediation alternative for the Airbase.

The No Action alternative is not considered an appropriate alternative for the Bien Hoa Airbase because:

- Concentrations of dioxin would continue to substantially exceed the allowable limits established by GVN for dioxin in soil and sediment.
- Exposure pathways would remain open, continuing to put environmental resources at risk of dioxin contamination and continuing the risk of human exposure to dioxin contamination. The significant gender-specific differences in the continued risk of human exposure to dioxin contamination would also persist.
- The ability to generate economic benefits by creating development opportunities and implementing the future land use plan for the Airbase cannot proceed under the No Action Alternative.
- Under the No Action alternative, contaminated material could be dispersed beyond its current distribution on the Airbase as a result of potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change.

With respect to the environmental and social consequences of the remedial alternatives:

1. The results of this EA suggest that environmental and social consequences of all actionable remediation alternatives are similar: (i) all remedial alternatives evaluated in this EA have the same set of environmental and social issues requiring assessment; (ii) all potential environmental and social effects associated with any remedial alternative evaluated in this EA are mitigable; and (iii), the conceptual EMMP developed in this EA is applicable to any remedial alternative evaluated in this EA.
2. Given the range of alternatives examined in this EA and the results of the environmental assessment described above, the same general conclusions regarding environmental and social consequences and conceptual scope of EMMP may be expected of any other remedial alternative that may be ultimately selected for Bien Hoa Airbase. This includes any variations on any of the remedial alternatives evaluated in this EA or any other remedial technology that might be selected and included in a remedial alternative.
3. An entirely new EA for these sorts of situations (i.e., variation on any of the remedial alternatives evaluated in this EA or any other remedial technology that might be selected and included in a remedial alternative) would therefore not be required. Rather, an amendment to this EA should be sufficient for these situations, and would be an early step to be done in a detailed design phase for the selected remedial alternative. This amended EA (if amendment required) would be the basis for an EIA for the selected remedial alternative that would need to be prepared by GVN in order to meet Vietnam's national environmental assessment regulations.

4.5 Lessons Learned

The implementation of dioxin remediation at the Danang Airport has yielded multiple lessons learned, some of which are important to consider as a part of this EA. The following lessons learned were incorporated into the conceptual designs in the alternatives listed above, and the subsequent evaluation of the alternatives:

- The most important lesson learned reflected in this EA is the use of MIS-based sampling methodology during the 2014/2015 EA sampling program to evaluate the magnitude and extent of dioxin contamination at the Airbase, the results of which are presented in **Section 3**. As further described in **Appendix A** and in the SAP for the 2015/2015 EA sampling program (USAID 2014), the MIS sampling technique is able to produce data with less variability, greater reproducibility, and therefore higher statistically-defensible level of confidence than discrete sampling or less robust composite sampling methods, thus limiting the effects of dioxin concentration heterogeneity in soils (ITRC 2012). This increased confidence in contamination volumes allows for better development of appropriate remediation alternatives.

- The implementation of *ex situ* TCH at the Danang Airport has provided several lessons, which are reflected in the conceptual design of applicable alternatives in this EA. These lessons learned include: appropriate cap design; appropriate design of treatment equipment for off-gas/condensate/leachate stream; appropriate handling of waste streams; and scheduling to avoid operation in the rainy season if feasible and necessary.
- Considerations are included throughout all alternatives for addressing arsenic-related issues. Although arsenic analyses conducted on 2014/2015 samples at the Airbase are generally below those found at the Danang Airport remediation project, arsenic was observed to be present above USEPA risk-based screening levels and in some locations above GVN standards.
- Several constructability-related lessons learned have been incorporated for all alternatives, including best methods for construction dewatering and treatment, and appropriate construction means and methods for excavation and hauling.
- Significant effort is assumed for H&S in the preliminary estimated overall costs for all alternatives. As described further in **Section 7.3.2** and **Table 7-7**, proper personal protective equipment (PPE), engineering controls, third-party H&S oversight, medical surveillance, and blood monitoring should be applied during all operations, especially during the management of any treatment residuals, to minimize exposure to workers.
- Costs presented have been compared to actual costs incurred at the Danang Airport remediation project, including volumetric unit cost rates, cost estimate assumptions, and construction means and methods assumed.

Table 4-1 Technologies Identified and Screening Results

Technology	Description	Screening Result
Containment Technologies		
Passive Landfill	Contaminated materials are placed in a landfill designed to contain hazardous waste.	Retained.
Active Landfill	Contaminated materials are placed in a standard landfill modified to allow bioremediation to occur.	Not retained as a primary technology; technology is not mature (bioremediation is not yet well demonstrated). However, additional testing may be helpful for this potential technology.
Capping	A durable isolation barrier is constructed over the top of contaminated material, and monitored.	Not retained; technology is not acceptable to GVN (because of protectiveness).
Solidification/Stabilization	Contaminated material is mixed with chemical agents to reduce leachability, erosion, and other transport mechanisms.	Retained.
Treatment Technologies		
Incineration	Contaminated materials are oxidized at high temperatures.	Retained.
In situ TCH	*In situ* soils are heated to drive desorption and *in situ* oxidation/pyrolysis.	Not retained; technology is mature (demonstrated for full-scale remediation) given site geometry to other concerns and expected heat losses, and also not cost competitive.
Ex Situ Thermal Desorption	Soils and sediments are heated to drive desorption and treatment by other steps.	MCS may warrant additional consideration as a pretreatment step.
Ex Situ TCH	Dioxin in contaminated materials is thermally desorbed/oxidized/pyrolyzed in piles or treated in off-gas treatment equipment.	*Ex situ* TCH was retained.
Plasma Arc and Pyrolysis	Thermal plasma field is used to pyrolyze contaminated materials or dissociate into its atomic elements.	Not retained; technology is not expected to be cost competitive (high energy requirements).
MCD / Ball Milling	Vibration of soils induces the formation of free radicals, which degrade organics such as dioxin.	Retained.

Technology	**Description**	**Screening Result**
Base Catalyzed Desorption	Following thermal desorption of contaminated materials, off-gas condensate is treated using sodium hydroxide and a hydrocarbon to dechlorinate dioxins.	Not retained; technology is not expected to be cost competitive or acceptable to GVN (because of large waste quantities).
Supercritical and Subcritical Water Treatment	Water in a supercritical state is used to oxidize organics, or water in a subcritical state is used to extract dioxins for further treatment.	Not retained; technology is not expected to be cost competitive because of pre-/post-processing requirements and throughput limitations.
Vitrification	Large quantities of electric current are used to convert contaminated materials into a vitreous and crystalline material.	Not retained; technology is not expected to be cost competitive (high energy requirements).
Soil Washing/Liquefied Gas Extraction	Solvent is added to extract dioxins from contaminated materials.	Not retained; technology is not mature (limited effectiveness with clays and silts). Preliminary testing by Shimizu may indicate potential value in combining with other technologies to reduce treatment volumes. Need to confirm dioxin mass balance and necessary post-washing treatment.
Gas-Phase Chemical Reduction	Hydrogen gas is mixed with contaminated materials at high temperatures to destroy dioxins and other organics.	Not retained; technology is not expected to be cost competitive (high reagent needs and low throughput).
In Situ Bioremediation	Liquid-phase amendments and/or specialized cultures are used to degrade dioxins *in situ*.	Not retained; technology is not mature (bioremediation is not yet well demonstrated and is expected to be especially difficult to implement *in situ*).
Ex Situ Chemical Reduction / Oxidation	Chemical reductants or oxidants are used to treat dioxins in contaminated materials.	Not retained; technology is not mature (not demonstrated for full-scale remediation) and is not expected to be cost effective.
Advanced Oxidation	Ultraviolet light, other oxidants, and/or catalysts are used to degrade dioxin and other organics in the aqueous phase.	Not retained; technology is not mature (not demonstrated for full-scale remediation) and is not expected to be cost competitive because of pre-/post-processing required to perform aqueous phase treatment.

Technology	Description	Screening Result
Biological / Chemical Hybrids	Oxidants and bioremediation are used in a phased manner to treat contaminated materials.	Not retained; technology is not mature (not demonstrated for full-scale remediation) based on pilot testing at the Airbase.
Solvated Electron Technology	Solvated electron solution is used to dehalogenate dioxins and other chlorinated organics.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive (low throughput).
Copper-Mediated Destruction	Following thermal desorption of contaminated materials, off-gas condensate is treated using copper as a catalyst to dechlorinate dioxins.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
In Situ Photolysis	Solvent is used to bring dioxin to the surface of *in situ* soils where it can be photodegraded.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
Steam Distillation	Steam is used to remove organics such as dioxin from soils.	Not retained; technology is not mature (not demonstrated for full-scale remediation). Very little information is available.
Radiolytic Degradation	High energy electron beams and gamma rays are used to ionize soil and destroy dioxins.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive (high energy requirements).
Hydrothermal Treatment	Contaminated materials are treated using heat and a solution of sodium hydroxide and methanol.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive.
Non-Thermal Plasma	Strong electrical fields are used to generate free radicals, which degrade dioxins and other organics.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
Phytoremediation	Plant growth and activity is used to remove/destroy dioxins from/in soils.	Not retained; technology is not mature (not demonstrated for full-scale remediation). Pilot testing underway at Airbase using Vetiver grass.
Mycoremediation	Fungal growth and activity is used to destroy dioxins in soils.	Not retained; technology is not mature (not demonstrated for full-scale remediation) and is not expected to be cost competitive (especially compared to other more effective technologies).

Table 4-2 Summary of Estimated Haul Distances from Contaminated Locations to Containment/Treatment Areas

Location/DU	Media	Estimated Excavation Volume (m^3)	Approximate One-Way Haul Distance (km)
Containment/Treatment in Pacer Ivy Area			
NE-7	Sediment	2,200	5.6
NE-8	Sediment	9,700	7.2
NE-9	Sediment	6,500	7.7
NE-11	Sediment	5,000	7.7
NE-12	Sediment	500	7.5
NE-15	Sediment	1,000	7.6
NF-4	Soil	34,300	5.2
NW-3	Sediment	6,100	3.0
NW-4	Sediment	500	1.8
PI-2	Soil	104,800	0.3
PI-8	Soil	1,300	0.7
PI-10	Soil	9,100	0.3
PI-12	Soil	10,400	0.6
PI-13	Soil	2,400	0.1
PI-15	Sediment	4,900	0.7
PI-16	Sediment	4,600	1.0
PI-17	Sediment	9,700	0.7
PI-18	Sediment	7,500	0.2
PI-20	Sediment	15,400	0.3
Containment/Treatment in Z1 Area			
G2L-1	Sediment	1,300	1.2
SW-1	Soil	16,100	1.2
SW-2	Soil	9,500	1.2
SW-3	Soil	24,600	0.9
SW-7	Soil	10,500	1.6
Z1-1	Soil	60,700	0.1
Z1-2	Soil	3,700	0.3
Z1-3	Soil	6,000	0.7
Z1-7	Soil	8,000	0.7
Z1-9	Sediment	14,200	1.0
Z1-10	Sediment	3,600	0.6
Z1-16	Soil	3,400	0.8
ZT-2	Soil	10,900	0.4

Table 4-3 Summary of Estimated Excavation Volumes for Alternatives 1 through 5

Location	Alternative 1	Alternative 2[1]	Alternative 3[2]	Alternative 4[2]	Alternative 5[3]
Estimated Volume for Containment/Treatment in Z1 Area (m^3)					
Z1 Area	0	38,900[4]	38,900[4]	99,600	99,600
ZT Area	0	10,900	10,900	10,900	10,900
Southwest Area	0	60,600	60,600	60,600	60,600
Southeast Area	0	0	0	0	0
Lakes Outside of Airbase	0	1,300	1,300	1,300	1,300
Subtotal	*0*	*111,700*	*111,700*	*172,400*	*172,400*
Contingency	0	28,800	28,800	49,000	49,000
Total	**0**	**140,500**	**140,500**	**221,400**	**221,400**
Estimated Volume for Containment/Treatment in Pacer Ivy Area (m^3)					
Pacer Ivy Area	0	170,200	170,200	170,200	170,200
Northwest Area	0	6,600	6,600	6,600	6,600
Northern Forest Area	0	34,300	34,300	34,300	34,300
Northeast Area	0	25,000	25,000	25,000	25,000
Subtotal	*0*	*236,100*	*236,100*	*236,100*	*236,100*
Contingency	0	37,800	37,800	37,800	37,800
Total	**0**	**273,900**	**273,900**	**273,900**	**273,900**

Notes:

1. All estimated volumes indicated for Alternative 2 would be contained.
2. Alternatives 3 and 4 are a combination of containment and treatment. See Table 4-9 for a breakdown of estimated containment and treatment volumes.
3. All estimated volumes indicated for Alternative 5 would be treated.
4. Existing Z1 Landfill would remain in place for Alternatives 2 and 3.

Table 4-4 Alternative 2A Passive Landfill – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2A Landfill (Passive)
Description: The landfill alternative will consist of: (1) constructing two landfills, one in the Z1 Area and one in the Pacer Ivy Area; (2) excavating, dewatering, and transporting contaminated soils and sediments to the landfills; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$74,268,754	$74,268,754	From detailed cost estimate
Contingency (Scope and Bid)	30%			$22,280,626	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$96,549,000	Rounded to nearest $1,000
Project Management	5%			$4,827,450	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$5,792,940	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$4,827,450	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$114,996,840	
TOTAL CONSTRUCTION CAPITAL COST				**$114,997,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	5	YR	**$22,999,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$338,249	$338,249	Sampling/analysis required by the EMMP; assume 0.5% of construction cost.
Contingency (Scope and Bid)	30%			$101,475	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$440,000	Rounded to nearest $1,000
Project Management	10%			$44,000	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$66,000	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$22,000	Assumed to apply to 50% of the EMMP implementation
TOTAL				$572,000	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$572,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	5	YR	$572,000	**$2,860,000**	Total O&M Cost over the assumed duration.

Table 4-4 Alternative 2A Passive Landfill – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 6 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction costs.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	45	YR	$115,000	**$5,175,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 6 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	45	YR	$69,000	**$3,105,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 2A Landfill (Passive)	**$126,137,000**	Assuming no discount factor

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-5 Alternative 2B Solidification/Stabilization – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2B Solidification/Stabilization
Description: The solidification/stabilization alternative will consist of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Mix the soils with admixtures (binders, stabilizers, etc.) to solidify and stabilize the soil and affix the dioxin; (3) stockpile the solidified soils in centralized stockpiles, and (4) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$123,293,670	$123,293,670	From detailed cost estimate
Contingency (Scope and Bid)	30%			$36,988,101	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$160,282,000	Rounded to nearest $1,000
Project Management	5%			$8,014,100	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$9,616,920	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$8,014,100	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$188,927,120	
TOTAL CONSTRUCTION CAPITAL COST				**$188,927,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	6	YR	**$31,488,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$525,261	$525,261	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$157,578	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$683,000	Rounded to nearest $1,000
Project Management	10%			$68,300	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$102,450	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$34,150	Assumed to apply to 50% of the EMMP implementation
TOTAL				$887,900	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$888,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	6	YR	$888,000	**$5,328,000**	Total O&M Cost over the assumed duration.

Table 4-5 Alternative 2B Solidification/Stabilization – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assumed to be same as landfill monitoring.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	44	YR	$115,000	**$5,060,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Sampling/analysis required by the EMMP; assumed to be same as landfill monitoring.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	44	YR	$69,000	**$3,036,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 2B Solidification/Stabilization	**$202,351,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-6 Alternative 5A Incineration – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5A Incineration
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using a rotary kiln incinerator; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$429,204,694	$429,204,694	From detailed cost estimate
Contingency (Scope and Bid)	30%			$128,761,408	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$557,966,000	Rounded to nearest $1,000
Project Management	5%			$27,898,300	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$33,477,960	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$27,898,300	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$652,240,560	
TOTAL CONSTRUCTION CAPITAL COST				**$652,241,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	8	YR	**$81,530,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,040,724	$1,040,724	Sampling/analysis required by the EMMP; assume 0.2% of construction cost.
Contingency (Scope and Bid)	30%			$312,217	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,353,000	Rounded to nearest $1,000
Project Management	10%			$135,300	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$202,950	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$67,650	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,758,900	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,759,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	8	YR	$1,759,000	**$14,072,000**	Total O&M Cost over the assumed duration.

Table 4-6 Alternative 5A Incineration – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5A Incineration	**$666,313,000**	Assuming no discount factor

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-7 Alternative 5B *Ex Situ* TCH – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5B Ex-Situ Thermal Conductive Heating (TCH)
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using ex-situ thermal conductive heating; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 14)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$338,403,580	$338,403,580	From detailed cost estimate
Contingency (Scope and Bid)	30%			$101,521,074	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$439,925,000	Rounded to nearest $1,000
Project Management	5%			$21,996,250	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$26,395,500	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$21,996,250	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$515,313,000	
TOTAL CONSTRUCTION CAPITAL COST				**$515,313,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	14	YR	**$36,808,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 14)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,004,917	$1,004,917	Sampling/analysis required by the EMMP; assume 0.3% of construction cost.
Contingency (Scope and Bid)	30%			$301,475	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,307,000	Rounded to nearest $1,000
Project Management	10%			$130,700	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$196,050	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$65,350	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,699,100	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,699,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	14	YR	$1,699,000	**$23,786,000**	Total O&M Cost over the assumed duration.

Table 4-7 Alternative 5B *Ex Situ* TCH – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 15 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	36	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 15 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	36	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5B Ex-Situ Thermal Conductive Heating (TCH)	**$539,099,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-8 Alternative 5C MCD – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5C Mechano-Chemical Destruction (MCD)
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using mechano-chemical destrucion (ball milling) reactors; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$385,403,409	$385,403,409	From detailed cost estimate
Contingency (Scope and Bid)	30%			$115,621,023	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$501,024,000	Rounded to nearest $1,000
Project Management	5%			$25,051,200	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$30,061,440	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$25,051,200	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$586,187,840	
TOTAL CONSTRUCTION CAPITAL COST				**$586,188,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	8	YR	**$73,274,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,035,803	$1,035,803	Sampling/analysis required by the EMMP; assume 0.3% of construction cost.
Contingency (Scope and Bid)	30%			$310,741	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,347,000	Rounded to nearest $1,000
Project Management	10%			$134,700	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$202,050	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$67,350	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,751,100	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,751,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	8	YR	$1,751,000	**$14,008,000**	Total O&M Cost over the assumed duration.

Table 4-8 Alternative 5C MCD – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5C Mechano-Chemical Destruction (MCD)	**$600,196,000**	Assuming no discount factor

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-9 Alternative 3 and 4 Containment/Treatment Hybrids – Volumes Summary

	Containment/Treatment in Z1 Area					Containment/Treatment in Pacer Ivy Area					TOTAL
	Z1 Area	ZT Area	Southwest Area	Gate 2 Lake	Subtotal	Pacer Ivy Area	Northwest Area	North Area	Northeast Area	Subtotal	
Alternative 3: Contain Material < 2,500 ppt and Treat Material > 2,500 ppt											
Containment Volume											
Soil (m³)	21,100	10,900	48,800	0	80,800	71,700	0	34,300	0	106,000	186,800
Sediment (m³)	17,800	0	0	1,300	19,100	26,700	6,600	0	25,000	58,300	77,400
Total (m³)	***38,900***	***10,900***	***48,800***	***1,300***	***99,900***	***98,400***	***6,600***	***34,300***	***25,000***	***164,300***	***264,200***
Treatment Volume											
Soil (m³)	0	0	11,800	0	11,800	56,400	0	0	0	56,400	68,200
Sediment (m³)	0	0	0	0	0	15,400	0	0	0	15,400	15,400
Total (m³)	***0***	***0***	***11,800***	***0***	***11,800***	***71,800***	***0***	***0***	***0***	***71,800***	***83,600***
Alternative 4: Contain Material < 1,200 ppt and Treat Material > 1,200 ppt											
Containment Volume											
Soil (m³)	21,100	0	41,500	0	62,600	27,600	0	34,300	0	61,900	124,500
Sediment (m³)	16,100	0	0	1,300	17,400	20,000	6,600	0	23,900	50,500	67,900
Total (m³)	***37,300***	***0***	***41,500***	***1,300***	***80,100***	***47,600***	***6,600***	***34,300***	***23,900***	***112,400***	***192,500***
Treatment Volume											
Soil (m³)	60,700	10,900	19,100	0	90,700	100,500	0	0	0	100,500	191,200
Sediment (m³)	1,700	0	0	0	1,700	22,100	0	0	1,100	23,200	24,900
Total (m³)	***62,300***	***10,900***	***19,100***	***0***	***92,300***	***122,600***	***0***	***0***	***1,100***	***123,700***	***216,000***

Table 4-10 Alternative 3 Containment/Treatment Hybrid (2,500 ppt) – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt

Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Landfilling of soils which have dioxin concentrations less than 2,500 ppt TEQ; (3) ex-situ TCH treatment of soils with greater than 2,500 ppt TEQ; and (4) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$135,726,640	$135,726,640	From detailed cost estimate
Contingency (Scope and Bid)	30%			$40,717,992	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$176,445,000	Rounded to nearest $1,000
Project Management	5%			$8,822,250	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$10,586,700	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$8,822,250	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$212,676,200	
TOTAL CONSTRUCTION CAPITAL COST				**$212,676,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	7	YR	**$30,382,000**		Average annual capital cost over the duration, rounded to the nearest $1,000.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$568,103	$568,103	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$170,431	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$739,000	Rounded to nearest $1,000
Project Management	10%			$73,900	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$110,850	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$36,950	Assumed to apply to 50% of the EMMP implementation
TOTAL				$960,700	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$961,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	7	YR	$961,000	**$6,727,000**	Total O&M Cost over the assumed duration.

Table 4-10 Alternative 3 Containment/Treatment Hybrid (2,500 ppt) – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$55,238	$55,238	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction costs.
Contingency (Scope and Bid)	30%			$16,571	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$71,809	
Project Management	10%			$7,181	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$10,771	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$3,590	Assumed to apply to 50% of the EMMP implementation
TOTAL				$93,351	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$93,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	43	YR	$93,000	**$3,999,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$33,143	$33,143	Includes annual landfill O&M; assume 0.3% of landfill construction costs.
Contingency (Scope and Bid)	30%			$9,943	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$43,086	
Project Management	10%			$4,309	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$6,463	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,154	Assumed to apply to 50% of the O&M
TOTAL				$56,012	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$56,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	43	YR	$56,000	**$2,408,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt	**$225,810,000**	Assuming no discount factor

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Table 4-11 Alternative 4 Containment/Treatment Hybrid (1,200 ppt) – Preliminary Estimated Overall Cost

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Landfilling of soils which have dioxin concentrations less than 1,200 ppt TEQ; (3) ex-situ TCH treatment of soils with greater than 1,200 ppt TEQ; and (4) backfilling excavations. Note that the 1,020 ppt corresponds to the industrial action level of 1,200 ppt less the 15% CSF.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$233,969,848	$233,969,848	From detailed cost estimate
Contingency (Scope and Bid)	30%			$70,190,954	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$304,161,000	Rounded to nearest $1,000
Project Management	5%			$15,208,050	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$18,249,660	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$15,208,050	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$360,826,760	
TOTAL CONSTRUCTION CAPITAL COST				**$360,827,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	10	YR	**$36,083,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$841,398	$841,398	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$252,419	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,094,000	Rounded to nearest $1,000
Project Management	10%			$109,400	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$164,100	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$54,700	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,422,200	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,422,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	10	YR	$1,422,000	**$14,220,000**	Total O&M Cost over the assumed duration.

Table 4-11 Alternative 4 Containment/Treatment Hybrid (1,200 ppt) – Preliminary Estimated Overall Cost (continued)

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	Not required since landfilled material <1200 ppt and located in industrial area.
Contingency (Scope and Bid)	30%			$0	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002)
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$30,462	$30,462	Includes annual landfill O&M; assume 0.3% of landfill construction costs.
Contingency (Scope and Bid)	30%			$9,139	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002)
SUBTOTAL				$39,601	
Project Management	10%			$3,960	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$5,940	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$1,980	Assumed to apply to 50% of the O&M
TOTAL				$51,481	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$51,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	40	YR	$51,000	**$2,040,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt	**$377,087,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity	CSF	Concentration Safety Factor
LS	Lump Sum	O&M	Operations and Maintenance		
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan		

Table 4-12 Comparison of Effectiveness Evaluation of Remediation Alternatives

Alternative	Effectiveness for Treatment	Effectiveness for Containment
Alternative 1 No Action	**Not effective for treatment.**	**Not effective for containment.**
Alternative 2A Landfill	**Not effective for treatment.** If technologies which effectively degrade dioxin are developed in the future (e.g., bioremediation), the landfill could be converted to an active landfill.	**Effective for containment** to reduce potential for exposure to dioxin, provided that appropriate landfill design/construction guidelines are followed.
Alternative 2B Solidification/Stabilization	**Not effective for treatment.**	**Effective for containment -** stabilization, and reduced leachability has been demonstrated in the short term, but long-term effectiveness is less certain. More effective than landfill due to physical binding of dioxin molecules in solidified matrix.
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	**Landfilling is not effective for treatment** as described under Alternative 2A. ***Ex situ* TCH is effective for treatment** and targeted to the highest-concentration soils at the Airbase.	**Landfill is effective for containment** as described under Alternative 2A. *Ex situ* TCH treats soil to below GVN standards based on land use, no long-term containment is required.
Alternative 4 Landfill material < 1200 ppt, *Ex situ* TCH for material > 1,200 ppt	**Landfilling is not effective for treatment** as described under Alternative 2A. ***Ex situ* TCH is effective for treatment**, and targeted to all soils which exceed the commercial/industrial land use criterion at the Airbase.	**Landfill is effective for containment** as described under Alternative 2A. *Ex situ* TCH treats soil to below GVN standards based on land use, no long-term containment is required.
Alternative 5A Incineration	**Demonstrated effective for treatment -** Able to treat soils to below GVN standards.	Treated soils below GVN standards do not require containment.
Alternative 5B *Ex Situ* TCH	**Demonstrated effective for treatment -** Able to treat soils to below GVN standards.	Treated soils below GVN standards do not require containment.

Alternative	Effectiveness for Treatment	Effectiveness for Containment
Alternative 5C MCD	**Effective for treatment** - Able to decrease dioxin concentrations in soils to < 1,000 ppt, but ability to decrease concentrations to below GVN standards for all land uses has not been field-demonstrated.	Treated soils below GVN standards do not require containment.

Table 4-13 Comparison of Implementability Evaluation of Remediation Alternatives

Alternative	Implementability
Alternative 1 No Action	Implementable: Not applicable.
Alternative 2A Landfill	Implementable: using conventional construction techniques and local resources. Landfill Siting: suitable landfill sites exist in Z1 Area, Pacer Ivy landfill areas can be constructed using imported fill material. Fill Material: significant quantities of clean fill required (~478,900 m^3). Long-Term O&M: landfill requires monitoring and maintenance to ensure containment.
Alternative 2B Solidification/Stabilization	Implementable: using conventional construction techniques and local resources, with the possible exception of some soil mixing equipment. Solidification/Stabilization Additives: requires treatability testing to determine optimal mixture. Fill Material: significant quantities of clean fill required (~433,600 m^3). Long-Term O&M: monitoring and maintenance required for solidified soil stockpiles to ensure that dioxins to not leach out of stockpiles.
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	***Landfill*** Implementable: using conventional construction techniques and local resources. Landfill Siting: suitable landfill sites exist in Z1 Area, Pacer Ivy landfill areas can be constructed using imported fill material. Long-Term O&M: landfill requires monitoring and maintenance to ensure containment. ***Ex Situ TCH*** Implementable with challenges: has been utilized successfully in-country for dioxin treatment. Energy Usage: requires significant electricity quantities for treatment. Infrastructure: significant infrastructure construction, some technology must be imported from overseas. Monitoring: significant monitoring required to ensure *ex situ* TCH and treatment system is effectively destroying dioxin. Long-Term O&M: no long-term maintenance or monitoring required for material treated by TCH. ***Overall*** Fill Material: requires ~353,000 m^3 of clean backfill material.

Alternative	Implementability
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	***Landfill*** Implementable: using conventional construction techniques and local resources. Landfill Siting: suitable landfill sites exist in Z1 Area, Pacer Ivy landfill areas can be constructed using imported fill material. Long-Term O&M: landfill requires maintenance and institutional controls to ensure containment. ***Ex Situ TCH*** Implementable with challenges: has been utilized successfully in-country for dioxin treatment; longer duration of operation than Alternative 3. Energy Usage: requires significant electricity inputs for treatment. Infrastructure: significant infrastructure construction, some technology must be imported from overseas. Monitoring: significant monitoring required to ensure *ex situ* TCH and treatment system is effectively destroying dioxin. Long-Term O&M: no long-term maintenance or monitoring required for material treated by TCH. ***Overall*** Fill Material: requires ~319,700 m^3 of clean backfill material.
Alternative 5A Incineration	Implementable with challenges. Energy Usage: significant energy inputs, uncertain of ability to obtain fuel gas supplies at incineration site. Infrastructure: significant construction required, some equipment may need to be imported. Monitoring: significant off-gas monitoring required to ensure incineration is effectively destroying dioxin. Long-Term O&M: no long-term maintenance or monitoring required for material treated by incineration. Fill Material: requires ~40,000 m^3 of fill material.
Alternative 5B *Ex Situ* TCH	Implementable with challenges: has been successfully implemented in-country for remediation of dioxin in soil. Energy Usage: significant electricity usage required at sites. Infrastructure: significant construction required, some equipment and technology must be imported. Monitoring: significant monitoring required to ensure *ex situ* TCH and treatment system is effectively destroying dioxin. Long-Term O&M: no long-term maintenance or monitoring required for material treated by TCH. Fill Material: requires ~40,000 m^3 of fill material.

Alternative	Implementability
Alternative 5C MCD	Implementable with challenges. Energy Usage: significant energy inputs, but less than other treatment alternatives. Infrastructure: significant construction required, some equipment may need to be imported. Monitoring: significant monitoring required to ensure MCD is effectively destroying dioxin. High likelihood of dust generation and accumulation of high-concentration fine-grained particulates. Long-Term O&M: no long-term maintenance or monitoring required for material treated by MCD. Fill Material: requires ~40,000 m^3 of fill material.

Table 4-14 Comparison of Implementation Cost Evaluation of Remediation Alternatives

Alternative	Preliminary Estimated Implementation Cost[1,2] (-40% to +75%) and Sensitivity to Volume Change[3]
Alternative 1 No Action	No cost.
Alternative 2A Landfill (Passive)	<u>Estimated Implementation Cost:</u> Baseline Volume = \$126M (\$76M to \$221M) Baseline with Contingency Volume = \$137M (\$82M to \$239M) <u>Cost Sensitivity:</u> Cost per additional cubic meter is relatively low once landfill liner is constructed (19% increase in volume leads to 8.3% cost increase).
Alternative 2B Solidification/Stabilization	<u>Estimated Implementation Cost</u>: Baseline Volume = \$202M (\$121M to \$354M) Baseline with Contingency Volume = \$229M (\$138M to \$402M) <u>Cost Sensitivity:</u> Cost will increase proportional to the quantity of material treated (significant material and operational costs for solidification/stabilization) (19% increase in volume leads to 13.4% cost increase).
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	<u>Estimated Implementation Cost</u>: Baseline Volume = \$226M (\$135M to \$395M) Baseline with Contingency Volume = \$236M (\$142M to \$413M) <u>Cost Sensitivity:</u> Landfill is relatively low cost for additional volume, *ex situ* TCH costs increase proportional to the volume of material treated. Contingency volume is expected to be below 2,500 ppt, and is anticipated to be landfilled. Overall, a 19% increase in volume leads to 4.6% cost increase.
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	<u>Estimated Implementation Cost</u>: Baseline Volume = \$377M (\$226M to \$660M) Baseline with Contingency Volume = \$390M (\$234M to \$683M) <u>Cost Sensitivity:</u> Landfill is relatively low cost for additional volume, *ex situ* TCH costs increase proportional to the volume of material treated. Contingency volume is expected to mostly below 1,200 ppt, and is anticipated to be landfilled. Overall, a 21% increase in volume leads to 3.5% cost increase.
Alternative 5A Incineration	<u>Estimated Implementation Cost</u>: Baseline Volume = \$666M (\$400M to \$1,166M) Baseline with Contingency Volume = \$794M (\$476M to \$1,389M) <u>Cost Sensitivity:</u> Cost increases proportional to the volume treated, due to significant operating costs for incineration (21% increase in volume leads to 19.1% increase in cost).

Alternative	Preliminary Estimated Implementation Cost[1,2] (-40% to +75%) and Sensitivity to Volume Change[3]
Alternative 5B *Ex Situ* TCH	Estimated Implementation Cost: Baseline Volume = $539M ($323M to $943M) Baseline with Contingency Volume = $640M ($384M to $1,121M) Cost Sensitivity: Cost increases proportional to the volume treated, due to significant operating costs for TCH treatment (21% increase in volume leads to 18.8% increase in cost).
Alternative 5C MCD	Estimated Implementation Cost: Baseline Volume = $600M ($360M to $1,050M) Baseline with Contingency Volume = $712M ($427M to $1,247) Cost Sensitivity: Cost increases proportional to the volume treated, due to significant operating costs for MCD treatment (21% increase in volume leads to 18.7% increase in cost).

Notes:

1. Alternatives 2 through 5 will require a 3 to 5-year planning, project approval, and procurement period that is in addition to the implementation/construction time. There will be unbudgeted USAID administrative costs during this period.
2. The remedial alternative preliminary estimated costs were developed during the EA primarily for the purpose of comparing alternatives during the remedial selection process, not for establishing Project budgets.
3. Cost sensitivity is based on comparing the estimated cost for the baseline volume scenario and comparing it to the estimated cost for the baseline with contingency volume scenario.

Table 4-15 Comparison of Potential Environmental Consequences Evaluation of Remediation Alternatives

Project Activities and Environmental Issues Common to All Remediation Activities

Activity	Environmental Issue
Excavation of contaminated soils	• Increased dust levels due to earthworks activities. • Increased noise and air emissions from construction equipment. • Management of surface water and groundwater inflows into excavations • Potential impacts on terrestrial biota.
Excavation of contaminated sediments	• Increased noise and air emissions from construction equipment. • Requires drainage of a wetland system with potential impacts on aquatic biota. • Management of contaminated water with the dewatering of sediments.
Construction of dewatering areas, surface water management system, and decontamination areas	• Increased dust levels due to earthworks activities. • Increased noise and air emissions from construction equipment. • Management of project-affected and 'clean' surface water. • Potential impacts on terrestrial biota.
Hauling contaminated soil/sediment containment and treatment areas (Pacer Ivy and Z1 Areas)	• Increased dust levels due to transportation activities. • Increased noise and air emission from construction equipment. • Management of dredgate. • Management of project-affected surface water.
Import of backfill materials	• Increased traffic levels on transportation route from backfill source quarry. • Increased dust levels on transportation route from backfill source quarry. • Increased noise and air emissions on transportation route from backfill source quarry.
Backfill/reclaim excavation and construction areas	• Increased dust levels due to earthworks activities. • Increased noise and air emission from construction equipment. • Management of surface water and groundwater inflows into excavation. • Management of landscape restoration activities.
Re-contamination of treated lakes on the Airbase	There are lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated/contained under all of the remedial alternatives, and which are situated adjacent to areas of soil with dioxin concentrations both greater than 150 ppt and also below any of the land use based dioxin limits. These areas of soil pose an ongoing re-contamination risk to the seven lakes that would be treated.
Effects of increased frequency and intensity of extreme weather events related to climate change	These effects would potentially influence the timing of construction activities between dry season and rainy season and may require more conservative assumptions about return frequencies of weather events when designing structures, facilities and environmental mitigations such as water management schemes. In general, longer construction schedules would require a greater consideration of these potential effects.

Project Activities and Environmental Issues Common to All Remediation Activities	
Activity	**Environmental Issue**
Provide safe working environment for workers with gender specific requirements for women	• Potential presence of UXO. • Potential increased exposure levels to dust, noise, air emissions, and contaminated materials, particularly for the most sensitive receptors (children, women).

Alternative	**Significant Environmental Consequences that Distinguish Remedial Alternatives**
Alternative 1 No Action	• Soil and sediment concentrations that exceed MND-approved dioxin limits and GVN land use requirements for dioxin contamination. • Continued potential exposure of Airbase residents and residents of neighborhoods that adjoin the Airbase to dioxin contamination. • Persistence of dioxin in soil and sediment that exceeds GVN standards, with associated persistence of exposure pathways that could impact environmental, biological and human receptors. • Contaminated material could be moved and dispersed beyond its current distribution as a result of potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change.
Alternative 2A Landfill	• Long-term environmental risks associated with maintenance of integrity of landfill including risks associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change. • Volume of clean fill required may require a separate EIA approved by GVN.
Alternative 2B Solidification/Stabilization	• Long-term environmental risks associated with maintenance of integrity of stabilized material including risks associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change. • Volume of clean fill required may require a separate EIA approved by GVN.
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	• Long-term environmental risks associated with maintenance of integrity of landfill including risks associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change. • Large energy requirements and associated environmental costs associated with the portion of contaminated material to be treated • Volume of clean fill required may require a separate EIA approved by GVN.

Alternative	Significant Environmental Consequences that Distinguish Remedial Alternatives
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	• Long-term environmental risks associated with maintenance of integrity of landfill including risks associated with potential inundation from sea level rise affecting Bien Hoa City and lower Dong Nai Province as well as from an increased frequency and intensity of extreme weather events as a result of climate change. • Large energy requirements and associated environmental costs associated with the portion of contaminated material to be treated • Volume of clean fill required may require a separate EIA approved by GVN.
Alternative 5A Incineration	• Large energy requirements and associated environmental costs associated with the treatment of contaminated material.
Alternative 5B *Ex Situ* TCH	• Large energy requirements and associated environmental costs associated with the treatment of contaminated material.
Alternative 5C MCD	• Large energy requirements and associated environmental costs associated with the treatment of contaminated material.

Figure 4-1 Range of Remediation Alternatives Considered for Bien Hoa EA

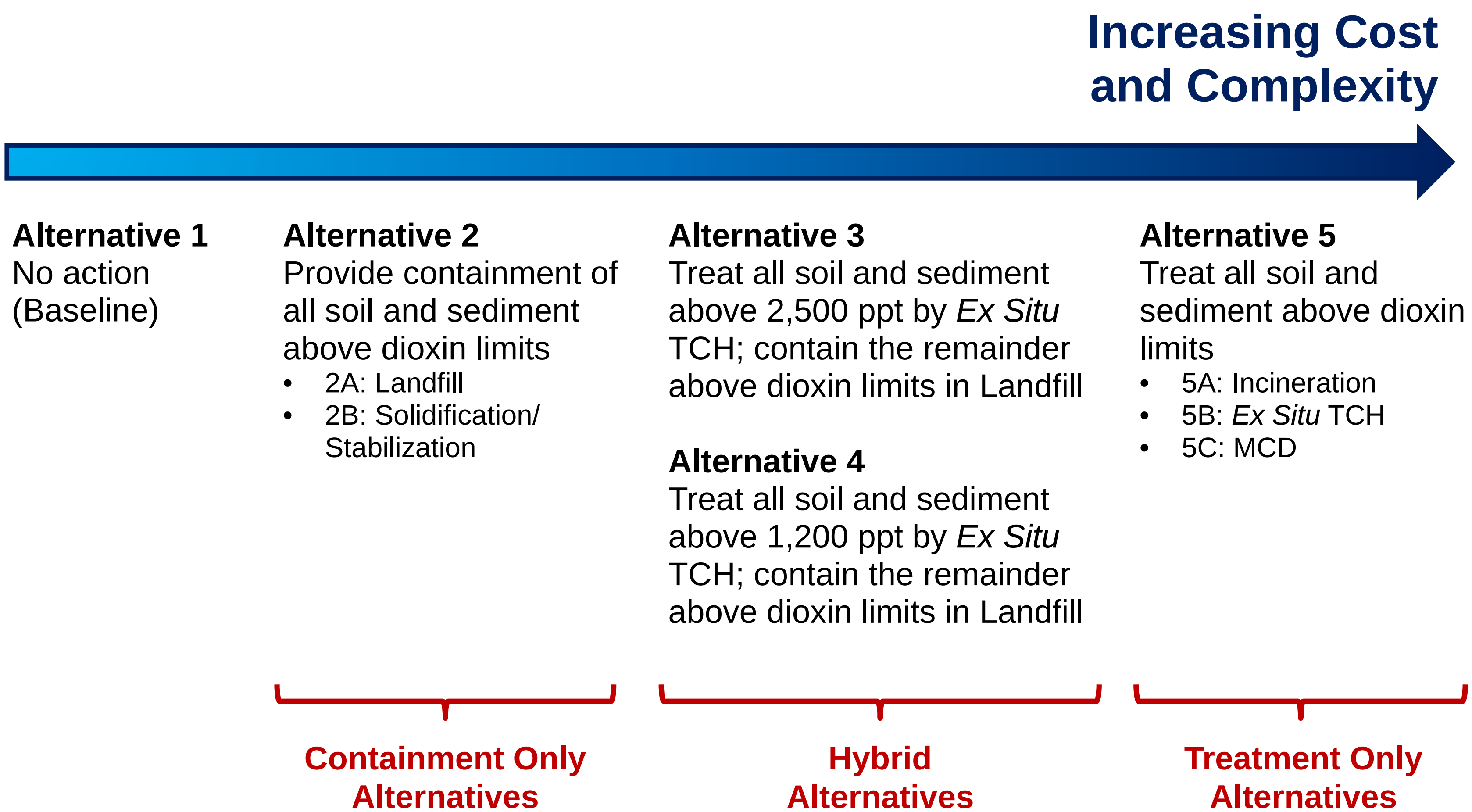


FIGURE 4-2 PRIMARY TRUCKING HAUL ROUTES, BIEN HOA AIRBASE, VIETNAM

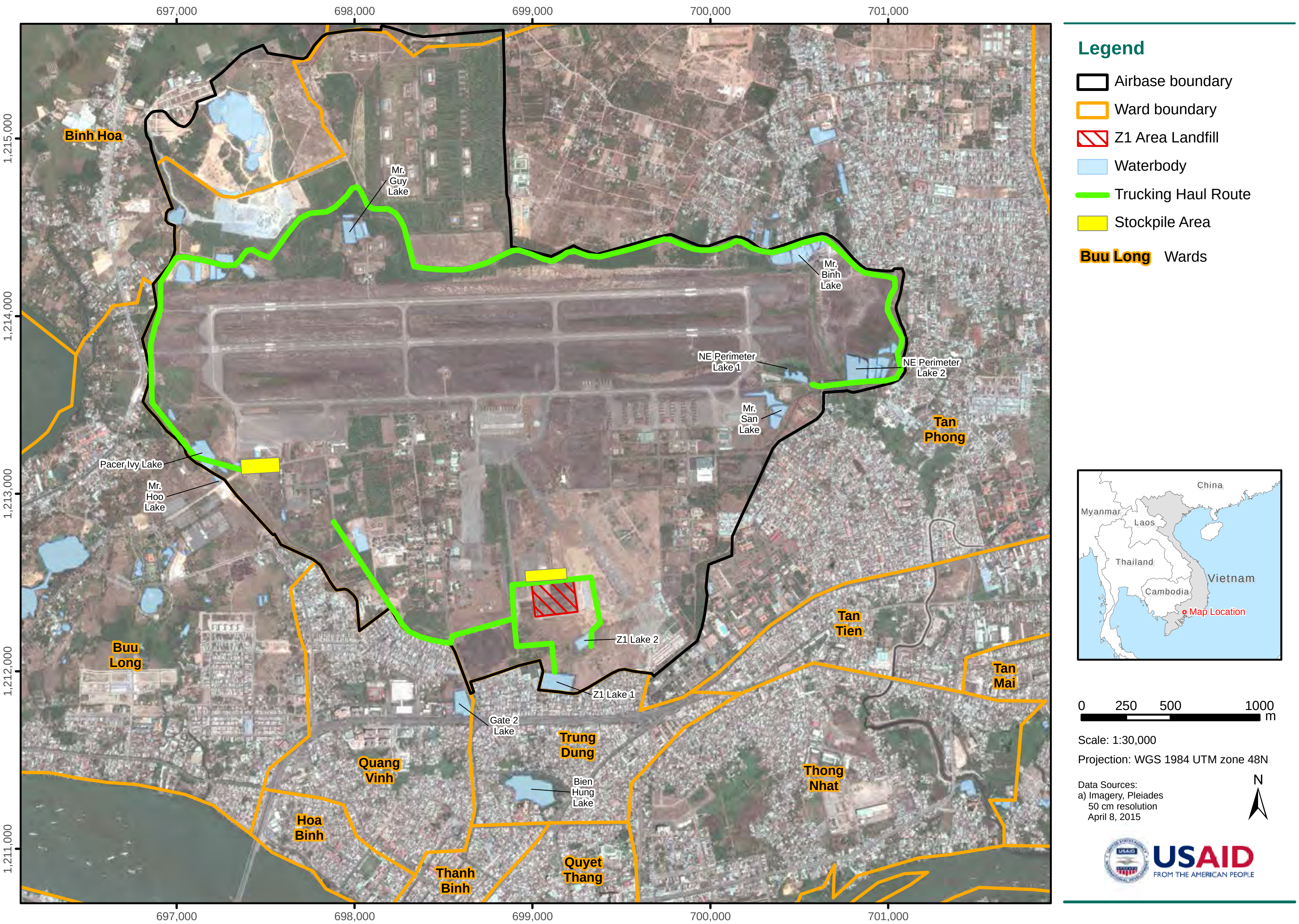


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FIGURE 4-3 CONCEPTUAL LAYOUT OF ALTERNATIVE 2A IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

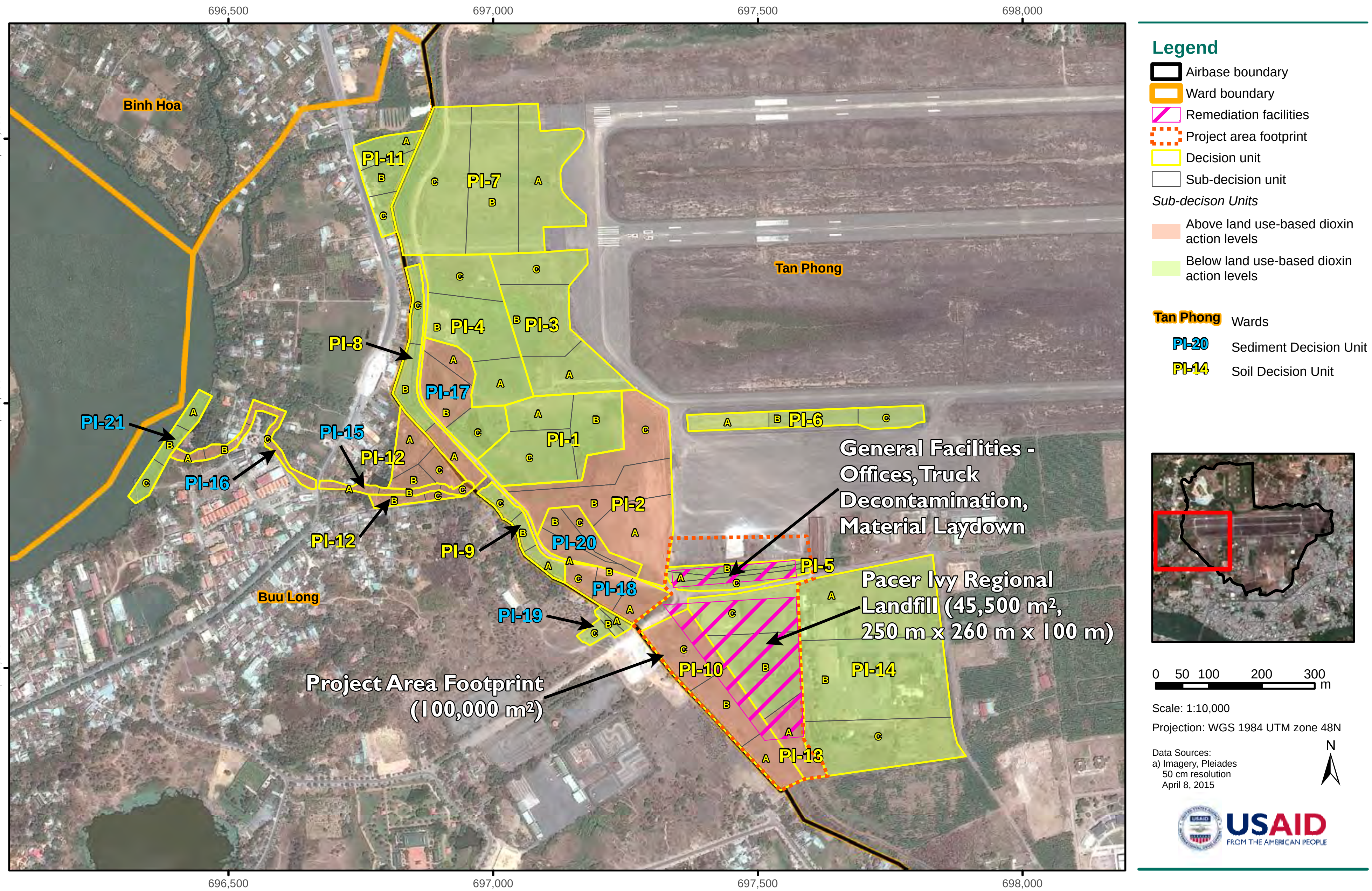

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FIGURE 4-4 CONCEPTUAL LAYOUT OF ALTERNATIVE 2A IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM

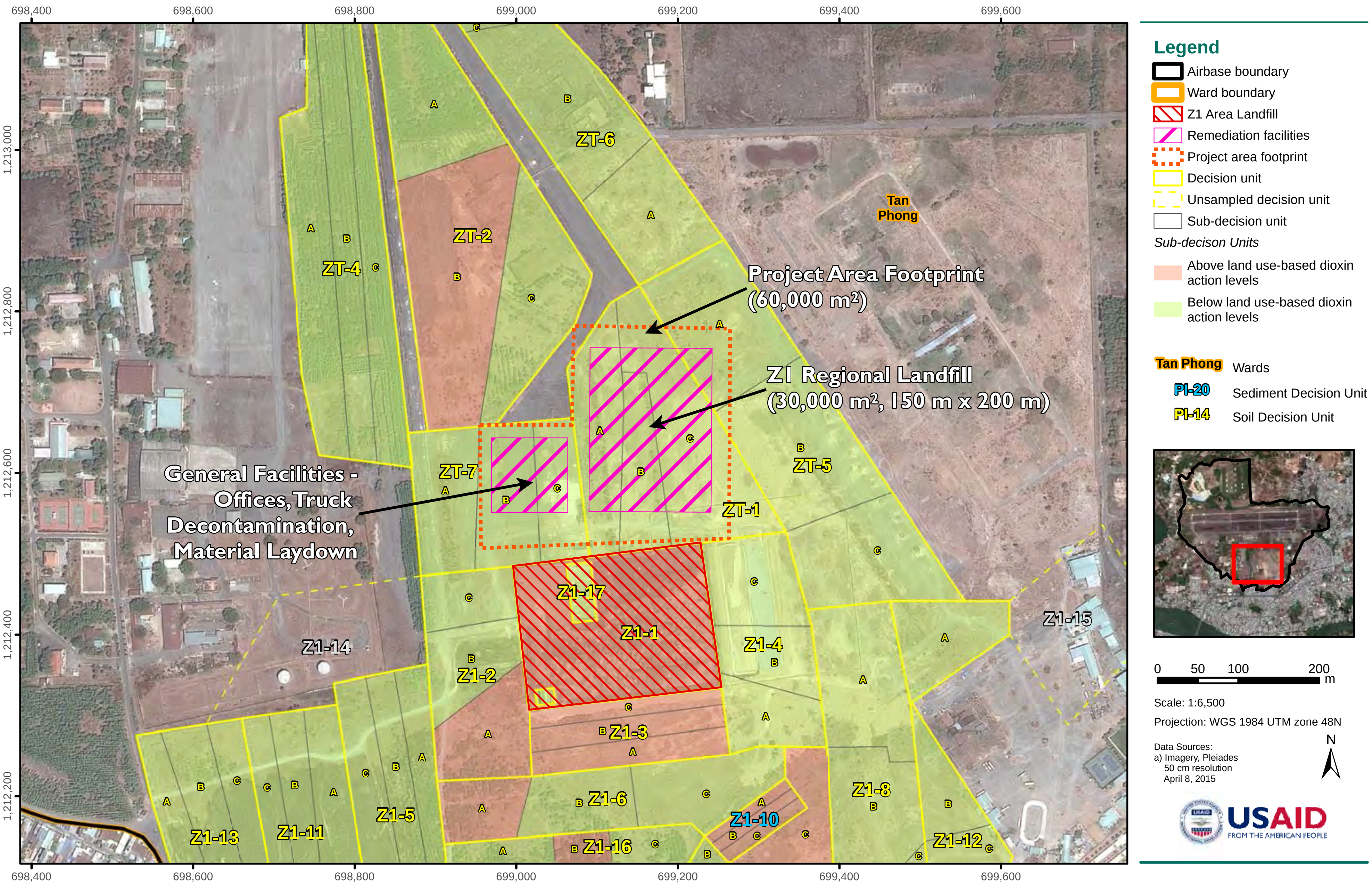

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Figure 4-5 Conceptual Landfill Cross-Section

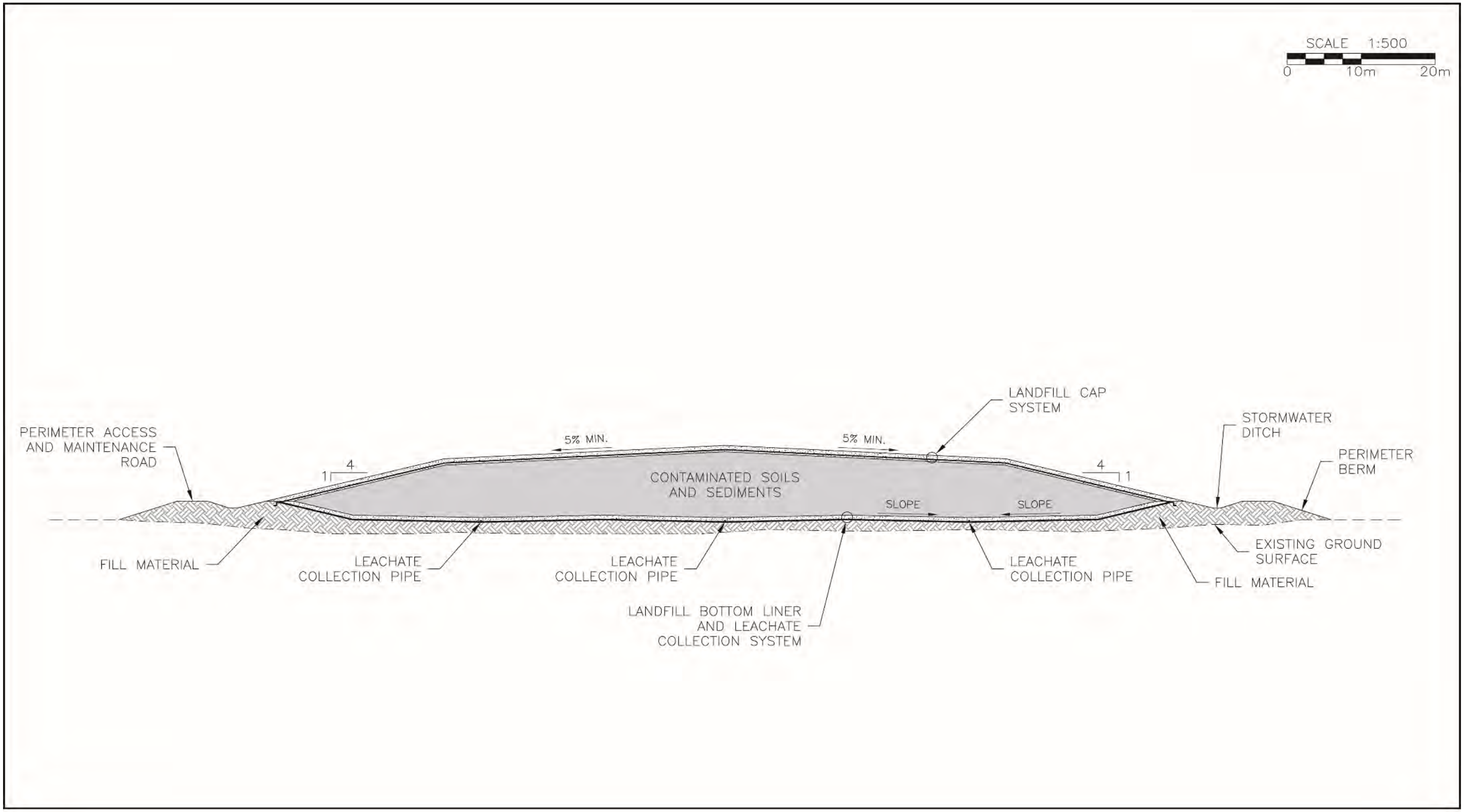

Figure 4-6 Alternative 2A Landfill Schedule

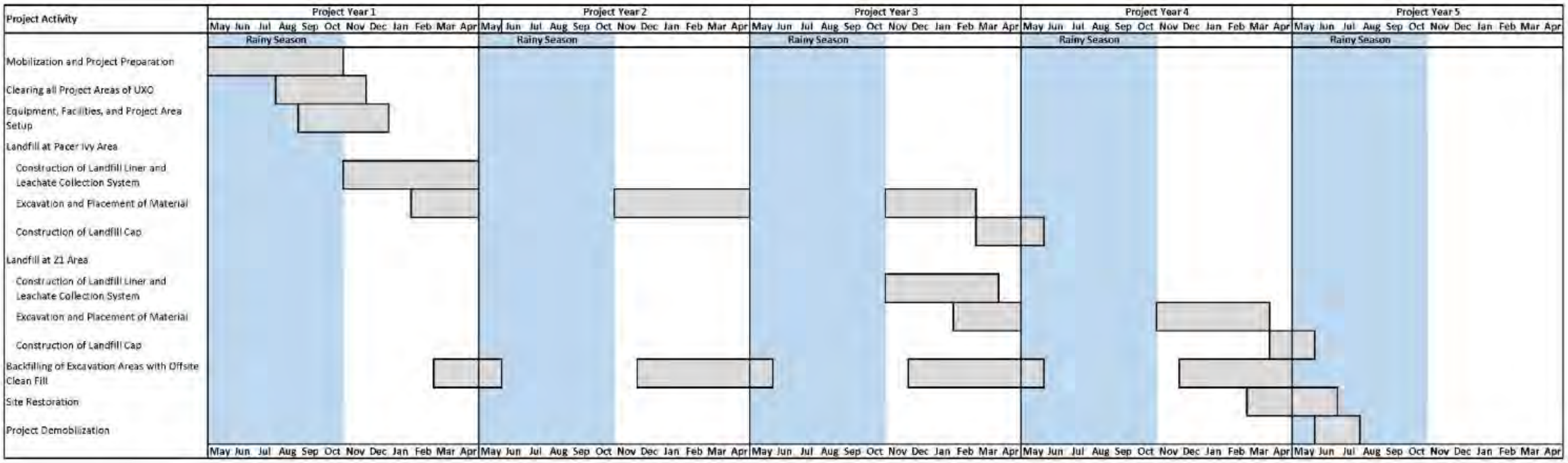

FIGURE 4-7 CONCEPTUAL LAYOUT OF ALTERNATIVE 2B IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

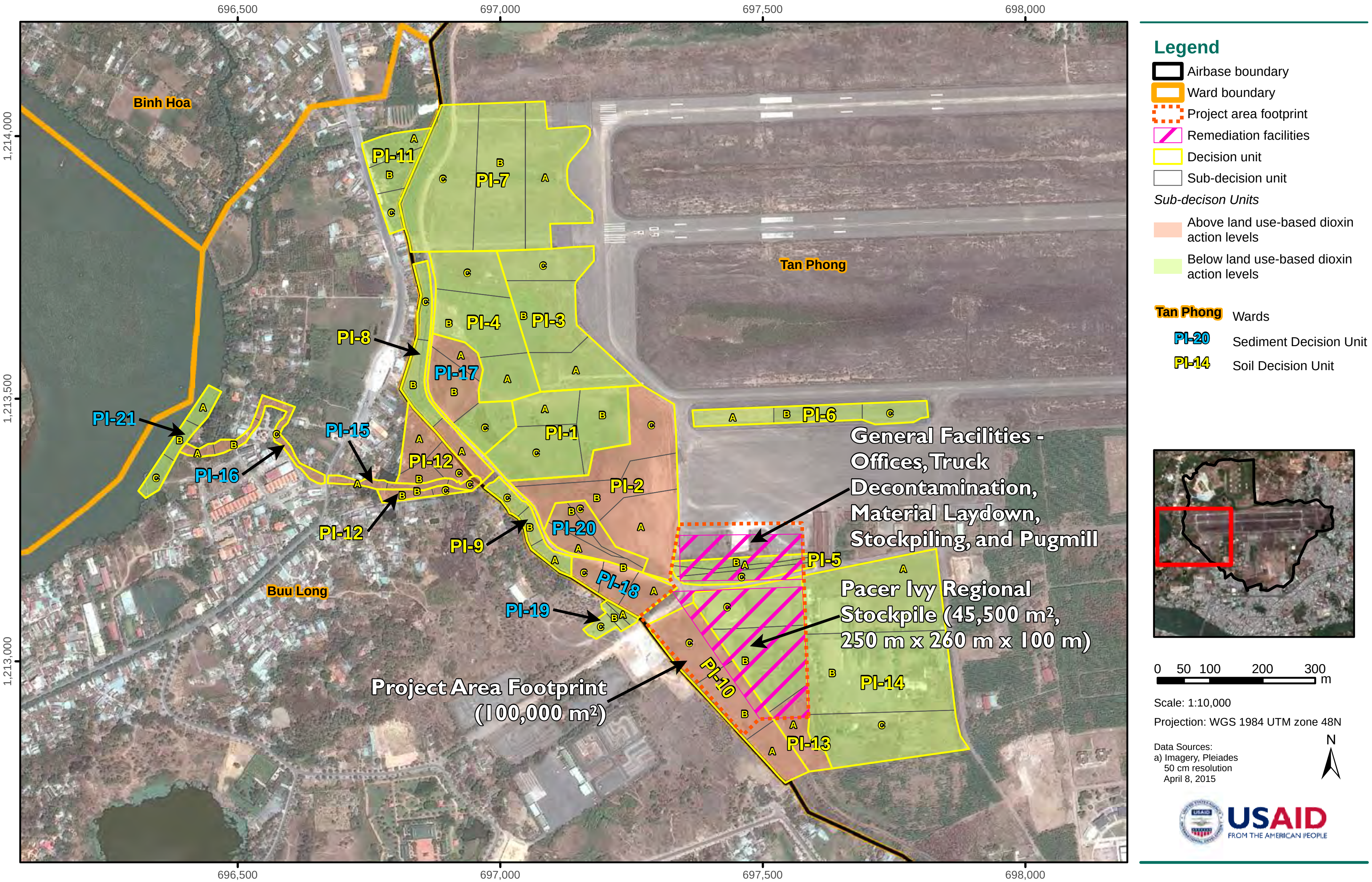

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FIGURE 4-8 CONCEPTUAL LAYOUT OF ALTERNATIVE 2B IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM

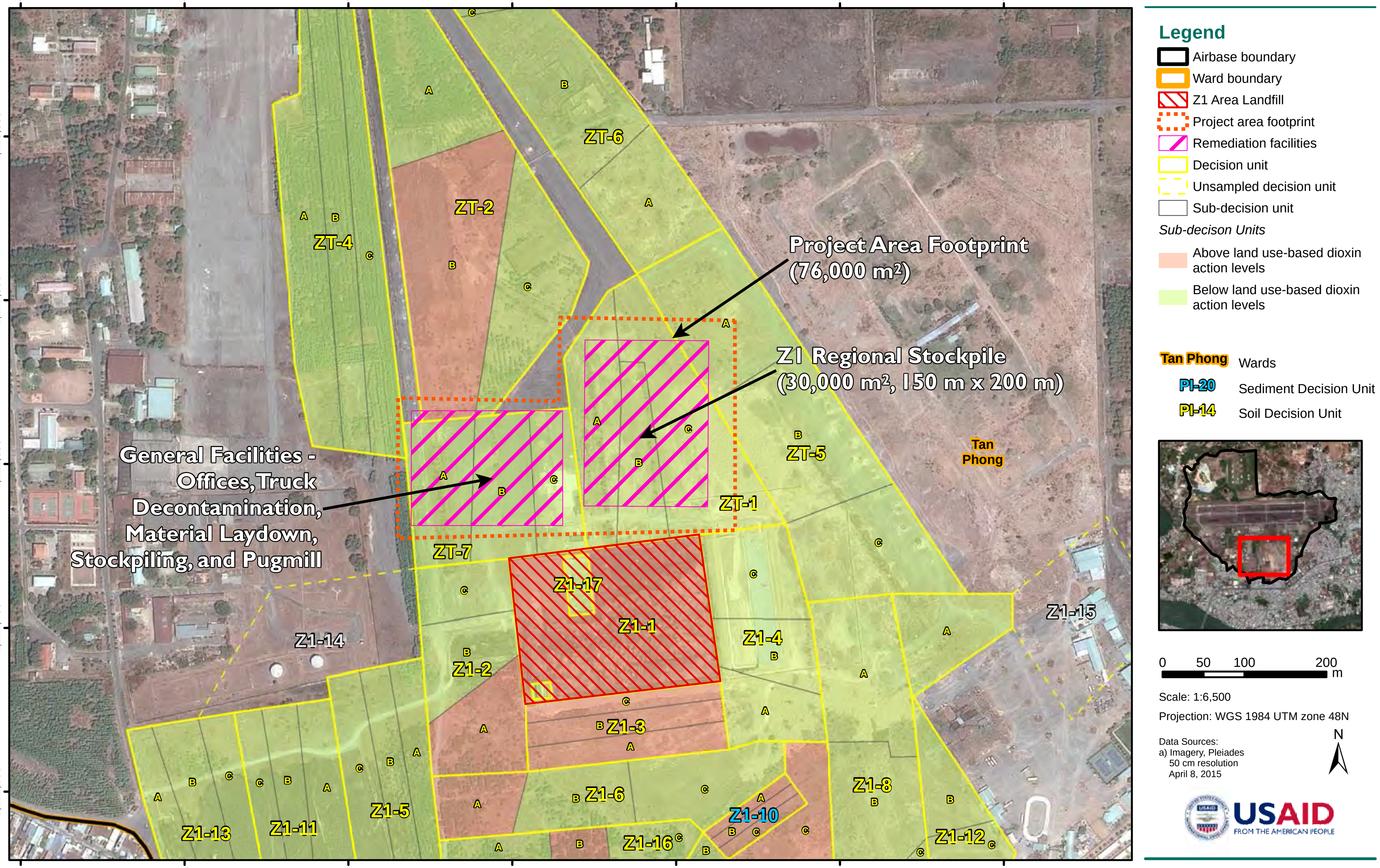

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Figure 4-9 Alternative 2B Stabilization/Solidification Schedule

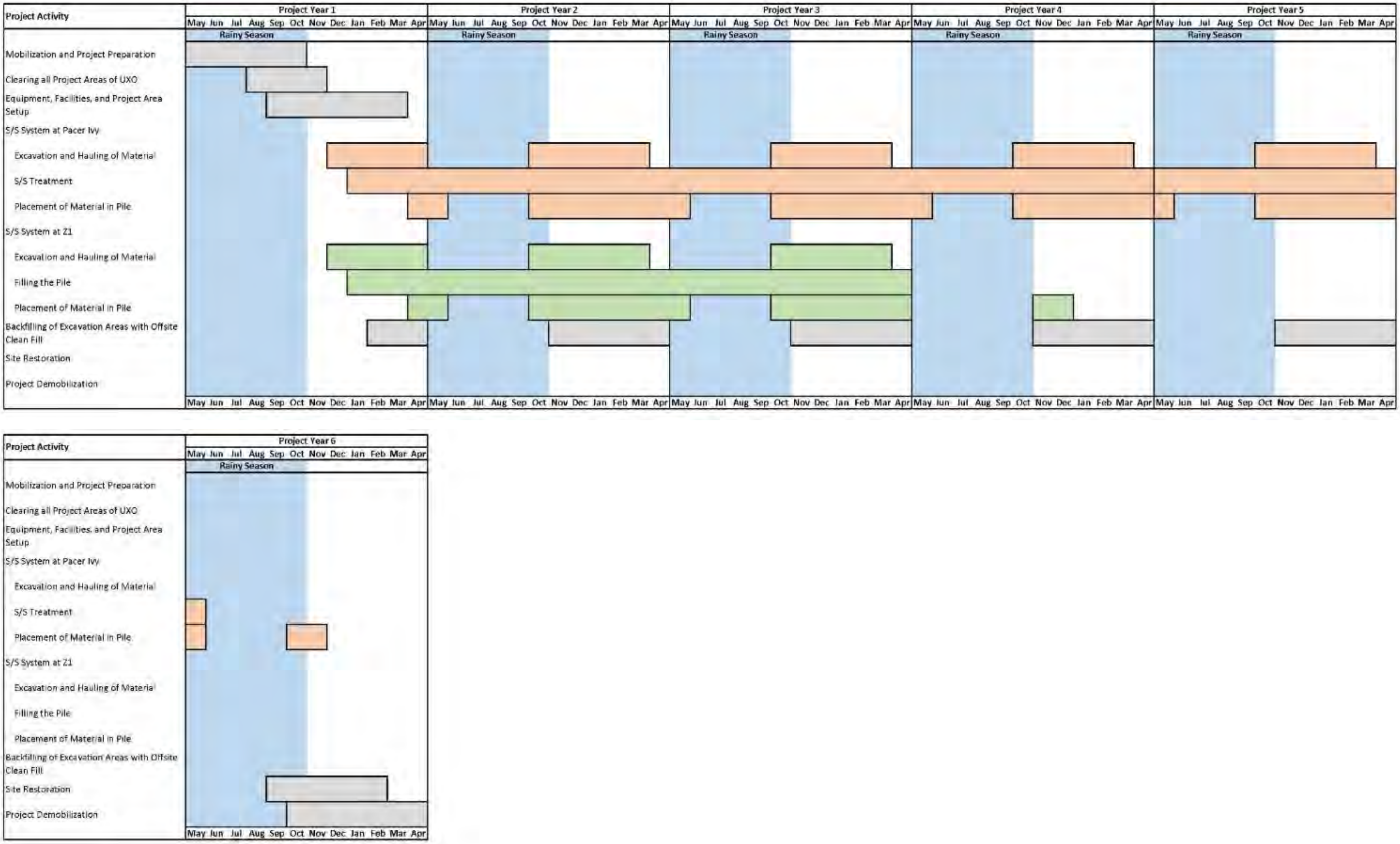

FIGURE 4-10 CONCEPTUAL LAYOUT OF ALTERNATIVE 5A IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

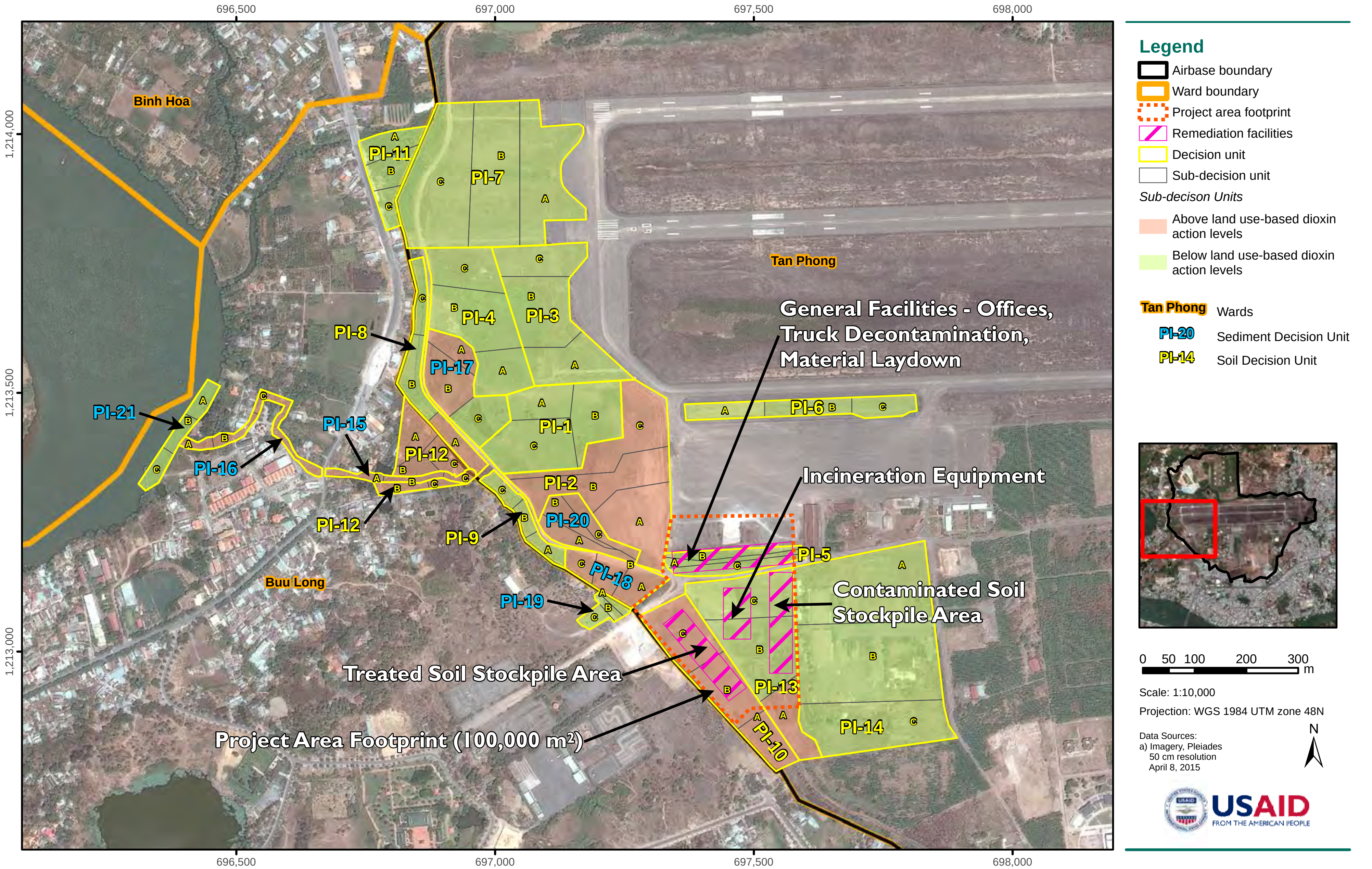

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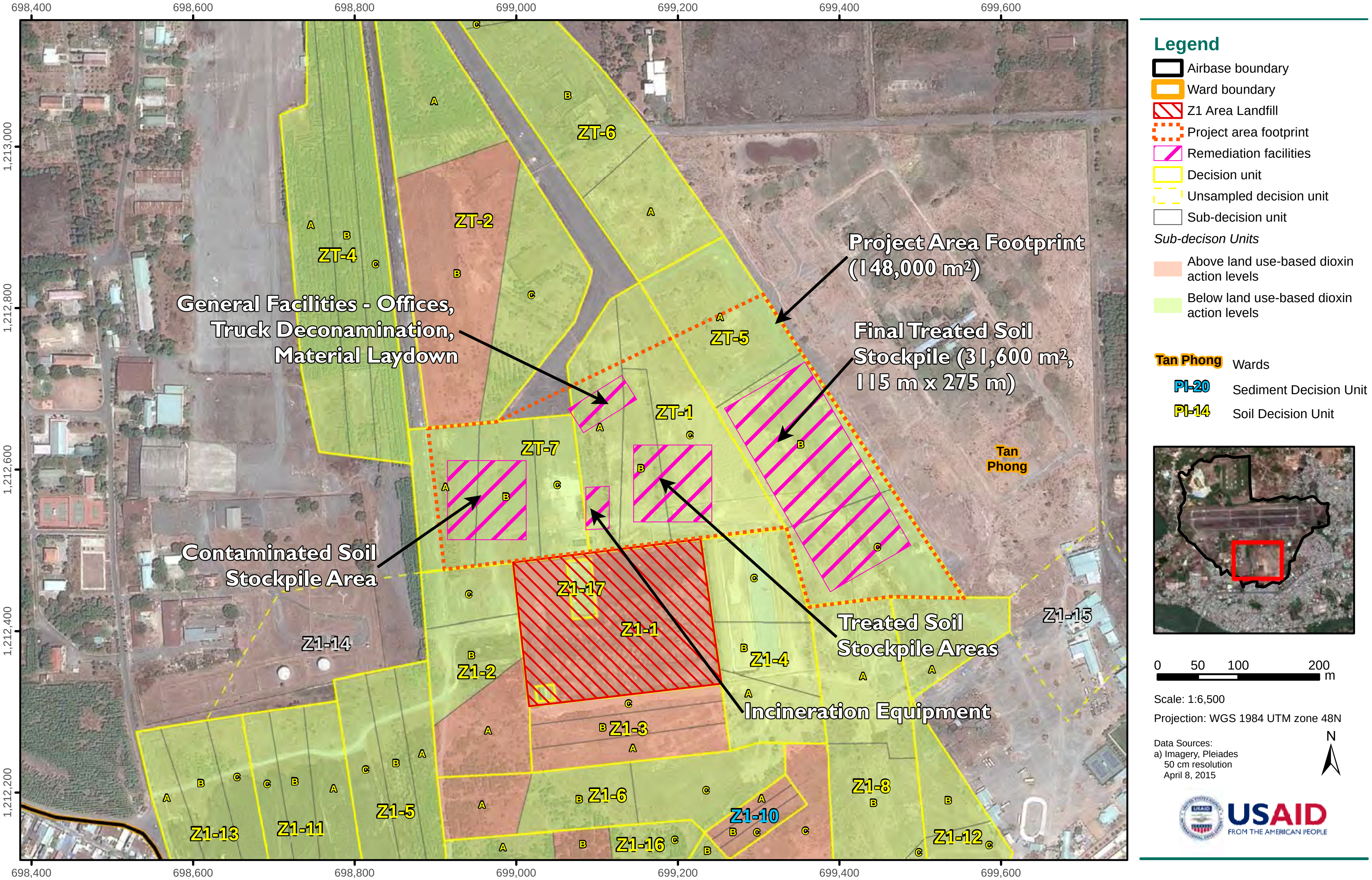
FIGURE 4-11 CONCEPTUAL LAYOUT OF ALTERNATIVE 5A IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM



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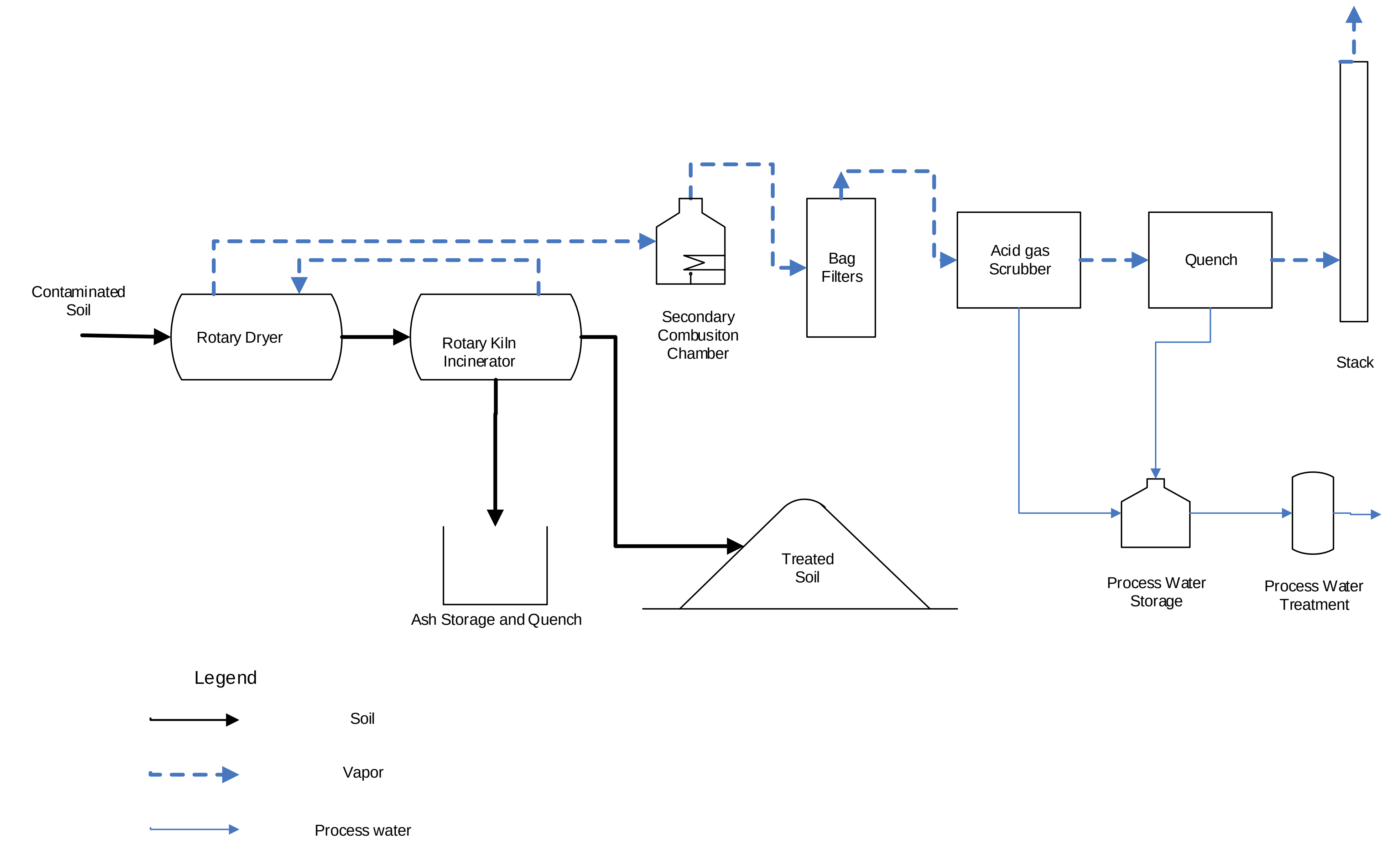

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Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase

Figure 4-12
Incineration Conceptual Process Flow Diagram

Figure 4-13 Alternative 5A Incineration Schedule

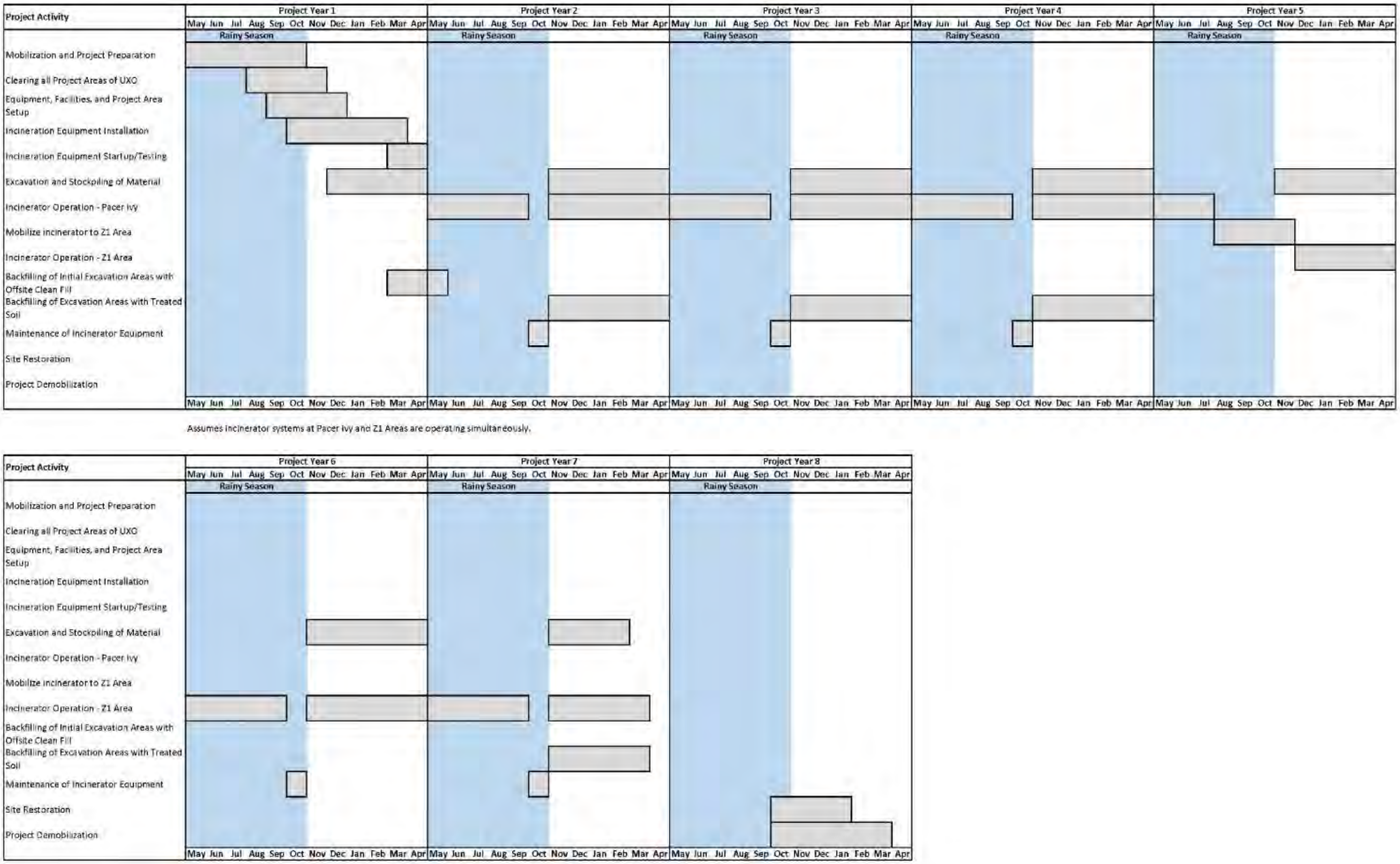

FIGURE 4-14 CONCEPTUAL LAYOUT OF ALTERNATIVE 5B IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

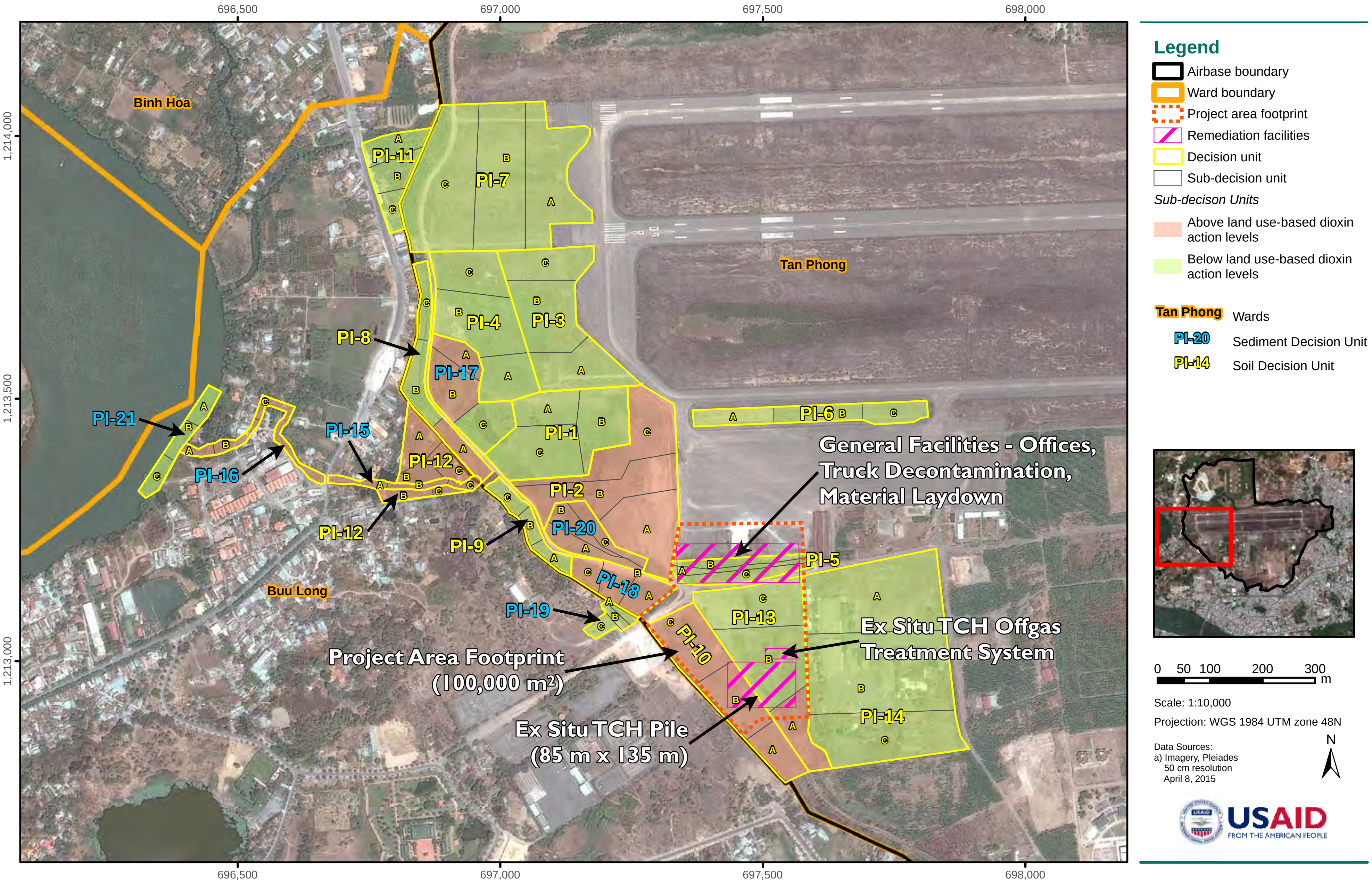

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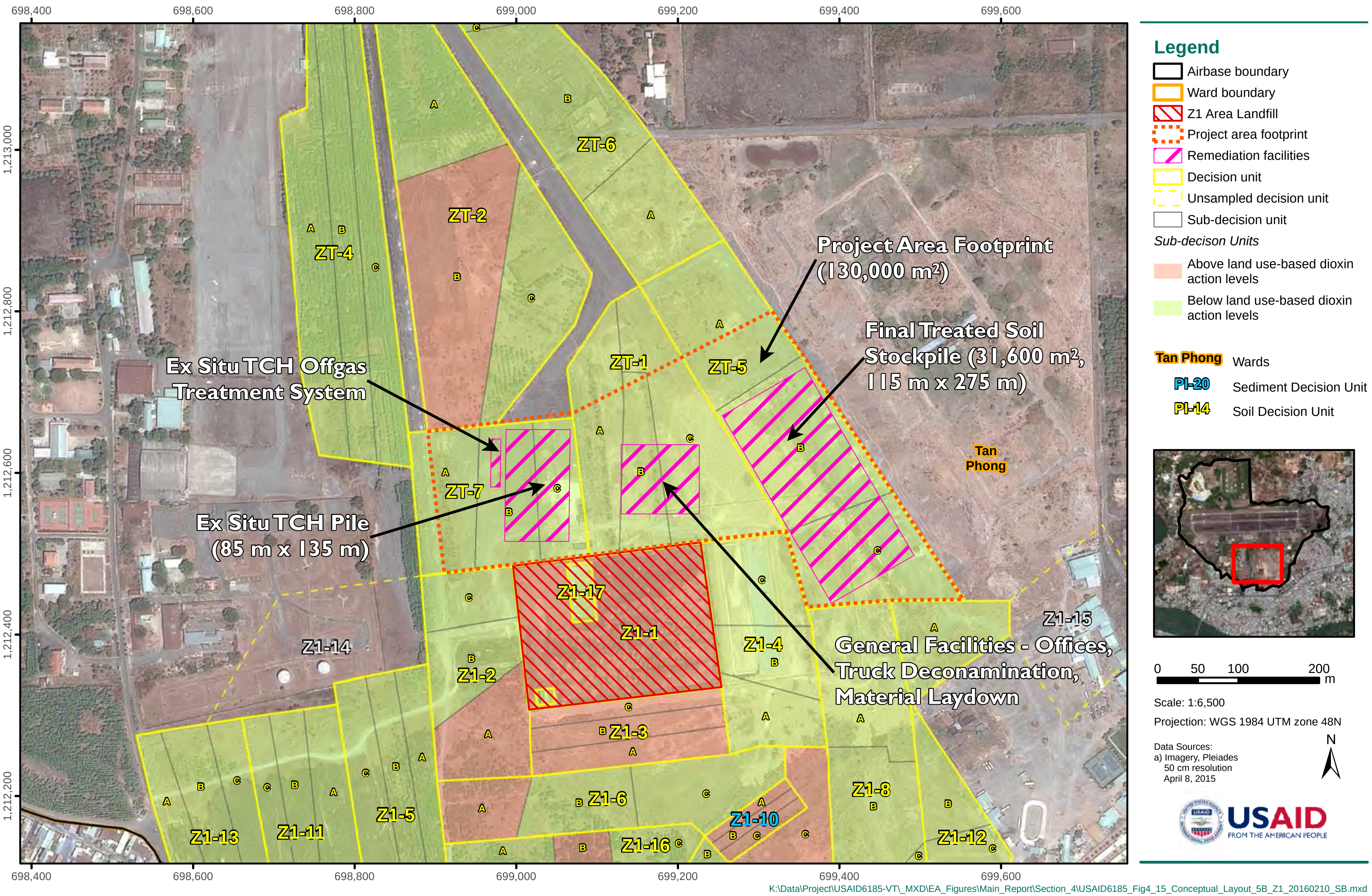
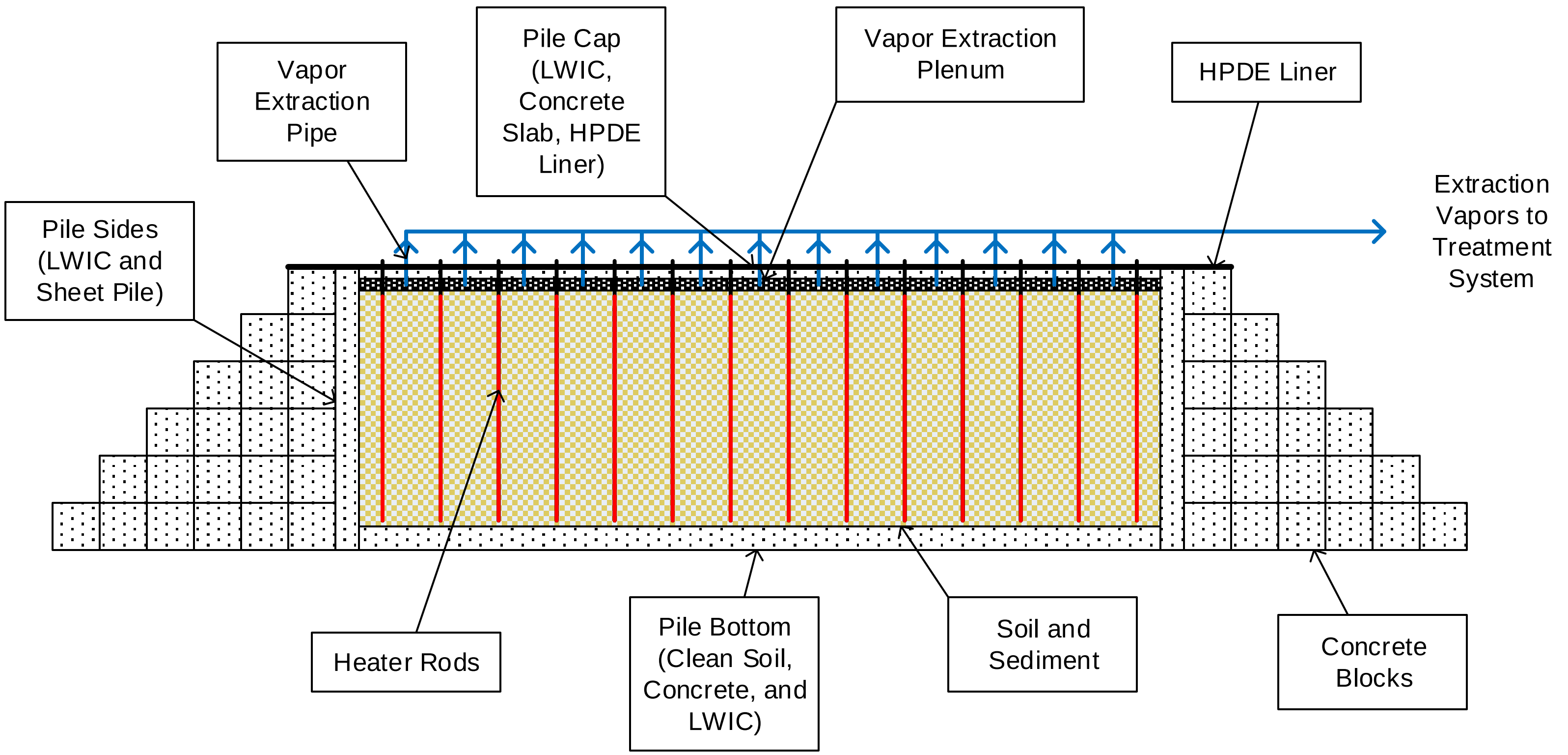
FIGURE 4-15 CONCEPTUAL LAYOUT OF ALTERNATIVE 5B IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM





Treatment Process:
1. Contaminated soil and sediment are loaded into the pile, which is then sealed.
2. Electrical power is applied to the heater rods, which convert electricity to heat via electrical resistance.
3. Heat is conducted out from the heater rods into the pile.
4. The heat boils water in the pile, and then drives the in pile temperatures higher. Insulation around the pile reduces heat losses.
5. Heated dioxin is degraded in the pile or volatilized and removed via vapor extraction piping.
6. Once the target temperature is maintained for the target duration, the pile is sampled to confirm dioxin removal.
7. Once the sample data indicates successful treatment, power to the pile is turned off.
8. The pile is emptied. The steps are repeated until no more contaminated soil or sediment remains to be treated.
9. The pile is demolished and the site is restored.

Not to Scale
LWIC = Lightweight Insulating Concrete

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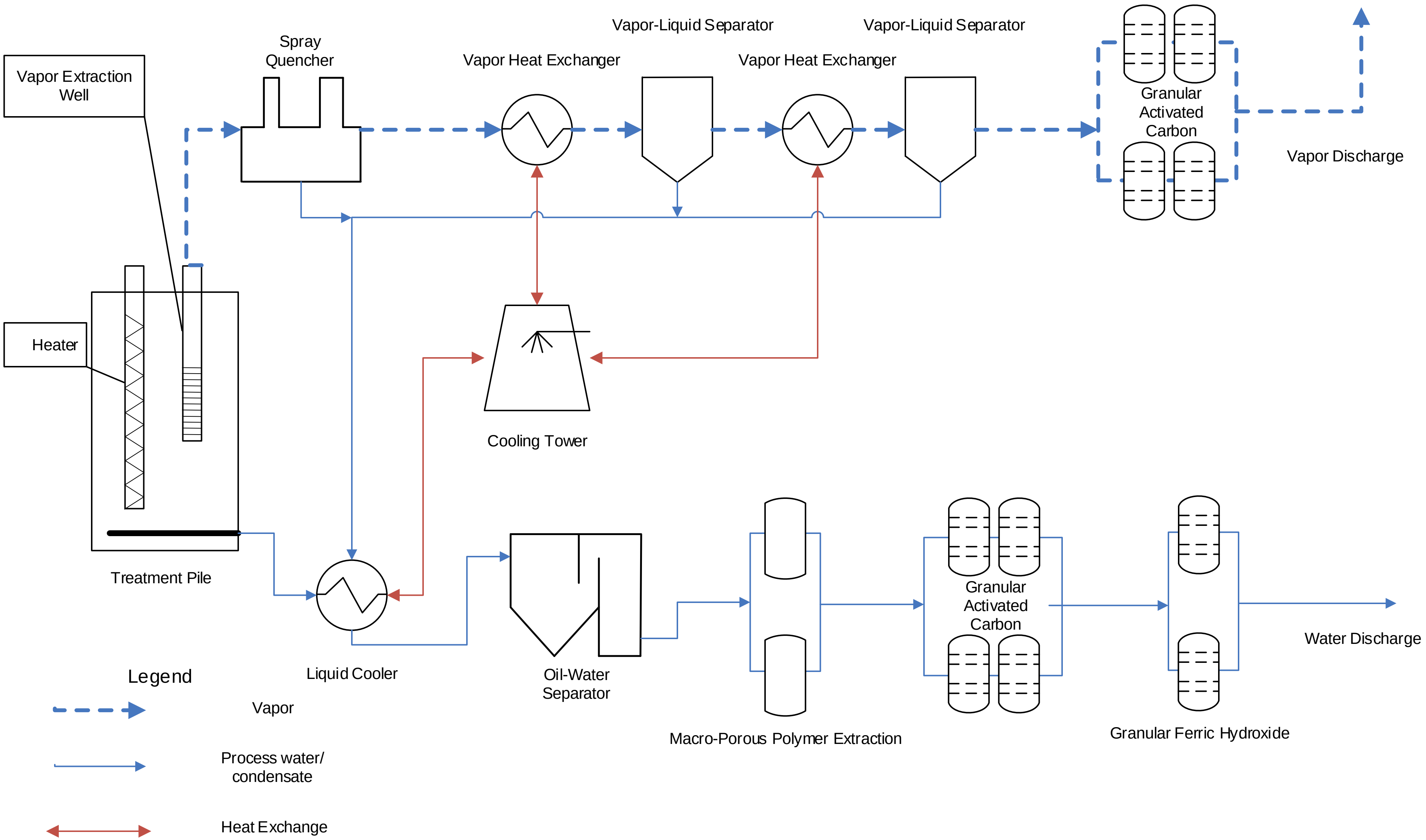
Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase

Figure 4-16
Ex-Situ TCH Conceptual Cross Section



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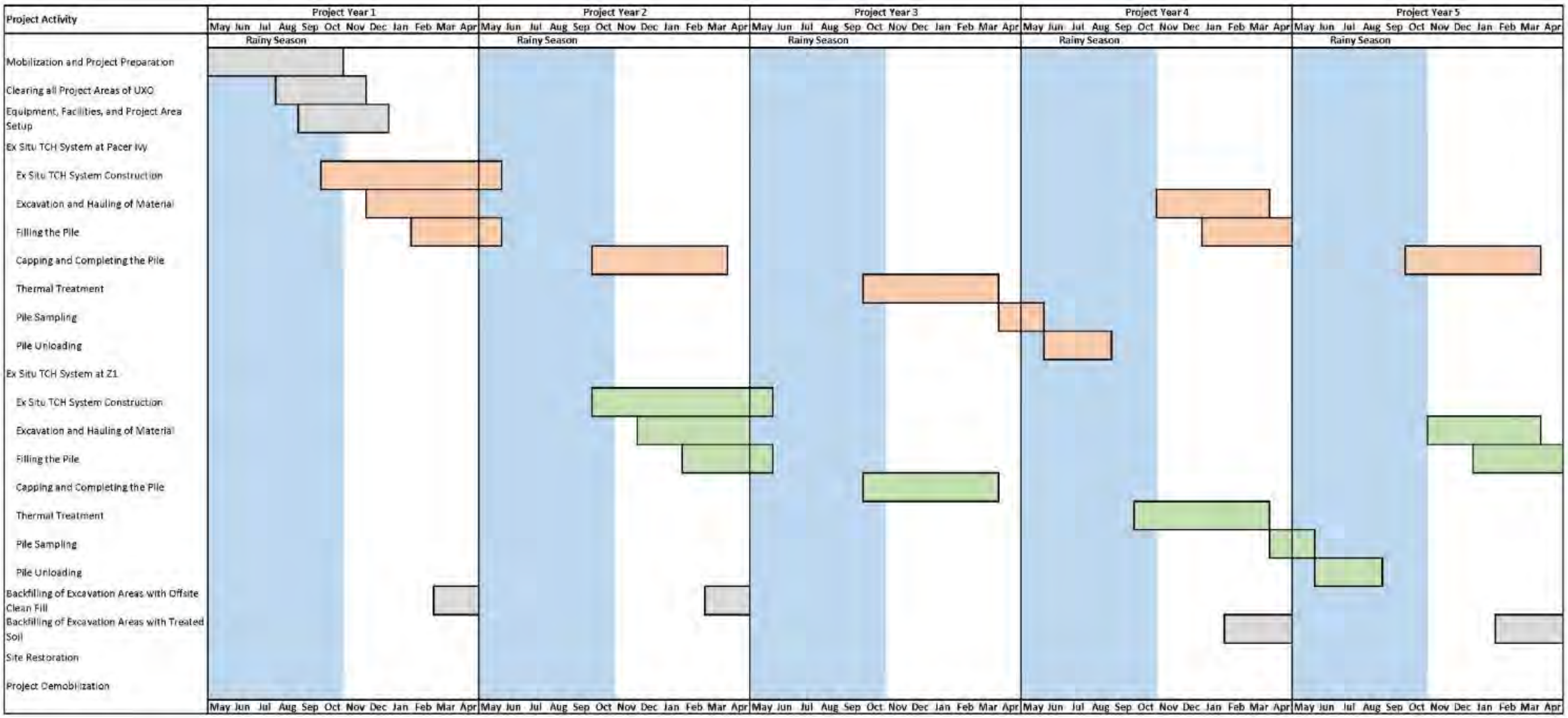
Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase

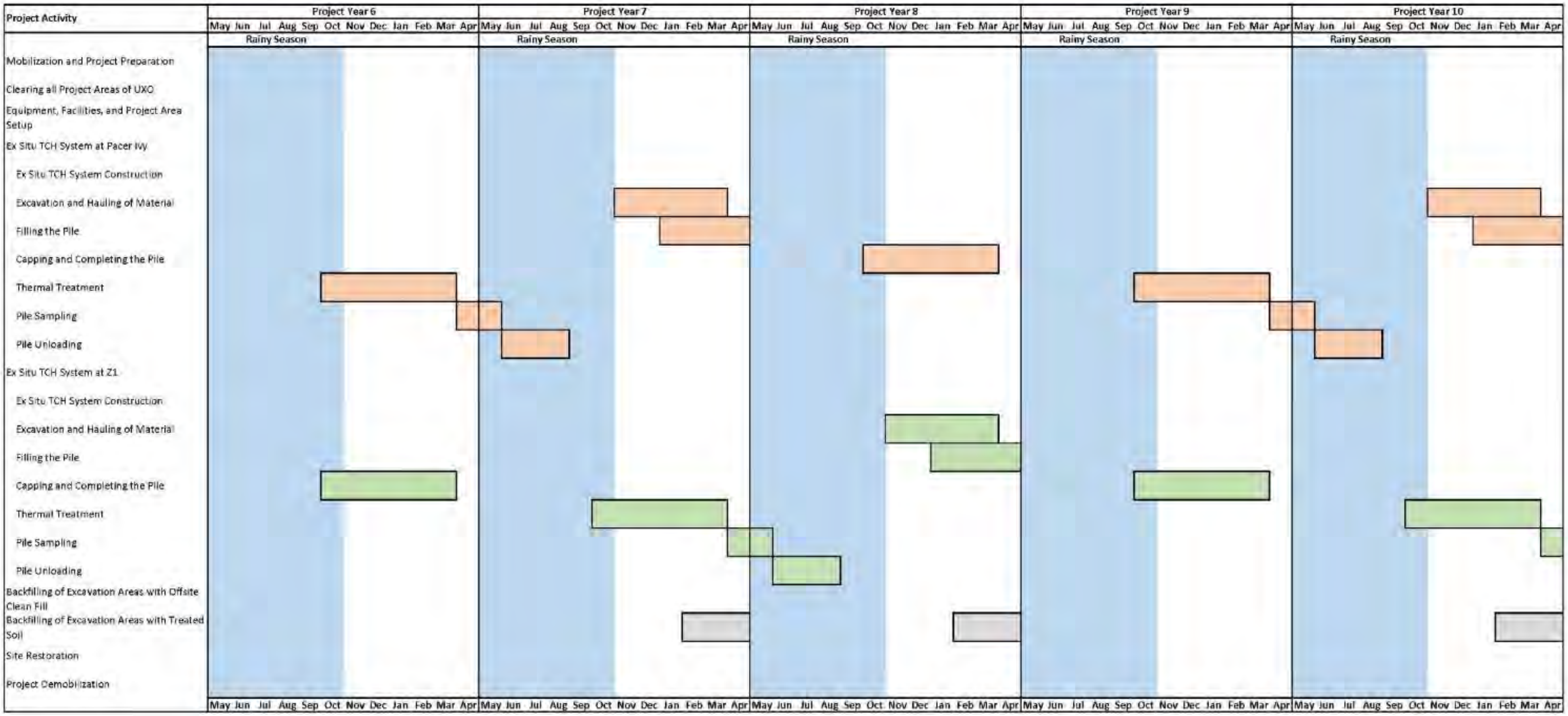
Figure 4-17
Ex-Situ TCH Treatment System Process Flow Diagram

Figure 4-18 Alternative 5B *Ex Situ* TCH Schedule



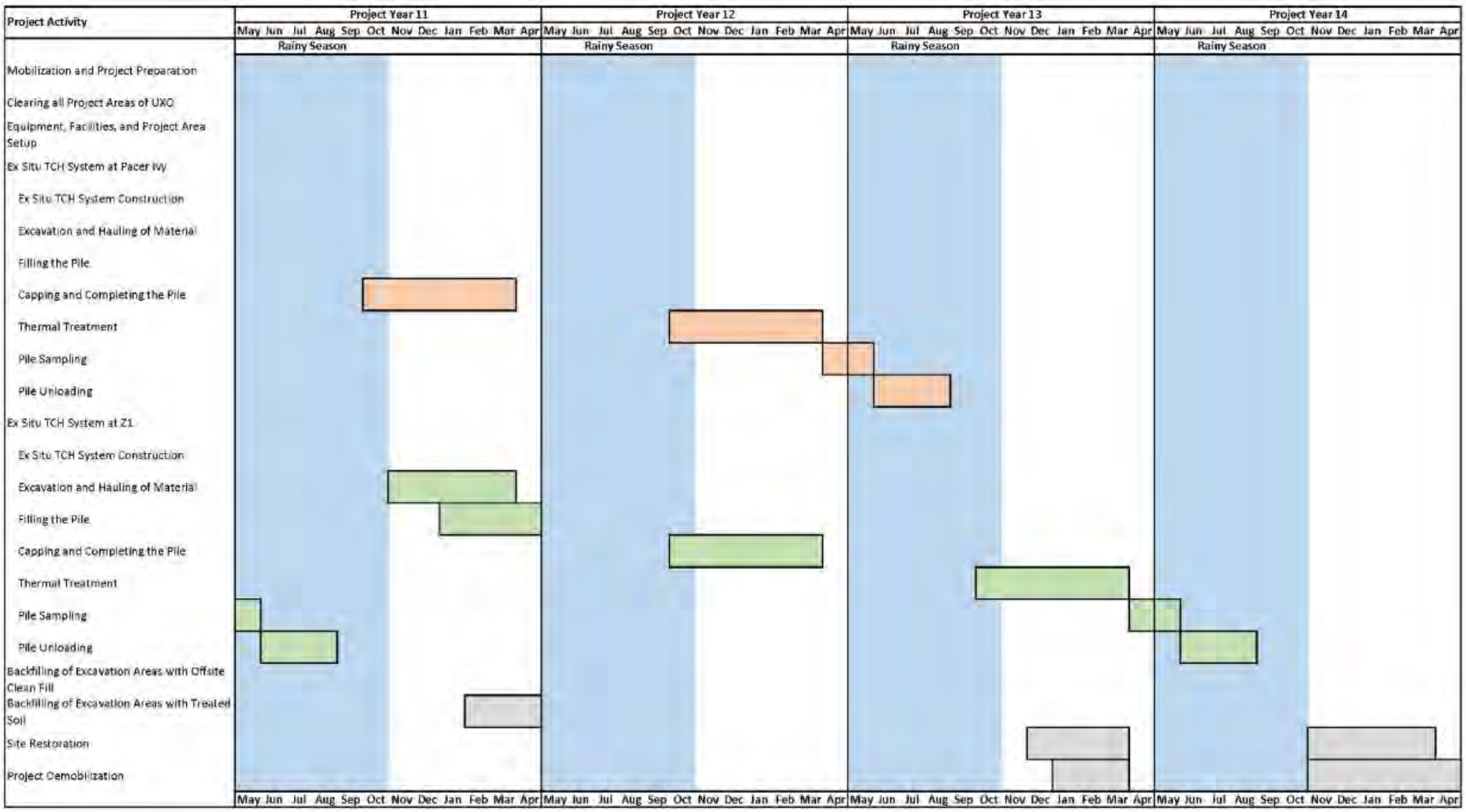
Assumes Ex Situ TCH systems at Pacer Ivy and Z1 Ex Situ TCH are operating in an alternating manner.

Figure 4-18 Alternative 5B *Ex Situ* TCH Schedule (continued)



Assumes Ex Situ TCH systems at Pacer Ivy and Z1 Ex Situ TCH are operating in an alternating manner.

Figure 4-18 Alternative 5B *Ex Situ* TCH Schedule (continued)



Assumes Ex Situ TCH systems at Pacer Ivy and Z1 Ex Situ TCH are operating in an alternating manner.

FIGURE 4-19 CONCEPTUAL LAYOUT OF ALTERNATIVE 5C IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

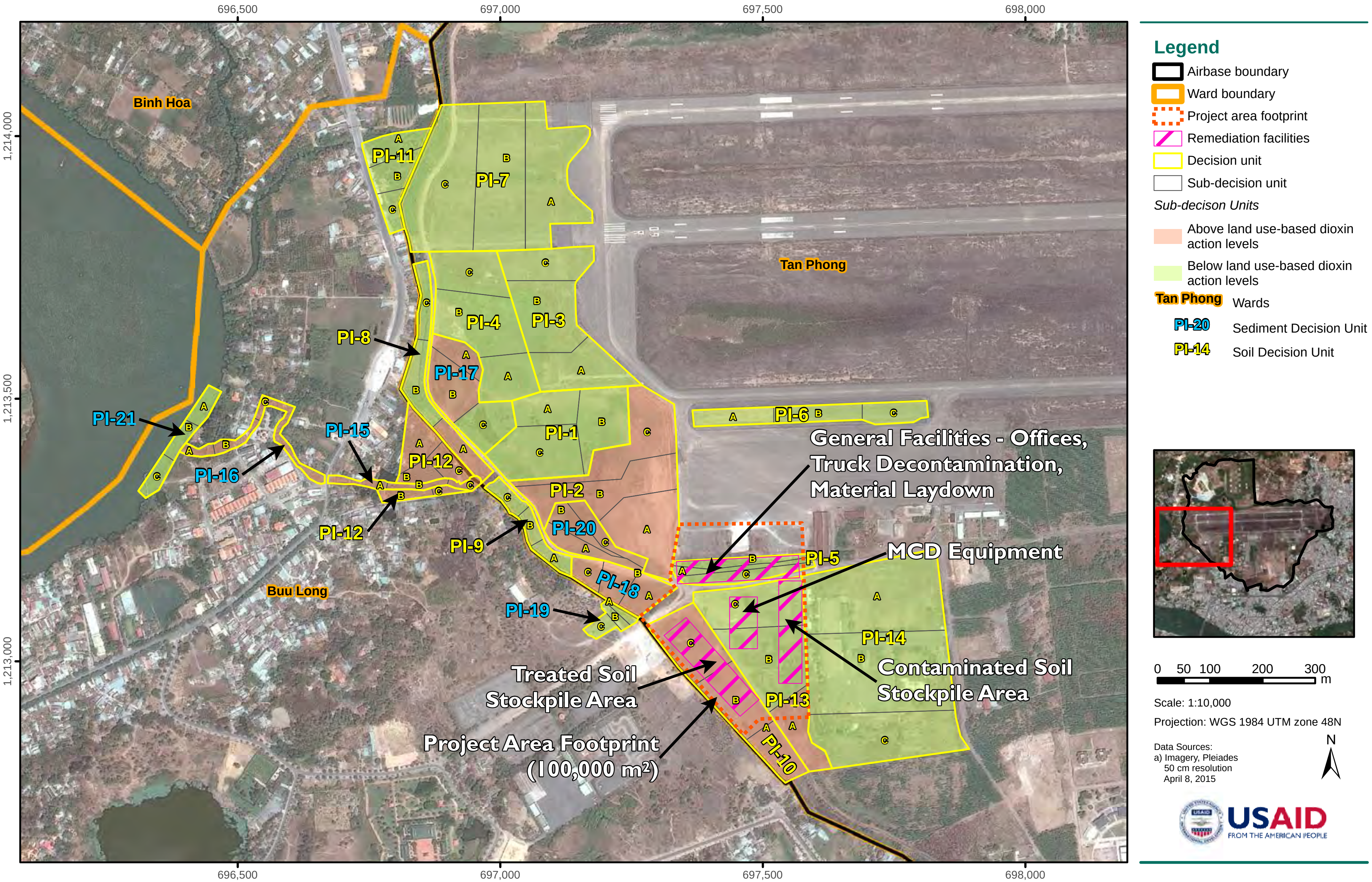


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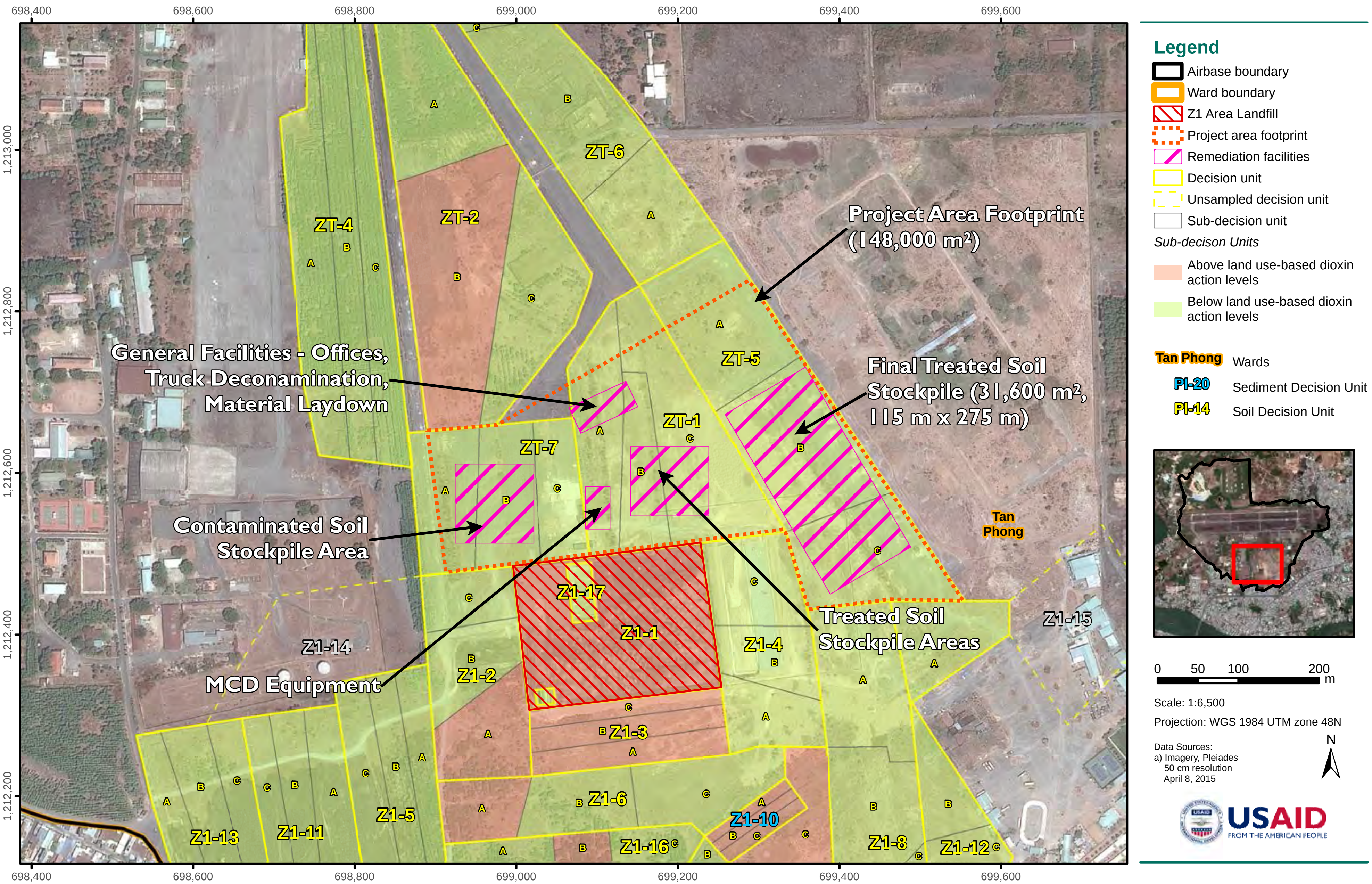
FIGURE 4-20 CONCEPTUAL LAYOUT OF ALTERNATIVE 5C IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM



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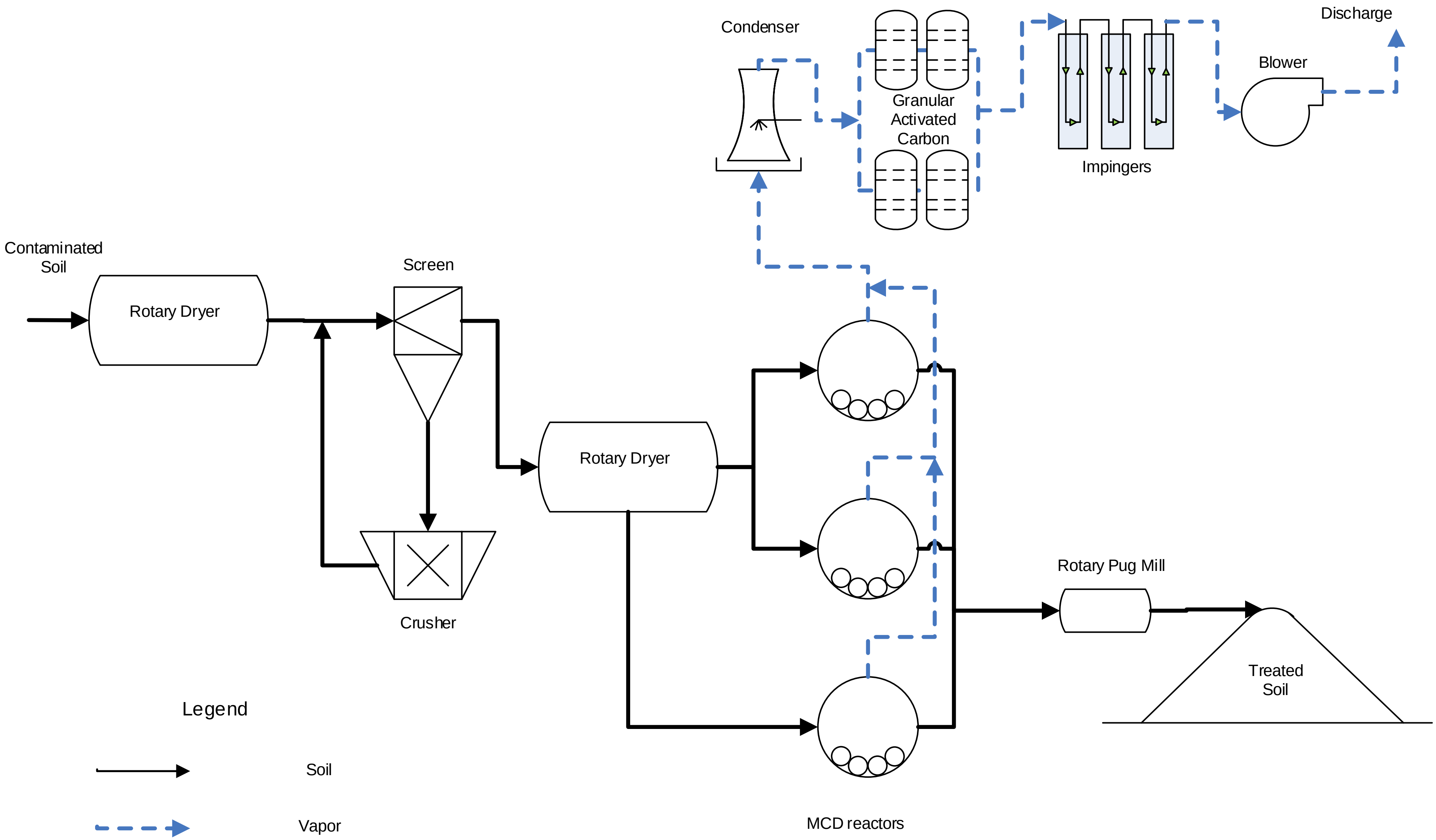

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Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase

Figure 4-21
Mechano-Chemical Destruction Conceptual Process Flow Diagram

Figure 4-22 Alternative 5C MCD Schedule

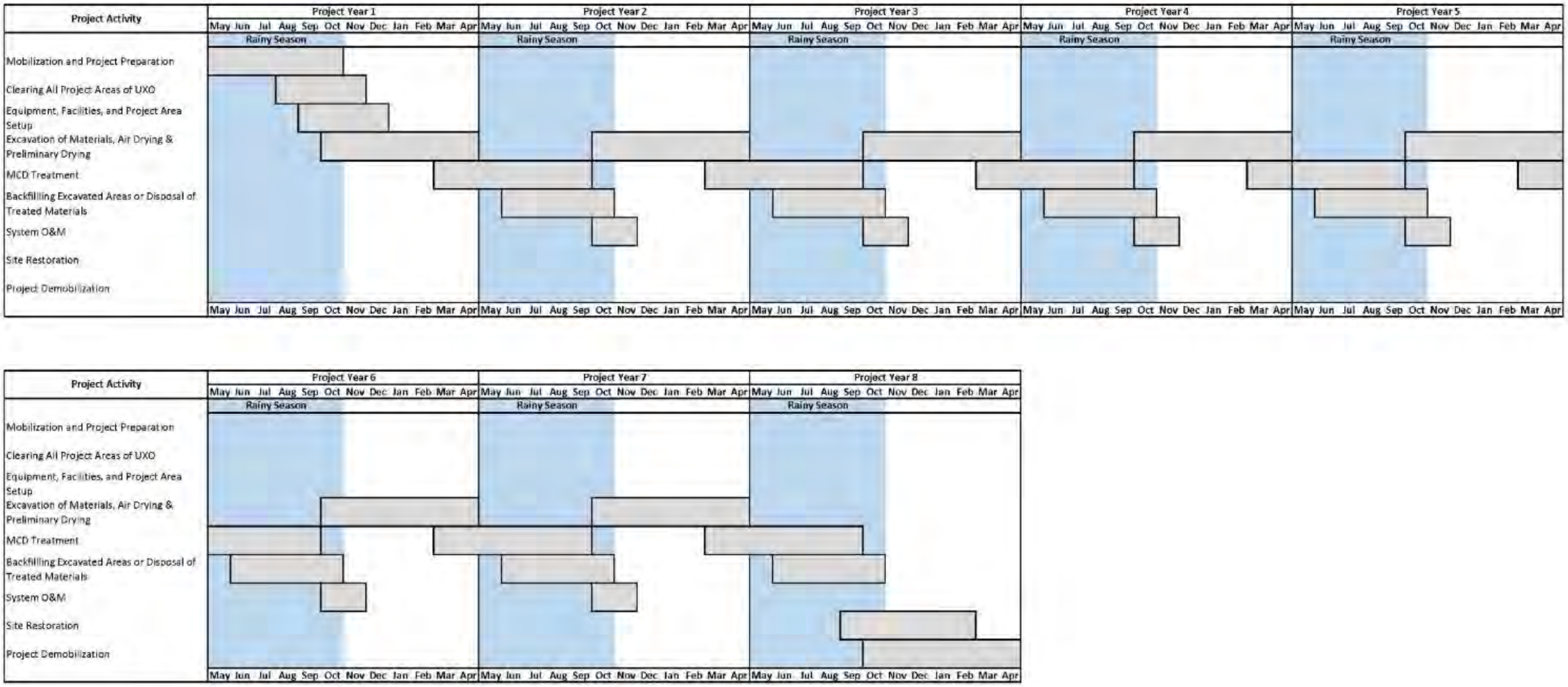

FIGURE 4-23 CONCEPTUAL LAYOUT OF ALTERNATIVE 3 IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

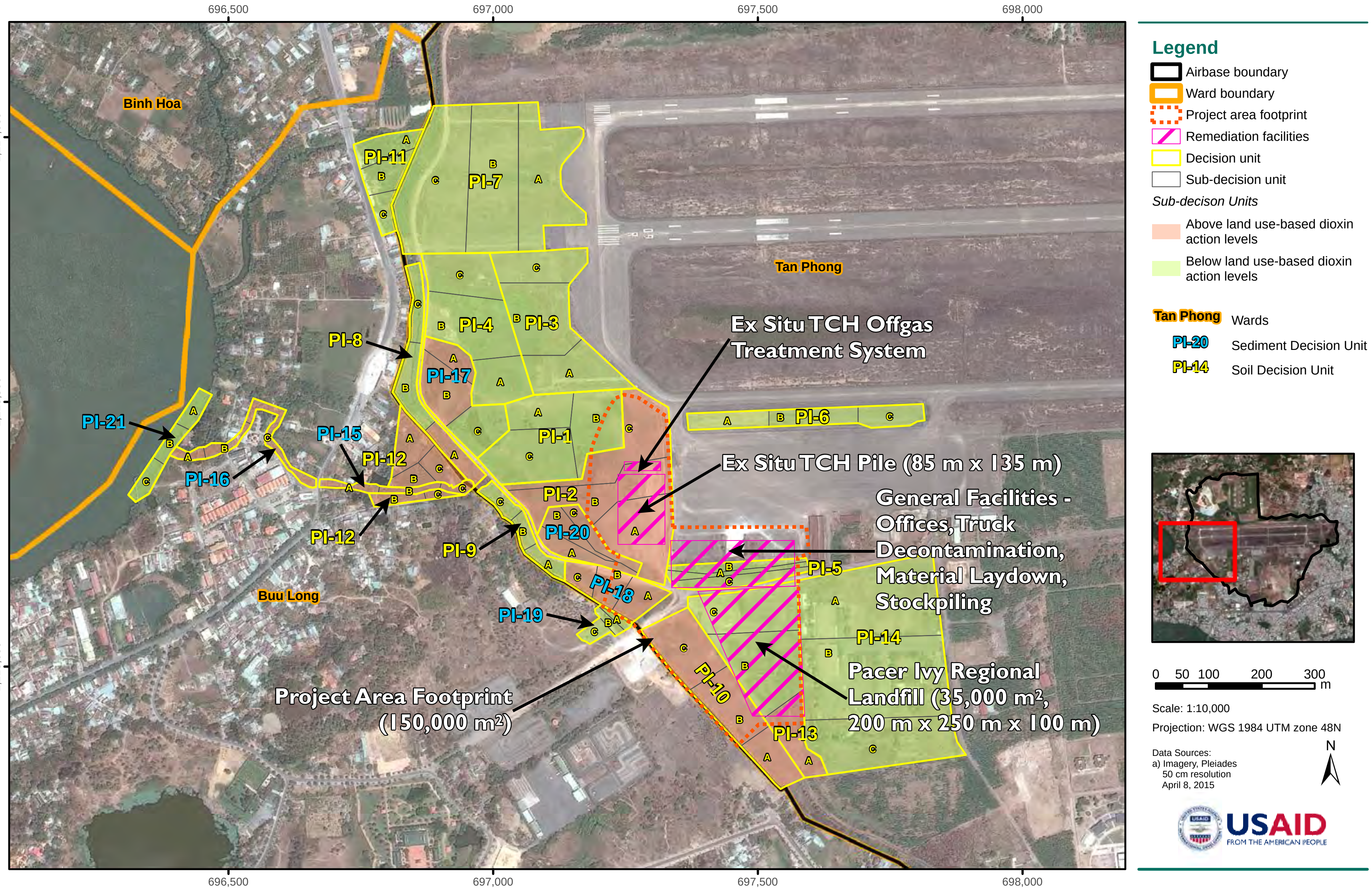

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FIGURE 4-24 CONCEPTUAL LAYOUT OF ALTERNATIVE 3 IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM

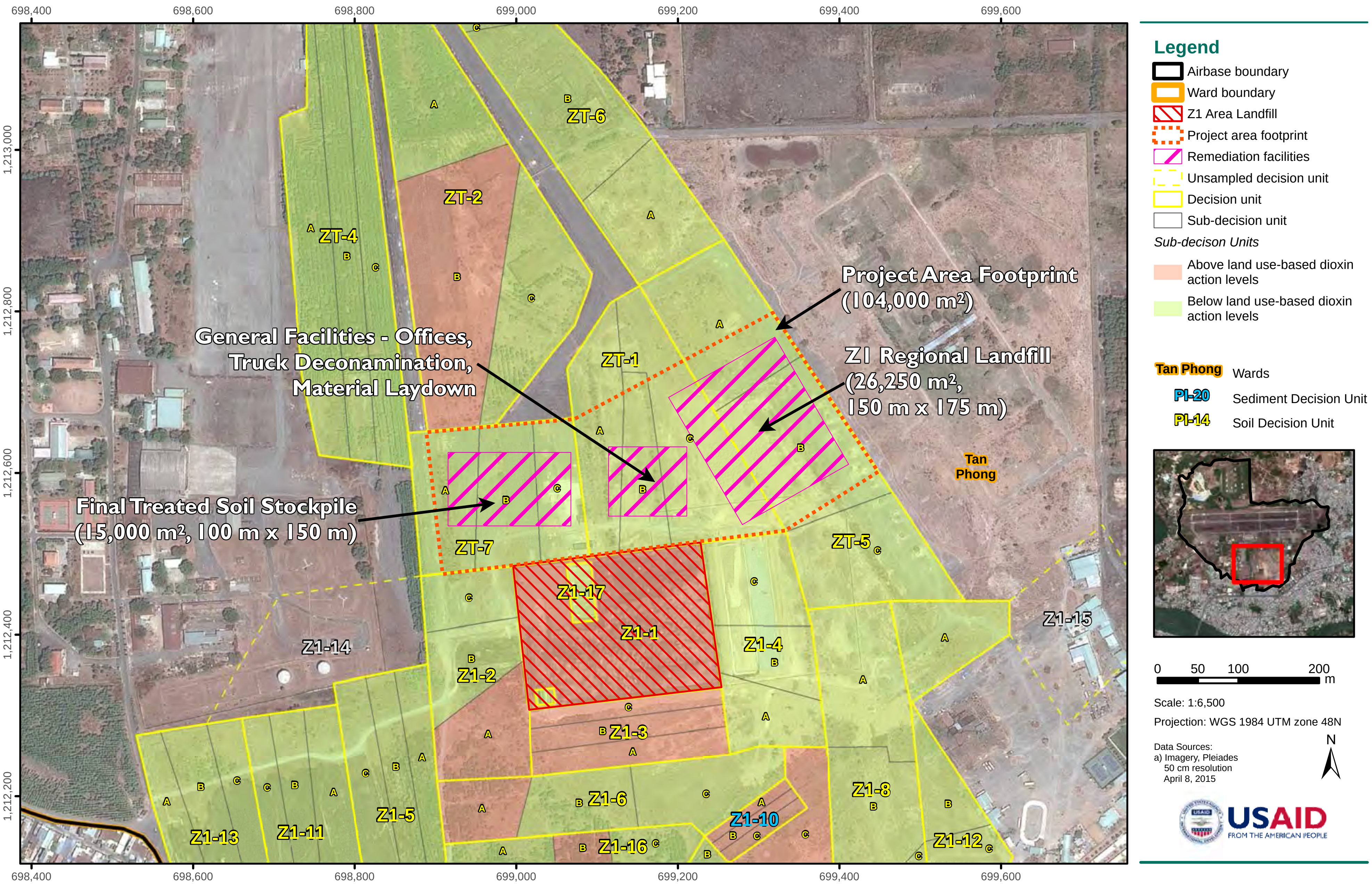

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Figure 4-25 Alternative 3 Containment/Treatment Hybrid (2,500 ppt) Schedule

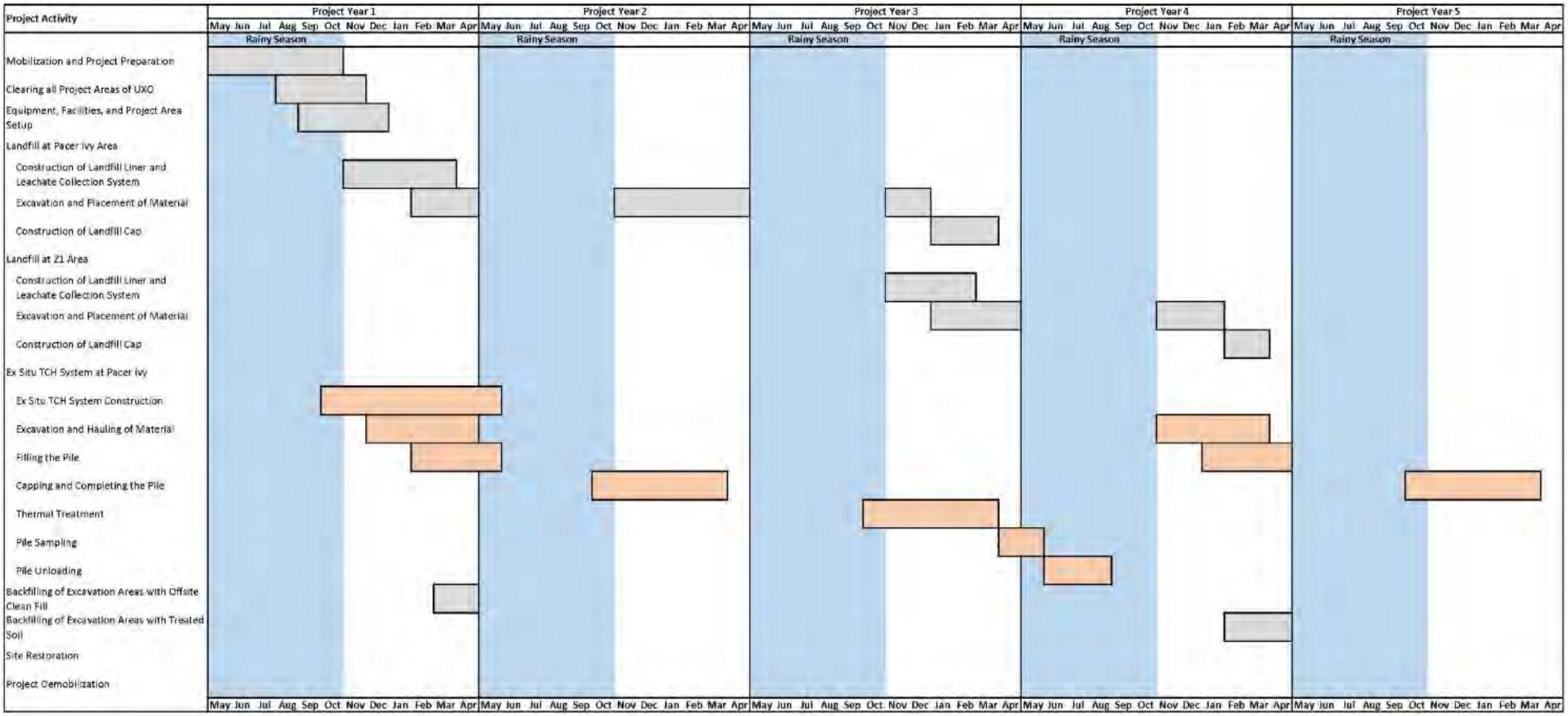

Figure 4-25 Alternative 3 Containment/Treatment Hybrid (2,500 ppt) Schedule (continued)

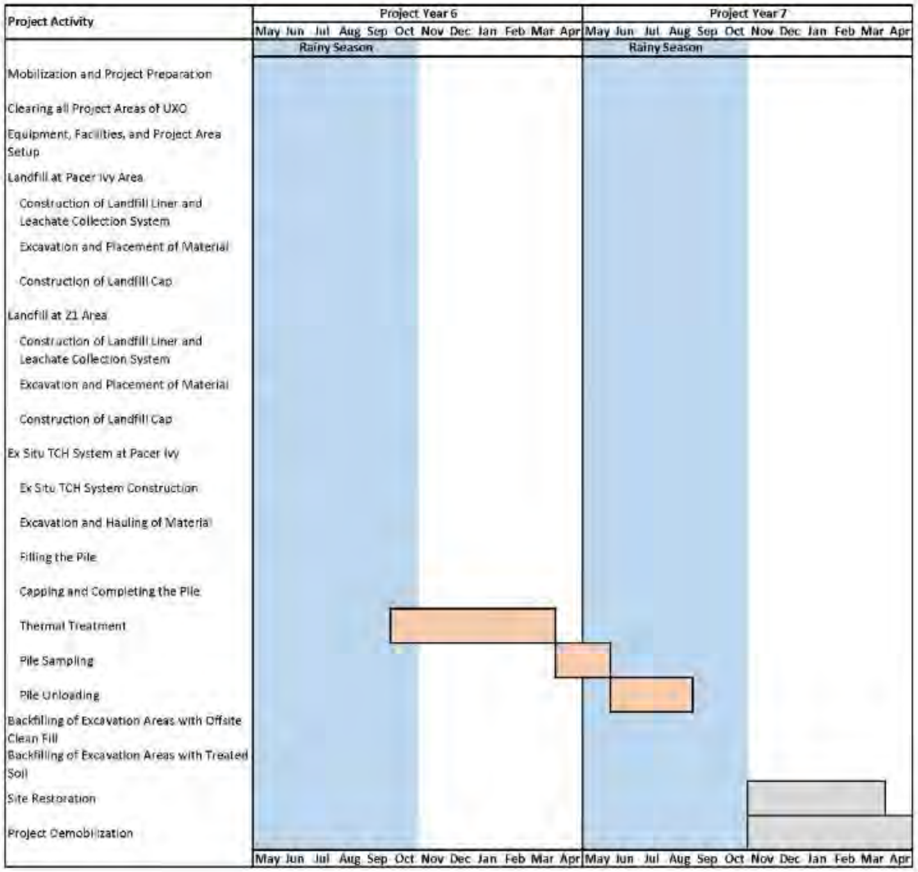

FIGURE 4-26 CONCEPTUAL LAYOUT OF ALTERNATIVE 4 IN THE PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM

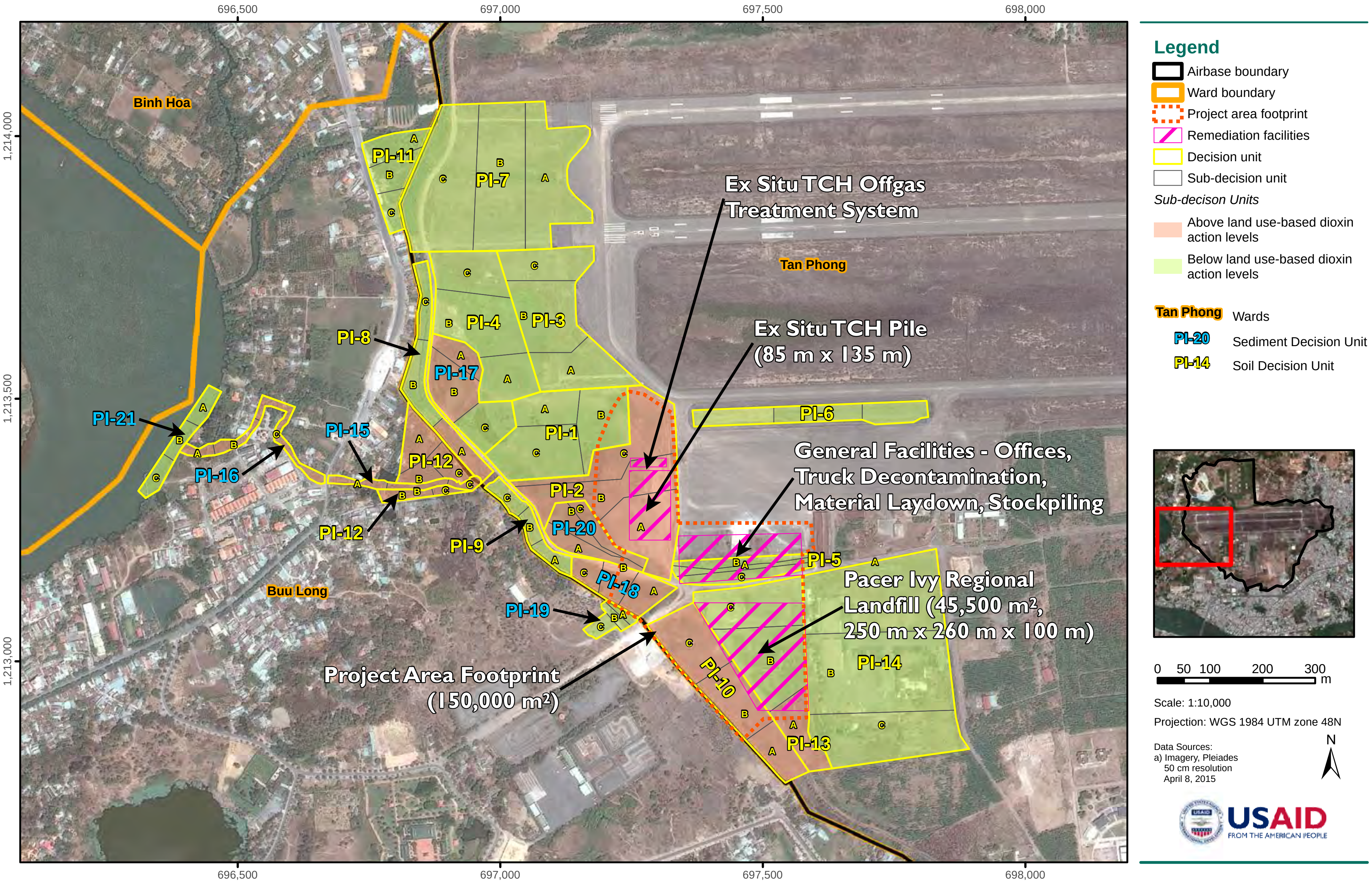

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FIGURE 4-27 CONCEPTUAL LAYOUT OF ALTERNATIVE 4 IN THE Z1 AREA, BIEN HOA AIRBASE, VIETNAM

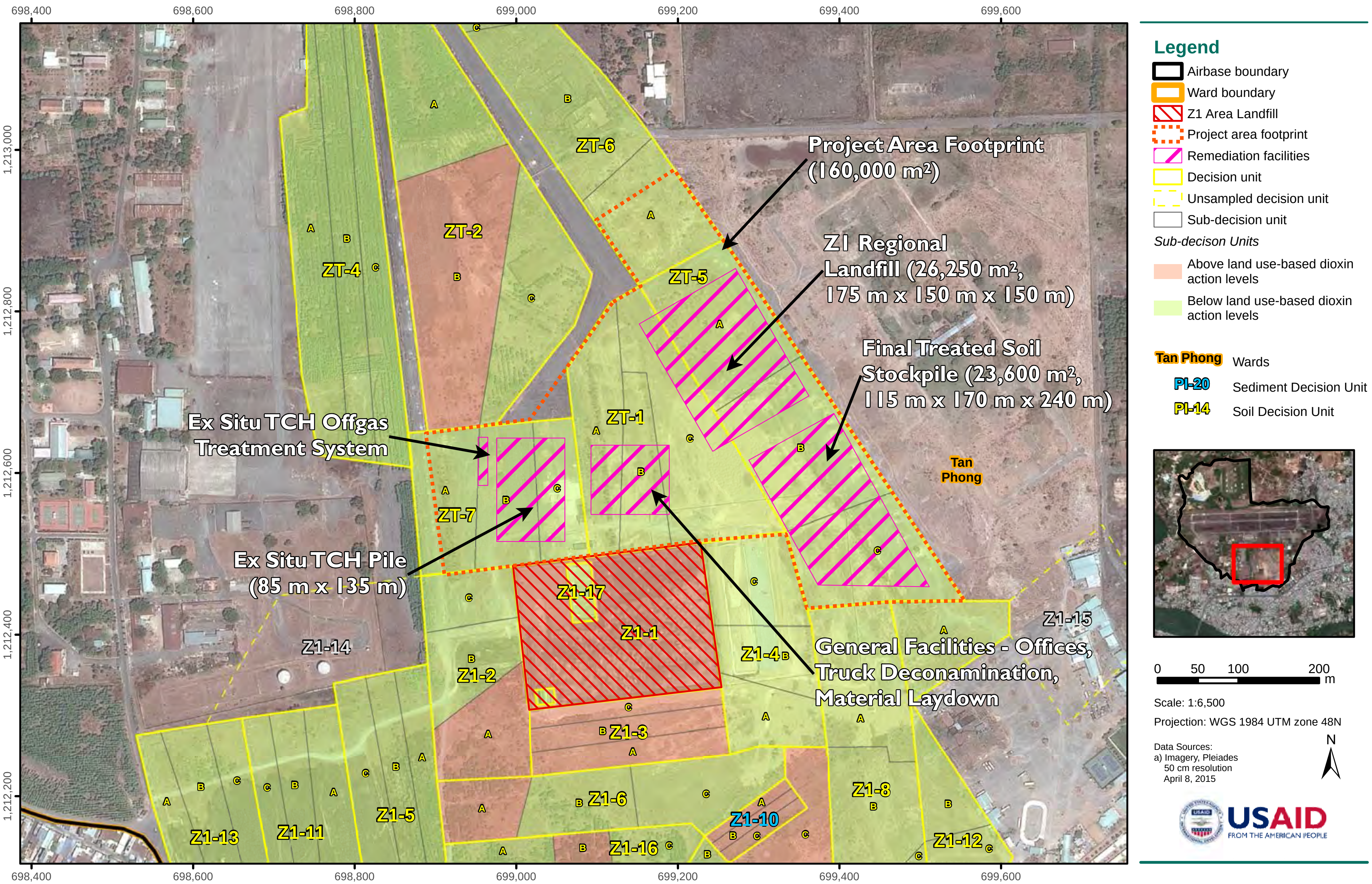

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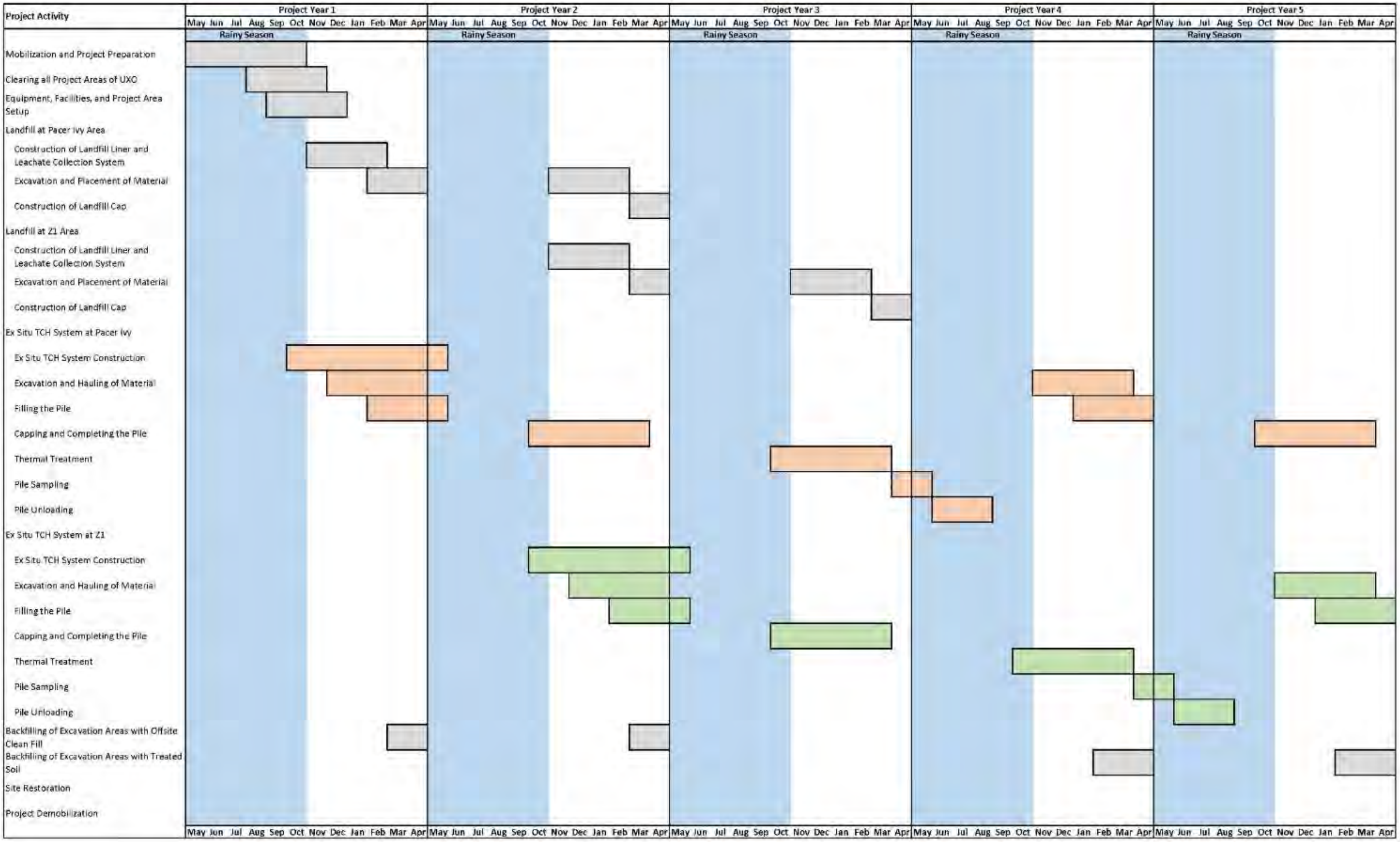
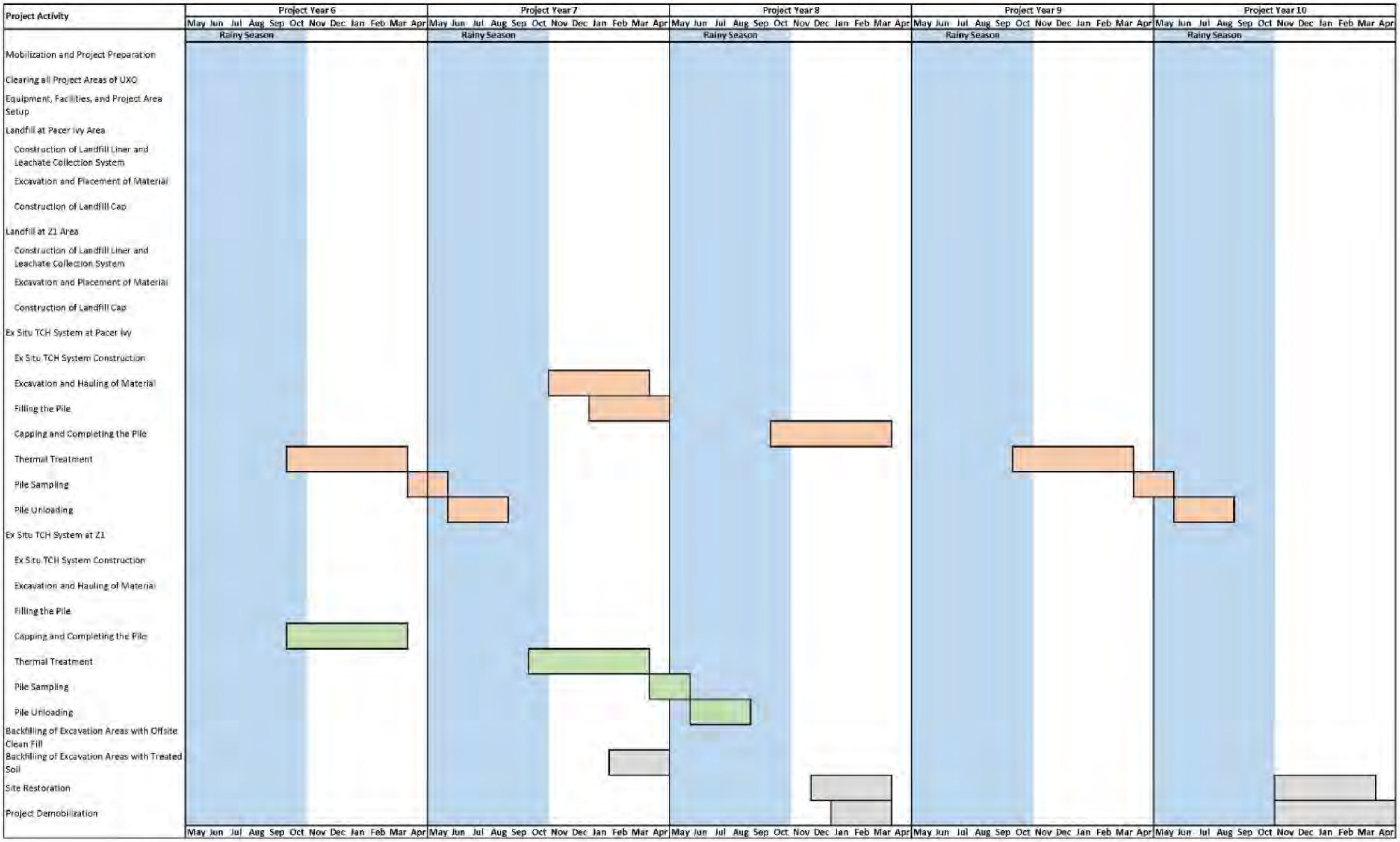
Figure 4-28 Alternative 4 Containment/Treatment Hybrid (1,200 ppt) Schedule



Assumes Ex Situ TCH systems at Pacer Ivy and Z1 Ex Situ TCH are operating in an alternating manner

Figure 4-28 Alternative 4 Containment/Treatment Hybrid (1,200 ppt) Schedule (continued)



Assumes Ex Situ TCH systems at Pacer Ivy and Z1 Ex Situ TCH are operating in an alternating manner.

Section 5 Affected Environment

This section presents a description of the environmental resources of the Airbase and Bien Hoa City that may be potentially influenced by one or more of the remedial alternatives.

Existing baseline information on most environmental resources related to the Airbase and Bien Hoa City is limited. In particular, a detailed description of the temporal and spatial variability of most of the environmental resources does not exist.

This is particularly the case for key environmental resources outside the Airbase that may be affected by any selected remedial alternative. While **Section 3.1** provides a general socioeconomic overview of the Bien Hoa City and of the wards immediately surrounding the Airbase, there is little information on environmental resources in the wards that surround the Airbase, including surface water and groundwater resources and air quality. The province of Dong Nai conducts annual monitoring programs for these environmental resources but these programs generally consist of a small number of monitoring locations throughout the entire province that are meant to be representative of similar conditions and economic activities for the provinces as whole. The locations in the city of Bien Hoa that are monitored under these programs tend to be located in industrial processing zones some distance from the Airbase.

While the quality of the current environmental baseline does not limit the ability to assess the environmental effects of the remedial alternatives, it will be necessary to continue to augment the environmental baseline with additional field programs if a remediation alternative is selected, both on the Airbase and in key areas and locations outside the Airbase. This would provide information required for an EIA that may be prepared by GVN prior to the start of the implementation of the selected alternative.

5.1 Physical Environmental Resources

5.1.1 Climate

Climate in Bien Hoa City is characterized by a dry season lasting from November to April and a rainy season lasting from May to October. Average annual rainfall is approximately 1,300 mm with historically 90% percent of total annual rainfall occurring in the rainy season (May to October); 16% percent of total annual rainfall historically occurs in the month of June.

The climate in Bien Hoa City (**Figure 5-1**) is characterized by:

- An average annual temperature of 27.3°C.
- An average humidity of 76%.
- An average annual rainfall of approximately 1,300 mm.
- A dry season lasting generally from November through April and a rainy season lasting generally from May through October. Approximately 90% of the total annual rainfall occurs during the rainy season.
- Predominantly south and southeast winds in the dry season and predominantly southwest winds in the rainy season.

With respect to climate change, research and assessments conducted by GVN indicate:

- Current long term projections are for an increase in mean annual temperature and mean annual precipitation of 1°C and 0.7%, respectively, by 2050 for the southern part of the province of Dong Nai (MONRE 2009, high emission scenario).
- The best current predictions are that Bien Hoa City and the entire province of Dong Nai will be relatively unaffected by inundation from sea level rise occurring as a result of climate change, with only modest effects on population and infrastructure (International Centre for Environmental Management [ICEM] 2008).
- Shorter-term impacts may include higher-intensity typhoons and extreme weather events occurring more frequently (MONRE 2009).

5.1.2 Site Topography and Surface Water Hydrology

Bien Hoa City is situated in the lowermost portion of the Dong Nai River watershed, approximately 8 km upstream of where the tidally influenced Dong Nai River becomes the Nha Be River as it enters Ho Chi Minh City. It eventually merges with the Sai Gon River before it discharges to the Can Gio Mangrove Nature Reserve (approximately 30 km downstream of Bien Hoa City and therefore unlikely to be affected by implementation of any remediation alternative) and the South China Sea.

The Airbase has little topographic relief, like much of the districts of Bien Hoa that adjoin the Airbase. The northern portion of the Airbase is slightly more elevated (north to south slope direction); surrounding areas, such as the Buu Long Tourist Area, are at higher elevation than the Airbase property.

Drainage/surface water flow from the Airbase generally flows west, south and southeast, eventually flowing into the Dong Nai River. Nghiem and Trinh (2014) summarize the drainage patterns of the Airbase as follows (**Figure 5-2**):

- There are 32 lakes on the Airbase property whose surface elevations and size vary between dry season and rainy season conditions.
- The northeastern part of the Airbase is at a higher elevation than the rest of the Airbase property and runoff from the northern part of the Airbase is generally to the southeast.
- The western and northwestern part of the Airbase drains into the Airbase drainage system, then into the drainage system of Buu Long Ward to the southwest of the Airbase and into the Dong Nai River.
- The eastern part of the Airbase drains into the Airbase drainage system, then into the drainage system of Tan Phong and Tong Nhat Wards to the southeast of the Airbase and into the Dong Nai River.
- The southern part of the Airbase drains generally southward into Gate 2 Lake and through Bien Hoa City's sewer system in Quang Binh and Trung Dung Wards and eventually into the Dong Nai River.

5.1.3 Soils and Sediments

The geological conditions of the Airbase are summarized in Dekonta (2014):

- The Airbase area is formed by sediments from river-sea-swamp of Pleistocene with components of clay, loam, mixed sand and clay. The thickness of this sedimentary complex reaches 22 to 25 m, with lower bedrock formed by Mesosoic grey-blue clay shale or greenish silt shale.
- The Pleistocene sedimentary complex consist of three layers as follows:
  - 1st layer: Red-brown sandy clay of laterite, semi-hard. The thickness of this layer varies from 3.8 m to 5.2 m and tends to increase in depth from the northern to the southern parts of the Airbase. The composition of this layer averages 44% clay; 25% sand, and 17% silt, with the rest being comprised of lateritic rock.
  - 2nd layer: Grey-brown silty clay with a thickness from 8.2 m to 10.5 m and the composition averages 41% clay; 10% sand, and 49% silt.
  - 3rd layer: Yellow-brown soft, silty clay, reaching a depth of up to 23.5 m and the composition averages 47.8% clay; 18% sand, and 33% silt.

A limited amount of sampling for soil properties was conducted as part of the 2014/2015 EA sampling program. Soils on the Airbase were found to be primarily sandy with lower and relatively similar amounts of silt and clays and small amounts of gravel, down to depths of more than 1 meter (**Appendix E, Table E1**), confirming the findings reported in Dekonta (2014), and reflecting the fact that the Airbase is situated in a depositional zone of the Dong Nai River. Soils and sediments on the Airbase were observed to have pH values ranging from 4.8 to 7 and total organic carbon from 1,900 to 9,100 mg/kg (**Table E1**).

The soil monitoring program in the province of Dong Nai that is implemented by the Dong Nai Center for Monitoring and Environmental Engineering focuses in Bien Hoa City on industrial zones and monitors for relatively few chemical constituents. Results of monitoring to date, however (e.g., Dong Nai Center for Monitoring and Environmental Engineering 2012, 2013) indicates relatively few exceedances of national soil quality guidelines in the chemical constituents that were sampled at locations in Bien Hoa City.

5.1.4 Groundwater Resources

The groundwater table of the uppermost aquifer occurs at a depth of 1 m to 3 m at the end of rainy season and 3 m to 5 m at the end of the dry season (Dekonta 2014); inferred groundwater flow directions on the Airbase are shown in **Figure 5-2**.

5.1.5 Groundwater Quality

The current understanding of groundwater quality on the Airbase is poor. Only basic groundwater quality information is available for a few locations on the Airbase, and little information exists on concentrations of many COPCs. In addition, while there is a groundwater quality monitoring program in the province of Dong Nai, the program consists of a small number of monitoring locations throughout the entire province that are meant to be representative of similar conditions and economic activities in the province as a whole. The monitoring locations in the city of Bien Hoa are restricted to industrial processing zones some distance from the Airbase.

A groundwater monitoring program is part of a long-term monitoring plan designed for the Airbase with development assistance provided by the Czech Republic (Dekonta 2013, 2014). The monitoring program includes six groundwater sampling locations (**Figure 5-2**): four wells in the vicinity of the Z1

Area; one well in the Southwest Area; and one well in the Pacer Ivy Area, and builds from an initial survey of groundwater resources conducted on the Airbase in 2012 (Dekonta 2013, 2014).

The data provided in Dekonta (2014) indicates detectable concentrations of dioxin in all but one of six groundwater wells established and sampled (**Figure 5-2, Table A18**). Detections of 2,3,7,8-TCDD in these wells ranged from a non-detectable concentration to 17 pg/L. There is no GVN standard for dioxin concentrations in surface water or groundwater but all of these concentrations are below the USEPA MCL for drinking water for 2,3,7,8-TCDD of 30 ppq. Picloram (a component of Agent Orange and Agent White) was also detected at all six groundwater wells ranging from 0.484 micrograms per liter (μg/L) to 1,050 μg/L (**Table E7**, the USEPA MCL for picloram is 500 μg/L). Concentrations of 2,4,-dichlorophenol (2,4-D) and 2,4,5-trichlorophenol (2,4,5-T) in one of the wells was also found to be above USEPA standards for these chemicals. Concentrations of all organochlorine pesticides were below detection limits in the 2012 groundwater monitoring program results reported in Dekonta (2014, **Table E7**). Similarly, concentrations of heavy metals in the 2012 groundwater monitoring program were below detection limits, as were the constituents of benzene, toluene, ethylbenzene, and xylene (**Table E8**).

The same groundwater wells were sampled as part of the 2014/2015 EA sampling program, and results indicate higher concentrations of metals than measured in 2012 by Dekonta (2014), but relatively few exceedances of GVN or USEPA standards. Picloram concentrations remained above USEPA standards at well MW-5 (in the Southwest Area), the same location where picloram concentrations were measured to be above guidelines in Dekonta (2014).

5.1.6 Surface Water Quality

No surface water quality information exists for the small watercourses that drain the Airbase. A surface water quality monitoring program is part of a long-term monitoring plan designed for the Airbase (Dekonta 2013)[5] but to date surface water quality monitoring has not yet begun.

Water quality of the lower Dong Nai River where the Airbase is situated is acknowledged to be extremely poor (World Bank 2007) given the extensive industrial development in the lower watershed of the Dong Nai River and in Dong Nai Province in general. The province of Dong Nai conducts monthly water quality monitoring in the Dong Nai River for a relatively small set of water quality variables and maintains a number of water quality monitoring stations on the Dong Nai River immediately downstream of the Airbase. Monitoring reports prepared for this program (e.g., Anon 2011, **Table E12**) indicate highly-degraded water quality in the Dong Nai River near Bien Hoa City.

5.1.7 Air Quality

There is no air quality information for the Airbase itself. There are periodic air quality campaigns conducted in Bien Hoa City by the province of Dong Nai; monitoring results to date (an example is provided in **Table E13**) indicate generally good air quality for the parameters sampled with the

[5] The proposed monitoring program includes five surface water quality sampling locations: two locations on the watercourse draining from the Pacer Ivy Area that flows towards the Dong Nai River (DUs PI-15 and PI-16); one location in the Z1 Area on the watercourse that runs from the Z1 Landfill to the Z1 Lake; one location on the watercourse located next to the Z1 Area that flows towards the Gate 2 Lake; and one location on the east side of the runway in the vicinity of Northeast Perimeter Lake 1 and Northeast Perimeter Lake 2.

exception of Total Suspended Particulates, which exceed national standards and which is reflective of the heavily-urbanized conditions of Bien Hoa City.

5.2 Natural and Biological Resources

5.2.1 Terrestrial Ecosystems and Biodiversity

The terrestrial ecosystems on the Airbase are composed of secondary and planted forest and shrub vegetation, indicating significant historical disturbance and alteration. While no biodiversity information is available for the terrestrial ecosystem on and adjacent to the Airbase, these terrestrial ecosystems appear to have negligible biodiversity value. USAID has conducted a detailed biodiversity assessment for Vietnam (USAID 2013c) and while serving as a repository for biodiversity is not a priority for an Airbase such as Bien Hoa, it is likely that a number of the negative influences on biodiversity in Vietnam citied in USAID (2013c), including overexploitation of local biological resources, agricultural practices reducing biodiversity, and local infrastructure development, are in play at the Airbase.

The nearest national-level nature reserves and internationally-recognized protected areas, Cat Tien National Park[6] and its international designation as the Dong Nai Biosphere Reserve[7], Bau Sao Ramsar Site (located in the Core Zone of Cat Tien National Park) are located in the northern part of Dong Nai Province, some distance from the Airbase and in the upper watershed of the Dong Nai River. The Can Gio Mangrove Nature Reserve, a provincial nature reserve containing the largest mangrove forest in Vietnam, designated in 2000 by UNESCO as the Can Gio Mangrove Biosphere Reserve, is approximately 30 km downstream of the Airbase, and receives flow from the Dong Nai River. The distance between Bien Hoa City and the Can Gio Mangrove Nature Reserve suggests that this Nature Reserve is: (i) likely not being affected by offsite transport of dioxin that may be occurring from the Airbase (surface water quality in the Nature Reserve is likely more affected by the urban and industrial activities of Ho Chi Minh City that are nearer); and (ii) unlikely to be affected by implementation of any dioxin remediation alternative(s) for the Airbase.

5.2.2 Wetlands, Aquatic Ecosystems and Biodiversity

The series of natural lakes on the Airbase suggest the land on which the Airbase is situated may have at one time been part of the floodplain of the lower Dong Nai River and the system of wetlands and aquatic ecosystems on the Airbase serve a stormwater management function for the Airbase property.

A number of ponds, lakes, wetlands, and other aquatic habitats are located along the perimeter of the Airbase. Most of these ponds are man-made, but others are remnants of historical wetlands in the Dong Nai River basin. The size and extent of these aquatic habitats varies by season, with some being ephemeral (no water present in the dry season), while others contain water year-round. The depth of

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[6] Cat Tien National Park is part of the Indo-Pacific Biogeographical Region and typical forest types include evergreen broad leaves forest, bamboo forest and other mixed forest. The forest types and geographical sites function as habitats for the unique tropical fauna which include 6,085 species of mammals, 259 bird species, 64 reptile species, 33 amphibian species and 99 fish species. These include the following endangered species: white-shouldered ibis (*Pseudibis davisoni*); Indochinese tiger (*Panthera tigris corbetti*); Asian elephant (*Elephas maximus*); and the critically-endangered Javan Rhinoceros (*Rhinoceros sondaicus annamiticus*).

[7] Cat Tien National Park was designed by UNESCO in 2001 as the Cat Tien Biosphere Reserve, which was renamed in 2011 as the Dong Nai Biosphere Reserve.

these ponds generally varies from approximately 50 cm to > 2 m. The amount of water in the ponds and wetlands is highly regulated by Airbase workers and local fishermen, who vary the water levels depending on the amount of rainfall, as well as to optimize conditions for fish farming (aquaculture).

All aquatic habitats on the Airbase contain fish and other aquatic animals (i.e., waterfowl including ducks and other birds, snails, etc.). Most of these ponds and lakes have been used in the past for aquaculture, and/or continue to be used for fishing and aquaculture to this day. Nile Tilapia is the most commonly farmed fish on the Airbase, although several species of carp (grass carp, *Ctenopharyngodon idella*), catfish (e.g., *Pangasius bocourti, P. hypophthalmus)* and snakehead *(Channa striata)* are also raised.

Approximately 300 m south of the Z1 Area at the southern border of the Airbase, there are two lakes (Z1-9 and Z1-10) which have been used extensively for fishing and aquaculture for decades; these lakes were originally connected to Bien Hung Lake (BHL-1) and Gate 2 Lake (G2L-1) in Bien Hoa City via a drainage canal. People from outside the Airbase have had relatively open access to these lakes over the years for fishing, despite the fishing bans which were enacted (Hatfield and Office 33, 2011).

The largest aquatic habitats on the Airbase are found in the Northeast Area, where there are a series of eight lakes (NE-8 to NE-15 inclusive) which were used in the past for aquaculture of Tilapia and other fish species; NE-14 is located outside the Airbase, and is connected to these lakes. Several man-made ponds in the Northwest Area were also used for aquaculture in the past (NW1 to NW4 inclusive). Previously, PI-20 in the Pacer Ivy Area was the site of a large aquaculture operation (Hatfield and Office 33, 2011), but fishing activities here ceased following interim remediation measures implemented under the UNDP GEF Dioxin Project (including drainage and hydrological modifications to PI-20). Fish raised in PI-20 were sourced from the aquaculture operations at Northeast Area lakes, and therefore movement of fish by people between lakes on the Airbase is common (Hatfield and Office 33, 2011). A series of smaller wetlands remain on the perimeter of the Airbase west of the Pacer Ivy Area (PI-17 and PI-18), which likely also contain fish and other aquatic animals. PI-5 includes a small drainage canal which is ephemeral, but provides suitable aquatic habitat in the wet season.

Ducks and other domestic waterfowl have also been raised in most Airbase ponds in the past, likely for sale both on an outside the Airbase, although this practice is now restricted to the lakes in the Northeast Area. Both fish and waterfowl are moved between different waterbodies at different times of the year (depending on the stage of rearing and grow-out), and therefore there is high potential for spreading of dioxin-contaminated food items around different parts of the Airbase (Hatfield and Office 33, 2011).

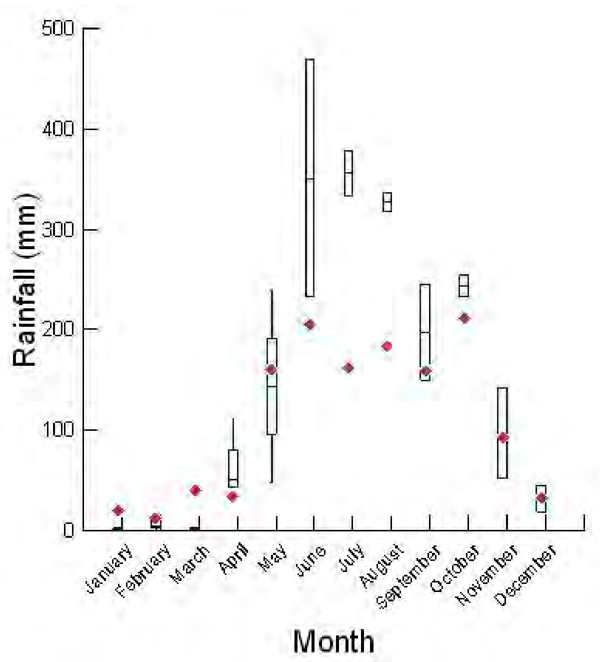
Primary aquatic habitats outside the Airbase which have historically been impacted by dioxin contamination include Bien Hung Lake (BHL-1) and Gate 2 Lake (G2L-1), NE-14 in Tan Phong Ward, as well as the drainage canal west of the Pacer Ivy Area (PI-15 and PI-16). Fish from the Dong Nai River likely migrate into PI-15 and PI-16 during the rainy season. There are also a number of recreational lakes outside the Airbase, although these are not directly connected to the Airbase drainage system and therefore are not likely impacted by Airbase operations.

5.2.3 Endangered Species

While the likelihood of rare and endangered species of flora or fauna residing on the Airbase is low given the degraded ecosystems on the Airbase, this is uncertain as it is likely that no biodiversity surveys have been conducted on the Airbase property.

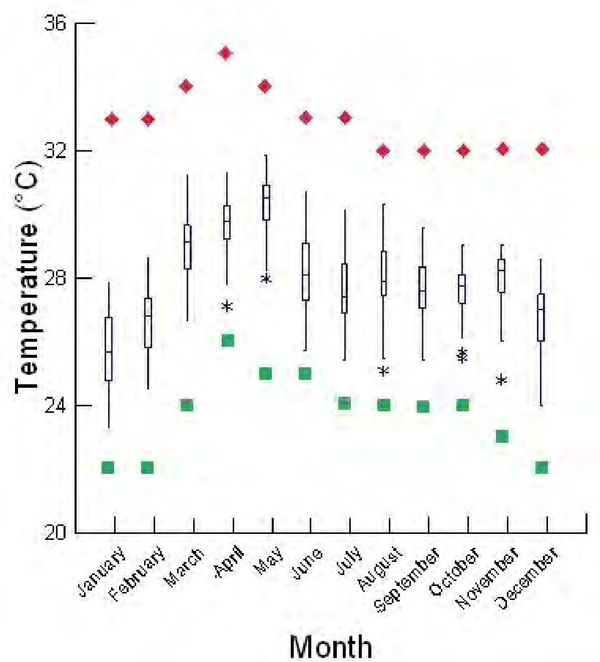
Figure 5-1 Summary of Climatic Conditions for Bien Hoa City

Precipitation



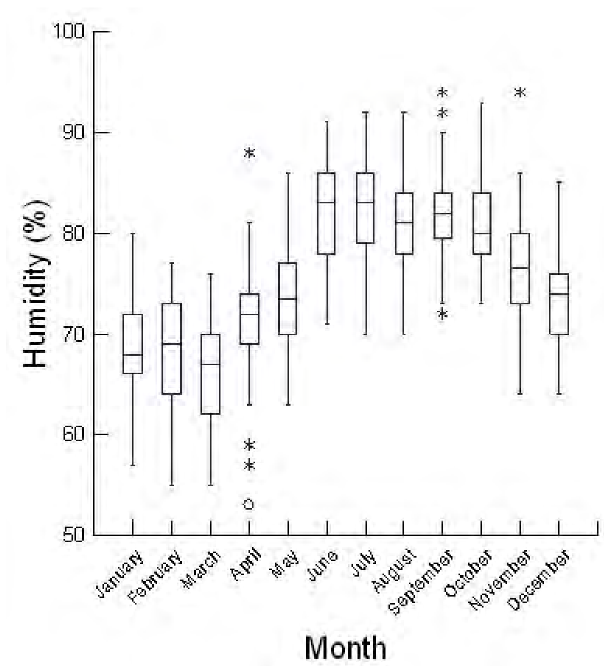
Note: red diamonds are long-term average monthly precipitation, while box plots are average monthly precipitation from July 2013 to June 2015.

Temperature



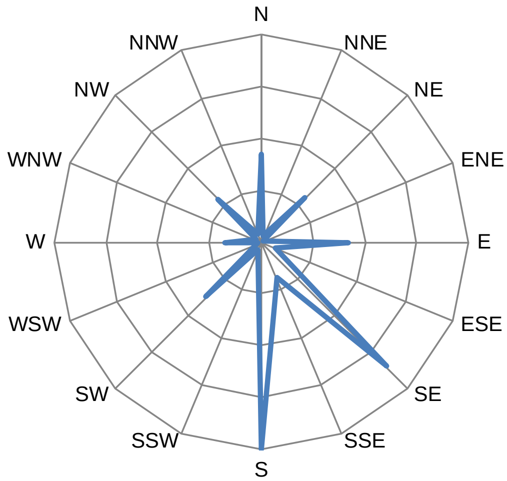
Note: red diamonds and green boxes are long-term average maximum and minimum monthly temperature, respectively, while box plots are average monthly temperature from July 2013 to June 2015.

Humidity

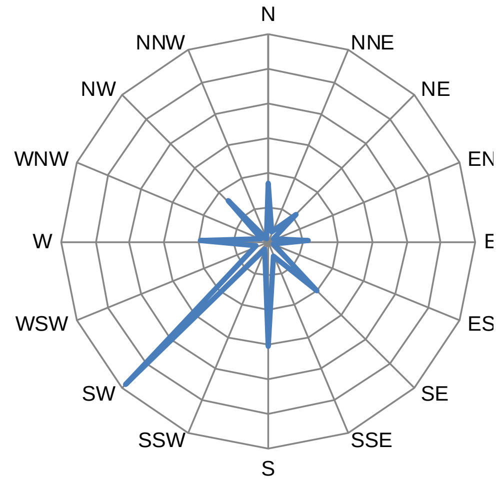


Note: data are from July 2013 to June 2015.

Dry Season:

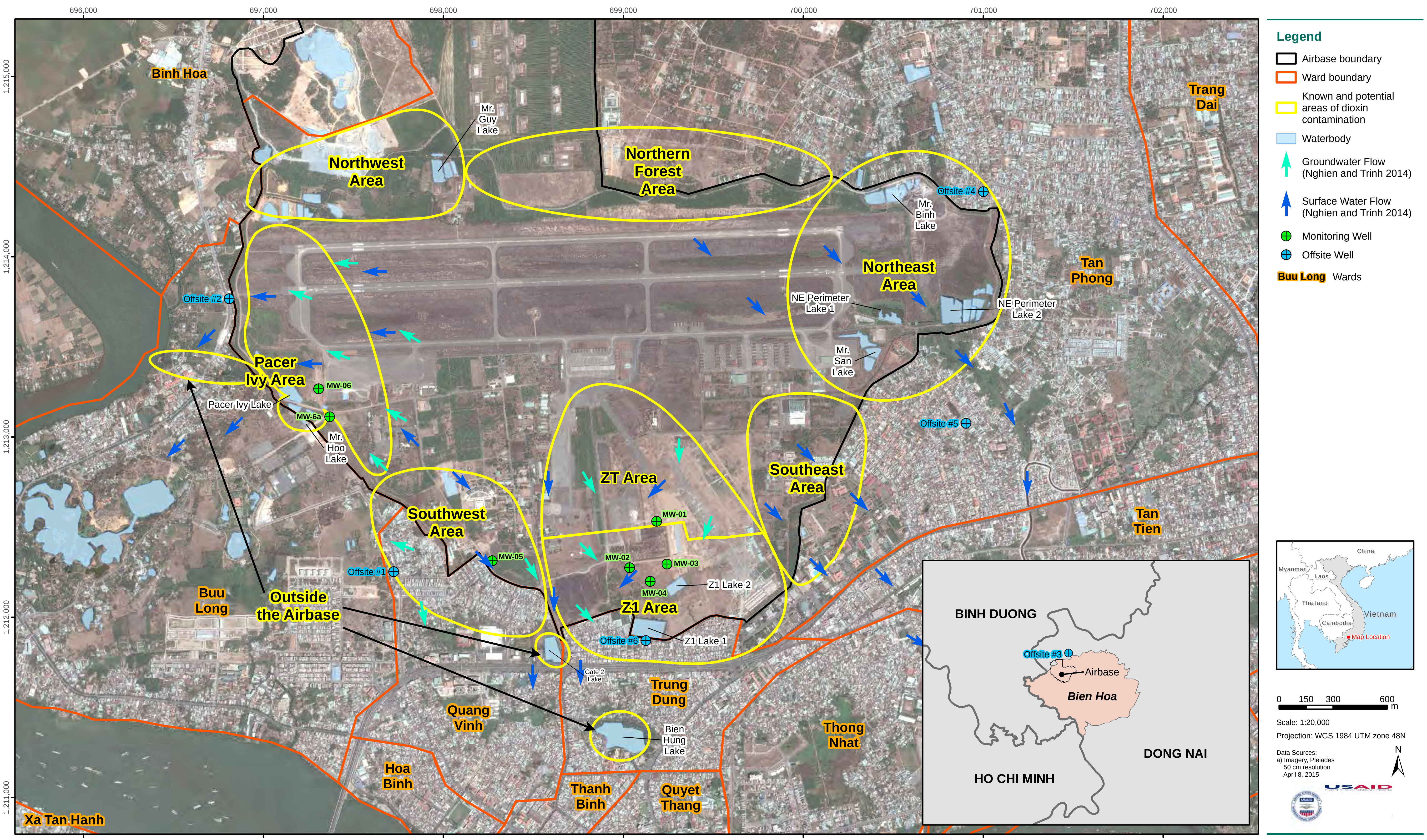


Rainy Season:



Note: data from July 2013 to June 2015

FIGURE 5-2 GENERAL PATTERN OF SURFACE WATER AND GROUNDWATER FLOWS ON AND IN THE VICINITY OF BIEN HOA AIRBASE, VIETNAM



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Section 6 Gender Baseline

6.1 Gender-Specific Regulatory Requirements

Vietnam has a strong legal framework for gender equality. Men and women are legally entitled to equal rights with respect to economic opportunities, political participation, land tenure, property ownership, marriage, and family (Asia Development Bank [ADB] 2005). The principles of Gender Equality and non-discrimination were first expressed in Vietnam's Constitution of 1946 and further amended and supplemented in 1959, 1980, 1992, and 2013. The 2013 constitution states "Male and female citizens have equal rights in all respects. The State has policies to ensure equal rights and opportunities….and strictly prohibits gender discrimination (Clause 1 and Clause 3, Article 26)" (United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP] 2014).

Gender concerns are managed under the Department of Gender Equality within the Ministry of Labor, Invalids and Social Affairs (MOLISA). MOLISA developed the Gender Equality Law 2006 (The National Assembly 2006), which lays the foundation for a sound legal system for gender equality in Vietnam, and is responsible for the National Strategy on Gender Equality (2011-2020) and the National Program on Gender Equality (2011-2015). MOLISA, since 2008, is also the designated president of Vietnam's National Committee for the Advancement of Women in Vietnam (NCFAW). NCFAW advises the Prime Minister of inter-sectoral issues concerning gender equality and women's empowerment nationwide. NCFAW is charged with:

- Researching and coordinating interdisciplinary issues related to advancement of women in Vietnam.
- Collaborating with all line ministries, ministerial-level agencies, People's committee at all levels and mass organizations to disseminate and promote the implementation of policies and laws regarding women's advancement.
- Achieving national targets related to women's advancement.
- Developing Committees for the Advancement of Women under each ministry and province. (United Nations Vietnam [UNVN] 2015b).

Principles of gender equality and non-discrimination are considered in many of Vietnam's policies, laws and regulations (ADB 2005; International Labor Organization [ILO] 2007; Chiongson 2009) including the following:

- **Law on National Assembly Election and Law on People's Council Election (1994)** states that women have the right to vote and run for election and participate in State Management. In February 2015, Members of the National Assembly Standing Committee met to discuss the draft Law on the election of National Assembly deputies and People's Councils. National Assembly Standing Committee Members agreed that the law should mandate a minimum percent of female and ethnic minority representatives in local and national government bodies (Vietnam News 2015).
- **Law on Protection of People's Health (1989)** affirms rights to choose contraceptive methods and states that women are legally entitled to voluntary abortion, periodic health checks during pregnancy, receive treatment for gynecological diseases, and birth delivery services (WHO and Ministry of Health [MOH] 2012; ADB 2005).

- **Criminal Code (1999)** prohibits acts that violate women's human rights, such as ill-treatment or persecution by family members, forcible marriage, human trafficking, etc. There are also regulations that take into consideration special circumstances of women (e.g., pregnancy, breastfeeding) in relation to criminal proceedings.
- **Law on Education 2005** stipulates that "all citizens, regardless of their ethnicity, religion, belief, gender, family background, social status, or economic conditions are equal in learning opportunities".
- **Law on Gender Equality 2006**[8] assigns the responsibility to all organizations to work towards the promotion of gender balance, provides an opportunity to evaluate the effectiveness of existing laws, and calls for enhanced supervision of the implementation of laws and policies on gender equality. It also allows specific provisions for protecting the H&S of women, while still promoting equal opportunities for men and women.
- **Law on Domestic Violence Prevention and Control 2007** regulates the prevention and control of domestic violence, and protecting and assisting the victims. Domestic violence is defined as corporal beating, insulting one's human pride, honor or dignity, isolating, preventing the exercise of the legal rights in relationships, forced sex, forced child marriage, destroying private property, and forcing family member to overwork. The law also stipulates re-education measures for repeat offenders.
- **National Strategy on Gender Equality for 2011-2020 and National Program for Gender Equality 2011-2015** highlights key challenges to address including increasing representation of women leaders, increasing opportunities for women to participate in political decision-making, improving women's employment opportunities, eliminating gender differences in educational outcomes, improving women's health care and a range of cultural issues including domestic violence and trafficking, the skewed sex ratio at birth, and men's lack of housework (ADB 2005).
- **Law on Anti-Human Trafficking 2011 and National Action Plan 2011-2016** expands the definition of trafficking in persons to include forms of trafficking not prohibited in the penal code and includes provisions for victim care and trafficking prevention (USAID 2012).
- **Socio-Economic Development Program 2011 to 2015** is the key national development plan focusing on the poor and other disadvantaged groups.
- **Vietnam Labor Code (Amended in 2012)**[9] The United Nations Population Fund (UNPF 2012) states that "The State, employers and the society have the responsibility to create employment, and guarantee that every person, who has the capacity to work, has access to employment opportunities". Chapter X of the law outlines the separate provisions concerning female employees including women's rights in recruitment, salaries, holidays, maternity leave, and education opportunities. There are also provisions designed to protect women from hazardous work

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[8] Vietnam Gender Equality Law: Article 13, Section 1: *1. Man and woman are equal in terms of qualifications and age in recruitment, are treated equally in the workplace regarding work, payment and bonus, social insurance, labor conditions and other working conditions. 2. Man and woman are equal in terms of qualifications and age in promotion or appointment to hold titles in the title-standard professions. 3. Measures to promote gender equality in the field of labor include: a) To provide for proportion of man and woman to be recruited; b) To train and enhance capacity for female employees; c) Employers create safe and hygienic working condition for female labors in some hard and dangerous professions and occupations or those that have direct contact with noxious substances.*

[9] Vietnam Labor Code: Article 1 of Chapter X: The labor user is not allowed to use female labor for heavy or dangerous jobs which necessitate contact with noxious substances having harmful effects on the reproductive and child rearing functions of the women laborer. Available from https://www.ilo.org/dyn/natlex/docs/MONOGRAPH/91650/114939/F224084256/VNM91650.pdf

environments. The revisions completed in 2012 also include provisions prohibiting sexual harassment (ILO 2013).

- **Code of Conduct on Sexual Harassment in the Workplace 2012** provides guidance to the Government, employer's organizations, trade unions and workers on what is meant by sexual harassment in the workplace, how it can be prevented and what steps should be taken if it occurs.
- **Employment Law 2013** provides workers with better protection, improved working conditions, higher wages and more effective dispute resolutions mechanisms (UNVN 2015a).
- **Marriage and Family Law (2014)** stipulates the basic principles of marriage as "Voluntary, progressive, and monogamous marriage in which husband and wife are equal." The Law prohibits underage and forced marriage or divorce, deception into marriage or divorce, and/or demanding a wedding dowry. Amendments to the law in 2014 repealed the ban on same sex marriage and increased the legal age of marriage for females from 16 to 18 and males from 18 to 20 (UNESCAP 2014).
- **Law on Occupational Safety and Health 2015 (will take effect 2016)** allowed for the ratification of the Convention on Promotional Framework for Occupational Safety and Health Convention (2006) (ILO 2015).

Vietnam is also a signatory to the: **United Nations Convention on the Elimination of Discrimination against Women (CEDAW)**, an international agreement that establishes standards and norms for laws and policies that should be enforced to eliminate discrimination against women; **International Covenant on Economic, Social and Cultural Rights; Covenant on Civil and Political Rights; and five ILO conventions on forced labor, equal remuneration, discrimination, minimum age and worst forms of child labor.**

Gender-based requirements under Vietnam's regulations, policies and laws of key importance to the environmental remediation efforts are:

- Vietnam Labor Code (2012) Article 154 outlines the obligations of employers toward female employees which states that "employers shall ensure the implementation of gender equality and measure to promote gender equality in recruitment, employment, training, working hours and rest periods, wages and other policies.
- Vietnam Labor Code (2012) Article 160 states that female employees are prohibited from "work that is harmful to child-bearing and parenting functions, as specified in the list of work issued by MOLISA in coordination with the MOH.
- Law on Gender Equality (2006) Article 13 states that in the field of labor, employers must provide for proportional recruitment of male and female workers and "create safe and hygienic working conditions for female works in some hard and dangerous professions and occupations or those that have direct contact with harmful substances".

6.2 Role and Status of Women in Vietnam

The role and status of women in Vietnamese society is improving. Vietnam has shown progress in reaching gender equality, particularly related to closing the gender gap in primary education and has generally improved economic opportunities for both men and women (USAID 2012). Despite advancements and a strong enabling environment, cultural structures remain that favor men and stereotype women.

On global gender indices, such as the World Economic Forum's Gender Gap Index (GGI) and UNDP's Gender Inequality Index (GII), Vietnam is a middle-tiered country (Hausmann 2014, UNDP 2014). Both indices are a composite measures of inequality that assess countries based on political empowerment, education, labor force and health[10]. Vietnam ranks 76th out of 142 countries and 5th among the listed Association of Southeast Asian Nation (ASEAN) member states on the GGI in 2014 (Hausmann 2014) (**Table 6-1**) and 58th out of 149 countries and territories on the GII in 2013 (UNDP 2014). Vietnam's key development indicators are consistent with other East Asia and Pacific countries, many of whom have much higher per capita GDP (**Table 6-2 and Table 6-3**).

Education statistics in Vietnam are progressive, with high literacy rates for both men (96% in 2013) and women (91% in 2013) (Hausmann 2014), and equal enrollment in primary school (net enrollment rate is 91.5% for girls and 92.3% for boys in 2012) (UNVN 2012). The proportion of girls enrolled in upper secondary school (63%) is now greater compared to boys (53.7%) (UNVN 2012). These achievements vary substantially on the subnational level, in rural communities and amongst different ethnic groups (World Bank 2011). In higher education, significant differences in enrollment levels across fields of study persist with women typically enrolling in business and education and men focusing on information technology, engineering, science, and craftsmanship (World Bank 2013)[11]. Vocational and job training opportunities are reportedly more often available to males (UNICEF 2003 and Kelly 2011). In 2014, Vietnam's Ministry of Planning and Investment GSO reported that 7.5% of males received vocational training compared to 2.1% of females (World Bank 2011). Vietnam's different legislated retirement ages for males (55) and females (60), likely impacts the distribution of investments and training opportunities made available to each gender.

Vietnam has one of the highest engagement of women in national parliament in the Asia-Pacific region (Vietnam 24.4% and East Asia and the Pacific average 18.7%) (UNDP 2014). However, Vietnam scored below the world average on the Global Gender Gap's political empowerment sub-index along with 97 (of 142) other countries (World Average 22% in 2014; Vietnam 13% in 2014). Empowerment is captured by the percent of females holding seats in the national parliament, the ratio of female ministers and the presence of a female heads of state. Only nine percent of ministerial positions were held by women for the 2011-2016 term.

Vietnam also fell below the world average for the Global Gender Gap's health and survival sub-index (World Average 96% in 2014; Vietnam 94% in 2014) and was one of the lowest-ranking countries (ranked 137 out of 142 countries). The health and survival sub-index is based on sex ratio at birth (SRB) and the gap between women's and men's healthy life expectancy. Vietnam's SRB is worsening and shows the remaining presence of son preference (Vietnam scored 0.89 out of 1.00 for sex ratio at birth

[10] GGI – composite measure based on labor force participation, salary differentials, rate of women in skilled positions, literacy rate, enrolment in primary, secondary and tertiary education, sex ratio at birth, life expectancy, women in parliament and ministerial positions and years with female head of state.
GII – composite measure based on maternal mortality ratio, adolescent fertility rate, female and male population with at least secondary education, share of parliament seats, labor force participation rates.

[11] 68% of urban women engaged in post-secondary are enrolled in education or business, compared to 7% enrolled in information technology, science, engineering or craftsmanship.

compared to average of 0.92 out of 1.00) (UNVN 2010b). Son ratio at birth has increased from 2005 (105.6 males per 100 females) compared to 2013 (113.8 males per 100 females) (GSO 2014b).

Vietnam has relatively high rates of male and female labor participation. In 2014, 85% of men and 79% of women between the ages of 15 and 64 were engaged in economic activities (Hausmann 2014). Occupational sex segregation and gender wage gaps remain; women's wages are 63% of men's for the same positions (Hausmann 2014) and women are less likely to fill technical, skilled and managerial positions (USAID 2010b). While agriculture, forestry and fisheries accounts for 23.4% of employment for females, other sectors are also primarily composed of women including domestic help (93%), education and training (71%) and hotel and restaurants (70%); in contrast, construction (9.8%), transportation and storage (9.8%), production and distribution of electricity, gas, steam and hot water, and air-conditioners (16%) have low employment of women (GSO 2014a). Women are also more likely to gain low-skilled, temporary, informal, and without contract work, typically with low productivity and export-oriented sectors (garments, textiles, electronics, etc.) (GSO 2014a; McCarty et al. 2009). The informal labor market is an important income source for many men and women in Vietnam; however, the lack of regulation within the sector can leave workers vulnerable, particularly women (ILO 2011). More than 42% of employed females are involved in the informal sector as self-employed and unpaid family workers (GSO 2014a).

Female economic and political participation is additionally strained by unrecognized and unpaid work hours in the home and providing care to children and the elderly. This undervalued work is still dominantly viewed as a women's role, with household and family responsibilities rarely being shared by men (UNVN 2010b; Teerawichitchainan et al. 2008). These long-standing gender biases continue to be present in education curricula and material and contribute to persisting inequalities (World Bank 2011). Cultural beliefs and gender stereotypes also drive gender-based violence which remains a significant concern in Vietnam. The UNVN reported that 58% of ever-married women experienced some form of domestic violence (UNVN 2015a).

6.3 Gender Conditions at Bien Hoa Airbase and Bien Hoa City

Gender conditions presented below for the Airbase and Bien Hoa City focus on the potential impacts on men and women within different functional labor groups associated with each step of the environmental remediation process as well as local residents within and surrounding the Airbase. Information for the assessment was derived through a review of relevant literature, accessible provincial and city statistics and on the key assumption that demographics and labor roles are aligned with those assessed for the Environmental Remediation at Danang Airport (USAID 2010b).

6.3.1 Residents of Bien Hoa City

Approximately 120,000 residents of Bien Hoa City are estimated to live in the immediate vicinity of the Airbase. Women account for approximately 51% of the total population in Bien Hoa City and comprise approximately 47% of its labor force (Dong Nai Statistical Office 2013). In the southeast region of Vietnam within which Bien Hoa City is located, the distribution of employed population by sector is increasingly dominated by industry and construction (43.7%) and services (33.7%), with the remaining 22.6% engaged in agriculture, fisheries and forestry (GSO 2015).

The Airbase has historically been used for agriculture, forestry, fishing, and aquaculture by residents and surrounding communities. Airbase workers and their families, particularly those who have consumed fish raised in lakes on the Airbase, have the highest dioxin concentrations in blood serum and breast milk measured to date in studies conducted in Bien Hoa City (Hatfield and Office 33 2011; Nguyen et al. 2011). Fishing and aquaculture on the Airbase has been banned since 2010 by Office 33, however the effectiveness of the ban has been limited. Fishing was observed as recently as December 2015 (Thien-Le Quan 2015). It is believed that fishing (and fish consumption) continues to occur on most Airbase lakes and is still also common in the outlet channel west of the Pacer Ivy Area.

Residents living within and surrounding the Airbase are potentially at risk from exposure to dioxins in the environment through contact with soil and sediment, inhalation, and consumption of locally-grown/sourced food products (Tuyet-Hanh et al. 2010; Hatfield and Office 33 2011). Tuyet-Hanh et al. (2010) also reported that the Dong Nai Association of Victims of Agent Orange/Dioxin estimate that 13,150 people within Dong Nai Province have experienced adverse health effects due to ongoing exposure to Agent Orange dioxin.

Vu-Anh et al. (2010) reported on pre- and post- intervention surveys undertaken in 2007 and 2009 on knowledge, attitudes, and practices (KAP) on dioxin and measures to prevent dioxin exposure of 400 households living near the Airbase, with intervention consisting of a series of awareness and education campaigns commencing in 2008. Approximately 83% of those surveyed in 2009 were women and almost half (42%) of the respondents' main occupation was in the home, with 5% of respondents noting direct contact with soil and sediment ('mud') in their daily work. Fewer than 15% of respondents surveyed in 2007 knew that dioxin could be present in food, with similar results reported for a KAP survey completed in 2009 of households living near the Danang Airport (Tuyet-hanh et al. 2013). Public health interventions since 2008 have been implemented at the Airbase and surrounding area to reduce the risk of dioxin exposure of residents. The post-intervention survey conducted in 2000 showed an increase in knowledge on the presence of dioxin in food by 21% (Vu-Anh et al. 2010). A study on "Food as a source of dioxin exposure in residents of Bien Hoa City" reported high dioxin concentrations in fish samples obtained from the Bien Hung Lake near the Airbase, as well as in ducks, chickens, and wild goose raised in areas containing contaminated soil (Schecter et al. 2003). The pre-intervention survey in 2007 reported that 10% of households in the area of the Airbase raised poultry, cattle, and grew crops predominantly for subsistence with fewer than 3 percent growing vegetables and crops for sale (Tuyet-Hanh et al. 2010).

Knowledge of the routes of exposure to dioxin, particularly through dioxins attached to particles in the air and water and through breastmilk, remained low 2.5 years after public health intervention was implemented in areas surrounding the Danang Airport (Tuyet-Hanh et al. 2013). Approximately 68% of residents are aware of potential exposure to dioxin through water, 17% are aware of exposure through air, and only approximately 9% understood that infants could be exposed through breast milk consumption. Similar figures are not available for the Airbase, although it is not unreasonable to assume similar rates of awareness for residents of the Airbase.

6.3.2 Military Personnel and Airbase Workers

The Airbase is an active military airport with approximately 1,200 persons living within the Airbase (Canh 2012b). While information was not available at the time this EA was prepared on the gender composition or the role of women in these military personnel, a significant number of women are known to work in the military and live on the Airbase.

During the war years (1960s and 1970s), women in Vietnam filled traditionally male roles such as acting as heads of households, maintaining agricultural production, working in the factories, as well as carrying food and munitions in the military, and serving as couriers and guides (UNVN 2010; Sen and Stiven 1998). Vietnamese women were also placed in major military roles by the Vietnamese Communist Party (VCP) cadres (Country Data 1987). This freed men for fighting and served to disband some gender-based stereotypes. While most women held technical and administrative roles within the military, they also engaged in combat assignments in guerilla units, as well as command assignments.

The People's Armed Forces of Vietnam consists of six branches: People's Army of Vietnam (PAVN), which includes the People's Navy Command; ADAFC; Border Defense Command; People's Public Security Forces; Militia Force; and the Self-Defense Forces (U.S. Central Intelligence Agency [CIA] 2015). Military service is compulsory for males aged 18 to 25 years and females may volunteer for active duty military service. The PAVN has approximately 450,000 active forces and 5 million reserves (MND 2013). As Vietnam's present day military is not highly active, the presence of women in the forces, as well as the intensity of their duties, have declined over the years.

6.3.3 Construction Workers

The construction industry in Vietnam is a male-dominated industry with women constituting only 9.8% of the labor force (Dong Nai Statistical Office 2013). In Dong Nai Province, women constitute 16% of the construction labor force. While detailed information on the role of women within the industry was not readily available, interviews conducted with four construction companies in Danang, prior to commencement of the environmental remediation project, is assumed to present a similar overview of the different roles of men and women within construction activities in Bien Hoa (USAID 2010b).

In general, it was found that women do not hold positions of authority on construction sites (USAID 2010b). With the four construction companies interviewed in Danang, all foreman or site manager positions (n=77) were held by men. The remaining employees were divided into construction workers and others, which included administrative, transportation, and security positions. Women composed 16% of the construction worker roles which equated to 59 positions held by women compared to 321 positions held by men. Only 12% of the other category positions were held by females. The low number of positions held by women was likely a result of the vocational training and bachelor degree requirements held by the construction companies. Both male and female employees are expected to work 8 to 10 hours per day and when workers were sought from outside the local area, they were occasionally expected to live on site to complete the construction activities.

Table 6-1 Vietnam's Performance on GGIs, 2014

Country	GGI		Economic Participation and Opportunity		Educational Attainment		Health and Survival		Political Empowerment	
	Rank (out of 142)	Score (out of 1)	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Global Average				0.5926		0.9364		0.9596		0.2164
Philippines	9	0.7814	24	0.7780	1	1.00	1	0.9796	17	0.3682
Singapore	59	0.7046	18	0.7899	110	0.9413	114	0.9671	90	0.1201
Lao PDR	60	0.7044	13	0.8016	118	0.9084	86	0.9721	81	0.1355
Thailand	61	0.7027	26	0.7677	64	0.9938	1	0.9796	121	0.0700
Vietnam	76	0.6915	41	0.7260	97	0.9719	137	0.9441	87	0.1241
Indonesia	97	0.6725	108	0.5984	78	0.9890	58	0.9762	86	0.1262
Brunei Darussalam	98	0.6719	36	0.7360	88	0.9858	126	0.9657	142	0.0000
Malaysia	107	0.6520	104	0.6174	100	0.9693	102	0.9692	132	0.0523
Cambodia	108	0.6520	77	0.6540	124	0.8833	1	0.9796	110	0.0911

Source: Hausmann 2014

Table 6-2 Vietnam's Performance on Human Development Index (HDI), 2013

Parameter	Vietnam	Medium HDI Countries (average)	East Asia and Pacific
HDI, 2013	0.638	0.614	0.703
Inequality Adjusted HDI, 2013	0.543	0.457	0.564
GDP per capita 2012 (2011Purchasing Power Parity [PPP] US$ adjusted)	$4,912	$7,233	$10,151
GII	0.322	0.502	0.331
Maternal mortality ratio (deaths per 100,000 live births)	59	186	72
Adolescent birth rate (births per 1,000 women aged 15-19)	29	42.8	19.7
Female seats in parliament (%)	24.4	17.5	18.7

Source: UNDP 2014

Table 6-3 Indicators for Vietnam for Gender Related Development Indices

Indicator	Vietnam		East Asia and Pacific	
	Female	Male	Female	Male
Life expectancy at birth (years)	80.5[a]	71.3[a]	75.8[a]	72.3[a]
Adult literacy rate (population +15 years)	91[b]	96[b]	--	--
Population with some secondary education (%)	59.4[a]	71.2[a]	54.6[a]	66.4[a]
Labor Force Participation (% aged +15)	72.8[a]	81.9[a]	62.8[a]	79.3[a]
Wage Gap (Female to Male Ratio)	0.63		--	--
Gross National Income (GNI) per capita (2011 PPP US$ adjusted)	4,147[a]	5,655[a]	8,154[a]	12,488[a]

Sources:
a UNDP 2014
b Hausmann 2014
c GSO 2013

Section 7 Environmental Consequences

This section presents a description of the determination environmental impacts associated with each remediation alternative. The determination of the potential environmental impacts assessment is organized as follows:

- The potential environmental (and associated social) effects are described for each of the environmental and social resources described in **Section 5**.
- An analysis of the potential impacts is presented.
- Mitigation measures are specified that would prevent or avoid potentially negative environmental consequences of the remedial alternative.
- A final determination of effects is made for the potential environmental (and associated) social effects, with the potential impacts of any given remedial alternative on environmental and associated social resources are assessed as being in one of the following five categories:
  - **NO IMPACT:** This determination is made when there is no impact of the remedial alternative on the environmental resource of concern. This assessment is made if the activities associated with the remedial alternative are to be spatially or temporally removed from the environmental resource being assessed.
  - **SIGNIFICANT AND UNMITIGABLE IMPACT:** This determination is made when there is expected to be an impact of a given remedial alternative on the environmental resource of concern and there are either no known mitigations or it is uncertain whether the significant impact can be effectively mitigated with available mitigation activities.
  - **MITIGABLE IMPACT:** The potential impact is Significant, as described above, but it can be effectively mitigated using well-accepted and proven mitigation measures.
  - **INSIGNIFICANT IMPACT:** This determination is made when there is expected to be an impact of a given remedial alternative on the environmental resource of concern but the impact is assessed to be too negligible to require intervention in the form of either mitigation or monitoring.
  - **POSITIVE IMPACT:** This determination is made when the effect of a given remedial alternative will be to improve the condition and integrity of the environmental resource of concern.

The determination of significance was based upon applying the following set of criteria to each potential environmental effect: magnitude; geographic extent; duration and frequency of impact; and ability of the environmental or social resource in question to recover after each remedial alternative had been implemented. Both objective and subjective considerations were included in the application of these criteria. Objective considerations included the ability to meet statutory or regulatory requirements related to environmental protection and management such as ambient air quality objectives and water quality guidelines, effluent discharge limits, regional environmental objectives, and international environmental obligations. Professional judgment was applied when potential effects could not be predicted quantitatively due to limited data availability or when there are no benchmarks against which to compare predicted quantitative impacts. The determination of significance integrated quantitative impact analysis (where possible) and professional judgment that took into account the assessments of each of the criteria listed above (i.e., magnitude, geographic extent, duration and frequency of impact; and ability of the environmental or social resource in question to recover after each remedial alternative had been implemented).

Gender issues in relation to the environmental consequences of the remediation alternatives and a determination of gender-related effects is then presented, followed by an EMMP that is applicable to all the remediation alternatives.

Conservative assumptions are used throughout the impact assessment to ensure that potential impacts are not underestimated.

7.1 Effects Assessment

7.1.1 Environmental Impacts Not Considered

The ESS (USAID 2015b) and additional environmental information obtained since the ESS was prepared confirms that there will be **NO IMPACT** of any of the remedial alternatives on the environmental resources listed below:

1. Nature Reserves and Protected Areas: The nearest national-level nature reserves and internationally-recognized protected areas, Bau Sao Ramsar Site, Cat Tien National Park, and Dong Nai Biosphere Reserve, are located in the northern part of Dong Nai Province, some distance from the Airbase and in the upper watershed of the Dong Nai River. The Can Gio Mangrove Nature Reserve and Biosphere Reserve, approximately 30 km downstream of the Airbase, receives flow from the Dong Nai River. The distance between Bien Hoa City and the Nature Reserve suggests that this Nature Reserve is: (i) likely not being affected by any offsite transport of dioxin that may be occurring from the Airbase (surface water quality in the Nature Reserve is likely more affected by the urban and industrial activities of Ho Chi Minh City that are nearer); and (ii) unlikely to be affected by implementation of any dioxin remediation alternative(s) for the Airbase. None of the remedial alternatives would negatively influence any of the nature reserves and protected areas.
2. Cultural and Historic Sites: There are no designated cultural and historic features on the Airbase property, and none of the remedial alternatives would negatively influence cultural and historic sites outside of the Airbase property.
3. Tourism Resources: While there are significant tourism resources throughout Bien Hoa City, these are located sufficiently far from the Airbase property that none of the remedial alternatives would negatively influence tourism resources in Bien Hoa City.

7.1.2 Potential Effects on Land Use and Land Disturbance

7.1.2.1 Description of Effects

Potential effects on Land Use are associated with: (i) the effect that any of the alternatives except for the No Action Alternative would have on land use on the Airbase; and (ii) the land disturbance area (in m^2) of each of the alternatives.

7.1.2.2 Impact Analysis

7.1.2.2.1 Land Use

All of the alternatives except for the No Action Alternative would have a Positive effect on land use because they would all result in dioxin concentrations in soils and sediments becoming lower than the dioxin limits set by GVN for the contaminated areas on the Airbase for the various types of land uses being contemplated and planned (**Section 3.2.4**, **Table 3-6**).

7.1.2.2.2 Land Disturbance

The difference in the amount of land disturbance associated with the alternatives is from 614,900 m^2 for Alternative 2A, the lowest amount of total land disturbance, to 832,400 m^2 for Alternative 4, the highest amount of land disturbance (**Table 7-1**); this is a result of the total amount of land disturbance being dominated by the total area of contaminated material to be excavated. Alternative 2A – Landfill is associated with the lowest total land disturbance area because it is the simplest of the technologies to implement and the land requirements for project facilities are relatively modest as a result. Alternative 4 (Landfill for Material Less than 1,200 ppt TEQ, *Ex Situ* TCH for Material Greater than 1,200 ppt TEQ) is associated with the highest total area of land disturbance due to a required combination of permanent and temporary stockpiles/treatment areas and landfill facilities.

The difference among the Alternatives with respect to the amount of land disturbance is great, with the amount of land disturbance associated with Alternative 4 being 35% greater than the amount of land disturbance for Alternative 2A. In addition, the total amount of land disturbance is 6% and 8% of the total area of the Airbase (1,000 ha) for Alternatives 2A and 4, respectively. While the differences among the alternatives is small relative to the total area of the Airbase, all alternatives require disturbance of a moderate proportion of the total area of the Airbase; this has implications for example, for the management of surface water during the implementation of any of the remedial alternatives (**Section 7.1.4**).

7.1.2.3 Determination of Effects

7.1.2.3.1 Land Use

Land use impacts are determined to be **POSITIVE** for all alternatives.

7.1.2.3.2 Land Disturbance

Land disturbance impacts are determined to be **MITIGABLE** for all remedial alternatives, with Alternative 2A – Landfill having the lowest potential land disturbance impact and Alternative 4 having the greatest potential land disturbance impact.

7.1.3 Potential Environmental and Health Impacts Associated with UXO Cleanup

7.1.3.1 Description of Effects

Given that the Airbase has served and continues to serve as a military base, there would be environmental and human health risks from UXO associated with land disturbance with any alternative.

7.1.3.2 Recommended Mitigation and Monitoring Measures and Impact Analysis

The following mitigation and monitoring measures are recommended:

- Preparation of a detailed UXO management plan to address how all Project areas will be surveyed and cleared of UXO prior to commencement of work activities including, but not limited to: training, PPE, and safety procedures to Project workers; and education and mitigation measures for nearby residents and Airbase personnel and passengers during Project construction.
- Implementation of the UXO management plan to clear project areas of UXO.

The potential effects would require mitigation measures to be applied, consisting of the standard protocols used by GVN and MND for surveying and clearing of UXO. There appear to be no extraordinary requirements for clearing UXO at the Airbase (such as munitions bunkers) for any of the remedial alternatives; these sorts of facilities were not seen during the numerous visits conducted to the Airbase or during implementation of the 2014/2015 EA sampling program.

7.1.3.3 Determination of Effects

The residual potential environmental and associated human health risks associated with UXO after the application of the mitigation and monitoring measures described above are determined to be **MITIGABLE** for all alternatives. As the magnitude and scope of potential environmental and associated human health risks associated with UXO are related to the size of the footprint for each alternative, the potential risk from UXO is lowest for Alternative 2A – Landfill and highest for Alternative 4 - Landfill for Material Less than 1,200 ppt TEQ, *Ex Situ* TCH for Material Greater than 1,200 ppt TEQ.

7.1.4 Effects on Surface Water Hydrology and Surface Water Quality

7.1.4.1 Description of Effects

Implementation of any of the alternatives would result in changes to surface water hydrology that would occur from:

- Clean water diversions around project areas in order to manage surface runoff and to minimize the generation of project-affected water.
- Potential changes to the hydrology of the lakes and ponds during the removal of contaminated sediments.
- Potential relocation or change in surface area or volume of lakes and ponds during remediation.

All alternatives would have potential impacts on surface water quality due to the generation of project-generated contaminated wastewater. Major sources of project-affected water for all alternatives would be:

- Precipitation onto sites being used for general facilities.
- Precipitation onto contaminated material as it is being hauled to remediation facilities.
- Precipitation onto temporary stockpiles.

- Dewatering and treatment of groundwater in excavation areas.
- Dredging and dewatering of sediments.

In addition, the major additional sources of project-affected water would be:

1. For landfill technologies, precipitation on the landfill during placement of contaminated material and capping and generation of landfill leachate.
2. For *ex situ* TCH technology, precipitation on the soil and sediment stockpiles during set-up, maintenance, treatment, and take-down.
3. For solidification and stabilization technologies, precipitation on the contaminated material before it is being solidified and stabilized, and after it is solidified and stabilized but before it is placed and capped.
4. For incineration and MCD technologies, precipitation on temporary stockpile areas associated with the treatment systems during operation.

7.1.4.2 Impact Analysis

While the magnitude of the project effects on surface hydrology will be related to the total area of land disturbance of the given alternative, with potential effects on surface hydrology being greater with higher amount of land disturbance, the impacts of any of the alternatives on surface water hydrology and surface water quality would be short in duration, reversible, and generally low in magnitude:

1. The diversion of any flows of the watercourses on the Airbase during excavation of sediments would likely have negligible effects on overall hydrological conditions of the Airbase.
2. The haul roads to be constructed or upgraded will incorporate culverts and surface runoff drainage systems to accommodate watercourse flows. These would be maintained throughout the implementation of the selected alternative.
3. The excavation of sediments from waterbodies is a component of all alternatives. Mitigation measures may be required to limit the hydrologic effects of excavating these sediments, but these would be applied irrespective of the remedial alternative that is selected.

However, the area over which the activities associated with the alternatives would occur ranges from 8% (for Alternative 2A) and 11% (for Alternative 4) of the total area of the Airbase and is small relative to both the total area of the Airbase and the total area of the drainage systems on the Airbase. All alternatives require disturbance of a moderate proportion of the total area of the Airbase; this has implications for example, for the management of surface water during the implementation of any of the remedial alternatives and the recommended mitigation measures described above (**Section 7.1.4.2**) will be required for all remedial alternatives.

Appendix F provides detailed calculations and assumptions for the volume of project-affected water generated for each alternative; these are summarized in **Table 7-2**.

<u>Alternative 2A - Landfill</u>

The amount of project-generated contaminated wastewater under Alternative 2A – Landfill is estimated at approximately 41,000 m^3. Precipitation and groundwater seepage into excavated areas of contaminated soils and sediments, as well as into the landfill construction site together, are estimated to generate approximately 37,000 m^3 of project-affected water; other Project activities are estimated to generate smaller amounts of project-affected water requiring treatment.

Alternative 2B – Solidification and Stabilization

The amount of project-generated contaminated wastewater under Alternative 2B – Solidification and Stabilization is estimated at approximately 194,000 m^3. Almost all of this is generated via precipitation and groundwater seepage into excavated areas of contaminated soils and sediments, as well as precipitation onto contaminated material stockpiles during the solidification and stabilization process.

Alternative 5A – Incineration

The amount of project-generated contaminated wastewater under Alternative 5A – Incineration is estimated at approximately 157,000 m^3. Most of this is generated from precipitation effects during handling of contaminated soil and sediments, both during excavation and during stockpiling and handling at the incineration facilities; handling of contaminated and clean materials under treatment alternatives is assumed to take longer than under the containment alternatives.

Alternative 5B – *Ex Situ* TCH

The amount of project-affected water generated under Alternative 5B – *Ex Situ* TCH is estimated at approximately 163,000 m^3. The main sources of project-affected water under this alternative are similar to Alternative 5A – Incineration. The total volume of project-affected water under this alternative is predicted to be higher than under Alternative 5A because of the assumed longer time required for handling of contaminated materials under this alternative.

Alternative 5C – MCD

The amount of project-affected water generated under Alternative 5C - MCD is estimated at approximately 269,000 m^3. Again, the main sources of project-affected water under this alternative are similar to Alternative 5A – Incineration and Alternative 5B – *Ex Situ* TCH. The total volume of project-affected water under this alternative is predicted to be higher than under either Alternative 5A or Alternative 5C because of the amount of time assumed to be required for handling of contaminated materials under this alternative.

Alternative 3 – Landfill for Material Less than 2,500 ppt TEQ, *Ex Situ* TCH for Material Greater than 2,500 ppt TEQ

The amount of project-generated contaminated wastewater under Alternative 3 is estimated at approximately 61,000 m^3. The total amount of project-affected water generated under this alternative is intermediate to the amount predicted to be generated under Alternative 2A – Landfill and Alternative 5B – *ex situ* TCH (as described above) because this alternative is a combination of these two remedial technologies.

Alternative 4 – Landfill for Material Less than 1,200 ppt TEQ, *Ex Situ* TCH for Material Greater than 1,200 ppt TEQ

The amount of project-generated contaminated wastewater under Alternative 4 is estimated at approximately 93,000 m^3. As with Alternative 3, the total amount of project-affected water generated under this alternative is intermediate to the amount predicted to be generated under Alternative 2A – Landfill and Alternative 5B – *ex situ* TCH (as described above) because this alternative is a combination of these two remedial technologies. However, the amount of Project-affected water generated under this alternative is greater than under Alternative 3 because a greater proportion of the contaminated material undergoes thermal treatment, which generates higher amounts of project-affected water in the conceptual layouts and schedules developed in this EA.

7.1.4.3 Recommended Mitigation and Monitoring Measures

Development and implementation of a surface water management plan is recommended in order to address all water management issues relating to project-affected and 'clean' water. This surface water management plan should include:

- Clean water diversion systems around excavation/construction areas.
- Appropriate handling of contaminated materials during excavation, dewatering, hauling, and all other activities.
- Inspection of all erosion/sedimentation controls and best management practices (BMPs).
- Management and handling of all hazardous materials.
- Spill prevention and controls.
- Project-affected water collection, storage and treatment systems for all project facilities.
- Water testing and water release requirements.
- Ensure that post remediation that the lakes and ponds are of comparable quantity and quality as was present pre remediation.

7.1.4.4 Determination of Effects

While there is variation in the amount of project-affected water generated under each alternative and in the predicted effects on surface water hydrology, with the application of the mitigation and monitoring measures described above, the residual effects on surface water hydrology and surface water quality are determined to be **MITIGABLE** for all alternatives.

7.1.5 Effects on Groundwater

7.1.5.1 Description of Effects

The following are potential effects of all of the alternatives on groundwater:

1. The depth of groundwater influences the amount of groundwater seepage into excavations, and amount of pumping and treatment required from excavations before discharge into the natural environment.
2. There is the potential for contamination of shallow groundwater due to the generation of landfill leachate in the alternatives that utilize landfill technologies, although with use of an appropriately-designed landfill liner and leachate collection system (as included in these alternatives), the potential for this contamination is low.

7.1.5.2 Impact Analysis

Given the low permeability of the shallow soils of the Airbase, the contribution of groundwater to water collecting in excavated areas would be small relative to the contribution of precipitation (**Appendix F**).

All excavation activities would be scheduled to occur as much as possible in the dry season when groundwater levels are at the lowest. For this reason, the amount of groundwater seepage into excavations is expected to be minimized, and would comprise an insignificant portion of the total volume of project-affected water generated by any of the remedial alternatives (**Table 7-2**).

For the construction of landfills and permanent stockpiles of decontaminated soils, a sufficient amount of clean fill would be imported to raise the landfill above flood levels and shallow groundwater.

7.1.5.3 Recommended Mitigation and Monitoring Measures

The collection, treatment, and release of project-affected water (**Section 7.1.4**) would reduce the amount of groundwater, either through reduction in the amount of infiltration or via loss of groundwater from seepage into excavated areas.

7.1.5.4 Determination of Effects

With the application of the mitigation and monitoring measures described above, the residual effects on groundwater are determined to be **MITIGABLE** for all alternatives.

7.1.6 Potential Effects of Dioxin-Contaminated Material, Other COPCs, and Dust on Air Quality

7.1.6.1 Description of Effects

This section assesses the potential environmental effects of:

- Extracting, dewatering, stockpiling, transporting, containing, and treating dioxin-contaminated material causing a release of this material into the air, transport, and dispersion of this material through the air, and potential exposure to this material by persons working and living on or near the Airbase.
- Emissions of other COPCs and dust on air quality, transport, and dispersion of these pollutants, and potential exposure to this material by persons working and living on or near the Airbase.

There would be gender differences in these potential effects.

The following are expected to be the potential sources of dioxin-contaminated material, other COPCs and dust:

- Excavation of contaminated materials and transport to the stockpiles, dewatering areas, or to the landfill or stabilized material stockpiles.
- Transport of clean fill and other materials, and stack emissions from:
  - Operation of the pug mill in Alternative 2A.
  - Operation of treatment piles in Alternatives 3, 4, and 5B.
  - Operation of the incinerators in Alternative 5A and the MCD facilities in Alternative 5C.

All alternatives require the excavation, hauling, and manipulation of large volumes of contaminated soil and sediment and the release of dioxin-contaminated material, other COPCs, and dust is a potential significant environment impact for all alternatives.

7.1.6.2 Impact Analysis

The transport of contaminated material to the Pacer Ivy and Z1 Areas along haul roads is a major potential source of dioxin contamination for all alternatives. Trucks conveying dioxin-contaminated material are significant potential sources of dioxin that require mitigation and monitoring. Without appropriate engineering controls in place, there would be a risk of potential exposure to dioxin to construction workers as well as residents on and near the Airbase that would be near to the haul road alignments.

Alternative 2A – Landfill

The main sources of additional potential exposure in Alternative 2A - Landfill beyond the excavation and transport of contaminated material to the Pacer Ivy and Z1 Areas are the existence of two stationary facilities in which dioxin-contaminated material would be exposed to the environment for an extended period of time: temporary storage and dewatering areas; and the landfills themselves. Landfill cells would be covered once they have been filled with contaminated material but would need to remain open during filling. In addition, the temporary storage and dewatering areas would need to be partially-exposed so that trucks can be loaded with contaminated material for transport to the landfill sites.

Alternative 2B – Solidification/Stabilization

The main sources of additional potential exposure in Alternative 2B – Solidification/Stabilization beyond the excavation and transport of contaminated material to the Pacer Ivy and Z1 Areas are the addition of binders and admixtures to contaminated material and mixing these into the contaminated material to ensure a homogeneous distribution of both dioxin and of binders and admixtures. The mixing of the binders and admixtures into and throughout the contaminated material would create additional exposure of construction workers to dioxin, which would be monitored and addressed with engineering controls and PPE, as appropriate. Conducting this activity in the dry season would increase the risk of exposure of residents living to the south of the Airbase given winds in the dry season are predominantly from the north (**Section 5.2.1**) although this risk would be tempered by the distance between both the Pacer Ivy and Z1 Areas to the southern perimeter of the Airbase.

Alternative 3 - Landfill for Material Less than 2,500 ppt TEQ, *Ex Situ* TCH for Material Greater than 2,500 ppt TEQ

The potential effects on air quality and associated human exposure to dioxin under this alternative would be lower than Alternative 2A – Landfill as a large proportion of the contaminated material would be treated via *ex situ* TCH, a technology that is assessed as having a lower overall risk of generating dioxin in air and associated human exposure to dioxin than other technologies (see below).

Alternative 4 - Landfill for Material Less than 1,200 ppt TEQ, *Ex Situ* TCH for Material Greater than 1,200 ppt TEQ

The potential effects on air quality and associated human exposure to dioxin under this alternative would be lower than Alternative 2A – Landfill as a large proportion of the contaminated material would be treated via *ex situ* TCH, a technology that is assessed as having a lower overall risk of generating dioxin in air and associated human exposure to dioxin than other technologies (see below). The potential effects on air quality and associated human exposure to dioxin under this alternative would also be lower than Alternative 3 as a greater proportion of the contaminated material would be treated via *ex situ* TCH than Alternative 3.

Alternative 5A – Incineration

The potential effects on air quality and associated human exposure to dioxin under this alternative are a result of material handling and transportation required for the alternative. The additional complexity and treatment residuals associated with the incineration process increase the risk of dioxin exposure to workers and the general public. However, the incineration process is not expected to increase potential for human exposure to dioxin, as the temperatures achieved during incineration are sufficient to destroy dioxins. In addition, if incineration were to be conducted at an offsite, existing facility, a large number of trucks and tens of thousands of truck loads carrying contaminated material on public streets would be required. Stakeholders expressed their concern in consultation meetings about contaminated material leaving the Airbase and a preference for keeping contaminated material on the Airbase.

Alternative 5B – *Ex Situ* TCH

The *ex situ* TCH alternative is predicted to result in less potential exposure to poorer air quality caused by extracting, dewatering, stockpiling, transporting, containing, and treating dioxin-contaminated material than any of the other alternatives. The main reason for this is Alternative 5B would have no facilities in which dioxin-contaminated material would be exposed to the environment for an extended period of time. The contaminated soil and contaminated sediment piles would be exposed while they are being constructed, but would be covered by clean fill on all sides to create the stockpile and the clean soil berm. This potential exposure would be similar relative to the potential exposure in other alternatives generated by temporary storage and dewatering areas, filling and capping of landfills and storage facilities for stabilized areas, or additional handling of contaminated material to mix in agents for treatment purposes. Additional exposure could occur during the *ex situ* TCH treatment process, as not all dioxin-contaminated material is expected to be destroyed in the *ex situ* TCH pile. However, a properly designed and operated off-gas and condensate treatment system (i.e., LVTP) is expected to be capable to meeting effluent limits for vapor and liquid discharge. Additional monitoring and controls would be implemented as needed to prevent exposure to construction workers from fugitive steam and treatment residuals.

Alternative 5C – MCD

The main sources of additional potential exposure in Alternative 5C – MCD, beyond the excavation and transport of contaminated material to the Pacer Ivy and Z1 Areas, are the existence of stationary facilities in which dioxin-contaminated material would be dried in stockpiles in readiness for treatment. The potential exposure associated with the material stockpiling process would be similar to other alternatives. Additional exposure that could occur during the MCD treatment include the generation and accumulation of fugitive dust and VOC emissions. However, similar to Alternative 5A and 5B, a properly designed and operated pollution control and monitoring system is expected to be capable of meeting applicable regulatory limits for particulate, vapor, and liquid discharges. Proper PPE usage, engineering controls, H&S oversight, and medical surveillance would be implemented during MCD operations and especially during handling and management of residual/secondary wastes to minimize exposure to workers and surrounding residents.

7.1.6.3 Recommended Mitigation and Monitoring Measures

Development and implementation of an air quality mitigation and management plan is recommended to address issues relating to increased risk to air quality from release of material contaminated with dioxin and other COPCs, as well as dust. Mitigation measures may include but not be restricted to:

- Scheduling excavation activities to minimize time and area of excavation which remains open/exposed.
- Frequent spraying/damping down of excavation areas, excavated soil, worksite surface, and sensitive areas along transportation route.
- Covering stockpiles, dewatering area, and transportation vehicles to avoid windblown dust mobilization.
- Cleaning transportation vehicles and construction equipment in decontamination areas prior to leaving excavation areas.
- Cleaning transportation vehicles prior to exiting import fill source quarry.
- Ensure all contaminated material remains on the Airbase and conduct no treatment or containment activities offsite

The air quality mitigation and management plan would need to include mitigative measures required for reducing potential impact to workers including, but not limited to: gathering of data on the workers, including awareness on the dioxin issues; distribution of awareness-raising materials for workers, with a specific emphasis on women of child-bearing age, regarding the hazards of working in dioxin-contaminated areas; and training of field crews to ensure adequate protection and proper utilization of personal protective equipment. In all alternatives, all soils and sediments would be partially dewatered prior to transport in order to reduce spillage of contaminated sediment and mud onto the road, which would prevent later release into the atmosphere as dust. The alternatives developed in this EA assume that all trucks would be covered, dust suppression would be conducted as needed, and dust monitoring would be conducted to validate the effectiveness of engineering controls applied.

Related to this, proper PPE, engineering controls, third-party H&S oversight, and medical surveillance would be needed during operations for all alternatives, as each alternative includes exposure to contaminated soils and sediments, and many also include potential exposure to partially-treated materials and treatment residuals.

7.1.6.4 Determination of Effects

While there is variation among the alternatives in the potential risk of release of dioxin-contaminated material into the air, as well as release of other COPCs and dust, and potential exposure to this material by persons working and living on or near the Airbase, with the application of the mitigation and monitoring measures described above, the residual effects on air quality are determined to be **MITIGABLE** for all alternatives.

7.1.7 Potential Effects on Greenhouse Gas Emissions

7.1.7.1 Description of Effects

Implementation of any of the remedial alternatives would result in effects on climate change, specifically due to the generation of GHGs[12].

[12] For the purposes of this analysis, carbon dioxide (CO_2), and carbon dioxide equivalent (CO_{2e}) are referred to collectively as GHG emissions.

7.1.7.2 Impact Analysis

Sources of GHG emissions considered in this analysis are:

- For all alternatives: setup of project facilities; excavation and hauling; backfilling excavated areas with clean fill, either after treatment or brought in from off the Airbase; site restoration; and demobilization.
- For landfills: landfill construction consisting of establishing subgrade and liner, leachate collection system and landfill cap, and filling of landfills with contaminated material.
- For solidification/stabilization: placement of contaminated material in piles and treatment, including operation of pug mills.
- For *ex situ* TCH: construction and dismantling of the treatment piles consisting of system construction, filling the pile, capping and completing the pile and pile unloading; and TCH operation and treatment.
- For incineration: operation of the incinerator and associated equipment.
- For MCD: pre-heating contaminated material and operation of the MCD facilities.

Impacts from GHG emissions are calculated using fuel based methods for localized construction activities (e.g., excavation) where fuel consumption rates of equipment is understood. Distance based methods are used for highly mobile activities (e.g., hauling of contaminated materials) where equipment types (and therefore fuel efficiency) is less understood/predictable. Fuel type, fuel efficiency of various equipment, and duration of equipment use, all contribute to calculations of total emissions for each alternative (see **Appendix F**). The methodology for calculating emissions, using default fuel economy and distance economy factors was guided by the Greenhouse Gas Protocol (2005) developed by the World Resources Institute and the World Business Council on Sustainable Development.

Appendix F provides detailed calculations and assumptions for the amount of GHG emissions associated with each alternative; these are summarized in **Table 7-3**.

<u>Alternative 2A - Landfill</u>

The amount of GHG emissions under Alternative 2A – Landfill is estimated at approximately 18,000 t. Most of this is generated through excavation and backfilling and the associated hauling of material, as well as creation and filling of the landfill.

<u>Alternative 2B – Solidification and Stabilization</u>

The amount of GHG emissions under Alternative 2B – Solidification and Stabilization is estimated at approximately 31,000 t. The largest source of GHG emissions in this alternative is generated through excavation and backfilling, and the associated hauling of material, as well as creation and filling of the stockpile.

<u>Alternative 3 – Landfill for Material Less than 2,500 ppt TEQ, *Ex Situ* TCH for Material Greater than 2,500 ppt TEQ</u>

The amount of GHG emissions under Alternative 3 is estimated at approximately 31,000 t. Much of the GHG emissions would be generated by *ex situ* TCH operation and construction of the treatment piles, as well as constructing and filling the landfills, followed by excavation and backfilling, and the associated hauling of material. The energy required to operate the treatment piles is a significant source of GHG emissions in all alternatives that employ *ex situ* TCH technology.

<u>Alternative 4 – Landfill for Material Less than 1,200 ppt TEQ, *ex situ* TCH for Material Greater than 1,200 ppt TEQ</u>

The amount of GHG emissions under Alternative 4 is estimated at approximately 52,000 t. The greater reliance on *ex situ* TCH technology in Alternative 4, and the resulting high energy use during treatment, as compared to Alternative 3 is the main reason why predicted GHG emissions are greater in this Alternative as compared to Alternative 3

<u>Alternative 5A – Incineration</u>

The amount of GHG emissions under Alternative 5A is estimated at approximately 76,000 t. The dominant source of GHG emissions under this Alternative is the energy required for the incineration process.

<u>Alternative 5B – *Ex Situ* TCH</u>

The amount of GHG emissions generated under Alternative 5B – *Ex Situ* TCH is estimated at approximately 61,000 t. The high amount of GHG emissions associated with this alternative is due entirely to the high amounts of electricity that are required for pile treatment and the fact that a high percentage of Vietnam's electricity is generated from the burning of hydrocarbons.

<u>Alternative 5C – MCD</u>

The amount of GHG emissions generated under Alternative 5C - MCD is estimated at approximately 30,000 t. The greatest proportion of these prediction GHG emissions would be generated by pre-heating contaminated material and operation of the MCD facilities.

A related set of potential effects are associated with producing and transporting the energy needed for each remedial alternative. Most of the electricity in Vietnam that is available on national and regional power grids is generated through major hydropower, coal-fired thermal, or natural gas thermal generating facilities. These facilities would have undergone an environmental assessment as part of the EIA regulations of Vietnam and in some cases the EIA requirements of international financial institutions (e.g., IFC, World Bank, Asian Development Bank) if these institutions invested in these projects. Environmental mitigation and monitoring program have therefore likely been developed and implemented for all these major facilities that would be providing the power required for any of the remedial alternatives. It is therefore assumed that externalities associated with environmental and social consequences of these energy development projects have been properly mitigated and these costs have been captured in the cost of energy that would need to be purchased for any of the remedial alternatives.

7.1.7.3 Recommended Mitigation and Monitoring Measures

The following mitigation measures are recommended for the potential effects on GHG emissions:

- Purchase of sufficient carbon credits to offset GHG emissions of the selected remedial alternative. **Table 7-4** provides the indicative costs of purchasing the required carbon credits for each of the remediation alternatives evaluated in this EA using two sets of carbon offset prices: the price on the California carbon credit market on February 8, 2016 and the price on the EU carbon credit market as of February 12, 2016. Carbon credits are estimated to cost from approximately U.S. $100,000 to U.S. $1 million depending on the alternative and the carbon price assumed; this represents from 0.03% to 0.20% of the total estimated cost of the remediation alternatives (**Table 4-14**, baseline volume scenario), which is negligible compared to the level of uncertainty that exists in the cost estimates at this stage of design. The costs to purchase carbon credits have not been included in the preliminary estimated overall cost estimates provided in **Section 4** and **Appendix D**.

- Use of most fuel-efficient/newer construction equipment fleets.
- Development and implementation of project policies to maximize energy efficiency including:
  - Minimizing construction equipment idling, ensuring that trucks only leave with a full load, "turn off and unplug" electricity sources when not in use, and use of energy-efficient lighting.
  - Recycling and reusing construction debris as feasible (minimizes landfill emissions and potential hauling for disposal).

7.1.7.4 Determination of Effects

While there is variation among the alternatives in the expected generation of GHG emissions, largely as a result of the variation the proportion of the contaminated material to be treated and the relatively high energy requirements of treatment technologies compared to containment technologies, GHG emissions are determined to be **MITIGABLE** for all alternatives.

7.1.8 Potential Effects on Terrestrial Ecosystems and Biodiversity

7.1.8.1 Description of Effects

Implementation of any of the alternatives would result in the temporary loss of some terrestrial habitat and associated biodiversity associated with excavation of dioxin source areas, creation and operation of temporary storage and dewatering areas (landfill alternatives), creation and operation of temporary treatment facilities (incineration, *ex situ* TCH, MCD facilities), as well as construction of laydown areas and associated project facilities. There would also be a permanent loss of some terrestrial habitat and biodiversity associated with permanent structures that would remain after project completion, under Alternatives 2A (landfill), 2B (piles of solidified and stabilized material), 3 and 4 (landfill and permanent treated material stockpile), and Alternatives 5A, 5B, and 5C (permanent treated material stockpiles).

7.1.8.2 Impact Analysis

The impacts of any of the alternatives on terrestrial ecosystems and biodiversity are assessed as low in magnitude, short in duration, and largely reversible because:

1. The terrestrial habitats on the Airbase property are highly altered and degraded as a result of human activities, and likely contain negligible terrestrial biodiversity value.
2. Excavation and facilities areas would be reclaimed and restored once the Project is complete.
3. Landfill caps and surfaces of permanent stockpiles of treated soils and sediments would be vegetated, thereby creating terrestrial habitat with a habitat value that would likely be similar to existing terrestrial ecosystems.

7.1.8.3 Recommended Mitigation and Monitoring Measures

Terrestrial biological surveys should be conducted prior to commencement of construction to confirm there are no rare and endangered species on the Airbase and within the area of influence of the selected remedial alternative; any rare and endangered species that are found would need to be relocated.

7.1.8.4 Determination of Effects

With the application of the mitigation measures described above, potential residual environmental impacts on terrestrial ecosystems and biodiversity are determined to be **MITIGABLE** for all alternatives.

7.1.9 Potential Effects on Wetlands, Aquatic Ecosystems, and Aquatic Biodiversity

7.1.9.1 Description of Effects

The wetlands, aquatic ecosystems, and aquatic biodiversity that may be affected by the alternatives are located essentially around the entire perimeter of the Airbase property as well as two lakes outside the Airbase (Gate 2 Lake and Bien Hung Lake). Potential effects on these aquatic environmental resources may occur as a result of changes in hydrologic conditions from excavation of sediments, and changes in water quality. In addition, there may be potential relocation or change in surface area or volume of lakes and ponds as part of remediation activities and this may influence the integrity of wetlands, aquatic ecosystems, and aquatic biodiversity.

7.1.9.2 Impact Analysis

Project effects on surface water hydrology have been assessed as **Mitigable** for all alternatives (**Section 7.1.4**). The impacts of any of the alternatives on wetlands, aquatic ecosystems, and aquatic biodiversity are assessed based on limited baseline data available (**Section 5.2.2**). With respect to the effect of any changes in hydrologic conditions on wetlands, aquatic ecosystems, and aquatic biodiversity:

1. The area over which the activities associated with the alternatives would occur is small relative to both the total area of the Airbase and the total area of the drainage systems on the Airbase; hydrologic effects from changes in drainage area associated with any lake or wetland are expected to be minor.
2. The haul roads to be constructed or upgraded would incorporate culverts and surface runoff drainage systems to accommodate watercourse flows to lakes and wetlands. These would be maintained throughout the implementation of the selected alternative.
3. The excavation of sediments from contaminated lakes would be a required component of all remedial alternatives. Mitigation measures may be required to limit the hydrologic effects of excavating these sediments and disposal of contaminated fish, but these would be applied irrespective of the alternative selected.

There may be specific, short-term changes in the integrity of wetlands, aquatic ecosystems, and aquatic biodiversity as a result of implementing any of the remedial alternatives. However, as the lakes and wetlands on the Airbase serve a stormwater management function, the restoration of the Airbase after completion of a selected remedial alternative would require wetlands, aquatic ecosystems, and aquatic biodiversity on the Airbase functioning similarly to current conditions Therefore, there are expected to be no long-term effect on wetlands from hydrologic changes; post-construction hydrologic conditions would be essentially the same as pre-construction, so that flows to lakes and wetlands on and outside the Airbase would not be altered.

With respect to potential effects via changes in surface water quality, all project-affected water would be treated to the required standards prior to release under any selected alternative.

7.1.9.3 Recommended Mitigation and Monitoring Measures

Aquatic biological surveys should be conducted prior to commencement of construction to confirm there are no rare and endangered species on the Airbase and within the area of influence of the selected remedial alternative; any rare and endangered species that are found would need to be relocated.

7.1.9.4 Determination of Effects

With the application of the mitigation measures described above, potential residual environmental impacts on aquatic ecosystems, and biodiversity are determined to be **MITIGABLE** for all alternatives.

7.1.10 Potential Effects on Noise Levels

7.1.10.1 Description of Effects

All alternatives would require the use of equipment and machinery for construction of facilities. They would also require truck movement and hauling of contaminated from the source areas to these facilities, as well as clean materials from off-site borrow sources. This equipment, machinery, and truck hauling would increase noise levels on, and in the vicinity of, the Airbase.

7.1.10.2 Impact Analysis

Two indicators of the amount of noise that would be generated for each alternative are provided in **Table 7-5**, which provides the estimated duration with which equipment and machinery would be used, and the total estimated distance driven by trucks for materials hauling.

The alternatives align themselves into two groups with respect to these indicators of noise levels, with Alternatives 5A, 5B, and 5C predicted to have lower potential effects on noise than Alternatives 2A, 2B, 3, or 4, largely because Alternatives 5A, 5B, and 5C would require less overall movement of either contaminated material or clean fill.

7.1.10.3 Recommended Mitigation and Monitoring Measures

Development and implementation of a noise management plan is recommended to address issues related to increased noise levels as a result of the project. Mitigation measures may include:

- Ensuring all vehicles and machinery are fitted with appropriate muffler systems.
- Scheduling regular maintenance of construction equipment and transportation vehicles.
- Avoiding construction and transportation activities during night time.

7.1.10.4 Determination of Effects

With the application of the mitigation and monitoring measures described above, potential effects on noise are determined to be **MITIGABLE** for all alternatives.

7.1.11 Potential Effects on Natural or Depletable Resource Requirements

7.1.11.1 Description of Effects

All alternatives would require the importation of clean fill and gravel. The sources of these materials are unknown and there may be environmental effects associated with providing these materials for any selected alternative. There may also be cumulative environmental effects, particularly when considered in the context of the demands for these types of materials throughout Bien Hoa City, given the rapid economic development in Dong Nai Province and the overall demand for clean fill and gravel.

7.1.11.2 Impact Analysis

It is noted that treated materials could be used as clean fill for backfilling excavated areas. Because of the greater degree of confidence from the MIS sampling, it is assumed that most excavated areas would be complete after one excavation. Areas would be filled in immediately after the receipt of confirmation test results demonstrating that contaminated material has been removed in order to minimize the generation of project-affected water. The determination conclusions described below and shown in **Table 7-6** are based on the estimated maximum required volumes of clean fill that may be required.

In general, alternatives requiring the construction of landfills have higher clean fill requirements than other alternatives because of the requirement to construct landfill subgrades and less (or no) treated materials available for backfilling excavation areas. Alternatives 5A – Incineration and 5C – MCD are assessed as having the lowest clean fill requirements due to the large amounts of clean fill generated to backfill excavation areas and no requirements for clean fill to construct the treatment facilities themselves, as would be the case for Alternative 5B – *Ex Situ* TCH.

Vietnamese environmental legislation requires a full EIA to be prepared for any facility that extracts "minerals" to use as leveling and filling materials with a capacity of 100,000 m^3 of fill per year or greater (Decree No. 21 2008). If the clean fill for the Project were to be obtained from a new single source, a full GVN EIA would be required specifically for the provision of clean fill for all the alternatives that have a landfill as a component.

7.1.11.2 Recommended Mitigation and Monitoring Measures

A key mitigation for the alternatives that consist of complete (Alternatives 5A, 5B, 5C) or partial (Alternatives 3, 4) treatment would be to use treated material as backfill for excavated areas; this mitigation has already been included in the estimate of the amount of clean fill required for each alternative (**Section 4**). It may be possible to perform *in situ* solidification/stabilization under Alternative 2B for some of the contaminated material to reduce the amount of clean fill required to fill excavated areas, although this is not part of the current conceptual design of Alternative 2A.

The treatment goal applied to the contaminated material would influence the extent to which the clean, post-treatment material could be used to backfill excavated areas near lakes on the Airbase. A treatment goal greater than 150 ppt would result in material that, post-treatment, would require mitigation measures if placed near lakes, so as to limit the risk of sediments in those lakes returning to dioxin concentrations greater than 150 ppt due to erosion and runoff from the backfill.

7.1.11.4 Determination of Effects

Given that the clean fill requirements for both landfill and solidification/stabilization alternatives are greater than the EIA trigger in Vietnamese environmental regulations, potential environmental impacts on natural or depletable resources are determined to be **MITIGABLE** for Alternatives 2A – Landfill, 2B – Solidification/Stabilization, 3 – Containment of Soils/Sediments Less than 2,500 ppt TEQ, Treatment of Soils/Sediments Greater than 2,500 ppt and 4 - Containment of Soils/Sediments Less than 1,200 ppt TEQ, Treatment of Soils/Sediments Greater than 1,200 ppt, and **INSIGNIFICANT** for Alternatives 5A – Incineration, 5B – *Ex Situ* TCH, and 5C - MCD.

7.1.12 Potential Long-Term Environmental Risks Associated with Operation of Selected Remedial Alternative

7.1.12.1 Description of Effects

There may be potential environmental impacts associated with the operation of a selected alternative.

7.1.12.2 Recommended Mitigation and Monitoring Measures and Impact Analysis

There are long-term environmental risks associated with the operation and maintenance of the landfills in Alternatives 2A, 3, and 4. Insufficient operation and maintenance of these landfills may result in the release of this contaminated material back into the natural environment. The magnitude of the risk would be a function of the concentration of dioxin in the contaminated material captured in the landfills; as a result, the long-term environmental risk associated with landfills decreases from Alternative 2A to Alternative 3, and then to Alternative 4.

In addition, there are long-term environmental risks associated with Alternate 2B – Solidification/Stabilization, as the long-term integrity of the stabilized materials is uncertain; it will be necessary to monitor the long-term effectiveness and integrity of these materials, with institutional controls needed to prevent disturbing the stabilized materials and maintain the cap system on top of the stabilized materials.

There are no long-term environmental risks associated with Alternatives 5A, 5B, or 5C as "operation" for these alternatives would be the actual treatment of the contaminated materials, through incineration, *ex situ* TCH, or MCD technology; no ongoing operation and maintenance or monitoring would be required after treatment.

7.1.12.3 Determination of Effects

With the application of the mitigation and monitoring measures described above, potential environmental impacts associated with the operation of a selected remedial alternative are determined to be **MITIGABLE** for Alternatives 2A, 2B, 3, and 4. The potential environmental impacts associated with the operation of a selected remedial alternative are assessed as **NO IMPACT** for Alternatives 5A, 5B, and 5C.

7.1.13 Risk of Re-Contamination of Treated Lakes

7.1.13.1 Description of Effects

There are several lakes on the Airbase that have dioxin concentrations greater than 150 ppt whose sediments would be removed and treated under all of the remedial alternatives. However, six of the lakes (Z1-9, Z1-10, PI-17, PI-18, PI-20, and NE-8) are situated adjacent to areas of soil with dioxin concentrations greater than 150 ppt but below any of the land use based dioxin limits (Z1-6, Z1-7, Z1-16, PI-4, PI-8, PI-9, and NE-4). These areas of soil pose an ongoing re-contamination risk to the six lakes that would be treated from migration of adjacent soil that exceeds the dioxin sediment limit. The magnitude of this residual risk needs to be quantified.

7.1.13.2 Recommended Mitigation and Monitoring Measures and Impact Analysis

Options to prevent recontamination of lakes after their sediments are remediated could include engineering and institutional controls to reduce the risk of recontamination of these lakes. These controls would need to be finalized as part of the detailed design of any selected remedial alternative, but could consist of re-grading the topography of the adjacent areas, capping the adjacent soil surface with clean fill, building berms from clean fill around the lakes, rerouting drainage, and/or installing sediment traps that would need to be periodically cleaned.

7.1.13.3 Determination of Effects

With the application of the mitigation and monitoring measures described above, potential environmental impacts associated with re-contamination of lakes on the Airbase are determined to be **MITIGABLE** for all remedial alternatives.

7.1.14 Potential Requirements for Resettlement

7.1.14.1 Description of Effects

Most proposed remediation activities at the Airbase will be undertaken in areas where there are no civilian or military housing or infrastructure. However, there are four DUs where resettlement and relocation of existing buildings may be required as follows: SW-7 (military barracks); PI-12 (one or two houses and a small business); and PI-15 and PI-16 (if excavation extends beyond the drainage channel boundaries). Should resettlement be required, the impacts will be significant and need to be handled carefully by local authorities.

7.1.14.2 Impact Analysis

Implementation of any of the alternatives would result in potential need for resettlement at SW-7, PI-12, and possibly PI-15 and PI-16. The following activities would have potential impacts:

1. All alternatives would require the use of equipment and machinery for excavation and hauling contaminated soil and sediments and construction of facilities. These activities may occur in close proximity to households, army barracks or other infrastructure.
2. PAPs and infrastructure located adjacent to or within contaminated areas may be subject to increased potential for dioxin exposure through air or water during excavation and handling of contaminated soils and sediments. Noise health effects may also occur for local residents.
3. The transport of contaminated material from PI-12, PI-15, and PI-16 to the Pacer Ivy Area along haul roads is a major potential source of dioxin contamination for all remedial alternatives.
4. Requirement for relocation or resettlement of PAPs may result in temporary loss of housing, businesses, livelihoods, and/or other assets, which will need to be replaced and/or other

compensation agreed to with local authorities. Grievances may arise if resettlement is not handled carefully and if fair compensation is not provided to PAPs.

The impacts of any of the alternatives on potential for resettlement would likely be short in duration, reversible, and generally low in magnitude, assuming that a RAP is developed and effectively implemented, since:

1. The number of PAPs and infrastructure to be potentially relocated is small (estimated <10 households) relative to the total population living on or in the vicinity of the Airbase.
2. The area over which the activities associated with the alternatives would occur is small relative to the total area of the Airbase.
3. Following remediation, PAPs could potentially return to the same locations where they resided previously, and/or move to nearby locations without long-term impacts to their livelihoods.
4. The risk of potential long-term dioxin exposure will be reduced as a result of the successful completion of the remediation activities.

7.1.14.3 Recommended Mitigation and Monitoring Measures

During detailed design of remediation activities, if resettlement is deemed necessary, a Resettlement Action Plan (RAP), following the guidance provided in OP4.12 of the World Bank[13], will be required, which will include a detailed inventory of: number of potentially impacted project affected people (PAP); houses/barracks, buildings, businesses and other infrastructure which needs to be relocated; and a list of assets (e.g., physical, economic, livelihoods, etc.) requiring compensation. The RAP would also include a community engagement and communication plan for guiding discussions with PAPs and local communities regarding the process for resettlement, including dealing with grievances. All PAPs must be provided with adequate compensation which results in them being 'equal to or better off' in terms of assets and livelihoods than they were before resettlement occurred.

7.1.14.4 Determination of Effects

Effects in relation to potential requirements for resettlement for all alternatives are determined to be **MITIGABLE**.

7.1.15 Potential Impacts from Climate Change

This section assesses the viability of the alternatives (including the No Action alternative) with respect to potential effects of climate change.

Research and assessments conducted by GVN indicate:

- Current long term projections are for an increase in mean annual temperature and mean annual precipitation of 1°C and 0.7%, respectively, by 2050 for the southern part of the province of Dong Nai (MONRE 2009, high emission scenario).

[13] World Bank Operational Policy 4.12 Involuntary Resettlement, located at http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/EXTPOLICIES/EXTOPMANUAL/0,,contentMDK:20064610~menuPK:64701637~pagePK:64709096~piPK:64709108~theSitePK:502184,00.html

- The best current predictions are that Bien Hoa City and the entire province of Dong Nai will be relatively unaffected by inundation from sea level rise occurring as a result of climate change, with only modest effects on population and infrastructure (ICEM 2008).. The elevation information provided in Dekonta (2014), states that much of the Airbase is at greater than 2.25 meters above sea level (masl)[14], which suggests that inundation from sea level rise is unlikely to be an issue for any of the remedial alternatives.
- Shorter-term impacts may include higher-intensity typhoons and extreme weather events occurring more frequently (MONRE, 2009).

An increased frequency and intensity of extreme weather events would potentially influence the timing of construction activities between dry season and rainy season and may require more conservative assumptions about return frequencies of weather events when designing structures, facilities and environmental mitigations such as water management schemes. In general, longer construction schedules would require a greater consideration of these potential effects. In this regard, most of the alternatives are equally-preferred with respect to this potential effect as their implementation schedules are similar in length (i.e., 5 year to 8 years). The exceptions are Alternatives 5B and 4, which are assessed as being less-preferred alternatives with respect to this potential effect because of their long implementation schedules (i.e., 14 years and 10 years, respectively). These effects, however, are mitigable and will likely be reflected in the actual cost of the selected remedial alternative.

Potential effects of increased frequency and intensity of extreme weather events are more problematic climate change issues with respect to longer-term effects on the viability of the alternatives:

1. Under the No Action alternative, contaminated material could be moved and dispersed beyond its current distribution as a result of increased frequency and intensity of extreme weather events.
2. The integrity of the landfills in Alternative 2A and stockpiles of stabilized/solidified material in Alternative 2B would be under increased risk of being compromised as a result of increased frequency and intensity of extreme weather events as a result of climate change.
3. There would be no effects of increased frequency and intensity of extreme weather events under Alternatives 5A, 5B, or 5C as no contaminated material above dioxin limits would remain in these alternatives.
4. Given their combination of landfill and treatment technologies, the effects of increased frequency and intensity of extreme weather events for Alternatives 3 and 4 would be intermediate to, on the one hand, Alternatives 2A and 2B (complete containment) and, on the other hand, Alternatives 5A, 5B, and 5C (complete treatment). Furthermore, there would be lower risk associated with Alternative 4 compared to Alternative 3, given the lower threshold of 1,200 ppt for containment associated with Alternative 4.

[14] The lowest-elevation measured in existing groundwater wells described in Dekonta (2014), in the Pacer Ivy area near the western boundary of the Airbase, is at 3.26 masl. Assuming the top of the well is 1 m above the ground, means that the ground at that part of the Airbase is approximately 2.25 masl, which is greater than an assumed 1 m rise in sea level that is the worst-case scenario used in ICEM (2008).

7.2 Gender Issues in Relation to Remediation Alternatives

7.2.1 Assessment of Gender-Related Effects

Each of the seven remediation alternatives, plus the No Action Alternative, are associated with potential dioxin exposure of local residents and construction workers. During the excavation and transportation of contaminated material, there is a risk of inhalation of dust particles and dermal absorption of dioxin from soil or sediment, which may occur in situations where certain people contact the soil or sediment during activities such as working on site. Because the surficial soil is contaminated, the finer contaminated particulates may on occasion become suspended in the air due to wind erosion or disturbance by cars and trucks. Airborne particulates carrying dioxins may then be inhaled, resulting in a portion of the contaminants being absorbed across the respiratory pathway. Alternatives that require increased handling of contaminated material are likely to have the greatest potential for exposure of local residents in the short term, while less effective alternatives would likely result in increased continued exposure in the long term.

Both men and women are directly impacted by exposure to dioxin with toxic effects ranging from skin lesions to immunotoxicity and developmental and neurodevelopmental effects (WHO 2010). Women of child-bearing age and children are considered sensitive receptors due to the reproductive and developmental effects of dioxin. Women with high concentrations of dioxins can expose the fetus in the womb and pass dioxin to infants through breast milk. Environmental and human health assessments completed in 2010 found that breastfed infants were the most highly exposed population on a body weight basis (Hatfield and Office 33 2011, Nguyen et al. 2011).

Potential gender-based impacts resulting from environmental remediation were analyzed for the different functional labor groups as well as the local residents in the following sections.

7.2.1.1 Construction Workers

Construction workers are likely to be the most at-risk functional labor group given their role in excavating and transporting contaminated material. Direct contact with soil and/or sediment is possible during these activities, as is inhalation of contaminated dust particles. Remediation alternatives including stabilization/solidification, incineration, *ex situ* TCH and MCD require more handling of contaminated material and would, therefore, increase the likelihood of exposure to dioxin by construction workers.

Based on statistics provided by the Dong Nai Statistical Office (2013), construction is a male-dominated industry with women accounting for only 9.8% of those employed (Dong Nai Statistical Office 2013). USAID (2010b) found that of the women typically employed in construction-related activities in Danang, 50% were in administrative and ‘other’ roles, while 50% were construction laborers. It is expected that the employment of women in construction companies based in Bien Hoa City and nearby would be qualitatively similar to the Danang situation reported by USAID (2010b). Mitigation measures required to eliminate or reduce health risks to construction workers, male and female, from exposure to dioxin during excavation and transport would therefore likely be independent of the actual percentage of women employed as construction laborers. Under Vietnamese law, women and men are entitled to equal employment opportunities. Women are additionally offered protection from hazardous work environments that may have harmful effect on their reproductive and childbearing ability[15].

Occupational hazards specific to women in construction include poorly fitting PPE, which are typically designed and sized for men, and a lack of clean and private sanitary facilities that consider the different needs of women. Particular attention on task assignments would be required for women of childbearing age as a result of the heightened impact of exposure experienced; this would be especially important for activities involving close contact and increased risk of exposure to contaminated material. Certain alternatives may be associated with added handling of material such as during the construction of the *ex situ* TCH piles and use of the conveyor system during thermal and MCD treatment system operations. If women's access to construction employment is limited due to health concerns, then alternative jobs or income generation activities must be offered.

Construction workers, employed to support the remediation efforts, would predominantly be sourced from local companies; however, for larger projects, labor may be required from other city centers (USAID 2010b). Migrant workers may be required to stay on-site to complete the construction activities. Temporary housing and other facilities would need to be designed and sited to limit exposure to contaminated material. Additionally, consideration needs to be given to ensuring female worker H&S, such as separate and private bathing and living facilities as well as a monitoring system to ensure women are not experiencing gender-based violence.

Influx of migrant workers associated with large-scale projects can increase the rate of communicable diseases in local communities as well as change the social and economic contexts. Community H&S plans as well as grievance mechanisms would be necessary to ensure potential negative impacts are limited.

7.2.1.2 Military Personnel and Airbase Workers

Information was not made available on the gender breakdown of military personnel and Airbase workers nor on the role of women working on the Airbase. Both male and female military personnel and Airbase workers have the potential to be exposed to contaminated particulate matter when working on the Airbase. Precautions should be taken to alter duties of women of childbearing age in order to limit their exposure to dust generated from remediation activities.

Livelihood and subsistence activities previously practiced on the Airbase such as fishing and farming have been restricted since 2010, with mixed effectiveness as described earlier. These restrictions should be maintained and enforced during the remediation activities.

7.2.1.3 Residents

The project would result in positive impacts overall for the residents in the wards surrounding the Airbase. The risk of potential long-term dioxin exposure would be reduced as a result of the successful completion of the remediation activities. Residents are currently potentially exposed to dioxin through dietary exposure, soil ingestion, dermal absorption, and inhalation.

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[15] Vietnam Labor Code (2012). Available from https://www.ilo.org/dyn/natlex/docs/MONOGRAPH/91650/114939/F224084256/VNM91650.pdf

During excavation and transportation of contaminated material, there is potential for increased exposure for Bien Hoa City residents through dust and air emissions. Alternatives requiring more movement of contaminated soil and sediment from excavation areas to contaminated stockpiles to treatment sites and other stockpiles (such as solidification/stabilization, incineration, and MCD), are likely to be associated with greater potential for dust generation. In contrast, those alternatives that are not destructive, such as landfill and stabilization/solidification, may extend the potential exposure timeframe for local residents and would extend the duration of restricted access to livelihood opportunities.

Indirect impacts from restricted access to the Airbase has resulted in a loss of livelihoods and means of subsistence food production through farming, forestry, fishing, and aquaculture for some residents. This may have disproportionately impacted women, who are primarily involved in these unpaid, informal livelihood activities. Additionally, women would play the primary role of ensuring children are not accessing the Airbase; this extra burden of ensuring that children are not playing on or near the Airbase would have time implications for women and restrict them from completing other activities.

7.2.2 Project Beneficiaries

Bien Hoa City is a densely populated city with roughly 1 million people. The project would result in positive impacts for the residents in the five wards (Trang Dai, Binh Hoa, Buu Long, Quang Vinh, and Trung Dung) directly adjacent to the Airbase. The risk of potential long-term dioxin exposure would be reduced as a result of the successful completion of the remediation activities.

Approximately 120,000 persons are estimated to live in the city wards surrounding the Airbase as well as on the Airbase itself[16]; there are upwards of 120,000 persons who would therefore directly benefit from implementation of any one of the project alternatives.

7.3 Environmental Mitigation and Monitoring

7.3.1 Overview

This section presents a preliminary conceptual EMMP that is based on information presented earlier in this EA, and is applicable as an indicative EMMP for all seven alternatives. It is expected that a revision and elaboration of this EMMP may be required if an alternative is selected and the entire dioxin remediation program for the Airbase moves to more advanced stages of planning and design. It is also expected that a final standalone EMMP that would be developed for the selected alternative would help form the basis for the completion of the GVN EIA for the remediation project, and would also be included as part of procurement documents used for solicitation of goods and services for remedial action.

7.3.2 Environmental Mitigation

Table 7-7 contains a set of environmental mitigation measures for the significant environmental issues identified in **Section 7.1**.

[16] In 2012, approximately 111,000 persons lived in the city wards surrounding the Airbase, while approximately 1,200 persons lived on the Airbase itself (Canh 2012b). For the purposes of this EA a current population of 120,000 persons living in the vicinity of and on the Airbase is assumed, with 1,200 of these persons assumed to be living on the Airbase. This estimate is reflective of recent population growth estimates of Dong Nai Province reported in Dong Nai Statistical Office (2013).

7.3.3 Environmental Monitoring

As indicated in **Section 5**, the existing baseline data on most environmental resources for the Airbase and off the Airbase are limited. Therefore, prior to implementing any selected alternative, a comprehensive environmental baseline survey would need to be undertaken both on and off the Airbase. These baseline data would act as indicators in monitoring environmental effects of the selected alternative during construction and operation activities. Following this baseline survey, a targeted monitoring plan would be developed. This plan would outline where surveyed monitoring points should be established and parameters to be analyzed to determine baseline surface water, groundwater, sediment, and air quality conditions. This plan would provide specific details on the:

- Type of monitoring required (analytical testing, field measurements, visual inspections, etc.).
- Frequency of monitoring required (daily, weekly, monthly, annually, etc.).
- Monitoring roles and responsibilities (contractor, environmental monitor, etc.).
- Reporting responsibilities.

7.3.4 Gender Considerations in EMMP Design and Implementation

The final EMMP for the selected alternative should be designed to ensure that women are provided with equal opportunity to participate in all facets of the Project and ensure that potential gender-based impacts outlined are accounted for and managed. Project oversight and management should also be sensitive to the different status of women and men and the influence of gender roles and norms in Vietnam. This might entail targeted measures to ensure that key decisions as well as decisions on safety and task assignments are being made by equal representation of males and females.

Recommendations to address key impacts identified for construction workers include the following:

- Require all-third party contractors undertaking the remediation activities to comply with Vietnamese regulations, specifically the Vietnam Labor Code 2012 and to be aware of the Law on Gender Equality.
- Conduct training and require use of international standard PPE for all construction workers. PPE required should be designed and sized appropriately for women as well as for the tropical climate. Feedback should be obtained from workers regarding the appropriateness of the PPE to ensure that they would wear the equipment and that the equipment itself is not resulting is other risks. Training should address the importance of, and proper use of, PPE.
- Ensure that all female construction workers are provided with information on their rights under the Vietnam Labor Code 2012 as well as the potential impacts and pathways for dioxin exposure. In the event that female workers do not compose the same percentage of the construction workforce as is reported by the Dong Nai Statistical Office 2013, or if female construction workers choose not to work on the site due to the potential dioxin contamination risks communicated to them, they must be offered alternative income generation activities to prevent discrimination under the Vietnam Labor Code 2012.
- Clearly communicate to the construction companies undertaking the remediation activities the potential dioxin pathway, and preventative measures for reducing risk of dioxin contamination in male and female workers. Heightened impacts for women of childbearing age needs to be

communicated to all workers and it should be required that all workers assist in ensuring women of childbearing age are restricted from certain activities.

- Contractors are required to ensure medical monitoring is conducted for employees working on the site. This includes use of health questionnaires and blood serum sampling to determine baseline dioxin concentrations in workers prior to commencing work on the site and regular monitoring over the period of employment on the remediation project.

Recommendations to address key impacts identified for military personnel and airbase workers include the following:

- Conduct education and awareness-raising outreach campaigns with male and female military personnel and Airbase workers regarding the potential dioxin pathways and preventative measures for dioxin contamination.
- Remediation planning documents must ensure that the most appropriate route is selected for transportation of contaminated materials to minimize potential impacts to military personnel, Airbase workers and residents of surrounding communities. The transportation route should be communicated to Airbase residents as well as residents of the wards adjacent to the Airbase. Transportation schedules should also be provided so that residents can take extra precautions to reduce exposure during transport times, with a specific emphasis on women of childbearing age and children.

Recommendations to mitigate any potential gender issues for residents include the following:

- Instill best practices for remediation activities to ensure contaminated material does not leave the Project area (e.g., air quality/dust monitoring, ban on fishing, appropriate decontamination of equipment and trucks, etc.).
- Engage with community leaders and key community groups to determine best ways of minimizing risk to the local communities. Ensure that women and women's groups are included in the discussions and their particular concerns are heard and addressed. Ongoing meetings with a gender–equal community advisory group should be implemented to monitor issues and concerns.
- Comprehensive surveys should be completed to determine the level of continued use of natural resources on and surrounding the Airbase, despite imposed restrictions. Researchers should determine the key reasons for continued access and identify appropriate means of eliminating this exposure pathway (e.g., are community members continuing to fish for livelihoods and subsistence, or because they lack an understanding of the exposure pathways?). High-risk foods known to be raised and/or cultivated on the Airbase include fresh water fish and other aquatic animals (e.g., snails), chicken, ducks, geese, cows, pigs, and root vegetables.
- Locate and identify sensitive receptors within the communities such as schools, hospitals, offices or buildings which have a high percentage of employees who are female and of childbearing age. Once located, construction routing and siting should be made to reduce exposure to these locations.
- Conduct education and outreach campaigns for nearby residents using local communication channels, such as community meetings, direct consultation, and distribution of leaflets to households. Campaigns should include information on:

  - Potential dioxin exposure pathways and risks. Local residents should be provided with specific information on the risk of dioxin exposure within their area, and measures to prevent dioxin exposure.
  - Information on consumption and cultivation of high-risk foods in the wards surrounding the Airbase.
  - Training on food and drinking water safety as well as investigations to ensure that local communities have access to safe foods.
- Conduct confirmatory sampling, which should include soil and sediment sampling following excavation and prior to backfilling with clean soil, to ensure concentrations of dioxin in soil and sediment are below GVN cleanup standards.
- Conduct annual fish tissue sampling for 3-5 years, at a minimum, to ensure that fisheries resources in the project area are safe for consumption following remediation activities.

7.3.5 Resettlement Considerations in EMMP Design and Implementation

Recommendations to address key impacts identified related to potential for resettlement include the following:

If resettlement is deemed necessary, a RAP would be required as a separate document to the EMMP, which would include a detailed inventory of:

- Number of potentially impacted PAPs.
- Houses/barracks, buildings, businesses and other infrastructure which needs to be relocated.
- A list of assets (e.g., physical, economic, livelihoods, etc.) requiring compensation.

The RAP should also include a community engagement and communication plan for guiding discussions with PAPs and local communities regarding the process for resettlement, including outlining grievance procedures.

All PAPs must be provided with adequate compensation which results in them being 'equal to or better off' in terms of assets and livelihoods than they were before resettlement occurred.

7.4 Summary of Environmental Consequences

7.4.1 No Action Alternative

The No Action alternative has no cost associated with project implementation. However, there would be significant externalized costs such as health effects of neighboring communities and of Airbase residents. In addition, the No Action alternative would result in continuation over the long term of the following environmental impacts:

- Soil and sediment concentrations that exceed MND-approved dioxin limits and GVN land use requirements for dioxin contamination.
- Continued fish contamination at levels that exceed international standards.
- Continued potential exposure of Airbase residents and residents of neighborhoods that adjoin the Airbase.

- Persistence of dioxin in soil and sediment that exceeds MND-approved dioxin limits, with associated persistence of exposure pathways that could impact environmental, biological and human receptors.

7.4.2 Remedial Alternatives

All remedial alternatives have a number of **POSITIVE** environmental consequences as a result of removing of dioxin exposure pathways and reducing exposure risk to dioxin, as well as removing dioxin concentrations on the Airbase as a constraint to land use changes and development. In addition, there are a number of environmental resources, notably protected areas and cultural, heritage, and tourism resources for which all remedial alternatives are predicted to have **NO IMPACT**.

In general, however, the overall environmental and associated social and gender impacts of all remedial alternatives are potentially substantial (**Section 7.1, Section 7.2**). All alternatives require the excavation, transport, and deposition of a large volume of dioxin-contaminated material from source areas into a landfill or stockpile for either containment or treatment, and wetland ecosystems must be drained and dredged to remove contaminated sediments. Environmental impacts are unavoidable over the short term in order to eliminate the possibility of future dioxin exposure to humans and the environment.

However, there are mitigation and monitoring measures available to address all potential environmental and associated social and gender impacts (**Section 7.3**). Properly implemented as part of the selected remedial alternatives, all potential environmental and associated social and gender impacts are assessed as **MITIGABLE**. The residual environmental and associated social and gender impacts are predicted to be as follows:

- **Geographic Extent:** Residual effects are predicted to occur almost exclusively within the Airbase property. The exception to this is GHG emissions which, by their very nature, are global in geographic extent.
- **Duration:** The duration of all residual effects is predicted to be long-term and occurring during the construction and operation of the remedial alternative, with the exception of risk of compromised integrity of containment landfills and solidification/stabilization structures for a number of the remedial alternatives, as well as the risk of re-contamination of selected Airbase lakes, both of which are predicted to be residual legacies of the remedial alternatives.
- **Magnitude:** All residual effects for all remedial alternatives considered in this EA are predicted to be of low magnitude. Residual effects are predicted to be somewhat above typical background conditions, but well within established or accepted protective standards and normal socio-economic fluctuations, and will cause no detectable change in ecological, social or economic conditions.
- **Confidence:** There is a **High** level of confidence in the predicted environmental effects of the remedial alternatives because predicted effects are based on good understanding of cause-effect relationships and data and information from the Airbase and Bien Hoa City, as well as a set of proven and well-accepted mitigation and monitoring measures for effectively reducing or limiting potential environmental and related social and gender impacts of any of the remedial alternatives assessed in this EA. The exception to this is confidence that the required institutional controls will be sufficiently maintained over time for:

- Containment landfills under a number of the remedial alternatives (**Section 7.1.12.2**) including being able to deal with potential increased frequency and intensity of extreme weather events, as a result of climate change, on the integrity of those containment landfills (**Section 7.1.15**).
- Prevention of recontamination of lakes and aquatic ecosystems on the Airbase from soils that are contaminated with dioxin at levels that are too low to warrant remediation but are sufficiently high to pose a risk to sediments on those lakes.

Table 7-1 Comparison of Land Disturbance Area for the Remediation Alternatives

Alternative	Project Footprint (m^2)		Total Area to be Excavated (m^2)	Total Land Disturbance (m^2)
	Pacer Ivy Area	Z1 Area		
Alternative 2A Landfill	100,000	60,000	481,900	641,900
Alternative 2B Solidification/Stabilization	100,000	76,000	481,900	657,900
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	150,000	104,000	522,400	776,400
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	150,000	160,000	522,400	832,400
Alternative 5A Incineration	100,000	148,000	522,400	770,400
Alternative 5B *Ex Situ* TCH	100,000	148,000	522,400	770,400
Alternative 5C MCD	100,000	148,000	522,400	770,400

Table 7-2 Estimated Volumes of Contaminated Wastewater for the Remedial Alternatives

Source of Wastewater	**Estimated Volume of Project-Affected Water Generated (m³)**						
	Alt. 2A Landfill	**Alt. 2B** Solidification / Stabilization	**Alt. 3** Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	**Alt. 4** Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	**Alt. 5A** Incineration	**Alt. 5B** *Ex Situ* TCH	**Alt. 5C** MCD
Precipitation onto facilities and project activities	27,813	187,867	47,055	80,262	147,295	153,271	259,365
Groundwater seepage into open excavations	189	275	177	161	321	233	404
Dredging and dewatering of sediments	9,744	9,744	9,744	9,744	9,744	9,744	9,744
Generation of landfill leachate	3,783		3,583	3,291			
Total	**41,529**	**194,886**	**60,559**	**93,458**	**157,360**	**163,248**	**269,513**

Note: See Appendix F for detailed calculations of wastewater generation

Table 7-3 Comparison of Estimated GHG Emissions for the Remedial Alternatives

	Project Activity	2A Landfill		2B SS		3 Ex-Situ TCH (>2,500 ppt)		4 Ex-situ TCH (>1,020 ppt)		5a Incineration		5B Ex-situ TCH		5C MCD	
		Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)	Impact Analysis	Amount (t)
A.	Equipment, Facilities, and Project Area Setup: construction of general facilities, stockpiles, temporary storage & dewatering area, and road upgrades	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 4 months 10,000 m^3 (imported soil, boulders), 20 km round-trip	2,031	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months 23,500 m3 import fill, 20 km round-trip	2,633	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 4 months 25,200 m3, 20 km roundtrip	2,977	Construction: Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2); 4 month duration, 39,360 m^3 (imported soil, boulders), 20 km round-trip	3,309	Construction: Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2); 4 month duration, 36,000 m^3 (imported soil, boulders), 20 km round-trip	3,629	Construction: Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2); 4 month duration, 38,160 m^3 (imported soil, boulders), 20 km round-trip	3,228	Construction: Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2); 4 month duration, 43,200 m^3 (imported soil, boulders), 20 km round-trip	4,145
B.	Landfill Construction - Establish subgrade & liner and leachate collection system and landfill cap	Dozer, Grader. 75,000 m^3 import fill. 14 m^3 trucks, import fill source 30 km round-trip, 8 months duration[2] Cap - Dozer (2), Compactor (2), Grader, 5 months 163,200 m3 import fill, 20 km round-trip	4,853	---	---	Dozer, Compactor (3), Grader, 14 m3 Truck (2), 9 months duration 131,250 m^3 Import fill, 20 km round-trip Cap - Dozer (2), Compactor (2), Grader, 5 months duration	4,031	Dozer, Compactor (3), Grader, 14 m3 Truck (2), 8 months duration 119,250 m^3 Import fill, 20 km round-trip Cap - Dozer (2), Compactor (2), Grader, 4 months duration	4,184	---	---	---	---	---	---
B.	SS Treatment at pace ivy - placement of material in pile, treatment or Incineration operation or MCD Treatment	---	---	Auger, Art-wheel loader, conveyor, 67 months Art-wheel loader, dozer, 14 m3 Truck (2), 51 months 43,460 m3 in admixture, 20 km round-trip 117,900 m3 in import fill for subgrade, 20 km round-trip	13,469	---	---	---	---	art-wheel loader, dozer, 36 months energy needs (electricity and natural gas - 1,003,276/project cycle	60,092	---	---	Dozer, Art-Wheel Loader, 49 months 163,200 m3 import fill, 20 km roundtrip Pre-heating electricity - 17,616,563 kWh/project Electricity MCD Treatment - 28,186,500 kWh/project	11,466
B.	Ex-situ TCH System Construction - system construction, filling the pile, capping and completing the pile and pile unloading	---	---	---	---	System construction - Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months; Filling and unloading pile - Dozer (2), Art-Wheel Loader, 12 months; Capping - Dozer, Compactor (2), Grader, 14 m3 Truck (2), auger or drill, 11 months Import fill 109,200 m3, 20 km round-trip	4,360	System construction - Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 14 months; Filling and unloading pile - Dozer (2), Art-Wheel Loader, 12 months; Capping - Dozer, Compactor (2), Grader, 14 m3 Truck (2), auger or drill, 14 months Import fill 163,200m3 20 km round-trip	9,964	---	---	IPTD system - Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 14 months Filling the pile - Dozer (2), Art-Wheel Loader, 24 months Capping - Dozer, Compactor (2), Grader, 14 m3 Truck (2), auger or drill, 42 months 163,200 m3 import fill, 20 km round-trip	14,030	---	---
B.	Ex-situ TCH Operation	---	---	---	---	21,000,000 kWh per pile	7,471	Electricity needs	18,678	---	---	Electricity - 168,000,000 kWh/projec lifecycle	29,885	---	---
B.	Excavation and hauling	Dozer (2), Art-Wheel Loader, 21 months 434,600 m3 excavated, 3.1 km round-trip	2,488	Dozer (2), Art-Wheel Loader, 36 months 434,600 m3 excavated, 3.1 km round-trip 478,060 m3, 0.1 km round-trip to landfill	3,427	Dozer (2), Art-Wheel Loader, 28 months, 417,360 m3 soil and sediment, trip length varies - 3.2 km round trip	2,899	Dozer (2), Art-Wheel Loader, 38 months, 490,200 m3 soil and sediment, 3.2 km round trip	3,740	Dozer (2), Art-Wheel Loader, 65 months 408,500 m3 excavated, 3.1 km round-trip	3,857	Dozer (2), Art-Wheel Loader, 40 months 408,500 m3 excavated, 3.2 km round-trip	3,858	Dozer (2), Art-Wheel Loader, 49 months 408,500 m3 excavated, 3.2 km round-trip	4,438
C.	Backfilling with offsite clean fill	Dozer, Compactor, 20 months 315,700 m3 clean fill, roundtrip 20 km	6,864	Dozer, Compactor, 24 months 315,700 m, 20 km round-trip	7,466	Dozer, Compactor, Art-Wheel Loader, 18 months 221,800 m3 import fill, 20 km round-trip	3,871	Dozer, Compactor, Art-Wheel Loader, 14 months 200,400 m3 import fill, 20 km round-trip	3,781	Dozer, Compactor, Art-Wheel Loader, 3 months	1,032	Dozer, Compactor, Art-Wheel Loader, 4 months 39,600 m3 import clean fill, 20 km round-trip	1,161	Dozer, Compactor, Art-Wheel Loader, 4 months 39,600 m3 import clean fill, 20 km round-trip	645
C.	Backfilling with treated soil	---	---	---	---	Dozer, Compactor, Art-Wheel Loader, 6 months 84,200 m3, 3.1 km round trip	859	Dozer, Compactor, Art-Wheel Loader, 15 months 178,400 m3, 3.1 km round trip	2,195	Dozer, Compactor, Art-Wheel Loader, 23 months	3,825	Dozer, Compactor, Art-Wheel Loader, 22 months 276,100 m3 backfill, 3.1 km round-trip	3,020	Dozer, Compactor, Art-Wheel Loader, 31 months 276,100 m3 backfill, 3.1 km round-trip	5,215
C.	Final Permanent Stockpile	---	---	---	---	Hauling of soil	127	Hauling of soil	131	Hauling of soil	249	Hauling of soil	249	Hauling of soil	249
D.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 4 months 2,500 m3 clean fill, roundtrip 20 km	1,342	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 6 months 2,500 m3 clean fill, roundtrip 20 km	1,945	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 6 months 7,500 m3 import fill, 20 km round-trip	1,801	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 6 months 8,200 m3 import fill, 20 km round-trip	3,061	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 4 months 7,500 m3 import clean fill, 20 km round-trip	1,609	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 9 months 7,500 m3 import clean fill, 20 km round-trip	3,048	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 6 months 9,000 m3 import clean fill, 20 km round-trip	2,211
E.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 2 months	602	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months	2,108	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months	1,757	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months	2,710	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 6 months	1,807	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 9 months	2,710	Dozer, Compactor (2), Grader, Paver, 14 m3 Truck (2), 7 months	2,108
	Total		**18,180**		**31,049**		**30,154**		**51,755**		**76,100**		**61,190**		**30,476**

Table 7-4 Indicative Costs of Purchasing the Required Carbon Credits for each of the Remedial Alternatives Evaluated in this EA

Alternative	Tonnes CO_2 Emitted[1]	Cost of Carbon Credit (USD)		Preliminary Estimated Overall Cost of Alternative (Million USD)[4]	Carbon Credits as Percentage of Estimated Project Cost	
		California $13.24/tonne[2]	EU $5.65/tonne[3]		California	EU
Alternative 2A Landfill	18,810	$249,044	$106,277	$126	0.20%	0.08%
Alternative 2B Solidification/ Stabilization	31,049	$411,089	$175,427	$202	0.20%	0.09%
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	30,154	$399,239	$170,370	$226	0.18%	0.08%
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	41,755	$552,836	$235,916	$377	0.15%	0.06%
Alternative 5A Incineration	76,100	$1,007,564	$429,965	$666	0.15%	0.06%
Alternative 5B *Ex Situ* TCH	61,190	$810,156	$345,724	$539	0.15%	0.06%
Alternative 5C MCD	30,476	$403,502	$172,189	$600	0.07%	0.03%

Notes:
1. See Table 7-3 for detailed calculations for these emissions.
2. Price on the California carbon credit market on February 8, 2016 (http://calcarbondash.org/).
3. Price on the EU carbon credit market as of February 12, 2016 (http://www.investing.com/commodities/carbon-emissions-historical-data).
4. Estimated overall cost is based on the baseline contamination volume of 408,500 m^3.

Table 7-5 Comparison of Noise Impacts for the Remedial Alternatives

Alternative	Total Estimated Duration of Heavy Equipment Use (hr)	Total Distance Driven by Hauling Equipment (km)
Alternative 2A Landfill	110,000	1,909,000
Alternative 2B Solidification/Stabilization	157,000	1,774,000
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	117,000	1,920,000
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	148,000	2,218,000
Alternative 5A Incineration	103,000	1,129,000
Alternative 5B *Ex Situ* TCH	104,000	1,158,000
Alternative 5C MCD	103,000	1,110,000

Note: Estimates generated from GHG calculations (Appendix F).

Table 7-6 Comparison of Clean Fill Required for the Remedial Alternatives

Alternative	Amount of Material Required (m^3)	Uses
Alternative 2A Landfill	478,000	• Landfill subgrades, to construct the landfill leachate collection system and final cap system. • Backfilling excavations resulting from the removal of contaminated soils.
Alternative 2B Solidification/Stabilization	434,000	• Soil cover over the solidified soil stockpiles. • Backfilling excavations resulting from the removal of contaminated soils.
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt	379,000	• Landfill subgrades, to construct the landfill leachate collection system and final cap system. • Backfilling excavations resulting from the removal of contaminated soils. • Construction of stockpiles for *ex situ* TCH treatment.
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt	357,000	• Landfill subgrades, to construct the landfill leachate collection system and final cap system. • Backfilling excavations resulting from the removal of contaminated soils. • Construction of stockpiles for *ex situ* TCH treatment.
Alternative 5A Incineration	50,000	• Backfilling excavations resulting from the removal of contaminated soils (treated soil would be used as backfill materials in the excavated areas).
Alternative 5B *Ex Situ* TCH	96,000	• Backfilling excavations resulting from the removal of contaminated soils. • Construction of stockpiles for *ex situ* TCH treatment.
Alternative 5C MCD	40,000	• Backfilling excavations resulting from the removal of contaminated soils (treated soil would be used as backfill materials in the excavated areas).

Table 7-7 Key Environmental Issues and Indicative Mitigation Measures

Key Environmental Issues	Mitigation Measures
Potential Environmental and Associated Human Health Risks Associated with UXO	• Develop detailed **UXO management plan** to address how all Project areas would be surveyed and cleared of UXO prior to commencement of work activities including, but not limited to: training and PPE and safety procedures to Project workers; and education and mitigation measures for nearby residents and Airbase personnel and passengers during Project construction. • Implement UXO management plan and clear project areas of UXO.
Potential Impacts on Hydrology and Surface Water Quality	Develop **surface water management plan** to address all water management issues relating to project-affected and 'clean' water including design details of: clean water diversion systems around excavation/construction areas; appropriate handling of contaminated materials during excavation, dewatering, hauling, and all other activities; inspection of all erosion/sedimentation controls and best management practices (BMPs); management and handling of all hazardous materials; spill prevention and controls; project-affected water collection, storage and treatment systems for all project facilities; and water testing and water release requirements.

Key Environmental Issues	Mitigation Measures
Potential Effects of Extraction, Transport, Containment, and Treatment of Dioxin-Contaminated Material on Air Quality and Human Exposure Potential Effects of Extraction, Transport, Containment, and Treatment of Other Contaminants of Potential Concern on Air Quality and Human Exposure	• Develop **air quality mitigation and management plan** to address issues relating to increased risk of contamination of air with dioxin, COPCs, and dust. Mitigation measures may include but not be restricted to: – Scheduling excavation activities to minimize time and area of excavation which remains open/exposed. – Frequent spraying/damping down of excavation areas, excavated soil, worksite surface, and sensitive areas along transportation route. – Covering stockpiles, dewatering area, and transportation vehicles to avoid windblown dust mobilization. – Cleaning transportation vehicles and construction equipment in decontamination area prior to leaving excavation areas. – Cleaning transportation vehicles prior to exiting import fill source quarry. • Ensure air quality mitigation and management plan addresses mitigative measures required for reducing potential impact to workers including, but not limited to: gathering of data on the workers, including their age, sex, awareness on the dioxin issue, food consumption patterns and work history; distribution of awareness raising materials for workers, with a specific emphasis on women of child-bearing age, regarding the hazards of working in source area areas; and training of field crews to ensure adequate protection and proper utilization of personal protective equipment.
Generation of GHGs during Project implementation	• Purchase sufficient carbon credits to offset GHG emissions of the selected remedial alternative. **Table 7-4** presents indicative costs of purchasing the required carbon credits for each of the remedial alternatives evaluated in this EA, as well as a percentage of the estimated total cost of each remedial alternative. • Use of appropriate biodiesels. • Use of most fuel efficient/newer construction equipment fleets. • Policies to maximize energy efficiency (e.g., minimize construction equipment idling, ensure that trucks only leave with a full load, "turn off and unplug" electricity sources when not in use, use of energy efficient lighting). • Recycle and reuse construction debris as feasible (minimizes landfill emissions and potential hauling for disposal).

Key Environmental Issues	Mitigation Measures
Potential Impacts on Terrestrial Ecosystems and Terrestrial Biodiversity Potential Impacts on Wetlands, Aquatic Ecosystems and Aquatic Biodiversity	Biological surveys (terrestrial and aquatic) should be conducted prior to commencement of construction to confirm there are no rare and endangered species on the Airbase and within the area of influence of the project.
Potential Effects on Noise Levels	Develop a **noise management plan** to address issues related to increased noise levels as a result of the project. Mitigation measures may include: • Ensuring all vehicles and machinery are fitted with appropriate muffler systems. • Scheduling regular maintenance of construction equipment and transportation vehicles. • Avoiding construction and transportation activities during night time.
Generation of Solid Waste	• Train contractors on waste minimization techniques. • Practice appropriate management practices for non-hazardous construction and office-related wastes. • Manage any hazardous wastes generated during treatment processes appropriately and in accordance with Vietnamese Hazardous Waste Regulations.
Human Health	Develop an **H&S Plan** to address issues related to increased safety hazards as a result of the project. Mitigation measures should include, but is not limited to: • Identification and prevention planning for all onsite hazards. • Adequate training on use of PPE. • Medical monitoring for all workers in close contact with dioxin-contaminated material and/or by request of any worker. • Provide sanitary/decontamination facilities for all workers. • Oversight of contractors by appropriate construction management or third-party personnel.

Key Environmental Issues	Mitigation Measures
Risk of Re-Contamination of Treated Lakes	Institute engineering and institutional controls after completion of the selected remedial alternatives to reduce the risk of re-contamination of the lakes on the Airbase. These controls would need to be finalized as part of the detailed design of any selected remedial alternative but could consist of re-grading the topography of the adjacent DUs, re-routing drainage, installing sediment traps that would need to be periodically cleaned. Future construction activities would also require careful planning and monitoring to avoid erosion and deposition in downstream lakes.
Potential Effects on Residents from Resettlement	Develop and implement a **Resettlement Action Plan** if required. Mitigation measures to include compensation and addressing any grievances.
Potential Effects of Climate Change on the Selected Remedial Alternative	Develop implementation schedules with the consideration of the effects of increased frequency and intensity of extreme weather events as a result of climate change influencing the timing of construction activities between dry season and rainy season. Consider using more conservative assumptions about return frequencies of weather events when designing structures, facilities and environmental mitigations such as water management schemes. In general, longer construction schedules would require a greater consideration of these potential effects.

Section 8 Overall Summary and Additional Considerations

The information in this section provides an overall summary of the EA and additional considerations to assist decision-makers and stakeholders regarding aspects of the project that are beyond this EA. These additional considerations are intended to supplement the information provided in the preceding sections. The items presented in **Sections 8.2 through 8.4** are organized in a rough chronological order, according to a typical project lifecycle (i.e., study through implementation).

8.1 Overall Summary

The overall findings of this EA are as follows:

- The results of the 2014/2015 sampling and investigation indicated the following:
  - The total estimated volume of dioxin-contaminated soils and sediments is approximately 408,500 (baseline estimated volume) to 495,300 m^3 (with contingency). This consists of approximately 315,700 to 377,700 m^3 of contaminated soil and 92,800 to 117,600 m^3 of contaminated sediment. Of the dioxin-contaminated baseline volume of 408,500 m^3, 42% is in the Pacer Ivy Area, 24% is in the Z1 Area (including the Z1 Landfill), and 15% is in the Southwest Area. The remaining 19% is located in the ZT, Northwest, and Northeast Areas. Approximately 5% of the dioxin-contaminated baseline volume is located off of the Airbase.
  - Dioxin contamination was confirmed in known source areas on the Airbase (i.e. Z1, Southwest, and Pacer Ivy Areas), other less contaminated areas (i.e., Northeast and Northwest Areas, Gate 2 Lake), and a few new areas on and off the Airbase (i.e., the ZT Area, and other portions of the Southwest and Pacer Ivy Areas).
  - Dioxin concentrations in the Southeast Area and Bien Hung Lake were below the MND-approved dioxin limits.
  - Excavation of contaminated soils and construction of the Z1 Landfill in 2009 appears to have been effective in significantly reducing overall dioxin concentrations outside of the landfill in the Z1 Area.; however the volume of dioxin-contaminated in the landfill is closer to 60,000 m^3 (previous reports had indicated 94,000 m^3) based on the as-built drawings of the landfill.
  - Concentrations of arsenic in soil and sediment were generally below those found at the Danang Airport remediation project. However, arsenic concentrations from all samples collected still exceeded USEPA risk-based screening levels (USEPA 2015), and some samples from the Pacer Ivy, Z1, and Southwest Areas exceeded GVN standards (QCVN 03:2008/BTNMT). No other compounds were found to be located in areas with dioxin contamination, nor were they present in the collected samples at concentrations above applicable GVN standards or appropriate USEPA screening levels. However, these compounds were only analyzed in 22 samples throughout the Airbase, which is sufficient to accomplish the objectives of this EA, but not sufficient to characterize the nature and extent of non-dioxin compounds across the Airbase.
  - Previous studies (Hatfield and Office 33 2011 Durant et al. 2014) have identified that the main pathway for exposure to dioxin from the site is consumption of fish and other aquatic organisms. All but one of the fish samples collected during the 2014/2015 sampling effort was

contaminated with dioxins, and fishing bans have not been effective to date (Thanh 2015). Therefore, this pathway remains the largest contributor to human health risk.

  - Samples from off-site groundwater production wells and on-site drinking water sources indicated no concentrations of dioxin, or any other analyte, above applicable USEPA or GVN drinking water standards. Dioxin and other compounds were detected in onsite monitoring wells (not drinking water sources) above USEPA standards in two unfiltered samples, and above GVN discharge standards in two filtered samples out of six groundwater samples collected in onsite wells.

- Eight different alternatives were developed and evaluated ranging from no action through complete containment through complete treatment. The findings of this evaluation are as follows:
  - All alternatives (except for the No Action Alternative, Alternative 1) would comply satisfactorily with GVN regulations and the land use based MND-approved dioxin limits, and to achieve acceptable environmental and social impacts.
  - Alternatives 2 through 5 have the following common elements:
    - Excavate all soils and sediments from each DU where dioxin concentrations were measured above MND-approved dioxin limits (except for the existing Z1 landfill in Alternatives 2 and 3) or 150 ppt for sediment.
    - Either contain or treat all excavated material in one or two centralized locations.
    - Remove and destroy all fish and other aquatic animals in all lakes, including Gate 2 Lake and Bien Hung Lake outside the Airbase.
  - All actionable alternatives reduce risk of human exposure to dioxin contamination. Therefore, any of the actionable alternatives (Alternatives 2 through 5) are preferable to the No Action Alternative. Given the current and foreseen land use of a large majority of the contaminated area as a military airbase, a hybrid alternative that treats the highest risk material and contains all other excavated material is a reasonable option that balances USG and GVN regulatory preferences for treatment with more practical, lower cost options for management of the lower risk material.
    - Between the two containment technologies, the solidification/stabilization option is preferable to landfilling as it requires less maintenance and is a potentially permanent solution that could allow some reuses of the land (as long as moisture could be kept out reliably), whereas landfilling requires maintenance and monitoring for the anticipated life of the landfill (typically 50 years after which the integrity of the landfill may become compromised) and no reuse within the landfill footprint.
    - Among the treatment technologies, incineration and *ex situ* TCH are preferable to MCD, as incineration and *ex situ* TCH are well demonstrated for dioxin remediation at full scale, and can be implemented with effective treatment of off-gases at the concentrations found at Bien Hoa. While MCD technology has been demonstrated for concentrations found at Bien Hoa, the test was not full scale (6 kilograms batches), upgrades are needed to improve issues associated with fugitive dust and off-gas controls, and air emissions control still needs to be verified through strict stack testing. Incineration bears more upfront capital costs but has the advantage of not requiring a patent and is something that could be sustained by the Vietnamese and used after dioxin remediation for treatment of other persistent organic pollutants. *Ex situ* TCH, on the other hand, must be conducted by the patent-holding

vendor, and while the good performance of such technology at the Danang Airport remediation project provides more certainty in implementation, this technology is not something that could be "left behind" for Vietnamese to use for other contaminants and/or lesser dioxin hotspots.

  - The overall environmental and associated social and gender impacts of all remedial alternatives are potentially substantial. However, Alternatives 2 through 5 do not contain any impacts that cannot be mitigated.

- Each of the alternatives is described and summarized in **Table 8-1,** along with advantages and disadvantages.

8.2 Additional Site Characterization Considerations

In addition to the comprehensive 2014/2015 EA sampling program, it may be advantageous to perform additional site characterization activities to gain further site information and allow further refinement of remedial designs and cost estimates, prior to implementation. This would include the following considerations:

- Unfiltered and filtered water samples were collected from monitoring wells on the Airbase. These samples indicated concentrations of dioxin above the USEPA MCL in unfiltered shallow groundwater and above its GVN discharge criterion in filtered shallow groundwater. While these data are helpful in evaluating how exposure may occur during remediation, the data may not be sufficient to evaluate all groundwater that may be encountered during future excavation and dewatering activities. . Given the size of the areas known to have deep contamination and shallow groundwater at the Airbase, additional groundwater investigation in specific areas may be warranted.
- Even though arsenic was found in samples at concentrations that were less than encountered on the Danang Airport remediation project, they still all exceeded USEPA risk-based screening levels, and some exceeded GVN limits. Therefore, it may be appropriate to collect samples from soil and sediment DUs with known dioxin contamination and higher levels of arsenic and analyze for arsenic speciation. A determination if the detected arsenic is organic or inorganic will likely be helpful information during future design activities.
- To refine the contaminated volume estimate and understand where additional excavation is still needed in the Southwest Area, it would be beneficial to review MND's excavation surveys, post excavation confirmatory sampling, and/or perform additional sampling activities in SW-1, SW-2, and any other excavated areas. Since the XD-2 Landfill is now a mixture of material coming from different areas and depths, MND's project report should be reviewed to understand the locations, volumes, and concentrations of the excavated area. Alternatively, it may also be beneficial to sample the XD-2 Landfill contents to determine how it would be integrated into a remedial alternative (i.e., determine average concentrations particularly for Alternatives 3 and 4).
- The findings of USAID (2013c) and the experience with the Danang Airport remediation project suggest there is unlikely to be significant biodiversity value in the ecosystems that are on the Airbase. However, during consultations with the GVN, USAID was informed of a recently completed biodiversity survey implemented by VRTC, and due diligence requires a review of this survey to confirm that that the ecosystems present on the Airbase have no significant biodiversity value and do not provide habitat to any rare or endangered species.

8.3 Pre-Implementation Considerations

All remediation alternatives require planning and engineering designs, project approval by the GVN, and procurement. **It is anticipated this process could take three to five years prior to implementation of any alternative.**

The following considerations are relevant to the pre-implementation phases:

- As described above in **Section 3.3**, it may be appropriate to implement interim measures early to address those factors that are known to contribute most to exposure risk due to the long time required to select, design, and procure a final remediation alternative. Highest among these is development of measures to eliminate consumption of contaminated fish and other biota from Airbase lakes. This would include both social and institutional measures (e.g., enforcement and monitoring of fishing bans, awareness raising campaigns, etc.) and environmental controls (e.g., physical removal of fish populations from aquaculture ponds on the Airbase).
- A risk assessment is strongly recommended to inform the design process for the following reasons:
  - To verify excavation and treatment goals for the project;
  - To prioritize remediation activities and/or sequencing with regard to human health risk exposure pathways (i.e., sediment in potential aquaculture ponds throughout the Airbase and contaminated areas outside the Airbase in the Pacer Ivy Area) and on upstream or upgradient source areas, so as to avoid recontamination and to maximize remediation efficiency (i.e., upgradient DUs in the Z1, Pacer Ivy, and Northeast Areas).
  - To validate excavation depths from a risk perspective. In the U.S., excavation of contaminated material below the ground water table is atypical. If mitigation or remediation is warranted, it is sometimes accomplished by providing an *in situ* reactive barrier or other *in situ* treatment, or pumping and treating groundwater at the surface (i.e., *ex situ*). Since the mobility of dioxin through groundwater is limited by its low water solubility and high affinity for soils, a risk assessment could provide the technical basis for determining a threshold beyond which it does not make sense to excavate contaminated material.
- Additional discussions will be necessary between USG, GVN, and other potential implementation partners following the finalization of this EA to develop an overall implementation strategy, the roles and responsibilities of all stakeholders in implementation, and other aspects of the project including land use designations and final excavation and treatment goals, as well as the final selection of treatment technologies.
  - Since land use designations have a direct impact on contamination volumes, and subsequently remediation costs, it may be advantageous to verify the suitability of the MND-approved dioxin limits, either for specific areas or the entire Airbase site, since the dioxin limits are not based on a formal land use process. For example, if the land use designation for soil areas were modified to be industrial/commercial (1,200 ppt) throughout the Airbase, the estimated baseline contamination volume would decrease from 408,500 m^3 to approximately 295,000 m^3. MND has already initiated a broader land use master planning process, and once final, this could inform these discussions.
  - Ultimately, excavation goals (and treatment goals if necessary) will need to be agreed upon by the GVN and any implementing partners prior to implementation of any remediation alternative. The recommended risk assessment could also help inform these discussions.

- While some remedial technologies and strategies are well-suited for knowledge transfer and capacity building, as described in **Section 4**, other technologies are not readily transferrable, and can only be implemented by companies external to Vietnam who have appropriate patents and employ technically-knowledgeable personnel. Those companies will be interested in protecting their intellectual property, not in capacity building. Decision makers will have to balance technology transfer with implementation speed.

- As described further in **Appendix D,** the significant uncertainty represented in the preliminary estimated overall costs (-40%/+75%) are typical for this stage of conceptual design (i.e., ~10% design), especially given the complexity of the site. While the MIS sampling methodology and contingency volume is believed to diminish greatly any uncertainty regarding contaminant volume, design and design-related work, technology evaluation, and other activities described in this section will be capable of narrowing these cost ranges as expected per USEPA guidelines for remediation projects as the level of project definition improves from the remedy selection stage to the full remedial design phase to the remedial action stage of any of the alternatives.
- Given the anticipated high cost associated with the entire remediation project, it may be advantageous to break it into smaller projects to accommodate potential project funding limitations. If it becomes necessary to develop cost estimates for separate projects, information is included in **Appendix D** explaining the organization and content of the detailed cost estimates, as well as some cautions and caveats regarding manipulation of these cost estimates.
- Additional design work will be necessary to develop and complete the conceptual designs presented in these alternatives to generate full, GVN-approved designs and a GVN-approved EIA on the final selected remediation alternative. In general, once an alternative has been selected and a design contractor has been procured (a process that could take 1 to 2 years), approximately 2 to 3 years should be allowed for the development of designs and EIA, and associated approval processes.
  - Depending on the alternative and technology/technologies involved (technology evaluation considerations are presented in **Section 8.4**), it may be advantageous or even necessary to involve technology vendors early in the design process. If multiple vendors are capable of providing the technology or strategy, vendor involvement in the design process will require more care to avoid conflicts of interest.
  - Sustainability practices should be included in the design and implemented during remediation, to ensure usage of the least amount of natural resources (i.e., water, energy, etc.) and generation of the least amount of emissions that contribute to climate change impacts. BMPs, such as those described in American Society for Testing and Materials (ASTM) Standard Guides E2876-13 (Standard Guide for Integrating Sustainable Objectives into Cleanup) and E2893-13 (Standard Guide for Greener Cleanups) should be considered during the design process.
  - A vulnerability assessment should also be conducted during the design process to ensure a remediation that is resilient to anticipated climate change impacts.
- Prior to any final design, it will be necessary to verify some of the assumptions made herein regarding local utility capacities for natural gas (for incineration), and for water and electricity (for all alternatives, but especially *ex situ* TCH). It will also be important to verify source(s) of the significant quantities of clean import fill needed for backfill, landfill construction (if implemented), and other miscellaneous needs. Verification of these local resources will require help from GVN.
- Careful planning of excavation operations could minimize the need for clean fill by timing most excavations to coincide with the availability of treated material to be used as backfill. Alternatively,

some material excavated from areas with lower dioxin limits would be suitable to use as backfill in areas with higher dioxin limits.

- Since the treatment options are on a large scale and energy intensive, there is an opportunity to directly or indirectly fund meaningful energy production projects that have less environmental impacts. There is also an opportunity to save costs by reviewing and maximizing the overall energy efficiency.
  - Many incineration operations do additional work with the high temperatures whether to increase efficiency by pre-heating process inputs or co-processing while in operation (e.g., cement kiln).
  - *Ex situ* TCH produces a batch of hot soil/sediment; the waste heat could be extracted for other useful work (e.g., steam turbine electrical production, or pre-heat untreated soils being prepared for treatment).
- Remediation in some areas would likely lead to significant impact to local residents in those areas when resettlement is needed, as noted in **Section 7.1.14**. Complete evaluation of impacts to local communities would be improved via additional planning and assessment, specifically the development of a RAP and identification of PAPs who may need to be resettled.
- A stakeholder engagement plan (SEP) may be beneficial in keeping all stakeholders engaged, facilitate future progress, and mitigate project risks. Guidance for such a document is provided by the International Finance Corporation (2007). The SEP would contain review of stakeholders required for the SEP including considerations for gender equality and vulnerable groups, analysis of stakeholder engagement methods and priorities based on the context, stakeholder engagement and capacity building activities for year one through to the project end, stakeholder engagement schedules and clear lines of responsibility, and a monitoring and evaluation plan to ensure engagement is effective on an on-going basis.
- Prior to any remedial action, the project areas will need to be cleared of existing UXO. It would likely be beneficial to develop a UXO Management Plan to address how areas would be cleared, how personnel would be trained, and other appropriate safety procedures.
- The Danang Airport remediation project has provided many important lessons that have been incorporated into the elements of this EA. Those associated with the 2014/2015 sampling and development of the remedial alternatives are listed in Section 4.5. Additional lessons learned relevant to design and planning should continue to be considered:
  - Some of the treatment technologies presented in the EA herein are patented, and therefore some licensing barriers may need to be overcome prior to procurement and implementation. Because this process may take a significant amount of time, it may be beneficial to start this process early, if feasible.
  - As mentioned in **Section 4.4**, the estimated schedules for the alternatives are for implementation only and do not take into consideration the time required to conduct studies, design, permitting, and contractor procurement. The Danang project experience, while much smaller and less complex, will provide valuable insight into what time may be necessary to conduct these pre-implementation activities; in that case it took three years to design and contract for project implementation after the EA was completed.

8.4 Technology Evaluation Considerations

Several dioxin treatment technologies were screened out during the technology evaluation process due to the lack of full-scale data to demonstrate maturity in treating the range of concentrations measured at the Airbase to below the range of required MND-approved dioxin limits. Some treatment technologies that were not screened out, however, are very site-specific or have some degree of uncertainty regarding how they might be beneficial to the project. Other technologies that were not used to develop alternatives may also still be worth additional evaluation and testing. Since there is not the same developmental pressure on the Bien Hoa Airbase as there was in Danang, the following activities may be performed to provide decision-makers and stakeholders with additional information regarding certain technologies:

- As described in **Section 4.4.2** and **Appendix C**, GVN researchers have indicated that an active landfill (bioremediation) is a potentially applicable remedial technology for dioxin. However, given the lack of published and peer-reviewed data to demonstrate technology maturity and effectiveness, there are many uncertainties regarding this technology and how it would be applied. Previous pilot testing by GVN researchers (e.g., at Danang Airport, in collaboration with USEPA, and in the bioremediation cell at the Z1 Landfill) have provided some data, but are not sufficient to answer all uncertainties. Given the potential promise of this technology, it may be appropriate to perform a robust pilot study at the Airbase using contaminated materials of varying dioxin concentrations, using knowledge and lessons learned from the previous study and oversight by non-GVN parties.
- While stabilization/solidification is a relatively mature technology, it is very site-specific (i.e., physical and chemical characteristics of those soils requiring treatment can affect how the technology should be implemented to achieve optimal results). As discussed in **Section 4.4.3.1**, a bench-scale treatability study utilizing Airbase materials would be helpful in reducing uncertainty in design parameters and costs, and could also be used to provide additional beneficial information regarding expected long-term effectiveness.
- As discussed in more detail in **Appendix C**, soil washing is an *ex situ* technique that involves water-based separation of soils that are more likely to be contaminated from those that are not contaminated. Shimizu Corporation, which has been recently engaging with the GVN, offers soil-washing and separation technology that may be applicable for concentrating the amount of dioxin contamination into a smaller total volume. Contaminated materials at the Airbase have been provided to Shimizu Corporation for testing by GVN. Some early performance data from samples from the Airbase with concentrations ranging from approximately 6,000 to 80,000 ppt indicates that this technology is capable of separating large diameter material (which usually contains less dioxin) from smaller-diameter material (which usually contains more dioxin), and that they could produce solids with concentrations below 1,000 ppt. However, it remains necessary to understand the complete mass balance for this non-destructive technology, and confirm how waste streams (i.e., the separated material that still contains dioxin) would have to be managed. If additional treatment of the washwater, separation and drying of the concentrated dioxin-containing solids, and any other additional work removes the cost benefit realized from reducing the original volume, the technology would not be value-added. Once additional performance and mass balance data have been received, it may be advantageous to perform a cost-benefit analysis of this technology to reduce volumes of soil and sediment above MND-approved dioxin limits. A more comprehensive treatability study to verify results may also be appropriate.

- As described in **Appendix C**, Matrix Constituent Separator (MCS) has been demonstrated as an effective technology for desorbing dioxins from soils from the Airbase. However, unlike all the other treatment technologies considered for alternatives (*ex situ* TCH, MCD, and incineration), it does not destroy or degrade the dioxin; it only transfers the dioxin to vapor and liquid streams for further treatment. Therefore, it was not used to generate any remedial alternatives. It may be feasible to combine this with other treatment technologies which would manage these gaseous and liquid streams, such as incineration, other off-gas technologies, or technologies that were screened out because they only work with liquids. Depending on the paired treatment technologies, MCS may be able to minimize the overall volume of material that is contaminated, thus minimizing the cost of additional treatment and/or containment needed after MCS. Further evaluation and coordination with the vendor would be necessary to evaluate this possibility further.

If it is determined that some of these technologies merit further evaluation in the form of remedial alternatives, an addendum to the EA could be generated.

Table 8-1 Summary of Remediation Alternatives

Summary of Remediation Alternatives	**Estimated Overall Cost at Contamination Volume Range (Million USD) (-40% to +75%)**		**Implementation Schedule for Contamination Volume Range**	**Advantages and Disadvantages**
	Baseline	**Baseline with Contingency**		
Alternative 1 No Action No Action – provides a baseline for evaluation; does not involve any proactive treatment, containment, or monitoring.	Not applicable (Externalized)	Not applicable (Externalized)	Not applicable	Advantages: none Disadvantages: continued risk of exposure to dioxin as existing effects and exposure pathways would persist; continued need to maintain interim measures; economic development via implementation the future land use plan for the Airbase is not possible under the No Action alternative.
Alternative 2A Landfill Excavate all contaminated material (except for existing Z1 Landfill) Construct two (2) hazardous waste landfills onsite (Traditional landfill could be augmented with bioremediation if future treatability studies are performed and successful)	$126M ($76M to $221M)	$137M ($82M to $239M)	• 3 to 5 years for planning, approvals, and procurement • 5 to 6 years construction • 50-year long-term O&M, monitoring, and institutional controls of the landfills	Advantages: eliminates existing exposure pathways; simple and lowest cost; applicable to widest range of contaminants (organic or inorganic); GVN has demonstrated capacity to construct. Disadvantages: does not eliminate dioxin; requires ongoing monitoring and maintenance; does not meet GVN policy favoring complete treatment; bioremediation technology not proven and does not eliminate dioxin in the near term; requires classification of PI-13 and PI-10 land use as Industrial; long-term environmental and social risks associated with (i) institutional controls required to maintain landfills and (ii) prevent recontamination of lakes by adjacent soils still above sediment dioxin limit; long-term integrity of the landfills in Alternative 2A would be at risk of being compromised by an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill required may trigger GVN EIA specifically for provision of clean fill.

Summary of Remediation Alternatives	Estimated Overall Cost at Contamination Volume Range (Million USD) (-40% to +75%)		Implementation Schedule for Contamination Volume Range	Advantages and Disadvantages
	Baseline	Baseline with Contingency		
Alternative 2B Solidification/ Stabilization Excavate all contaminated material (except for existing Z1 Landfill) Construct two (2) stockpiles with admixtures to reduce mobility of dioxin based on treatability studies	$202M ($121M to $354M)	$229M ($138M to $402M)	• 3 to 5 years for planning, approvals, and procurement • 6 to 7 years construction • 50-year long-term monitoring and maintenance	<u>Advantages</u>: eliminates existing exposure pathways; lower cost than treatment; demonstrated technology; applicable to organic and inorganic contaminants; potentially a permanent solution; less risk of exposure over the long term than with a landfill. <u>Disadvantages</u>: does not eliminate dioxin; long term effectiveness currently demonstrated only to ten years; requires monitoring and maintenance of a moisture cap; lack of GVN familiarity with this technology; does not meet GVN policy favoring complete treatment; requires classification of PI-13 and PI-10 land use as Industrial long-term environmental and social risks associated with institutional controls required to (i) maintain stockpiles (lower risk than Alternative 2A) and (ii) prevent recontamination of lakes by adjacent soils still above sediment dioxin limit; long-term integrity of the stockpiles would be at risk of being compromised by an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill required may trigger GVN EIA specifically for provision of clean fill.
Alternative 3 Landfill material < 2,500 ppt, *Ex situ* TCH for material > 2,500 ppt Excavate all contaminated material (except for existing Z1 Landfill) Construct two (2) hazardous waste landfills onsite and fill with materials below 2,500 ppt (about 75% of total volume) Build one *ex situ* TCH treatment structure (2 treatment phases/batches) and treat all materials above 2,500 ppt (about 25% of total volume)	$226M ($135M to $395M)	$236M ($142M to $413M)	• 3 to 5 years for planning, approvals, and procurement • 7-year construction and operation • 50-year long-term O&M, monitoring, and institutional controls of landfill	<u>Advantages</u>: eliminates existing exposure pathways; treats/destroys the highest dioxin concentration (and highest risk) material while landfilling the remainder; GVN has demonstrated landfilling capacity. <u>Disadvantages</u>: requires ongoing monitoring and maintenance; dioxin concentrations in landfill (above 1,200 and below 2,500 ppt) would require additional long term management as hazardous waste; does not meet GVN policy favoring complete treatment; requires classification of PI-13 and PI-10 land use as Industrial; long-term environmental and social risks associated with institutional controls required to (i) maintain landfills (lower risk than Alternatives 2A and 2B) and (ii) prevent recontamination of lakes by adjacent soils still above sediment dioxin limit; long-term integrity of the landfills would be at risk of being compromised by an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill required may trigger GVN EIA specifically for provision of clean fill.

Summary of Remediation Alternatives	Estimated Overall Cost at Contamination Volume Range (Million USD) (-40% to +75%)		Implementation Schedule for Contamination Volume Range	Advantages and Disadvantages
	Baseline	**Baseline with Contingency**		
Alternative 4 Landfill material < 1,200 ppt, *Ex situ* TCH for material > 1,200 ppt Excavate all contaminated material including Z1 Landfill Construct two (2) landfills onsite and fill with materials below 1,200 ppt (about 50% of total volume) Build two (2) *ex situ* TCH treatment structures (5 treatment phases/batches) and treat all materials above 1,200 ppt (about 50% of total volume)	$377M ($226M to $660M)	$390M ($234M to $683M)	• 3 to 5 years for planning, approvals, and procurement • 10-year construction and operation • Long-term O&M and institutional controls of landfill	Advantages: eliminates existing exposure pathways; treats/destroys the highest dioxin concentration (and highest risk) material while landfilling the remainder; GVN has demonstrated landfilling capacity; 1,200 ppt threshold is based on an approved land use standard (industrial) for dioxin in Vietnamese law; material contained on industrial use land would not be considered hazardous waste. Disadvantages: lengthy implementation period; requires institutional controls to maintain existing industrial land uses and avoid the need to monitor this as a hazardous waste landfill; requires classification of PI-13 and PI-10 land use as Industrial; long-term environmental and social risks associated with institutional controls required to (i) maintain landfills (lower risk than Alternative 3 given lower concentrations contained) and (ii) prevent recontamination of lakes by adjacent soils still above sediment dioxin limit; long-term integrity of the landfills would be at risk of being compromised by an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill required may trigger GVN EIA specifically for provision of clean fill.
Alternative 5A Incineration Excavate all contaminated material including Z1 Landfill Build one (1) incinerator onsite and incinerate all excavated soil and sediment Incineration would be completed sequentially in two locations (continuous feed)	$666M ($400M to $1,166M)	$794M ($476M to $1,389M)	• 3 to 5 years for planning, approvals, and procurement • 8 to 10 years construction and operation • No long-term O&M	Advantages: eliminates existing exposure pathways; widely used and demonstrated technology; has been used in Vietnam with GVN approval for other persistent organic pollutants; treats/destroys dioxin above dioxin limits; applicable to organic contaminants; no long-term environmental risk associated with maintaining institutional controls on containment structures; no long-term risk to containment structures associated with an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill are sufficiently low that GVN EIA specifically for provision of clean fill would not be required. Disadvantages: highest expense; high energy use; public perception towards incineration off-gassing may potentially be negative; generally not effective for inorganic contaminants; generation of large quantities of GHGs associated with energy requirements for treatment; long-term environmental and social risks associated with institutional controls required to prevent recontamination of lakes by adjacent soils still above sediment dioxin limit.

Summary of Remediation Alternatives	Estimated Overall Cost at Contamination Volume Range (Million USD) (-40% to +75%)		Implementation Schedule for Contamination Volume Range	Advantages and Disadvantages
	Baseline	Baseline with Contingency		
Alternative 5B *Ex Situ* TCH Excavate all contaminated material including Z1 Landfill Build two (2) above ground/*ex situ* TCH treatment structures (each with capacity of about 50,000 m^3 (8 treatment phases/batches total) and treat all excavated material Heating would be staggered to minimize overall power requirements.	$539M ($323M to $943M)	$640M ($384M to $1,121M)	• 3 to 5 years for planning, approvals, and procurement • 14 to 16 years construction and operation • No long-term O&M	<u>Advantages</u>: eliminates existing exposure pathways; proven technology used in Vietnam with GVN approval; treats/destroys dioxin above dioxin limits; applicable to organic contaminants; no long-term environmental risk associated with maintaining institutional controls on containment structures; no long-term risk to containment structures associated with an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill are sufficiently low that GVN EIA specifically for provision of clean fill would not be required. <u>Disadvantages</u>: high expense; moderate to high energy use; generally not applicable for inorganic contaminants; long implementation period because of potential impacts of rainy seasons to heating; generation of large quantities of GHGs associated with energy requirements for treatment; long-term environmental and social risks associated with institutional controls required to prevent recontamination of lakes by adjacent soils still above sediment dioxin limit.
Alternative 5C MCD Excavate all contaminated material including Z1 Landfill Construct one (1) ball milling reactor system and treat all excavated material MCD treatment would be completed sequentially in two locations (continuous feed)	$600M ($360M to $1,050M)	$712M ($427M to $1,247)	• 3 to 5 years for planning, approvals, and procurement • 8 to 10 years construction and operation • No long-term O&M	<u>Advantages</u>: eliminates existing exposure pathways; mostly proven at pilot scale with soil from Bien Hoa; potential for in-country licensing; treats/destroys dioxin above dioxin limits; no long-term risk to containment structures associated with an increased frequency and intensity of extreme weather events as a result of climate change; amounts of clean fill are sufficiently low that GVN EIA specifically for provision of clean fill would not be required. <u>Disadvantages</u>: some question of reliability of dioxin treatment; complete liquid and vapor control not fully demonstrated; high expense; generally not applicable for inorganic contaminants; generation of large quantities of GHGs associated with energy requirements for treatment; long-term environmental and social risks associated with institutional controls required to prevent recontamination of lakes by adjacent soils still above sediment dioxin limit.

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APPENDIX A

SUMMARY OF DIOXIN CONTAMINATION AT BIEN HOA AIRBASE

Appendix A: Summary of Dioxin Contamination at Bien Hoa Airbase

1 Introduction

The field sampling program conducted for the Environmental Assessment (EA) at Bien Hoa Airbase (Airbase) was conducted in November through December 2014 and March through April 2015, and was implemented as described in the Sampling and Analysis Plan (SAP) prepared by CDM International, Inc. (CDM Smith) and Hatfield Consultants (Hatfield) for the United States Agency for International Development (USAID) (USAID 2014). This appendix provides information related to the field sampling methodology based on the Sampling Design and Technical Approach outlined in the SAP, field notes recorded during the sampling program, and also tables and figures of final dioxin and furan analytical results. Also included are dioxin/furan results from previous studies (Hatfield and VRTC 2009; Hatfield and Office 33 2011; United States Environmental Protection Agency (USEPA)/Vietnamese Academy of Science and Technology (VAST) and the Ministry of National Defense (MND) unpublished data [from the Environmental Scoping Statement (ESS)]), for reference. Results from the 2014/2015 EA sampling program have been used to generate dioxin concentration maps and estimates of volumes of soil and sediment that require remediation.

2 Sampling Methodology

2.1 Background

As stated in the SAP (USAID 2014), the overall objective of the 2014/2015 EA sampling program was to collect analytical data required to fill gaps in the existing site characterization data, to inform a detailed characterization of the extent and magnitude of dioxin and non-dioxin contamination on and around the Airbase, and to provide information required to accomplish the objectives of the EA. The specific objectives (or data quality objectives [DQOs]) of the sampling effort were to:

1. Delineate the vertical and lateral extent of dioxin contamination on and around the Airbase.
2. Determine the nature of non-dioxin contamination in areas of influence of dioxin.
3. Identify which lakes require remediation to prevent human exposure to dioxin contamination.
4. Determine the amount of soil, sediment, and groundwater that must be remediated in order to close dioxin exposure pathways.

In addition, field sampling on and off the Airbase was required to provide internationally-accepted analytical data using high-resolution gas chromatography-mass spectrometry (HR-GCMS). Analyses of the samples were performed by the laboratories indicated in **Table 1**.

Table 1 Summary of Analytical Laboratories used for EA Sample Analysis

Laboratory	Location	Analyses Performed
AXYS Analytical Services Ltd. (AXYS)	2045 Mills Road West Sidney, British Columbia Canada V8L 5X2	Soil and Water • Dioxin/furans (PCDD/PCDF)
Kemron Environmental Services, Inc. (Kemron)	1359-A Ellsworth Industrial Blvd Atlanta, Georgia 30318 United States	Soil • SVOCs • Metals • PCBs • Arsenic speciation • Physical properties (particle size, moisture content, pH, total organic carbon) Soil and Water • Herbicides
SGS Vietnam Ltd. (SGS)	119-121 Vo Van Tran Street District 3 Ho Chi Minh City, Vietnam	Soil and Water • VOCs Water • SVOCs • Metals • PCBs
Vietnam-Russia Tropical Center (VRTC)	58 Nguyen Van Huyen Street Cau Giay District Hanoi, Vietnam	Soil • Dioxin/furans (PCDD/PCDF) (QA/QC samples)

Acronyms:

PCB polychlorinated biphenyls
PCDD polychlorinated dibenzo-p-dioxins
PCDF polychlorinated dibenzofurans
SVOC semivolatile organic compounds
VOC volatile organic compounds
QA/QC quality assurance/quality control

The SAP was developed in accordance with the *Environmental Protection Agency Requirements for Quality Assurance Project Plans*, EPA QA/R-5 (USEPA 2006a), and the *Guidance on Systematic Planning Using the Data Quality Objectives (DQO) Process*, EPA QA/G4 (USEPA 2006b). DQOs were developed, consisting of seven steps; the output from each step was used to determine the choices made later in the process. These steps included:

- Step 1: State the problem.
- Step 2: Identify the decision.
- Step 3: Identify information inputs.

- Step 4: Define the boundaries of the study.
- Step 5: Develop decision rules.
- Step 6: Specify tolerable limits on decision errors.
- Step 7: Develop the plan for obtaining the data.

During the first six steps of the process, the planning team developed decision performance criteria (i.e., DQOs) that were used to develop the data collection design. The final step of the process involved developing the data collection design based on the DQOs. Limits on decision errors for each of the Principal Study Questions and as guided by the DQO process are in **Table 2**.

Table 2 Decision Error Limits for Principal Study Questions

Principal Study Question		Null Hypothesis	Discussion of Error
1.	What is the full nature and extent (i.e., lateral and vertical extent) of dioxin contamination on and around the Airbase?	Dioxin concentration in a surface/subsurface soil/sediment sample is equal to or greater than appropriate MND-approved dioxin limits and the area/depth sampled is designated as "dioxin-contaminated" soil/sediment.	**Type I Error will result in:** Determining that an area/depth sampled is "clean", when it is actually "dioxin-contaminated." This may result in underestimation of the extent of contamination, and ultimately increased risk to human health. **Type II Error will result in:** Determining that an area/depth sampled is "dioxin-contaminated," when it is actually "clean." This may result in overestimation of the extent of contamination, and unnecessary remediation costs.
2.	What is the nature of non-dioxin contamination and physical soil/sediment properties in areas of influence of dioxin?	Non-dioxin contaminant (metals, volatile organic compounds [VOC], semivolatile organic compounds [SVOC], herbicide, and/or polychlorinated biphenyls [PCB]) concentrations in surface/subsurface soil/sediment sample represents the actual concentrations. Physical parameters measurements represent actual conditions.	**Type I Error will result in:** Determining that non-dioxin contaminant (metals, VOC, SVOC, herbicide, and/or PCB) concentrations are less than their actual concentrations, or determining that the physical parameters represent more difficult conditions than measured. This may result in under designing a remediation technology, and ultimately require modifications to the technology to properly handle the non-dioxin contaminant(s). **Type II Error will result in:** Determining that the non-dioxin (metals, VOC, SVOC, herbicide, and/or PCB) contaminant concentrations are greater than their actual concentrations, or determining that the physical parameters represent less difficult conditions than measured. This may result in over designing a remediation technology, and unnecessary remediation costs.

Principal Study Question		Null Hypothesis	Discussion of Error
3.	Which lakes require remediation to prevent human exposure to dioxin contamination?	Dioxin concentration in a sediment or fish tissue sample is equal to or greater than appropriate MND-approved dioxin limits and the lake is designated as "dioxin-contaminated."	**Type I Error will result in:** Determining that a lake is "clean," when it is actually "dioxin-contaminated." This may result in underestimation of the extent of contamination, and ultimately increased risk to human health. **Type II Error will result in:** Determining that a lake is "dioxin-contaminated," when it is actually "clean." This may result overestimation of the extent of contamination, and unnecessary remediation costs.
4.	What amount of soil, sediment, and groundwater must be addressed to close exposure pathways?	The calculated amount of soil, sediment, and groundwater that must be addressed to close exposure pathways represents the actual amount.	**Type I Error will result in:** Determining that the calculated amount of soil, sediment, and groundwater that must be addressed to close exposure pathways is less than the actual amount. This may result in underestimating the total amount of materials that needs treatment and ultimately increased risk to human health. **Type II Error will result in:** Determining that the calculated amount of soil, sediment, and groundwater that must be addressed to close exposure pathways is greater than the actual amount. This may result in overestimating the total amount of materials that needs treatment and ultimately adds unnecessary remediation costs.

Through the DQO process, the multi-increment® sampling (MIS) methodology was selected in order to generate results with significantly less variability and a higher statistically-defensible level of confidence than discrete sampling or less robust composite sampling methods (Interstate Technology and Regulatory Council [ITRC] 2012). The MIS approach used for sampling each Decision Unit (DU) was generally the same for both soil and sediment DUs. Within each DU, multiple depth intervals were sampled, and each depth interval within a DU comprised a single MIS sample derived from 30 aliquots/intervals. Sub-DUs were comprised of ten aliquots from each of three distinct areas within each DU, as determined by field personnel based on observed conditions. Locations for each of the 30 aliquots were decided in a systematic random manner.

Prior to conducting sampling, the area was screened for unexploded ordnance (UXO) and other explosive remnants of war (ERW). Following UXO/ERW screening, each DU was surveyed and the 30 increment sampling points were marked prior to collection of soil or sediment samples.

2.2 Sampling Methodology

This section summarizes the methodology used to implement the 2014/2015 EA sampling program. The primary objective of these investigations was to better delineate the lateral and vertical extent of dioxin and other contaminants at the Airbase in soil and sediments, as well as verify dioxin concentrations in groundwater and aquatic biota. The following sections were organized by the sampling media of interest:

Soil

Two types of soil collection methods were used to conduct the soil sampling at the Airbase. Generally, for areas where the target sampling depth was less than 1 meter (m), stainless steel soil probes and soil hand augers were used to facilitate sample collection. Hammering drill rigs were used for collecting samples at DUs where the target sampling depth exceeded 1 m.

Specifically, at DUs where the target sampling depth was less than 1 meter, soil probes were used to collect samples at the shallowest depth (i.e., 0-30 centimeters [cm]). Subsequently, another probe was used to collect a sample at the next sampling depth interval (i.e., 30-60 cm). This process was repeated until soil samples were collected at all target depth intervals. Following sample collection, a stainless steel (SS) spoon or SS chopsticks were used to transfer the collected materials into dedicated pre-labeled SS bowls. It should be noted that a dedicated soil probe was used for collecting samples at each discrete depth interval within a sub-DU (i.e., A, B or C) to avoid cross-contamination. In addition, sampling equipment was decontaminated between sub-DUs as well as between DUs.

For DUs where the target sampling depth exceed 1 m, hammering drill rigs were used to facilitate sample collection using SS split spoon samplers. Similar to the method described above with soil probes and soil augers, a dedicated split spoon was used for each target depth interval for sampling. In addition, a larger diameter split spoon sampler was used to clean the borehole between sampling depths. Following sample collection and confirmation of the target depth, the sampler was opened and a SS spoon was used to extract the collected materials into a dedicated and pre-labeled SS bowl.

Sediment

Wildco® Ogeechee™ samplers were used to facilitate sediment sampling at the Airbase. The sediment sampling tool was made entirely of 2-inch diameter, Type 316 SS, consisting of a top closing valve, a solid body, and a bottom cap, and measured approximately 50 cm in length. The cap could be unscrewed from the body to allow for insertion of a hollow SS sample liner. 5-foot long, ¾-inch diameter Schedule 40 steel extension rods were installed on top of the sampling tool to facilitate sample collection in water bodies. In addition, a 12-pound slide hammer was employed to drive the Ogeechee™ corers into the sediments. In general, the corers were driven to 45 cm at all sediment DUs. To avoid cross contamination, a dedicated and pre-labeled sample liner was used for each of the thirty sampling locations within each DU. Upon completion of the sample collection process, the liner (which was full of sampled materials) was retrieved from the Ogeechee™ body, capped with aluminum foil and plastic caps, and placed in a cooler. All sample processing work was conducted at a centralized processing location where the collected samples were pushed out of the liners, photo-documented, and divided into different SS bowls based on the sampling depths. Upon removal of samples, each liner was decontaminated by washing with Alconox®, rinsed three times with tap water followed by three rinses each of hexane and acetone. Once decontaminated, the liners were wrapped with aluminum foil at their ends.

Soil and Sediment Sample Processing

After the soil and sediment subsamples were collected in dedicated SS bowls, they were allowed to air dry in the sample storage room. Occasionally, the collected soil/sediment samples were stirred and broken apart to facilitate the drying process. The purpose of the drying process was to facilitate sieving and collecting samples of the portion of the soil which is less than 2 millimeter (mm) in diameter. Following sieving, each subsample composite was evenly spread on a dedicated SS tray, and a grid of 30 cells was imprinted onto the surface. For each subsample, an equal volume of materials was transferred using a decontaminated SS scoop from each of the 30 cells into a pre-cleaned, pre-weighed, and pre-labeled 120-millilieter (mL) wide mouth glass jar with Teflon® lid. Once subsamples were processed, an equivalent amount of the remaining materials from each of the three subsample trays was transferred to and homogenized in a SS bowl. This homogenized sample represented the MIS sample for the DU of interest. Upon homogenization, the MIS sample was evenly spread on a SS tray and a grid of 30 cells was imprinted onto the surface. Subsequently, an equal volume of materials was transferred using a decontaminated SS scoop from each of the 30 cells into pre-cleaned, pre-weighed, and pre-labeled 120-mL wide mouth glass jars with Teflon® lid.

Groundwater

Prior to commencement of any groundwater sampling activities, the depth to water and total well depth were measured using a weighted tape measure at each groundwater monitoring well to aid the calculation of well casing volume as follows:

$V = 0.041 \times D^2 (d_2 - d_1)$ where,

V = well casing volume in gallons
D = inner diameter of well casing in inches
d_2 = total well depth in feet
d_1 = depth to water in feet

Approximately three well volumes of water were removed from each sampled groundwater monitoring well prior to sample collection to ensure that the samples collected for laboratory analysis were representative of the aquifer formation. A battery-powered submersible pump was used to facilitate groundwater purging. Purged groundwater was collected in graduated SS buckets to facilitate volume tracking and was subsequently disposed onto the surface of the sampled area. Water quality parameters, including pH and conductivity, were periodically collected. Once the three casing volumes had been removed, the groundwater sampling was completed using a Teflon® bailer lowered into the monitoring well to collect formation-representative groundwater samples. To differentiate the amount of dioxins present sorbed to particulate matter and the dissolved phase, one filtered and one unfiltered sample were collected at each monitoring well. 0.5-micron Teflon-coated bag filters were used to facilitate the filtration processes. While the same pump tubing was used at different monitoring wells as it was only used for purging and not sample collection, a dedicated Teflon-coated bailer and Teflon-coated bag filter were used at each groundwater sampling location to avoid cross-contamination. Groundwater samples were collected in pre-cleaned laboratory sample containers, preserved, packaged, and sent to the appropriate analytical facilities in accordance to the SAP.

Additional groundwater samples were collected at six offsite drinking water pumping wells used by nearby residents. Prior to sample collection, information regarding each well including global positioning system (GPS) coordinates, drilling date, well depth, and water use purposes were discussed with the residents and recorded. At each sampling location, water was allowed to purge for approximately five minutes prior to sample collection. Sample preservation, packaging, and shipping were performed similarly to the other groundwater samples.

Biota

Methodology employed for sampling fish and other aquatic biota followed procedures described by Hatfield and Office 33 (2011). Local fishermen were hired to facilitate collection of biota samples (primarily fish, and to a lesser extent, snails) using seine nets at a number of lakes on the Airbase. Unless immediately processed, the biota samples were frozen within one hour of collection. Fish were thawed prior to processing, which included measuring fork length (mm) and weight (g), and were then dissected to remove tissue samples for analysis. All dissection equipment used was stainless steel, which was decontaminated by washing with Alconox®, rinsed three times with tap water followed by three rinses each of hexane and acetone. Following dissection, muscle, fat, and egg samples were weighed (g) and separated in pre-cleaned, pre-weighed, and pre-labeled 120-mL wide mouth glass jars with Teflon® lids. In some instances, biota samples were submitted as whole specimens for laboratory analysis.

2.3 Samples Collected and Analyzed

A two-phase sampling program was implemented at the Airbase. Phase 1 was conducted from November 3, 2014 to December 5, 2014 and Phase 2 was conducted from March 9, 2015 to April 17, 2015. Summaries of the number samples collected and analyzed are provided in **Tables 3 and 4**, respectively.

Participants included CDM Smith, Hatfield, Academy of Military Science and Technology (AMST), Vietnam-Russia Tropical Center (VRTC), Regiment 935, and Union of Science and Geology, Foundation Engineering & Building Materials (UGEFEM). Members of AMST provided administrative/logistical support with the Airbase, as well as assistance with field sampling. VRTC assisted with sample collection and analysis, as well as logistical support. Labor and logistical support from the Airbase was provided by Regiment 935. Drilling was performed by UGEFEM.

Soil and sediment sampling at the Airbase was conducted at the following locations: Pacer Ivy Area; Southwest Area; Z1 Area; ZT Area; Southeast Area; Northeast Area; Northern Forest Area; and Northwest Area. Sediment sampling occurred at lakes in the: Z1 Area; Pacer Ivy Area; Northwest Area; Northeast Area; and at Gate 2 Lake and Bien Hung Lake.

Groundwater samples were collected from 14 locations (8 onsite locations and 6 offsite locations). The onsite locations included 6 monitoring wells (MW-1 through MW-6) installed in 2014 by Dekonta and the Czech Development Agency, and two locations at the Airbase water supply well (one before treatment system, and one after treatment system). The six offsite locations are spread distributed around the perimeter of the Airbase.

Fish samples (whole body, muscle, fat and eggs) and snail tissue (whole body) samples were collected from lakes within and outside of the Airbase in the Northwest Area, Pacer Ivy Area, Z1 Area, Northeast Area, and Bien Hung Lake.

During the sampling investigation, several locations identified in the SAP were not sampled. The areas which were not sampled, in addition to the reasons why, are provided below:

- ***Northeast Area, NE-16:*** The lake that comprises NE-16 no longer exists. It was observed that significant construction and excavation activities have occurred in the area and are still ongoing. Historical samples in this area indicate low dioxin concentrations (less than 80 parts per trillion

[ppt]) that are below the dioxin limits for sediment (150 ppt). At a meeting with AMST on 05/07/15, VRTC reported similar observations about NE-16 and concurred that it was reasonable to eliminate this from the sampling program.

- ***Northwest Area, NW-5:*** Historical sampling in the Northwest Area has indicated low dioxin concentrations in soil. However, elevated dioxin concentrations were identified in a few lakes in the area from previous sampling programs (VRTC unpublished data). As a result, the sampling plan for the Northwest Area was developed with the primary goal of assessing the sediment dioxin concentrations in the lakes. Based on older satellite imagery, it appeared that a lake was present in the NW-5 area; thus it was planned to take sediment samples from this area. However, site reconnaissance during sampling indicated that a lake does not exist in NW-5. This is further supported by the review of more recent aerial imagery. In hindsight, it appears that shadows in the older aerial imagery gave the illusion of a lake in the area. Due to the absence of a lake and the low historical data concerning dioxin concentrations in soil, it was decided to not sample NW-5. At a meeting with AMST on 05/07/15, VRTC reported similar observations about NW-5, and concurred that it was reasonable to eliminate this from sampling.
- ***Southwest Area, SW-5:*** The area of SW-5 has been used a borrow source for recent construction projects at the Airbase, which has resulted in the vast majority of the area being excavated to a depth of about 2 m. Therefore, almost all of the original surface soil in the area has been removed. Also, construction debris (primarily soil, concrete, and bricks) from other areas is being backfilled into the area. Laboratory results from the surrounding areas (SW-4, SW-6, SW-7, SW-8, and PI-14) indicate low dioxin concentrations at the surface and even lower with depth. Considering these results and the 2-m excavation depth, it is highly unlikely that dioxin could be present in what remains of SW-5. As a result, it was decided not to sample this area. At a meeting with AMST on 05/07/15, VRTC reported similar observations about SW-5 and concurred that it was unnecessary to sample this area.
- ***Z1 Area, Z1-14:*** Almost the entire area of Z1-14 is a walled, restricted area and access to proposed sampling sites was not permitted by the Airbase. Laboratory results from the surrounding areas (Z1-2B, Z1-2C, Z1-5, Z1-11, and ZT-4) indicate low dioxin concentrations (less than 170 ppt). On the east side of Z1-14, a narrow strip of trees that was outside of the restricted area was incorporated into Z1-2 and sampled in Phase 2.
- ***Z1Area, Z1-15:*** The area of Z1-15 has become much more developed in recent years with large buildings and paved parking areas. It appears that fill has been brought into the area as part of the development. Laboratory results from the surrounding areas (Z1-4, Z1-8, Z1-12, and ZT-5), which are also between Z1-15 and the Z1 Landfill, indicate low dioxin concentrations (less than 100 ppt). Due to consideration of the preliminary laboratory results obtained on samples collected during Phase 1 and the extremely difficult sampling conditions, it was decided not to sample Z1-15.
- ***ZT Area, ZT-3***: The southern portion of ZT-3 is a walled, restricted area and access to sample was not permitted by the Airbase. Laboratory results from the surrounding areas (ZT-4, ZT-7) indicate low dioxin concentrations (less than 100 ppt). The northern portion of ZT-3 was incorporated into ZT-4 and sampled during Phase 1, and the eastern side was added to ZT-7 and sampled in Phase 2.

In addition, the number of sampling depths was modified in the field at the following locations:

- Z1-12 in the Z1 Area was only sampled to 60 cm depth due to very dense/hard soil conditions which did not allow for deeper sample collection.

- BHL-1 at Bien Hung Lake was too deep to allow use of the Ogeechee™ sampler; as a result, a surface sediment sample (approximately 0-15 cm) was collected from the bottom of the lake using an Ekman dredge.

All sediment and soil MIS samples collected were processed as described in the SAP, and the homogenized MIS samples were split into two batches, one for transportation to VRTC for analysis and archiving and one for transportation to Canada for HR-GCMS analysis by AXYS and archiving. The VRTC archive samples also serve as a backup for the supplemental metals, PCBs and PAH analyses.

Summaries of the number samples collected and analyzed are provided in **Tables 3 and 4**, respectively.

The attached figures (**Figures A1.1 to A1.14**) provide a spatial view of sample distribution and analytical results for toxic equivalency quotient (TEQ) ppt in soil and sediment. Analytical results for all dioxin congeners in soil, sediment and water are provided in **Tables A1 to A22**. Samples aimed at measuring laboratory and environmental variance are provided in **Tables A23 and A26**. Analytical results for other contaminants of potential concern (COPCs) and metals in soil, sediment and water are provided in **Tables E3 to E9** in **Appendix E** (Environmental Baselines) to the EA.

Additional Sampling by AMST

In December 2015 and January 2016, AMST conducted additional sampling at the Airbase. The areas sampled included the six DUs that were not sampled during the November-December 2014 and March-April 2015 sampling program (NE-16, NW-15, SW-5, Z1-14, Z1-15, and ZT-3) and five new DUs. The results of this additional sampling program are summarized in **Appendix G**. Based on anticipated land use, the dioxin concentrations reported in the additional sampling are below the dioxin limits (i.e., dioxin contamination was not identified in these additional areas).

Table 3 Summary of Samples Collected for the 2014/2015 EA Sampling Program, Bien Hoa Airbase 2014/2015

Media and Analyses	Z1 Area	ZT Area	SW Area	Pacer Ivy Area	NW Area	N. Forest Area	NE Area	SE Area	Offsite Lakes	Other	Total
Soil/Sediment											
Depths Sampled (cm)	0-390	0-150	0-150	0-300	0-45	0-60	0-60	0-60	0-45	NA	-
Dioxin (subtotal)	330	102	121	380	63	44	224	21	21	0	1,306
MIS Samples	64	20	23	72	12	8	40	4	4	0	247
Sub-DU Samples	168	60	69	216	36	24	120	12	12	0	717
Triplicates	20	0	2	8	0	2	16	0	0	0	48
Duplicates	8	1	3	8	2	2	4	1	1	0	30
Discrete Sample[1]	1	0	0	0	0	0	0	0	0	0	1
Split Samples (AXYS)	4	1	1	4	1	0	4	0	0	0	15
Split Samples (VRTC)[2]	65	20	23	72	12	8	40	4	4	0	248
VOCs, SVOCs, Metals, PCBs, Herbicides	7	1	3	8	0	0	1	0	2	0	22
Physical Properties	2	0	1	1	0	0	2	0	0	0	6
Groundwater											
Dioxin	8	2	2	2	0	0	0	0	0	8[3]	22
Herbicides	4	1	1	1	0	0	0	0	0	8[3]	15
VOCs, SVOCs, Metals, PCBs	4	1	1	1	0	0	0	0	0	1[4]	8
Biota (Fish / Snails)											
Dioxin	4	0	0	4	6	0	16	0	3	0	33
Totals	**359**	**107**	**129**	**397**	**69**	**44**	**243**	**21**	**26**	**17**	**1,412**
Aliquots for Soil/Sediment											
MIS and Triplicate Samples	2,320	600	750	2,400	360	300	1,740	120	120	0	8,710

Notes:
1. One discrete sample was collected from the bioremediation study area in Z1 Landfill.
2. VRTC received a split of all MIS samples and the one discrete sample.
3. Groundwater samples were collected from 6 offsite locations and at the Airbase water supply tower (before and after treatment).
4. Groundwater samples were collected at the Airbase water supply tower after treatment.

Table 4 Samples Analyzed, Bien Hoa Airbase 2014/2015

Media	Number of Samples Analyzed						
	Dioxin / Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical Properties
Soil/Sediment	507	22	22	22	22	22	6
MIS	*247*	22	22	22	22	22	6
Sub-DU	*181*	*0*	*0*	*0*	*0*	*0*	*0*
Other[1]	79	*0*	*0*	*0*	*0*	*0*	*0*
Water	22	8	8	15	8	8	0
Biota	22	0	0	0	0	0	0
Totals	**551**	**30**	**30**	**37**	**30**	**30**	**6**

Note:
1 Includes one discrete sample collected from the bioremediation study area in Z1 Landfill, 48 triplicates, and 30 duplicates.

2.4 Quality Assurance

Field quality control (QC) samples were collected in accordance with the SAP (USAID 2014) to provide information on equipment decontamination, sample handling, storage, and shipment procedures. These are also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples. The field QC samples collected for this sampling event, and a summary of the results of the QC samples, are described below:

- A total of 30 laboratory duplicate samples were analyzed for dioxins and furans. These samples are analyzed as part of the laboratory's QC processes, where the laboratory analyzes two aliquots of soil from the same jar. **Table A23** presents the results of the laboratory duplicate samples.
- A total of 15 field split samples (11 soil, 4 sediment) were collected during the sampling event. Field split samples were collected from the same homogenized MIS sample. The split samples are intended to measure the variability in analytical data due to a combination of laboratory variability and inherent environmental heterogeneity. Field split samples were submitted to the laboratory as blind samples, in that they were not identified as splits and they were separate and unique from the "parent" sample. **Table A24** presents the results of the field split samples.
- A total of 24 sets of triplicate soil samples were collected and analyzed. Triplicate soil samples are utilized to ensure that the mean is not underestimated, and to calculate a 95% upper confidence limit (UCL) using results of replicate samples collected from one DU. Three samples (i.e., triplicates) are the minimum number of replicates needed from one DU to calculate the standard deviation and 95% UCL of a DU. Triplicate samples were collected in the same systematic random manner as the original samples, with randomly-determined offsets from the original sample locations. **Table A25** presents the results of the triplicate samples and the UCL calculations.
- A total of 20 rinsate samples were collected (one or more from each type of sampling equipment: Ekman/Ogeechee corer, soil corer, split spoon sampler, sample processing equipment) to provide a measure of potential cross-contamination. Rinsate blanks consisted of a sample of analyte-free water passed through/over a pre-cleaned/decontaminated sampling device. The rinsate samples are

an effective indicator of cross contamination resulting from equipment residues. All rinsate blanks collected were submitted for dioxin/furan analysis. **Table A26** presents the results of the rinsate samples.

- Temperature blanks were not carried in each cooler, as the laboratories use digital temperature readers to record sample temperature upon receipt by the laboratory.
- To ensure samples were not contaminated during the collection process, and to ensure highest quality data and samples were collected, a number of sampling quality control measures were incorporated into the sampling procedures:
  - Disposable powder-free nitrile gloves were used to handle all sampling equipment. Gloves were changed between sample sites, and care was taken to not touch the soil with gloved hands.
  - All sampling equipment that came in direct contact with samples was constructed of stainless steel.
  - All stainless steel equipment (sample collection tools, trays, scoops, sieves, scalpels, forceps, calipers, etc.) was cleaned using Alconox® and rinsed using ambient water, triple-rinsed with reagent grade hexane and triple rinsed with reagent grade acetone, before each use and between sample collections.
  - Sample jars were pre-labeled, cross-referenced to field sheets, and stored in a cool/dark area. Once filled, samples were stored in freezers until shipping.
  - The location of each sampling station was recorded using a hand-held GPS to ensure repeatability in future sampling programs.
  - Smoking was not permitted in the vicinity of sampling activities.

2.5 Summary of Data Validation Activities

Dioxin data validation was performed on a minimum of 10% of the sample data as determined by the project team's analytical coordinator. The data was validated to a stage 2B level as defined in the *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*, EPA 540-R-08-005, January 13, 2009. Validation was performed in accordance with method 1613B, the measurement performance criteria as presented in the SAP, the laboratory SOPs, and *the USEPA Contract Laboratory Program National Functional Guidelines for Chlorinated Dioxin/Furan Data Review*, EPA-540-R-11-016, September 2011. The HR-GCMS dioxin/furan analyses were performed by AXYS.

Analytical QA results and adherence to method requirements are summarized in a data validation worksheet for each sample work group assessed. Analytical QA/QC includes method blanks, ongoing precision and recovery samples (OPRs), laboratory duplicates, calibration, and method requirements. The sensitivity and compound identification is discussed and qualifications applied where applicable. Only validated samples had qualifiers beyond those used by the laboratory applied to the data.

Reporting limits were assessed to ensure the reporting limits were sufficient to meet the data quality objectives. AXYS reporting limits are based on the sample specific detection limit (SDL). This reporting limit is determined individually for every sample taking into consideration the level of noise and matrix interference observed. However, to be conservative, there is a lower limit to this method of sample specific reporting limit calculation, as calculated using 0.5 pgs absolute. The contract defined limit (QDL) is 0.5 picograms divided by the sample volume/mass.

The SDL is well below the sample equivalent to the lowest standard concentration in the calibration curve. Sample target concentrations below the lowest standard equivalent are qualified by the laboratory with a "J" flag, to denote that the concentration is estimated, down to the SDL, or the QDL, whichever is greater. Consistent with this approach, the reporting limit used for the TEQ calculations, reflects the lowest concentration that would be reported.

CDM Smith and Hatfield reports the AXYS TEQ calculated such that non-detect (ND) values are assigned a value of ½ the RL, whether the RL is the SDL or the QDL. When a peak is detected that does not meet all the criteria for positive identification, for example the peak is within the retention time window and contains both the quantitation and the confirmation ion (m/z), but the ratio between these two ions is not within 15% of the expected ratio, the lab will flag the quantitation as an estimated maximum possible concentration and these values are not included in the TEQ calculation. In practice, this is usually the case when the concentration is low and the difference in the final TEQ calculation tends to be minimal.

All data were found to be usable and suitable to meet the project DQOs.

3 Health and Safety

Health, safety, and security of Hatfield, CDM Smith and Vietnamese personnel working on the project was top priority, to protect workers from exposure to toxic contamination and UXO/ERW, and to ensure safety of all day-to-day fieldwork activities. Prior to initiating field activities, an H&S training class was held for the sampling team members and focused on working in a hazardous waste environment. Daily H&S briefings were held prior to commencing sampling activities. A Site H&S Officer ensured compliance with the requirements of the H&S Plan. As a results of these efforts, no safety accidents or injuries occurred during the sampling program.

Demining personnel from MND accompanied Hatfield and CDM Smith staff to all sites and screened all sampling locations prior to collection of samples.

4 Analytical Results

Summary tables provide the results for each sample analyzed during 2014/2015 program. Tables are organized by area, and TEQ values that exceed the guidelines for biota (20 ppt TEQ), sediment (150 ppt TEQ), and soil (varies depending on MND-approved dioxin limits) are highlighted. Historical TCDD and/or TEQ values have also been provided, from previous studies at the Airbase (Hatfield and 10-80 Division 2006; Hatfield and VRTC 2009; Hatfield and Office 33 2011; VEA 2012; Dekonta 2014). Data tables are provided for 2014/2015 particle size and total organic carbon (TOC) results for soils and sediments, and COPC results for water, soil and sediment samples, and historical COPC data in **Appendix E**. Data are also presented in a series of figures highlighting dioxin concentrations (TEQs) at various areas and depths sampled.

5 List of Tables

6 List of Figures

Table A1 Site locations for soil and sediment samples collected and analyzed, Pacer Ivy Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-01A	0-30	4/13/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	0-30	4/13/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	0-30	4/13/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	0-30	4/13/2015	697,117	1,213,435	✓	✓	✓	✓	✓	✓	✓
Pacer Ivy area	Soil	PI-01A	30-60	4/13/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	30-60	4/13/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	30-60	4/13/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	30-60	4/13/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-01A	60-90	4/14/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	60-90	4/14/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	60-90	4/14/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	60-90	4/14/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-01A	90-120	4/14/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	90-120	4/14/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	90-120	4/14/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	90-120	4/14/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-01A	150-180	4/14/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	150-180	4/14/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	150-180	4/14/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	150-180	4/14/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-01A	210-240	4/14/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	210-240	4/14/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	210-240	4/14/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	210-240	4/14/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-01A	270-300	4/14/2015	697,090	1,213,481	✓						
Pacer Ivy area	Soil	PI-01B	270-300	4/14/2015	697,194	1,213,458	✓						
Pacer Ivy area	Soil	PI-01C	270-300	4/14/2015	697,073	1,213,397	✓						
Pacer Ivy area	Soil	PI-01	270-300	4/14/2015	697,117	1,213,435	✓						
Pacer Ivy area	Soil	PI-02A	0-30	11/24/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	0-30	11/24/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	0-30	11/24/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	0-30	11/24/2014	697,243	1,213,335	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-02A	30-60	11/21/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	30-60	11/21/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	30-60	11/21/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	30-60	11/21/2014	697,243	1,213,335	✓						
Pacer Ivy area	Soil	PI-02A	60-90	11/24/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	60-90	11/24/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	60-90	11/24/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	697,243	1,213,335	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-02A	90-120	11/24/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	90-120	11/24/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	90-120	11/24/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	90-120	11/24/2014	697,243	1,213,335	✓						
Pacer Ivy area	Soil	PI-02A	150-180	11/29/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	150-180	11/29/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	150-180	11/29/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	150-180	11/29/2014	697,243	1,213,335	✓						
Pacer Ivy area	Soil	PI-02A	240-270	12/1/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	240-270	12/1/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	240-270	12/1/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	240-270	12/1/2014	697,243	1,213,335	✓						
Pacer Ivy area	Soil	PI-02A	270-300	11/27/2014	697,279	1,213,252	✓						
Pacer Ivy area	Soil	PI-02B	270-300	11/27/2014	697,202	1,213,330	✓						
Pacer Ivy area	Soil	PI-02C	270-300	11/27/2014	697,252	1,213,448	✓						
Pacer Ivy area	Soil	PI-02	270-300	11/27/2014	697,243	1,213,335	✓						
Pacer Ivy area	Soil	PI-03A	0-30	3/24/2015	697,151	1,213,556	✓						
Pacer Ivy area	Soil	PI-03B	0-30	3/24/2015	697,089	1,213,659	✓						
Pacer Ivy area	Soil	PI-03C	0-30	3/24/2015	697,088	1,213,757	✓						
Pacer Ivy area	Soil	PI-03	0-30	3/24/2015	697,110	1,213,650	✓						
Pacer Ivy area	Soil	PI-03A	30-60	4/4/2015	697,151	1,213,556	✓						
Pacer Ivy area	Soil	PI-03B	30-60	4/4/2015	697,089	1,213,659	✓						
Pacer Ivy area	Soil	PI-03C	30-60	4/4/2015	697,088	1,213,757	✓						
Pacer Ivy area	Soil	PI-03	30-60	4/4/2015	697,110	1,213,650	✓						

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Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-03A	60-90	3/27/2015	697,151	1,213,556	✓						
Pacer Ivy area	Soil	PI-03B	60-90	3/27/2015	697,089	1,213,659	✓						
Pacer Ivy area	Soil	PI-03C	60-90	3/27/2015	697,088	1,213,757	✓						
Pacer Ivy area	Soil	PI-03	60-90	3/27/2015	697,110	1,213,650	✓						
Pacer Ivy area	Soil	PI-03A	90-120	4/4/2015	697,151	1,213,556	✓						
Pacer Ivy area	Soil	PI-03B	90-120	4/4/2015	697,089	1,213,659	✓						
Pacer Ivy area	Soil	PI-03C	90-120	4/4/2015	697,088	1,213,757	✓						
Pacer Ivy area	Soil	PI-03	90-120	4/4/2015	697,110	1,213,650	✓						
Pacer Ivy area	Soil	PI-03A	120-150	3/25/2015	697,151	1,213,556	✓						
Pacer Ivy area	Soil	PI-03B	120-150	3/25/2015	697,089	1,213,659	✓						
Pacer Ivy area	Soil	PI-03C	120-150	3/25/2015	697,088	1,213,757	✓						
Pacer Ivy area	Soil	PI-03	120-150	3/25/2015	697,110	1,213,650	✓						
Pacer Ivy area	Soil	PI-04A	0-30	4/8/2015	697,013	1,213,539	✓						
Pacer Ivy area	Soil	PI-04B	0-30	4/8/2015	696,960	1,213,645	✓						
Pacer Ivy area	Soil	PI-04C	0-30	4/8/2015	696,942	1,213,740	✓						
Pacer Ivy area	Soil	PI-04	0-30	4/8/2015	696,968	1,213,647	✓						
Pacer Ivy area	Soil	PI-04A	30-60	4/8/2015	697,013	1,213,539	✓						
Pacer Ivy area	Soil	PI-04B	30-60	4/8/2015	696,960	1,213,645	✓						
Pacer Ivy area	Soil	PI-04C	30-60	4/8/2015	696,942	1,213,740	✓						
Pacer Ivy area	Soil	PI-04	30-60	4/8/2015	696,968	1,213,647	✓						
Pacer Ivy area	Soil	PI-04A	60-90	4/8/2015	697,013	1,213,539	✓						
Pacer Ivy area	Soil	PI-04B	60-90	4/8/2015	696,960	1,213,645	✓						
Pacer Ivy area	Soil	PI-04C	60-90	4/8/2015	696,942	1,213,740	✓						
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	696,968	1,213,647	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-04A	90-120	4/8/2015	697,013	1,213,539	✓						
Pacer Ivy area	Soil	PI-04B	90-120	4/8/2015	696,960	1,213,645	✓						
Pacer Ivy area	Soil	PI-04C	90-120	4/8/2015	696,942	1,213,740	✓						
Pacer Ivy area	Soil	PI-04	90-120	4/8/2015	696,968	1,213,647	✓						
Pacer Ivy area	Soil	PI-04A	120-150	4/9/2015	697,013	1,213,539	✓						
Pacer Ivy area	Soil	PI-04B	120-150	4/9/2015	696,960	1,213,645	✓						
Pacer Ivy area	Soil	PI-04C	120-150	4/9/2015	696,942	1,213,740	✓						
Pacer Ivy area	Soil	PI-04	120-150	4/9/2015	696,968	1,213,647	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-05A	0-30	3/21/2015	697,446	1,213,178	✓						
Pacer Ivy area	Soil	PI-05B	0-30	3/21/2015	697,451	1,213,190	✓						
Pacer Ivy area	Soil	PI-05C	0-30	3/21/2015	697,461	1,213,164	✓						
Pacer Ivy area	Soil	PI-05	0-30	3/21/2015	697,454	1,213,176	✓						
Pacer Ivy area	Soil	PI-05A	30-60	4/6/2015	697,446	1,213,178	✓						
Pacer Ivy area	Soil	PI-05B	30-60	4/6/2015	697,451	1,213,190	✓						
Pacer Ivy area	Soil	PI-05C	30-60	4/6/2015	697,461	1,213,164	✓						
Pacer Ivy area	Soil	PI-05	30-60	4/6/2015	697,454	1,213,176	✓						
Pacer Ivy area	Soil	PI-05A	60-90	4/7/2015	697,446	1,213,178	✓						
Pacer Ivy area	Soil	PI-05B	60-90	4/7/2015	697,451	1,213,190	✓						
Pacer Ivy area	Soil	PI-05C	60-90	4/7/2015	697,461	1,213,164	✓						
Pacer Ivy area	Soil	PI-05	60-90	4/7/2015	697,454	1,213,176	✓						
Pacer Ivy area	Soil	PI-06A	0-30	11/18/2014	697,444	1,213,466	✓						
Pacer Ivy area	Soil	PI-06B	0-30	11/18/2014	697,605	1,213,472	✓						
Pacer Ivy area	Soil	PI-06C	0-30	11/18/2014	697,751	1,213,474	✓						
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	697,600	1,213,471	✓						
Pacer Ivy area	Soil	PI-06A	30-60	11/18/2014	697,444	1,213,466	✓						
Pacer Ivy area	Soil	PI-06B	30-60	11/18/2014	697,605	1,213,472	✓						
Pacer Ivy area	Soil	PI-06C	30-60	11/18/2014	697,751	1,213,474	✓						
Pacer Ivy area	Soil	PI-06	30-60	11/18/2014	697,600	1,213,471	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-07A	0-30	11/25/2014	697,095	1,213,922	✓						
Pacer Ivy area	Soil	PI-07B	0-30	11/25/2014	697,001	1,213,920	✓						
Pacer Ivy area	Soil	PI-07C	0-30	11/25/2014	696,894	1,213,908	✓						
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	696,985	1,213,916	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-07A	30-60	11/25/2014	697,095	1,213,922	✓						
Pacer Ivy area	Soil	PI-07B	30-60	11/25/2014	697,001	1,213,920	✓						
Pacer Ivy area	Soil	PI-07C	30-60	11/25/2014	696,894	1,213,908	✓						
Pacer Ivy area	Soil	PI-07	30-60	11/25/2014	696,985	1,213,916	✓						
Pacer Ivy area	Soil	PI-07A	60-90	11/26/2014	697,095	1,213,922	✓						
Pacer Ivy area	Soil	PI-07B	60-90	11/26/2014	697,001	1,213,920	✓						
Pacer Ivy area	Soil	PI-07C	60-90	11/26/2014	696,894	1,213,908	✓						
Pacer Ivy area	Soil	PI-07	60-90	11/26/2014	696,985	1,213,916	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-08A	0-30	3/26/2015	696,928	1,213,402	✓						
Pacer Ivy area	Soil	PI-08B	0-30	3/26/2015	696,846	1,213,528	✓						
Pacer Ivy area	Soil	PI-08C	0-30	3/26/2015	696,855	1,213,686	✓						
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	696,849	1,213,528	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-08A	30-60	4/8/2015	696,928	1,213,402	✓						
Pacer Ivy area	Soil	PI-08B	30-60	4/8/2015	696,846	1,213,528	✓						
Pacer Ivy area	Soil	PI-08C	30-60	4/8/2015	696,855	1,213,686	✓						
Pacer Ivy area	Soil	PI-08	30-60	4/8/2015	696,849	1,213,528	✓						
Pacer Ivy area	Soil	PI-08A	60-90	4/2/2015	696,928	1,213,402	✓						
Pacer Ivy area	Soil	PI-08B	60-90	4/2/2015	696,846	1,213,528	✓						
Pacer Ivy area	Soil	PI-08C	60-90	4/2/2015	696,855	1,213,686	✓						
Pacer Ivy area	Soil	PI-08	60-90	4/2/2015	696,849	1,213,528	✓						
Pacer Ivy area	Soil	PI-09A	0-30	3/24/2015	697,102	1,213,197	✓						
Pacer Ivy area	Soil	PI-09B	0-30	3/24/2015	697,058	1,213,256	✓						
Pacer Ivy area	Soil	PI-09C	0-30	3/24/2015	697,014	1,213,312	✓						
Pacer Ivy area	Soil	PI-09	0-30	3/24/2015	697,057	1,213,257	✓						
Pacer Ivy area	Soil	PI-09A	30-60	3/24/2015	697,102	1,213,197	✓						
Pacer Ivy area	Soil	PI-09B	30-60	3/24/2015	697,058	1,213,256	✓						
Pacer Ivy area	Soil	PI-09C	30-60	3/24/2015	697,014	1,213,312	✓						
Pacer Ivy area	Soil	PI-09	30-60	3/24/2015	697,057	1,213,257	✓						
Pacer Ivy area	Soil	PI-09A	60-90	3/25/2015	697,102	1,213,197	✓						
Pacer Ivy area	Soil	PI-09B	60-90	3/25/2015	697,058	1,213,256	✓						
Pacer Ivy area	Soil	PI-09C	60-90	3/25/2015	697,014	1,213,312	✓						
Pacer Ivy area	Soil	PI-09	60-90	3/25/2015	697,057	1,213,257	✓						
Pacer Ivy area	Soil	PI-10A	0-30	3/20/2015	697,528	1,212,826	✓						
Pacer Ivy area	Soil	PI-10B	0-30	3/20/2015	697,449	1,212,926	✓						
Pacer Ivy area	Soil	PI-10C	0-30	3/20/2015	697,363	1,213,035	✓						
Pacer Ivy area	Soil	PI-10	0-30	3/20/2015	697,429	1,212,951	✓						
Pacer Ivy area	Soil	PI-10A	30-60	3/19/2015	697,528	1,212,826	✓						
Pacer Ivy area	Soil	PI-10B	30-60	3/19/2015	697,449	1,212,926	✓						
Pacer Ivy area	Soil	PI-10C	30-60	3/19/2015	697,363	1,213,035	✓						
Pacer Ivy area	Soil	PI-10	30-60	3/19/2015	697,429	1,212,951	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-10A	60-90	3/19/2015	697,528	1,212,826	✓						
Pacer Ivy area	Soil	PI-10B	60-90	3/19/2015	697,449	1,212,926	✓						
Pacer Ivy area	Soil	PI-10C	60-90	3/19/2015	697,363	1,213,035	✓						
Pacer Ivy area	Soil	PI-10	60-90	3/19/2015	697,429	1,212,951	✓						
Pacer Ivy area	Soil	PI-11A	0-30	4/6/2015	696,797	1,213,981	✓						
Pacer Ivy area	Soil	PI-11B	0-30	4/6/2015	696,799	1,213,931	✓						
Pacer Ivy area	Soil	PI-11C	0-30	4/6/2015	696,794	1,213,860	✓						
Pacer Ivy area	Soil	PI-11	0-30	4/6/2015	696,797	1,213,936	✓						
Pacer Ivy area	Soil	PI-11A	30-60	3/25/2015	696,797	1,213,981	✓						
Pacer Ivy area	Soil	PI-11B	30-60	3/25/2015	696,799	1,213,931	✓						
Pacer Ivy area	Soil	PI-11C	30-60	3/25/2015	696,794	1,213,860	✓						
Pacer Ivy area	Soil	PI-11	30-60	3/25/2015	696,797	1,213,936	✓						
Pacer Ivy area	Soil	PI-11A	60-90	3/24/2015	696,797	1,213,981	✓						
Pacer Ivy area	Soil	PI-11B	60-90	3/24/2015	696,799	1,213,931	✓						
Pacer Ivy area	Soil	PI-11C	60-90	3/24/2015	696,794	1,213,860	✓						
Pacer Ivy area	Soil	PI-11	60-90	3/24/2015	696,797	1,213,936	✓						
Pacer Ivy area	Soil	PI-12A	0-30	3/21/2015	696,842	1,213,421	✓						
Pacer Ivy area	Soil	PI-12B	0-30	3/21/2015	696,815	1,213,317	✓						
Pacer Ivy area	Soil	PI-12C	0-30	3/21/2015	696,903	1,213,375	✓						
Pacer Ivy area	Soil	PI-12	0-30	3/21/2015	696,862	1,213,393	✓						
Pacer Ivy area	Soil	PI-12A	30-60	4/2/2015	696,842	1,213,421	✓						
Pacer Ivy area	Soil	PI-12B	30-60	4/2/2015	696,815	1,213,317	✓						
Pacer Ivy area	Soil	PI-12C	30-60	4/2/2015	696,903	1,213,375	✓						
Pacer Ivy area	Soil	PI-12	30-60	4/2/2015	696,862	1,213,393	✓						
Pacer Ivy area	Soil	PI-12A	60-90	4/1/2015	696,842	1,213,421	✓						
Pacer Ivy area	Soil	PI-12B	60-90	4/1/2015	696,815	1,213,317	✓						
Pacer Ivy area	Soil	PI-12C	60-90	4/1/2015	696,903	1,213,375	✓						
Pacer Ivy area	Soil	PI-12	60-90	4/1/2015	696,862	1,213,393	✓						
Pacer Ivy area	Soil	PI-13A	0-30	11/17/2014	697,571	1,212,869	✓						
Pacer Ivy area	Soil	PI-13B	0-30	11/17/2014	697,512	1,213,002	✓						
Pacer Ivy area	Soil	PI-13C	0-30	11/17/2014	697,483	1,213,106	✓						
Pacer Ivy area	Soil	PI-13	0-30	11/17/2014	697,512	1,213,016	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Soil	PI-13A	30-60	11/17/2014	697,571	1,212,869	✓						
Pacer Ivy area	Soil	PI-13B	30-60	11/17/2014	697,512	1,213,002	✓						
Pacer Ivy area	Soil	PI-13C	30-60	11/17/2014	697,483	1,213,106	✓						
Pacer Ivy area	Soil	PI-13	30-60	11/17/2014	697,512	1,213,016	✓						
Pacer Ivy area	Soil	PI-14A	0-30	11/20/2014	697,716	1,213,122	✓						
Pacer Ivy area	Soil	PI-14B	0-30	11/20/2014	697,721	1,212,979	✓						
Pacer Ivy area	Soil	PI-14C	0-30	11/20/2014	697,731	1,212,858	✓						
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	697,722	1,212,999	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Soil	PI-14A	30-60	11/21/2014	697,716	1,213,122	✓						
Pacer Ivy area	Soil	PI-14B	30-60	11/21/2014	697,721	1,212,979	✓						
Pacer Ivy area	Soil	PI-14C	30-60	11/21/2014	697,731	1,212,858	✓						
Pacer Ivy area	Soil	PI-14	30-60	11/21/2014	697,722	1,212,999	✓						
Pacer Ivy area	Sediment	PI-15A	0-15	3/27/2015	696,730	1,213,341	✓						
Pacer Ivy area	Sediment	PI-15B	0-15	3/27/2015	696,843	1,213,335	✓						
Pacer Ivy area	Sediment	PI-15C	0-15	3/27/2015	696,935	1,213,338	✓						
Pacer Ivy area	Sediment	PI-15	0-15	3/27/2015	696,823	1,213,338	✓						
Pacer Ivy area	Sediment	PI-15A	15-30	4/2/2015	696,730	1,213,341	✓						
Pacer Ivy area	Sediment	PI-15B	15-30	4/2/2015	696,843	1,213,335	✓						
Pacer Ivy area	Sediment	PI-15C	15-30	4/2/2015	696,935	1,213,338	✓						
Pacer Ivy area	Sediment	PI-15	15-30	4/2/2015	696,823	1,213,338	✓						
Pacer Ivy area	Sediment	PI-15A	30-45	3/26/2015	696,730	1,213,341	✓						
Pacer Ivy area	Sediment	PI-15B	30-45	3/26/2015	696,843	1,213,335	✓						
Pacer Ivy area	Sediment	PI-15C	30-45	3/26/2015	696,935	1,213,338	✓						
Pacer Ivy area	Sediment	PI-15	30-45	3/26/2015	696,823	1,213,338	✓						
Pacer Ivy area	Sediment	PI-16A	0-15	3/26/2015	696,425	1,213,401	✓						
Pacer Ivy area	Sediment	PI-16B	0-15	3/26/2015	696,495	1,213,421	✓						
Pacer Ivy area	Sediment	PI-16C	0-15	3/26/2015	696,590	1,213,453	✓						
Pacer Ivy area	Sediment	PI-16	0-15	3/26/2015	696,521	1,213,433	✓						
Pacer Ivy area	Sediment	PI-16A	15-30	4/3/2015	696,425	1,213,401	✓						
Pacer Ivy area	Sediment	PI-16B	15-30	4/3/2015	696,495	1,213,421	✓						
Pacer Ivy area	Sediment	PI-16C	15-30	4/3/2015	696,590	1,213,453	✓						
Pacer Ivy area	Sediment	PI-16	15-30	4/3/2015	696,521	1,213,433	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Sediment	PI-16A	30-45	4/1/2015	696,425	1,213,401	✓						
Pacer Ivy area	Sediment	PI-16B	30-45	4/1/2015	696,495	1,213,421	✓						
Pacer Ivy area	Sediment	PI-16C	30-45	4/1/2015	696,590	1,213,453	✓						
Pacer Ivy area	Sediment	PI-16	30-45	4/1/2015	696,521	1,213,433	✓						
Pacer Ivy area	Sediment	PI-17A	0-15	3/27/2015	696,922	1,213,584	✓						
Pacer Ivy area	Sediment	PI-17B	0-15	3/27/2015	696,907	1,213,523	✓						
Pacer Ivy area	Sediment	PI-17C	0-15	3/27/2015	696,976	1,213,452	✓						
Pacer Ivy area	Sediment	PI-17	0-15	3/27/2015	696,935	1,213,509	✓						
Pacer Ivy area	Sediment	PI-17A	15-30	3/25/2015	696,922	1,213,584	✓						
Pacer Ivy area	Sediment	PI-17B	15-30	3/25/2015	696,907	1,213,523	✓						
Pacer Ivy area	Sediment	PI-17C	15-30	3/25/2015	696,976	1,213,452	✓						
Pacer Ivy area	Sediment	PI-17	15-30	3/25/2015	696,935	1,213,509	✓						
Pacer Ivy area	Sediment	PI-17A	30-45	3/26/2015	696,922	1,213,584	✓						
Pacer Ivy area	Sediment	PI-17B	30-45	3/26/2015	696,907	1,213,523	✓						
Pacer Ivy area	Sediment	PI-17C	30-45	3/26/2015	696,976	1,213,452	✓						
Pacer Ivy area	Sediment	PI-17	30-45	3/26/2015	696,935	1,213,509	✓						
Pacer Ivy area	Sediment	PI-18A	0-15	3/23/2015	697,275	1,213,128	✓						
Pacer Ivy area	Sediment	PI-18B	0-15	3/23/2015	697,220	1,213,151	✓						
Pacer Ivy area	Sediment	PI-18C	0-15	3/23/2015	697,166	1,213,170	✓						
Pacer Ivy area	Sediment	PI-18	0-15	3/23/2015	697,229	1,213,146	✓						
Pacer Ivy area	Sediment	PI-18A	15-30	3/24/2015	697,275	1,213,128	✓						
Pacer Ivy area	Sediment	PI-18B	15-30	3/24/2015	697,220	1,213,151	✓						
Pacer Ivy area	Sediment	PI-18C	15-30	3/24/2015	697,166	1,213,170	✓						
Pacer Ivy area	Sediment	PI-18	15-30	3/24/2015	697,229	1,213,146	✓						
Pacer Ivy area	Sediment	PI-18A	30-45	3/25/2015	697,275	1,213,128	✓						
Pacer Ivy area	Sediment	PI-18B	30-45	3/25/2015	697,220	1,213,151	✓						
Pacer Ivy area	Sediment	PI-18C	30-45	3/25/2015	697,166	1,213,170	✓						
Pacer Ivy area	Sediment	PI-18	30-45	3/25/2015	697,229	1,213,146	✓						
Pacer Ivy area	Sediment	PI-19A	0-15	4/6/2015	697,235	1,213,091	✓						
Pacer Ivy area	Sediment	PI-19B	0-15	4/6/2015	697,219	1,213,085	✓						
Pacer Ivy area	Sediment	PI-19C	0-15	4/6/2015	697,192	1,213,066	✓						
Pacer Ivy area	Sediment	PI-19	0-15	4/6/2015	697,210	1,213,078	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Pacer Ivy area	Sediment	PI-19A	15-30	4/6/2015	697,235	1,213,091	✓						
Pacer Ivy area	Sediment	PI-19B	15-30	4/6/2015	697,219	1,213,085	✓						
Pacer Ivy area	Sediment	PI-19C	15-30	4/6/2015	697,192	1,213,066	✓						
Pacer Ivy area	Sediment	PI-19	15-30	4/6/2015	697,210	1,213,078	✓						
Pacer Ivy area	Sediment	PI-19A	30-45	4/6/2015	697,235	1,213,091	✓						
Pacer Ivy area	Sediment	PI-19B	30-45	4/6/2015	697,219	1,213,085	✓						
Pacer Ivy area	Sediment	PI-19C	30-45	4/6/2015	697,192	1,213,066	✓						
Pacer Ivy area	Sediment	PI-19	30-45	4/6/2015	697,210	1,213,078	✓						
Pacer Ivy area	Sediment	PI-20A	0-15	3/23/2015	697,159	1,213,216	✓						
Pacer Ivy area	Sediment	PI-20B	0-15	3/23/2015	697,141	1,213,258	✓						
Pacer Ivy area	Sediment	PI-20C	0-15	3/23/2015	697,195	1,213,245	✓						
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	697,165	1,213,239	✓	✓	✓	✓	✓	✓	
Pacer Ivy area	Sediment	PI-20A	15-30	3/20/2015	697,159	1,213,216	✓						
Pacer Ivy area	Sediment	PI-20B	15-30	3/20/2015	697,141	1,213,258	✓						
Pacer Ivy area	Sediment	PI-20C	15-30	3/20/2015	697,195	1,213,245	✓						
Pacer Ivy area	Sediment	PI-20	15-30	3/20/2015	697,165	1,213,239	✓						
Pacer Ivy area	Sediment	PI-20A	30-45	3/25/2015	697,159	1,213,216	✓						
Pacer Ivy area	Sediment	PI-20B	30-45	3/25/2015	697,141	1,213,258	✓						
Pacer Ivy area	Sediment	PI-20C	30-45	3/25/2015	697,195	1,213,245	✓						
Pacer Ivy area	Sediment	PI-20	30-45	3/25/2015	697,165	1,213,239	✓						
Pacer Ivy area	Sediment	PI-21A	0-15	4/3/2015	696,436	1,213,485	✓						
Pacer Ivy area	Sediment	PI-21B	0-15	4/3/2015	696,391	1,213,422	✓						
Pacer Ivy area	Sediment	PI-21C	0-15	4/3/2015	696,346	1,213,352	✓						
Pacer Ivy area	Sediment	PI-21	0-15	4/3/2015	696,390	1,213,419	✓						
Pacer Ivy area	Sediment	PI-21A	15-30	4/1/2015	696,436	1,213,485	✓						
Pacer Ivy area	Sediment	PI-21B	15-30	4/1/2015	696,391	1,213,422	✓						
Pacer Ivy area	Sediment	PI-21C	15-30	4/1/2015	696,346	1,213,352	✓						
Pacer Ivy area	Sediment	PI-21	15-30	4/1/2015	696,390	1,213,419	✓						
Pacer Ivy area	Sediment	PI-21A	30-45	4/3/2015	696,436	1,213,485	✓						
Pacer Ivy area	Sediment	PI-21B	30-45	4/3/2015	696,391	1,213,422	✓						
Pacer Ivy area	Sediment	PI-21C	30-45	4/3/2015	696,346	1,213,352	✓						
Pacer Ivy area	Sediment	PI-21	30-45	4/3/2015	696,390	1,213,419	✓						

Table A1 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A2 Site locations for soil samples collected and analyzed, Southwest Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Southwest area	Soil	SW-01A	0-30	11/13/2014	698,220	1,212,409	✓						
Southwest area	Soil	SW-01B	0-30	11/13/2014	698,248	1,212,387	✓						
Southwest area	Soil	SW-01C	0-30	11/13/2014	698,284	1,212,438	✓						
Southwest area	Soil	SW-01	0-30	11/13/2014	698,252	1,212,411	✓	✓	✓	✓	✓	✓	
Southwest area	Soil	SW-01A	30-60	11/15/2014	698,220	1,212,409	✓						
Southwest area	Soil	SW-01B	30-60	11/15/2014	698,248	1,212,387	✓						
Southwest area	Soil	SW-01C	30-60	11/15/2014	698,284	1,212,438	✓						
Southwest area	Soil	SW-01	30-60	11/15/2014	698,252	1,212,411	✓						
Southwest area	Soil	SW-01A	60-90	11/15/2014	698,220	1,212,409	✓						
Southwest area	Soil	SW-01B	60-90	11/15/2014	698,248	1,212,387	✓						
Southwest area	Soil	SW-01C	60-90	11/15/2014	698,284	1,212,438	✓						
Southwest area	Soil	SW-01	60-90	11/15/2014	698,252	1,212,411	✓						
Southwest area	Soil	SW-01A	90-120	11/17/2014	698,220	1,212,409	✓						
Southwest area	Soil	SW-01B	90-120	11/17/2014	698,248	1,212,387	✓						
Southwest area	Soil	SW-01C	90-120	11/17/2014	698,284	1,212,438	✓						
Southwest area	Soil	SW-01	90-120	11/17/2014	698,252	1,212,411	✓						
Southwest area	Soil	SW-01A	120-150	11/17/2014	698,220	1,212,409	✓						
Southwest area	Soil	SW-01B	120-150	11/17/2014	698,248	1,212,387	✓						
Southwest area	Soil	SW-01C	120-150	11/17/2014	698,284	1,212,438	✓						
Southwest area	Soil	SW-01	120-150	11/17/2014	698,252	1,212,411	✓						
Southwest area	Soil	SW-02A	0-30	11/15/2014	698,283	1,212,348	✓						
Southwest area	Soil	SW-02B	0-30	11/15/2014	698,323	1,212,460	✓						
Southwest area	Soil	SW-02C	0-30	11/15/2014	698,221	1,212,482	✓						
Southwest area	Soil	SW-02	0-30	11/15/2014	698,253	1,212,461	✓	✓	✓	✓	✓	✓	
Southwest area	Soil	SW-02A	30-60	11/15/2014	698,283	1,212,348	✓						
Southwest area	Soil	SW-02B	30-60	11/15/2014	698,323	1,212,460	✓						
Southwest area	Soil	SW-02C	30-60	11/15/2014	698,221	1,212,482	✓						
Southwest area	Soil	SW-02	30-60	11/15/2014	698,253	1,212,461	✓						

Table A2 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Southwest area	Soil	SW-02A	60-90	11/15/2014	698,283	1,212,348	✓						
Southwest area	Soil	SW-02B	60-90	11/15/2014	698,323	1,212,460	✓						
Southwest area	Soil	SW-02C	60-90	11/15/2014	698,221	1,212,482	✓						
Southwest area	Soil	SW-02	60-90	11/15/2014	698,253	1,212,461	✓						
Southwest area	Soil	SW-03A	0-30	11/15/2014	698,461	1,212,219	✓						
Southwest area	Soil	SW-03B	0-30	11/15/2014	698,418	1,212,278	✓						
Southwest area	Soil	SW-03C	0-30	11/15/2014	698,355	1,212,316	✓						
Southwest area	Soil	SW-03	0-30	11/15/2014	698,413	1,212,269	✓	✓	✓	✓	✓	✓	
Southwest area	Soil	SW-03A	30-60	11/15/2014	698,461	1,212,219	✓						
Southwest area	Soil	SW-03B	30-60	11/15/2014	698,418	1,212,278	✓						
Southwest area	Soil	SW-03C	30-60	11/15/2014	698,355	1,212,316	✓						
Southwest area	Soil	SW-03	30-60	11/15/2014	698,413	1,212,269	✓						
Southwest area	Soil	SW-03A	60-90	11/15/2014	698,461	1,212,219	✓						
Southwest area	Soil	SW-03B	60-90	11/15/2014	698,418	1,212,278	✓						
Southwest area	Soil	SW-03C	60-90	11/15/2014	698,355	1,212,316	✓						
Southwest area	Soil	SW-03	60-90	11/15/2014	698,413	1,212,269	✓						
Southwest area	Soil	SW-04A	0-30	11/19/2014	698,140	1,212,530	✓						
Southwest area	Soil	SW-04B	0-30	11/19/2014	698,181	1,212,545	✓						
Southwest area	Soil	SW-04C	0-30	11/19/2014	698,239	1,212,575	✓						
Southwest area	Soil	SW-04	0-30	11/19/2014	698,183	1,212,548	✓						
Southwest area	Soil	SW-04A	30-60	11/21/2014	698,140	1,212,530	✓						
Southwest area	Soil	SW-04B	30-60	11/21/2014	698,181	1,212,545	✓						
Southwest area	Soil	SW-04C	30-60	11/21/2014	698,239	1,212,575	✓						
Southwest area	Soil	SW-04	30-60	11/21/2014	698,183	1,212,548	✓						
Southwest area	Soil	SW-04A	60-90	11/21/2014	698,140	1,212,530	✓						
Southwest area	Soil	SW-04B	60-90	11/21/2014	698,181	1,212,545	✓						
Southwest area	Soil	SW-04C	60-90	11/21/2014	698,239	1,212,575	✓						
Southwest area	Soil	SW-04	60-90	11/21/2014	698,183	1,212,548	✓						

Table A2 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Southwest area	Soil	SW-06A	0-30	11/12/2014	698,018	1,212,477	✓						
Southwest area	Soil	SW-06B	0-30	11/12/2014	698,089	1,212,404	✓						
Southwest area	Soil	SW-06C	0-30	11/12/2014	698,097	1,212,321	✓						
Southwest area	Soil	SW-06	0-30	11/12/2014	698,068	1,212,403	✓						
Southwest area	Soil	SW-06A	30-60	11/13/2014	698,018	1,212,477	✓						
Southwest area	Soil	SW-06B	30-60	11/13/2014	698,089	1,212,404	✓						
Southwest area	Soil	SW-06C	30-60	11/13/2014	698,097	1,212,321	✓						
Southwest area	Soil	SW-06	30-60	11/13/2014	698,068	1,212,403	✓						
Southwest area	Soil	SW-06A	60-90	11/14/2014	698,018	1,212,477	✓						
Southwest area	Soil	SW-06B	60-90	11/14/2014	698,089	1,212,404	✓						
Southwest area	Soil	SW-06C	60-90	11/14/2014	698,097	1,212,321	✓						
Southwest area	Soil	SW-06	60-90	11/14/2014	698,068	1,212,403	✓						
Southwest area	Soil	SW-07A	0-30	11/15/2014	697,971	1,212,537	✓						
Southwest area	Soil	SW-07B	0-30	11/15/2014	697,926	1,212,611	✓						
Southwest area	Soil	SW-07C	0-30	11/15/2014	697,865	1,212,667	✓						
Southwest area	Soil	SW-07	0-30	11/15/2014	697,925	1,212,602	✓						
Southwest area	Soil	SW-07A	30-60	11/17/2014	697,971	1,212,537	✓						
Southwest area	Soil	SW-07B	30-60	11/17/2014	697,926	1,212,611	✓						
Southwest area	Soil	SW-07C	30-60	11/17/2014	697,865	1,212,667	✓						
Southwest area	Soil	SW-07	30-60	11/17/2014	697,925	1,212,602	✓						
Southwest area	Soil	SW-07A	60-90	11/17/2014	697,971	1,212,537	✓						
Southwest area	Soil	SW-07B	60-90	11/17/2014	697,926	1,212,611	✓						
Southwest area	Soil	SW-07C	60-90	11/17/2014	697,865	1,212,667	✓						
Southwest area	Soil	SW-07	60-90	11/17/2014	697,925	1,212,602	✓						
Southwest area	Soil	SW-08A	0-30	11/18/2014	697,704	1,212,787	✓						
Southwest area	Soil	SW-08B	0-30	11/18/2014	697,745	1,212,741	✓						
Southwest area	Soil	SW-08C	0-30	11/18/2014	697,824	1,212,712	✓						
Southwest area	Soil	SW-08	0-30	11/18/2014	697,758	1,212,744	✓	✓	✓	✓	✓	✓	

Table A2 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Southwest area	Soil	SW-08A	30-60	11/18/2014	697,704	1,212,787	✓						
Southwest area	Soil	SW-08B	30-60	11/18/2014	697,745	1,212,741	✓						
Southwest area	Soil	SW-08C	30-60	11/18/2014	697,824	1,212,712	✓						
Southwest area	Soil	SW-08	30-60	11/18/2014	697,758	1,212,744	✓						
Southwest area	Soil	SW-08A	60-90	11/18/2014	697,704	1,212,787	✓						
Southwest area	Soil	SW-08B	60-90	11/18/2014	697,745	1,212,741	✓						
Southwest area	Soil	SW-08C	60-90	11/18/2014	697,824	1,212,712	✓						
Southwest area	Soil	SW-08	60-90	11/18/2014	697,758	1,212,744	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A3 Site locations for soil and sediment samples collected and analyzed, Z1 Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-01-Bio	0-100	4/14/2015	699,126	1,212,408	✓						
Z1 area	Soil	Z1-01-Landfill	0-100	4/14/2015	699,126	1,212,408	✓	✓	✓	✓	✓	✓	✓
Z1 area	Soil	Z1-02A	0-30	3/25/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	0-30	3/25/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	0-30	3/25/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	0-30	3/25/2015	698,951	1,212,350	✓	✓	✓	✓	✓	✓	
Z1 area	Soil	Z1-02A	60-90	3/24/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	60-90	3/24/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	60-90	3/24/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	60-90	3/24/2015	698,951	1,212,350	✓						
Z1 area	Soil	Z1-02A	120-150	4/3/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	120-150	4/3/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	120-150	4/3/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	120-150	4/3/2015	698,951	1,212,350	✓						
Z1 area	Soil	Z1-02A	180-210	4/4/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	180-210	4/4/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	180-210	4/4/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	180-210	4/4/2015	698,951	1,212,350	✓						
Z1 area	Soil	Z1-02A	240-270	4/4/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	240-270	4/4/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	240-270	4/4/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	240-270	4/4/2015	698,951	1,212,350	✓						
Z1 area	Soil	Z1-02A	300-330	4/6/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	300-330	4/6/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	300-330	4/6/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	300-330	4/6/2015	698,951	1,212,350	✓						
Z1 area	Soil	Z1-02A	360-390	4/6/2015	698,965	1,212,277	✓						
Z1 area	Soil	Z1-02B	360-390	4/6/2015	698,942	1,212,366	✓						
Z1 area	Soil	Z1-02C	360-390	4/6/2015	698,941	1,212,446	✓						
Z1 area	Soil	Z1-02	360-390	4/6/2015	698,951	1,212,350	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-03A	0-30	12/3/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	0-30	12/3/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	0-30	12/3/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	0-30	12/3/2014	699,139	1,212,280	✓						
Z1 area	Soil	Z1-03A	60-90	12/2/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	60-90	12/2/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	60-90	12/2/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	60-90	12/2/2014	699,139	1,212,280	✓	✓	✓	✓	✓	✓	
Z1 area	Soil	Z1-03A	120-150	12/2/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	120-150	12/2/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	120-150	12/2/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	120-150	12/2/2014	699,139	1,212,280	✓						
Z1 area	Soil	Z1-03A	180-210	12/2/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	180-210	12/2/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	180-210	12/2/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	180-210	12/2/2014	699,139	1,212,280	✓						
Z1 area	Soil	Z1-03A	240-270	12/2/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	240-270	12/2/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	240-270	12/2/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	240-270	12/2/2014	699,139	1,212,280	✓						
Z1 area	Soil	Z1-03A	300-330	12/4/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	300-330	12/4/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	300-330	12/4/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	300-330	12/4/2014	699,139	1,212,280	✓						
Z1 area	Soil	Z1-03A	360-390	12/4/2014	699,144	1,212,255	✓						
Z1 area	Soil	Z1-03B	360-390	12/4/2014	699,137	1,212,285	✓						
Z1 area	Soil	Z1-03C	360-390	12/4/2014	699,134	1,212,310	✓						
Z1 area	Soil	Z1-03	360-390	12/4/2014	699,139	1,212,280	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-04A	0-30	12/3/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	0-30	12/3/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	0-30	12/3/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	0-30	12/3/2014	699,306	1,212,389	✓						
Z1 area	Soil	Z1-04A	60-90	11/29/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	60-90	11/29/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	60-90	11/29/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	60-90	11/29/2014	699,306	1,212,389	✓						
Z1 area	Soil	Z1-04A	120-150	12/1/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	120-150	12/1/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	120-150	12/1/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	120-150	12/1/2014	699,306	1,212,389	✓	✓	✓	✓	✓	✓	
Z1 area	Soil	Z1-04A	180-210	12/1/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	180-210	12/1/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	180-210	12/1/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	180-210	12/1/2014	699,306	1,212,389	✓						
Z1 area	Soil	Z1-04A	240-270	11/29/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	240-270	11/29/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	240-270	11/29/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	240-270	11/29/2014	699,306	1,212,389	✓						
Z1 area	Soil	Z1-04A	300-330	12/1/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	300-330	12/1/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	300-330	12/1/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	300-330	12/1/2014	699,306	1,212,389	✓						
Z1 area	Soil	Z1-04A	360-390	12/3/2014	699,314	1,212,299	✓						
Z1 area	Soil	Z1-04B	360-390	12/3/2014	699,314	1,212,373	✓						
Z1 area	Soil	Z1-04C	360-390	12/3/2014	699,294	1,212,465	✓						
Z1 area	Soil	Z1-04	360-390	12/3/2014	699,306	1,212,389	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-05A	0-30	12/4/2014	698,888	1,212,216	✓						
Z1 area	Soil	Z1-05B	0-30	12/4/2014	698,859	1,212,190	✓						
Z1 area	Soil	Z1-05C	0-30	12/4/2014	698,823	1,212,169	✓						
Z1 area	Soil	Z1-05	0-30	12/4/2014	698,852	1,212,188	✓						
Z1 area	Soil	Z1-05A	30-60	12/4/2014	698,888	1,212,216	✓						
Z1 area	Soil	Z1-05B	30-60	12/4/2014	698,859	1,212,190	✓						
Z1 area	Soil	Z1-05C	30-60	12/4/2014	698,823	1,212,169	✓						
Z1 area	Soil	Z1-05	30-60	12/4/2014	698,852	1,212,188	✓						
Z1 area	Soil	Z1-05A	60-90	12/4/2014	698,888	1,212,216	✓						
Z1 area	Soil	Z1-05B	60-90	12/4/2014	698,859	1,212,190	✓						
Z1 area	Soil	Z1-05C	60-90	12/4/2014	698,823	1,212,169	✓						
Z1 area	Soil	Z1-05	60-90	12/4/2014	698,852	1,212,188	✓						
Z1 area	Soil	Z1-06A	0-30	3/18/2015	698,958	1,212,185	✓						
Z1 area	Soil	Z1-06B	0-30	3/18/2015	699,078	1,212,192	✓						
Z1 area	Soil	Z1-06C	0-30	3/18/2015	699,233	1,212,211	✓						
Z1 area	Soil	Z1-06	0-30	3/18/2015	699,116	1,212,199	✓						
Z1 area	Soil	Z1-06A	30-60	3/18/2015	698,958	1,212,185	✓						
Z1 area	Soil	Z1-06B	30-60	3/18/2015	699,078	1,212,192	✓						
Z1 area	Soil	Z1-06C	30-60	3/18/2015	699,233	1,212,211	✓						
Z1 area	Soil	Z1-06	30-60	3/18/2015	699,116	1,212,199	✓	✓	✓	✓	✓	✓	
Z1 area	Soil	Z1-06A	60-90	3/20/2015	698,958	1,212,185	✓						
Z1 area	Soil	Z1-06B	60-90	3/20/2015	699,078	1,212,192	✓						
Z1 area	Soil	Z1-06C	60-90	3/20/2015	699,233	1,212,211	✓						
Z1 area	Soil	Z1-06	60-90	3/20/2015	699,116	1,212,199	✓						
Z1 area	Soil	Z1-06A	120-150	4/3/2015	698,958	1,212,185	✓						
Z1 area	Soil	Z1-06B	120-150	4/3/2015	699,078	1,212,192	✓						
Z1 area	Soil	Z1-06C	120-150	4/3/2015	699,233	1,212,211	✓						
Z1 area	Soil	Z1-06	120-150	4/3/2015	699,116	1,212,199	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-06A	180-210	4/2/2015	698,958	1,212,185	✓						
Z1 area	Soil	Z1-06B	180-210	4/2/2015	699,078	1,212,192	✓						
Z1 area	Soil	Z1-06C	180-210	4/2/2015	699,233	1,212,211	✓						
Z1 area	Soil	Z1-06	180-210	4/2/2015	699,116	1,212,199	✓						
Z1 area	Soil	Z1-07A	0-30	4/10/2015	699,304	1,211,979	✓						
Z1 area	Soil	Z1-07B	0-30	4/10/2015	699,253	1,212,061	✓						
Z1 area	Soil	Z1-07C	0-30	4/10/2015	699,352	1,212,150	✓						
Z1 area	Soil	Z1-07	0-30	4/10/2015	699,300	1,212,055	✓						
Z1 area	Soil	Z1-07A	30-60	4/9/2015	699,304	1,211,979	✓						
Z1 area	Soil	Z1-07B	30-60	4/9/2015	699,253	1,212,061	✓						
Z1 area	Soil	Z1-07C	30-60	4/9/2015	699,352	1,212,150	✓						
Z1 area	Soil	Z1-07	30-60	4/9/2015	699,300	1,212,055	✓						
Z1 area	Soil	Z1-07A	60-90	4/7/2015	699,304	1,211,979	✓						
Z1 area	Soil	Z1-07B	60-90	4/7/2015	699,253	1,212,061	✓						
Z1 area	Soil	Z1-07C	60-90	4/7/2015	699,352	1,212,150	✓						
Z1 area	Soil	Z1-07	60-90	4/7/2015	699,300	1,212,055	✓						
Z1 area	Soil	Z1-07A	120-150	4/7/2015	699,304	1,211,979	✓						
Z1 area	Soil	Z1-07B	120-150	4/7/2015	699,253	1,212,061	✓						
Z1 area	Soil	Z1-07C	120-150	4/7/2015	699,352	1,212,150	✓						
Z1 area	Soil	Z1-07	120-150	4/7/2015	699,300	1,212,055	✓						
Z1 area	Soil	Z1-07A	180-210	4/7/2015	699,304	1,211,979	✓						
Z1 area	Soil	Z1-07B	180-210	4/7/2015	699,253	1,212,061	✓						
Z1 area	Soil	Z1-07C	180-210	4/7/2015	699,352	1,212,150	✓						
Z1 area	Soil	Z1-07	180-210	4/7/2015	699,300	1,212,055	✓						
Z1 area	Soil	Z1-08A	0-30	11/25/2014	699,429	1,212,343	✓						
Z1 area	Soil	Z1-08B	0-30	11/25/2014	699,442	1,212,182	✓						
Z1 area	Soil	Z1-08C	0-30	11/25/2014	699,453	1,212,052	✓						
Z1 area	Soil	Z1-08	0-30	11/25/2014	699,440	1,212,208	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-08A	30-60	11/26/2014	699,429	1,212,343	✓						
Z1 area	Soil	Z1-08B	30-60	11/26/2014	699,442	1,212,182	✓						
Z1 area	Soil	Z1-08C	30-60	11/26/2014	699,453	1,212,052	✓						
Z1 area	Soil	Z1-08	30-60	11/26/2014	699,440	1,212,208	✓						
Z1 area	Soil	Z1-08A	60-90	11/26/2014	699,429	1,212,343	✓						
Z1 area	Soil	Z1-08B	60-90	11/26/2014	699,442	1,212,182	✓						
Z1 area	Soil	Z1-08C	60-90	11/26/2014	699,453	1,212,052	✓						
Z1 area	Soil	Z1-08	60-90	11/26/2014	699,440	1,212,208	✓						
Z1 area	Sediment	Z1-09A	0-15	4/8/2015	699,072	1,211,942	✓						
Z1 area	Sediment	Z1-09B	0-15	4/8/2015	699,125	1,211,945	✓						
Z1 area	Sediment	Z1-09C	0-15	4/8/2015	699,194	1,211,939	✓						
Z1 area	Sediment	Z1-09	0-15	4/8/2015	699,142	1,211,942	✓						
Z1 area	Sediment	Z1-09A	15-30	4/8/2015	699,072	1,211,942	✓						
Z1 area	Sediment	Z1-09B	15-30	4/8/2015	699,125	1,211,945	✓						
Z1 area	Sediment	Z1-09C	15-30	4/8/2015	699,194	1,211,939	✓						
Z1 area	Sediment	Z1-09	15-30	4/8/2015	699,142	1,211,942	✓						
Z1 area	Sediment	Z1-09A	30-45	4/8/2015	699,072	1,211,942	✓						
Z1 area	Sediment	Z1-09B	30-45	4/8/2015	699,125	1,211,945	✓						
Z1 area	Sediment	Z1-09C	30-45	4/8/2015	699,194	1,211,939	✓						
Z1 area	Sediment	Z1-09	30-45	4/8/2015	699,142	1,211,942	✓						
Z1 area	Sediment	Z1-10A	0-15	4/10/2015	699,289	1,212,183	✓						
Z1 area	Sediment	Z1-10B	0-15	4/10/2015	699,295	1,212,171	✓						
Z1 area	Sediment	Z1-10C	0-15	4/10/2015	699,306	1,212,158	✓						
Z1 area	Sediment	Z1-10	0-15	4/10/2015	699,297	1,212,169	✓						
Z1 area	Sediment	Z1-10A	15-30	4/11/2015	699,289	1,212,183	✓						
Z1 area	Sediment	Z1-10B	15-30	4/11/2015	699,295	1,212,171	✓						
Z1 area	Sediment	Z1-10C	15-30	4/11/2015	699,306	1,212,158	✓						
Z1 area	Sediment	Z1-10	15-30	4/11/2015	699,297	1,212,169	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Sediment	Z1-10A	30-45	4/13/2015	699,289	1,212,183	✓						
Z1 area	Sediment	Z1-10B	30-45	4/13/2015	699,295	1,212,171	✓						
Z1 area	Sediment	Z1-10C	30-45	4/13/2015	699,306	1,212,158	✓						
Z1 area	Sediment	Z1-10	30-45	4/13/2015	699,297	1,212,169	✓						
Z1 area	Soil	Z1-11A	0-30	12/1/2014	698,779	1,212,141	✓						
Z1 area	Soil	Z1-11B	0-30	12/1/2014	698,735	1,212,156	✓						
Z1 area	Soil	Z1-11C	0-30	12/1/2014	698,705	1,212,138	✓						
Z1 area	Soil	Z1-11	0-30	12/1/2014	698,746	1,212,145	✓						
Z1 area	Soil	Z1-11A	30-60	12/2/2014	698,779	1,212,141	✓						
Z1 area	Soil	Z1-11B	30-60	12/2/2014	698,735	1,212,156	✓						
Z1 area	Soil	Z1-11C	30-60	12/2/2014	698,705	1,212,138	✓						
Z1 area	Soil	Z1-11	30-60	12/2/2014	698,746	1,212,145	✓						
Z1 area	Soil	Z1-11A	60-90	12/3/2014	698,779	1,212,141	✓						
Z1 area	Soil	Z1-11B	60-90	12/3/2014	698,735	1,212,156	✓						
Z1 area	Soil	Z1-11C	60-90	12/3/2014	698,705	1,212,138	✓						
Z1 area	Soil	Z1-11	60-90	12/3/2014	698,746	1,212,145	✓						
Z1 area	Soil	Z1-12A	0-30	4/14/2015	699,531	1,212,397	✓						
Z1 area	Soil	Z1-12B	0-30	4/14/2015	699,527	1,212,209	✓						
Z1 area	Soil	Z1-12C	0-30	4/14/2015	699,554	1,212,090	✓						
Z1 area	Soil	Z1-12	0-30	4/14/2015	699,539	1,212,235	✓						
Z1 area	Soil	Z1-12A	30-60	4/13/2015	699,531	1,212,397	✓						
Z1 area	Soil	Z1-12B	30-60	4/13/2015	699,527	1,212,209	✓						
Z1 area	Soil	Z1-12C	30-60	4/13/2015	699,554	1,212,090	✓						
Z1 area	Soil	Z1-12	30-60	4/13/2015	699,539	1,212,235	✓						
Z1 area	Soil	Z1-13A	0-30	12/4/2014	698,598	1,212,107	✓						
Z1 area	Soil	Z1-13B	0-30	12/4/2014	698,632	1,212,135	✓						
Z1 area	Soil	Z1-13C	0-30	12/4/2014	698,671	1,212,146	✓						
Z1 area	Soil	Z1-13	0-30	12/4/2014	698,632	1,212,129	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-13A	30-60	12/4/2014	698,598	1,212,107	✓						
Z1 area	Soil	Z1-13B	30-60	12/4/2014	698,632	1,212,135	✓						
Z1 area	Soil	Z1-13C	30-60	12/4/2014	698,671	1,212,146	✓						
Z1 area	Soil	Z1-13	30-60	12/4/2014	698,632	1,212,129	✓						
Z1 area	Soil	Z1-13A	60-90	12/4/2014	698,598	1,212,107	✓						
Z1 area	Soil	Z1-13B	60-90	12/4/2014	698,632	1,212,135	✓						
Z1 area	Soil	Z1-13C	60-90	12/4/2014	698,671	1,212,146	✓						
Z1 area	Soil	Z1-13	60-90	12/4/2014	698,632	1,212,129	✓						
Z1 area	Soil	Z1-16A	0-30	4/10/2015	698,982	1,212,095	✓						
Z1 area	Soil	Z1-16B	0-30	4/10/2015	699,088	1,212,076	✓						
Z1 area	Soil	Z1-16C	0-30	4/10/2015	699,162	1,212,101	✓						
Z1 area	Soil	Z1-16	0-30	4/10/2015	699,071	1,212,091	✓						
Z1 area	Soil	Z1-16A	30-60	4/10/2015	698,982	1,212,095	✓						
Z1 area	Soil	Z1-16B	30-60	4/10/2015	699,088	1,212,076	✓						
Z1 area	Soil	Z1-16C	30-60	4/10/2015	699,162	1,212,101	✓						
Z1 area	Soil	Z1-16	30-60	4/10/2015	699,071	1,212,091	✓	✓	✓	✓	✓	✓	
Z1 area	Soil	Z1-16A	60-90	4/10/2015	698,982	1,212,095	✓						
Z1 area	Soil	Z1-16B	60-90	4/10/2015	699,088	1,212,076	✓						
Z1 area	Soil	Z1-16C	60-90	4/10/2015	699,162	1,212,101	✓						
Z1 area	Soil	Z1-16	60-90	4/10/2015	699,071	1,212,091	✓						
Z1 area	Soil	Z1-16A	120-150	4/10/2015	698,982	1,212,095	✓						
Z1 area	Soil	Z1-16B	120-150	4/10/2015	699,088	1,212,076	✓						
Z1 area	Soil	Z1-16C	120-150	4/10/2015	699,162	1,212,101	✓						
Z1 area	Soil	Z1-16	120-150	4/10/2015	699,071	1,212,091	✓						
Z1 area	Soil	Z1-16A	180-210	4/9/2015	698,982	1,212,095	✓						
Z1 area	Soil	Z1-16B	180-210	4/9/2015	699,088	1,212,076	✓						
Z1 area	Soil	Z1-16C	180-210	4/9/2015	699,162	1,212,101	✓						
Z1 area	Soil	Z1-16	180-210	4/9/2015	699,071	1,212,091	✓						

Table A3 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 area	Soil	Z1-17	0-30	4/13/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	60-90	4/11/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	120-150	4/13/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	180-210	4/13/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	240-270	4/14/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	300-330	4/13/2015	699,081	1,212,453	✓						
Z1 area	Soil	Z1-17	360-390	4/13/2015	699,081	1,212,453	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A4 Site locations for soil samples collected and analyzed, ZT Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 taxiway area	Soil	ZT-01A	0-30	4/11/2015	699,103	1,212,653	✓						
Z1 taxiway area	Soil	ZT-01B	0-30	4/11/2015	699,154	1,212,601	✓						
Z1 taxiway area	Soil	ZT-01C	0-30	4/11/2015	699,215	1,212,642	✓						
Z1 taxiway area	Soil	ZT-01	0-30	4/11/2015	699,171	1,212,637	✓						
Z1 taxiway area	Soil	ZT-01A	30-60	4/11/2015	699,103	1,212,653	✓						
Z1 taxiway area	Soil	ZT-01B	30-60	4/11/2015	699,154	1,212,601	✓						
Z1 taxiway area	Soil	ZT-01C	30-60	4/11/2015	699,215	1,212,642	✓						
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	699,171	1,212,637	✓	✓	✓	✓	✓	✓	
Z1 taxiway area	Soil	ZT-01A	60-90	4/11/2015	699,103	1,212,653	✓						
Z1 taxiway area	Soil	ZT-01B	60-90	4/11/2015	699,154	1,212,601	✓						
Z1 taxiway area	Soil	ZT-01C	60-90	4/11/2015	699,215	1,212,642	✓						
Z1 taxiway area	Soil	ZT-01	60-90	4/11/2015	699,171	1,212,637	✓						
Z1 taxiway area	Soil	ZT-01A	120-150	4/11/2015	699,103	1,212,653	✓						
Z1 taxiway area	Soil	ZT-01B	120-150	4/11/2015	699,154	1,212,601	✓						
Z1 taxiway area	Soil	ZT-01C	120-150	4/11/2015	699,215	1,212,642	✓						
Z1 taxiway area	Soil	ZT-01	120-150	4/11/2015	699,171	1,212,637	✓						
Z1 taxiway area	Soil	ZT-02A	0-30	12/1/2014	698,891	1,213,066	✓						
Z1 taxiway area	Soil	ZT-02B	0-30	12/1/2014	698,927	1,212,844	✓						
Z1 taxiway area	Soil	ZT-02C	0-30	12/1/2014	699,019	1,212,816	✓						
Z1 taxiway area	Soil	ZT-02	0-30	12/1/2014	698,943	1,212,895	✓						
Z1 taxiway area	Soil	ZT-02A	30-60	12/2/2014	698,891	1,213,066	✓						
Z1 taxiway area	Soil	ZT-02B	30-60	12/2/2014	698,927	1,212,844	✓						
Z1 taxiway area	Soil	ZT-02C	30-60	12/2/2014	699,019	1,212,816	✓						
Z1 taxiway area	Soil	ZT-02	30-60	12/2/2014	698,943	1,212,895	✓						
Z1 taxiway area	Soil	ZT-02A	60-90	12/2/2014	698,891	1,213,066	✓						
Z1 taxiway area	Soil	ZT-02B	60-90	12/2/2014	698,927	1,212,844	✓						
Z1 taxiway area	Soil	ZT-02C	60-90	12/2/2014	699,019	1,212,816	✓						
Z1 taxiway area	Soil	ZT-02	60-90	12/2/2014	698,943	1,212,895	✓						

Table A4 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 taxiway area	Soil	ZT-04A	0-30	12/2/2014	698,751	1,212,858	✓						
Z1 taxiway area	Soil	ZT-04B	0-30	12/2/2014	698,789	1,212,894	✓						
Z1 taxiway area	Soil	ZT-04C	0-30	12/2/2014	698,825	1,212,857	✓						
Z1 taxiway area	Soil	ZT-04	0-30	12/2/2014	698,785	1,212,869	✓						
Z1 taxiway area	Soil	ZT-04A	30-60	12/3/2014	698,751	1,212,858	✓						
Z1 taxiway area	Soil	ZT-04B	30-60	12/3/2014	698,789	1,212,894	✓						
Z1 taxiway area	Soil	ZT-04C	30-60	12/3/2014	698,825	1,212,857	✓						
Z1 taxiway area	Soil	ZT-04	30-60	12/3/2014	698,785	1,212,869	✓						
Z1 taxiway area	Soil	ZT-04A	60-90	12/4/2014	698,751	1,212,858	✓						
Z1 taxiway area	Soil	ZT-04B	60-90	12/4/2014	698,789	1,212,894	✓						
Z1 taxiway area	Soil	ZT-04C	60-90	12/4/2014	698,825	1,212,857	✓						
Z1 taxiway area	Soil	ZT-04	60-90	12/4/2014	698,785	1,212,869	✓						
Z1 taxiway area	Soil	ZT-05A	0-30	12/2/2014	699,252	1,212,785	✓						
Z1 taxiway area	Soil	ZT-05B	0-30	12/2/2014	699,352	1,212,631	✓						
Z1 taxiway area	Soil	ZT-05C	0-30	12/2/2014	699,435	1,212,494	✓						
Z1 taxiway area	Soil	ZT-05	0-30	12/2/2014	699,344	1,212,640	✓						
Z1 taxiway area	Soil	ZT-05A	30-60	12/2/2014	699,252	1,212,785	✓						
Z1 taxiway area	Soil	ZT-05B	30-60	12/2/2014	699,352	1,212,631	✓						
Z1 taxiway area	Soil	ZT-05C	30-60	12/2/2014	699,435	1,212,494	✓						
Z1 taxiway area	Soil	ZT-05	30-60	12/2/2014	699,344	1,212,640	✓						
Z1 taxiway area	Soil	ZT-05A	60-90	12/4/2014	699,252	1,212,785	✓						
Z1 taxiway area	Soil	ZT-05B	60-90	12/4/2014	699,352	1,212,631	✓						
Z1 taxiway area	Soil	ZT-05C	60-90	12/4/2014	699,435	1,212,494	✓						
Z1 taxiway area	Soil	ZT-05	60-90	12/4/2014	699,344	1,212,640	✓						
Z1 taxiway area	Soil	ZT-06A	0-30	12/4/2014	699,166	1,212,919	✓						
Z1 taxiway area	Soil	ZT-06B	0-30	12/4/2014	699,058	1,213,061	✓						
Z1 taxiway area	Soil	ZT-06C	0-30	12/4/2014	698,960	1,213,194	✓						
Z1 taxiway area	Soil	ZT-06	0-30	12/4/2014	699,077	1,213,038	✓						

Table A4 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Z1 taxiway area	Soil	ZT-06A	30-60	12/4/2014	699,166	1,212,919	✓						
Z1 taxiway area	Soil	ZT-06B	30-60	12/4/2014	699,058	1,213,061	✓						
Z1 taxiway area	Soil	ZT-06C	30-60	12/4/2014	698,960	1,213,194	✓						
Z1 taxiway area	Soil	ZT-06	30-60	12/4/2014	699,077	1,213,038	✓						
Z1 taxiway area	Soil	ZT-06A	60-90	12/4/2014	699,166	1,212,919	✓						
Z1 taxiway area	Soil	ZT-06B	60-90	12/4/2014	699,058	1,213,061	✓						
Z1 taxiway area	Soil	ZT-06C	60-90	12/4/2014	698,960	1,213,194	✓						
Z1 taxiway area	Soil	ZT-06	60-90	12/4/2014	699,077	1,213,038	✓						
Z1 taxiway area	Soil	ZT-07A	0-30	4/13/2015	698,913	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07B	0-30	4/13/2015	698,988	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07C	0-30	4/13/2015	699,053	1,212,577	✓						
Z1 taxiway area	Soil	ZT-07	0-30	4/13/2015	698,977	1,212,572	✓						
Z1 taxiway area	Soil	ZT-07A	30-60	4/13/2015	698,913	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07B	30-60	4/13/2015	698,988	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07C	30-60	4/13/2015	699,053	1,212,577	✓						
Z1 taxiway area	Soil	ZT-07	30-60	4/13/2015	698,977	1,212,572	✓						
Z1 taxiway area	Soil	ZT-07A	60-90	4/10/2015	698,913	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07B	60-90	4/10/2015	698,988	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07C	60-90	4/10/2015	699,053	1,212,577	✓						
Z1 taxiway area	Soil	ZT-07	60-90	4/10/2015	698,977	1,212,572	✓						
Z1 taxiway area	Soil	ZT-07A	120-150	4/10/2015	698,913	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07B	120-150	4/10/2015	698,988	1,212,570	✓						
Z1 taxiway area	Soil	ZT-07C	120-150	4/10/2015	699,053	1,212,577	✓						
Z1 taxiway area	Soil	ZT-07	120-150	4/10/2015	698,977	1,212,572	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

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Table A5 Site locations for sediment samples collected and analyzed, Northeast Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Soil	NE-01A	0-30	4/10/2015	700,353	1,214,069	✓						
Northeast area	Soil	NE-01B	0-30	4/10/2015	700,385	1,214,216	✓						
Northeast area	Soil	NE-01C	0-30	4/10/2015	700,504	1,214,094	✓						
Northeast area	Soil	NE-01	0-30	4/10/2015	700,421	1,214,125	✓						✓
Northeast area	Soil	NE-01A	30-60	4/9/2015	700,353	1,214,069	✓						
Northeast area	Soil	NE-01B	30-60	4/9/2015	700,385	1,214,216	✓						
Northeast area	Soil	NE-01C	30-60	4/9/2015	700,504	1,214,094	✓						
Northeast area	Soil	NE-01	30-60	4/9/2015	700,421	1,214,125	✓						
Northeast area	Soil	NE-02A	0-30	11/29/2014	700,735	1,214,257	✓						
Northeast area	Soil	NE-02B	0-30	11/29/2014	700,900	1,214,082	✓						
Northeast area	Soil	NE-02C	0-30	11/29/2014	700,676	1,214,084	✓						
Northeast area	Soil	NE-02	0-30	11/29/2014	700,762	1,214,160	✓						
Northeast area	Soil	NE-02A	30-60	12/1/2014	700,735	1,214,257	✓						
Northeast area	Soil	NE-02B	30-60	12/1/2014	700,900	1,214,082	✓						
Northeast area	Soil	NE-02C	30-60	12/1/2014	700,676	1,214,084	✓						
Northeast area	Soil	NE-02	30-60	12/1/2014	700,762	1,214,160	✓						
Northeast area	Soil	NE-03A	0-30	4/11/2015	700,425	1,213,964	✓						
Northeast area	Soil	NE-03B	0-30	4/11/2015	700,462	1,213,819	✓						
Northeast area	Soil	NE-03C	0-30	4/11/2015	700,551	1,213,730	✓						
Northeast area	Soil	NE-03	0-30	4/11/2015	700,473	1,213,831	✓	✓	✓	✓	✓	✓	
Northeast area	Soil	NE-03A	30-60	4/11/2015	700,425	1,213,964	✓						
Northeast area	Soil	NE-03B	30-60	4/11/2015	700,462	1,213,819	✓						
Northeast area	Soil	NE-03C	30-60	4/11/2015	700,551	1,213,730	✓						
Northeast area	Soil	NE-03	30-60	4/11/2015	700,473	1,213,831	✓						
Northeast area	Soil	NE-04A	0-30	4/11/2015	700,941	1,213,895	✓						
Northeast area	Soil	NE-04B	0-30	4/11/2015	700,802	1,213,891	✓						
Northeast area	Soil	NE-04C	0-30	4/11/2015	700,682	1,213,851	✓						
Northeast area	Soil	NE-04	0-30	4/11/2015	700,799	1,213,875	✓						

Table A5 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Soil	NE-04A	30-60	4/13/2015	700,941	1,213,895	✓						
Northeast area	Soil	NE-04B	30-60	4/13/2015	700,802	1,213,891	✓						
Northeast area	Soil	NE-04C	30-60	4/13/2015	700,682	1,213,851	✓						
Northeast area	Soil	NE-04	30-60	4/13/2015	700,799	1,213,875	✓						
Northeast area	Soil	NE-05A	0-30	12/4/2014	700,469	1,213,397	✓						
Northeast area	Soil	NE-05B	0-30	12/4/2014	700,535	1,213,464	✓						
Northeast area	Soil	NE-05C	0-30	12/4/2014	700,573	1,213,523	✓						
Northeast area	Soil	NE-05	0-30	12/4/2014	700,525	1,213,461	✓						
Northeast area	Soil	NE-05A	30-60	12/4/2014	700,469	1,213,397	✓						
Northeast area	Soil	NE-05B	30-60	12/4/2014	700,535	1,213,464	✓						
Northeast area	Soil	NE-05C	30-60	12/4/2014	700,573	1,213,523	✓						
Northeast area	Soil	NE-05	30-60	12/4/2014	700,525	1,213,461	✓						
Northeast area	Sediment	NE-06A	0-15	4/13/2015	700,187	1,214,393	✓						
Northeast area	Sediment	NE-06B	0-15	4/13/2015	700,182	1,214,381	✓						
Northeast area	Sediment	NE-06C	0-15	4/13/2015	700,178	1,214,370	✓						
Northeast area	Sediment	NE-06	0-15	4/13/2015	700,183	1,214,383	✓						
Northeast area	Sediment	NE-06A	15-30	4/9/2015	700,187	1,214,393	✓						
Northeast area	Sediment	NE-06B	15-30	4/9/2015	700,182	1,214,381	✓						
Northeast area	Sediment	NE-06C	15-30	4/9/2015	700,178	1,214,370	✓						
Northeast area	Sediment	NE-06	15-30	4/9/2015	700,183	1,214,383	✓						
Northeast area	Sediment	NE-06A	30-45	4/10/2015	700,187	1,214,393	✓						
Northeast area	Sediment	NE-06B	30-45	4/10/2015	700,182	1,214,381	✓						
Northeast area	Sediment	NE-06C	30-45	4/10/2015	700,178	1,214,370	✓						
Northeast area	Sediment	NE-06	30-45	4/10/2015	700,183	1,214,383	✓						
Northeast area	Sediment	NE-07A	0-15	4/9/2015	700,395	1,214,352	✓						
Northeast area	Sediment	NE-07B	0-15	4/9/2015	700,402	1,214,332	✓						
Northeast area	Sediment	NE-07C	0-15	4/9/2015	700,406	1,214,311	✓						
Northeast area	Sediment	NE-07	0-15	4/9/2015	700,401	1,214,332	✓						

Table A5 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Sediment	NE-07A	15-30	4/9/2015	700,395	1,214,352	✓						
Northeast area	Sediment	NE-07B	15-30	4/9/2015	700,402	1,214,332	✓						
Northeast area	Sediment	NE-07C	15-30	4/9/2015	700,406	1,214,311	✓						
Northeast area	Sediment	NE-07	15-30	4/9/2015	700,401	1,214,332	✓						
Northeast area	Sediment	NE-07A	30-45	4/9/2015	700,395	1,214,352	✓						
Northeast area	Sediment	NE-07B	30-45	4/9/2015	700,402	1,214,332	✓						
Northeast area	Sediment	NE-07C	30-45	4/9/2015	700,406	1,214,311	✓						
Northeast area	Sediment	NE-07	30-45	4/9/2015	700,401	1,214,332	✓						
Northeast area	Sediment	NE-08A	0-15	4/7/2015	701,004	1,213,820	✓						
Northeast area	Sediment	NE-08B	0-15	4/7/2015	700,956	1,213,719	✓						
Northeast area	Sediment	NE-08C	0-15	4/7/2015	700,823	1,213,708	✓						
Northeast area	Sediment	NE-08	0-15	4/7/2015	700,909	1,213,730	✓						
Northeast area	Sediment	NE-08A	15-30	4/7/2015	701,004	1,213,820	✓						
Northeast area	Sediment	NE-08B	15-30	4/7/2015	700,956	1,213,719	✓						
Northeast area	Sediment	NE-08C	15-30	4/7/2015	700,823	1,213,708	✓						
Northeast area	Sediment	NE-08	15-30	4/7/2015	700,909	1,213,730	✓						
Northeast area	Sediment	NE-08A	30-45	4/7/2015	701,004	1,213,820	✓						
Northeast area	Sediment	NE-08B	30-45	4/7/2015	700,956	1,213,719	✓						
Northeast area	Sediment	NE-08C	30-45	4/7/2015	700,823	1,213,708	✓						
Northeast area	Sediment	NE-08	30-45	4/7/2015	700,909	1,213,730	✓						
Northeast area	Sediment	NE-09A	0-15	3/25/2015	700,332	1,213,662	✓						
Northeast area	Sediment	NE-09B	0-15	3/25/2015	700,332	1,213,627	✓						
Northeast area	Sediment	NE-09C	0-15	3/25/2015	700,442	1,213,636	✓						
Northeast area	Sediment	NE-09	0-15	3/25/2015	700,356	1,213,644	✓						
Northeast area	Sediment	NE-09A	15-30	3/24/2015	700,332	1,213,662	✓						
Northeast area	Sediment	NE-09B	15-30	3/24/2015	700,332	1,213,627	✓						
Northeast area	Sediment	NE-09C	15-30	3/24/2015	700,442	1,213,636	✓						
Northeast area	Sediment	NE-09	15-30	3/24/2015	700,356	1,213,644	✓						

Table A5 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Sediment	NE-09A	30-45	3/23/2015	700,332	1,213,662	✓						
Northeast area	Sediment	NE-09B	30-45	3/23/2015	700,332	1,213,627	✓						
Northeast area	Sediment	NE-09C	30-45	3/23/2015	700,442	1,213,636	✓						
Northeast area	Sediment	NE-09	30-45	3/23/2015	700,356	1,213,644	✓						
Northeast area	Sediment	NE-10A	0-15	4/10/2015	700,390	1,213,477	✓						
Northeast area	Sediment	NE-10B	0-15	4/10/2015	700,373	1,213,432	✓						
Northeast area	Sediment	NE-10C	0-15	4/10/2015	700,363	1,213,391	✓						
Northeast area	Sediment	NE-10	0-15	4/10/2015	700,378	1,213,442	✓						
Northeast area	Sediment	NE-10A	15-30	4/8/2015	700,390	1,213,477	✓						
Northeast area	Sediment	NE-10B	15-30	4/8/2015	700,373	1,213,432	✓						
Northeast area	Sediment	NE-10C	15-30	4/8/2015	700,363	1,213,391	✓						
Northeast area	Sediment	NE-10	15-30	4/8/2015	700,378	1,213,442	✓						
Northeast area	Sediment	NE-10A	30-45	4/10/2015	700,390	1,213,477	✓						
Northeast area	Sediment	NE-10B	30-45	4/10/2015	700,373	1,213,432	✓						
Northeast area	Sediment	NE-10C	30-45	4/10/2015	700,363	1,213,391	✓						
Northeast area	Sediment	NE-10	30-45	4/10/2015	700,378	1,213,442	✓						
Northeast area	Sediment	NE-11A	0-15	4/4/2015	700,293	1,213,571	✓						
Northeast area	Sediment	NE-11B	0-15	4/4/2015	700,340	1,213,547	✓						
Northeast area	Sediment	NE-11C	0-15	4/4/2015	700,351	1,213,514	✓						
Northeast area	Sediment	NE-11	0-15	4/4/2015	700,321	1,213,548	✓						
Northeast area	Sediment	NE-11A	15-30	4/4/2015	700,293	1,213,571	✓						
Northeast area	Sediment	NE-11B	15-30	4/4/2015	700,340	1,213,547	✓						
Northeast area	Sediment	NE-11C	15-30	4/4/2015	700,351	1,213,514	✓						
Northeast area	Sediment	NE-11	15-30	4/4/2015	700,321	1,213,548	✓						
Northeast area	Sediment	NE-11A	30-45	4/4/2015	700,293	1,213,571	✓						
Northeast area	Sediment	NE-11B	30-45	4/4/2015	700,340	1,213,547	✓						
Northeast area	Sediment	NE-11C	30-45	4/4/2015	700,351	1,213,514	✓						
Northeast area	Sediment	NE-11	30-45	4/4/2015	700,321	1,213,548	✓						

Table A5 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Sediment	NE-12A	0-15	4/3/2015	700,553	1,213,590	✓						
Northeast area	Sediment	NE-12B	0-15	4/3/2015	700,505	1,213,594	✓						
Northeast area	Sediment	NE-12C	0-15	4/3/2015	700,502	1,213,571	✓						
Northeast area	Sediment	NE-12	0-15	4/3/2015	700,511	1,213,584	✓						
Northeast area	Sediment	NE-12A	15-30	4/9/2015	700,553	1,213,590	✓						
Northeast area	Sediment	NE-12B	15-30	4/9/2015	700,505	1,213,594	✓						
Northeast area	Sediment	NE-12C	15-30	4/9/2015	700,502	1,213,571	✓						
Northeast area	Sediment	NE-12	15-30	4/9/2015	700,511	1,213,584	✓						
Northeast area	Sediment	NE-12A	30-45	4/9/2015	700,553	1,213,590	✓						
Northeast area	Sediment	NE-12B	30-45	4/9/2015	700,505	1,213,594	✓						
Northeast area	Sediment	NE-12C	30-45	4/9/2015	700,502	1,213,571	✓						
Northeast area	Sediment	NE-12	30-45	4/9/2015	700,511	1,213,584	✓						
Northeast area	Sediment	NE-13A	0-15	4/9/2015	700,658	1,213,630	✓						
Northeast area	Sediment	NE-13B	0-15	4/9/2015	700,616	1,213,591	✓						
Northeast area	Sediment	NE-13C	0-15	4/9/2015	700,721	1,213,598	✓						
Northeast area	Sediment	NE-13	0-15	4/9/2015	700,661	1,213,610	✓						
Northeast area	Sediment	NE-13A	15-30	4/9/2015	700,658	1,213,630	✓						
Northeast area	Sediment	NE-13B	15-30	4/9/2015	700,616	1,213,591	✓						
Northeast area	Sediment	NE-13C	15-30	4/9/2015	700,721	1,213,598	✓						
Northeast area	Sediment	NE-13	15-30	4/9/2015	700,661	1,213,610	✓						
Northeast area	Sediment	NE-13A	30-45	4/6/2015	700,658	1,213,630	✓						
Northeast area	Sediment	NE-13B	30-45	4/6/2015	700,616	1,213,591	✓						
Northeast area	Sediment	NE-13C	30-45	4/6/2015	700,721	1,213,598	✓						
Northeast area	Sediment	NE-13	30-45	4/6/2015	700,661	1,213,610	✓						
Northeast area	Sediment	NE-14A	0-15	4/1/2015	700,787	1,213,569	✓						
Northeast area	Sediment	NE-14B	0-15	4/1/2015	700,795	1,213,545	✓						
Northeast area	Sediment	NE-14C	0-15	4/1/2015	700,808	1,213,516	✓						
Northeast area	Sediment	NE-14	0-15	4/1/2015	700,798	1,213,540	✓						

Table A5 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northeast area	Sediment	NE-14A	15-30	4/1/2015	700,787	1,213,569	✓						
Northeast area	Sediment	NE-14B	15-30	4/1/2015	700,795	1,213,545	✓						
Northeast area	Sediment	NE-14C	15-30	4/1/2015	700,808	1,213,516	✓						
Northeast area	Sediment	NE-14	15-30	4/1/2015	700,798	1,213,540	✓						
Northeast area	Sediment	NE-14A	30-45	4/3/2015	700,787	1,213,569	✓						
Northeast area	Sediment	NE-14B	30-45	4/3/2015	700,795	1,213,545	✓						
Northeast area	Sediment	NE-14C	30-45	4/3/2015	700,808	1,213,516	✓						
Northeast area	Sediment	NE-14	30-45	4/3/2015	700,798	1,213,540	✓						
Northeast area	Sediment	NE-15A	0-15	3/23/2015	700,450	1,213,719	✓						
Northeast area	Sediment	NE-15B	0-15	3/23/2015	700,447	1,213,688	✓						
Northeast area	Sediment	NE-15C	0-15	3/23/2015	700,436	1,213,664	✓						
Northeast area	Sediment	NE-15	0-15	3/23/2015	700,445	1,213,692	✓						
Northeast area	Sediment	NE-15A	15-30	3/21/2015	700,450	1,213,719	✓						
Northeast area	Sediment	NE-15B	15-30	3/21/2015	700,447	1,213,688	✓						
Northeast area	Sediment	NE-15C	15-30	3/21/2015	700,436	1,213,664	✓						
Northeast area	Sediment	NE-15	15-30	3/21/2015	700,445	1,213,692	✓						✓
Northeast area	Sediment	NE-15A	30-45	3/21/2015	700,450	1,213,719	✓						
Northeast area	Sediment	NE-15B	30-45	3/21/2015	700,447	1,213,688	✓						
Northeast area	Sediment	NE-15C	30-45	3/21/2015	700,436	1,213,664	✓						
Northeast area	Sediment	NE-15	30-45	3/21/2015	700,445	1,213,692	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A6 Site locations for soil samples collected and analyzed, North Forest Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
North forest area	Soil	NF-01A	0-30	11/28/2014	698,782	1,214,355	✓						
North forest area	Soil	NF-01B	0-30	11/28/2014	698,592	1,214,358	✓						
North forest area	Soil	NF-01C	0-30	11/28/2014	698,377	1,214,332	✓						
North forest area	Soil	NF-01	0-30	11/28/2014	698,564	1,214,347	✓						
North forest area	Soil	NF-01A	30-60	11/28/2014	698,782	1,214,355	✓						
North forest area	Soil	NF-01B	30-60	11/28/2014	698,592	1,214,358	✓						
North forest area	Soil	NF-01C	30-60	11/28/2014	698,377	1,214,332	✓						
North forest area	Soil	NF-01	30-60	11/28/2014	698,564	1,214,347	✓						
North forest area	Soil	NF-02A	0-30	11/27/2014	698,930	1,214,335	✓						
North forest area	Soil	NF-02B	0-30	11/27/2014	699,041	1,214,319	✓						
North forest area	Soil	NF-02C	0-30	11/27/2014	699,206	1,214,335	✓						
North forest area	Soil	NF-02	0-30	11/27/2014	699,082	1,214,331	✓						
North forest area	Soil	NF-02A	30-60	11/27/2014	698,930	1,214,335	✓						
North forest area	Soil	NF-02B	30-60	11/27/2014	699,041	1,214,319	✓						
North forest area	Soil	NF-02C	30-60	11/27/2014	699,206	1,214,335	✓						
North forest area	Soil	NF-02	30-60	11/27/2014	699,082	1,214,331	✓						
North forest area	Soil	NF-03A	0-30	11/28/2014	699,364	1,214,316	✓						
North forest area	Soil	NF-03B	0-30	11/28/2014	699,517	1,214,326	✓						
North forest area	Soil	NF-03C	0-30	11/28/2014	699,643	1,214,353	✓						
North forest area	Soil	NF-03	0-30	11/28/2014	699,522	1,214,333	✓						
North forest area	Soil	NF-03A	30-60	11/28/2014	699,364	1,214,316	✓						
North forest area	Soil	NF-03B	30-60	11/28/2014	699,517	1,214,326	✓						
North forest area	Soil	NF-03C	30-60	11/28/2014	699,643	1,214,353	✓						
North forest area	Soil	NF-03	30-60	11/28/2014	699,522	1,214,333	✓						
North forest area	Soil	NF-04A	0-30	12/1/2014	699,760	1,214,371	✓						
North forest area	Soil	NF-04B	0-30	12/1/2014	699,886	1,214,337	✓						
North forest area	Soil	NF-04C	0-30	12/1/2014	700,055	1,214,347	✓						
North forest area	Soil	NF-04	0-30	12/1/2014	699,904	1,214,351	✓						

Table A6 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
North forest area	Soil	NF-04A	30-60	12/1/2014	699,760	1,214,371	✓						
North forest area	Soil	NF-04B	30-60	12/1/2014	699,886	1,214,337	✓						
North forest area	Soil	NF-04C	30-60	12/1/2014	700,055	1,214,347	✓						
North forest area	Soil	NF-04	30-60	12/1/2014	699,904	1,214,351	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A7 Site locations for soil and sediment samples collected and analyzed, Northwest Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northwest area	Sediment	NW-01A	0-15	4/13/2015	697,077	1,214,239	✓						
Northwest area	Sediment	NW-01B	0-15	4/13/2015	697,045	1,214,237	✓						
Northwest area	Sediment	NW-01C	0-15	4/13/2015	697,009	1,214,240	✓						
Northwest area	Sediment	NW-01	0-15	4/13/2015	697,040	1,214,239	✓						
Northwest area	Sediment	NW-01A	15-30	4/13/2015	697,077	1,214,239	✓						
Northwest area	Sediment	NW-01B	15-30	4/13/2015	697,045	1,214,237	✓						
Northwest area	Sediment	NW-01C	15-30	4/13/2015	697,009	1,214,240	✓						
Northwest area	Sediment	NW-01	15-30	4/13/2015	697,040	1,214,239	✓						
Northwest area	Sediment	NW-01A	30-45	4/13/2015	697,077	1,214,239	✓						
Northwest area	Sediment	NW-01B	30-45	4/13/2015	697,045	1,214,237	✓						
Northwest area	Sediment	NW-01C	30-45	4/13/2015	697,009	1,214,240	✓						
Northwest area	Sediment	NW-01	30-45	4/13/2015	697,040	1,214,239	✓						
Northwest area	Sediment	NW-02A	0-15	4/13/2015	697,370	1,214,289	✓						
Northwest area	Sediment	NW-02B	0-15	4/13/2015	697,396	1,214,263	✓						
Northwest area	Sediment	NW-02C	0-15	4/13/2015	697,424	1,214,240	✓						
Northwest area	Sediment	NW-02	0-15	4/13/2015	697,398	1,214,262	✓						
Northwest area	Sediment	NW-02A	15-30	4/13/2015	697,370	1,214,289	✓						
Northwest area	Sediment	NW-02B	15-30	4/13/2015	697,396	1,214,263	✓						
Northwest area	Sediment	NW-02C	15-30	4/13/2015	697,424	1,214,240	✓						
Northwest area	Sediment	NW-02	15-30	4/13/2015	697,398	1,214,262	✓						
Northwest area	Sediment	NW-02A	30-45	4/13/2015	697,370	1,214,289	✓						
Northwest area	Sediment	NW-02B	30-45	4/13/2015	697,396	1,214,263	✓						
Northwest area	Sediment	NW-02C	30-45	4/13/2015	697,424	1,214,240	✓						
Northwest area	Sediment	NW-02	30-45	4/13/2015	697,398	1,214,262	✓						
Northwest area	Sediment	NW-03A	0-15	4/11/2015	698,061	1,214,485	✓						
Northwest area	Sediment	NW-03B	0-15	4/11/2015	698,025	1,214,484	✓						
Northwest area	Sediment	NW-03C	0-15	4/11/2015	697,972	1,214,475	✓						
Northwest area	Sediment	NW-03	0-15	4/11/2015	698,003	1,214,479	✓						

Table A7 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Northwest area	Sediment	NW-03A	15-30	4/11/2015	698,061	1,214,485	✓						
Northwest area	Sediment	NW-03B	15-30	4/11/2015	698,025	1,214,484	✓						
Northwest area	Sediment	NW-03C	15-30	4/11/2015	697,972	1,214,475	✓						
Northwest area	Sediment	NW-03	15-30	4/11/2015	698,003	1,214,479	✓						
Northwest area	Sediment	NW-03A	30-45	4/9/2015	698,061	1,214,485	✓						
Northwest area	Sediment	NW-03B	30-45	4/9/2015	698,025	1,214,484	✓						
Northwest area	Sediment	NW-03C	30-45	4/9/2015	697,972	1,214,475	✓						
Northwest area	Sediment	NW-03	30-45	4/9/2015	698,003	1,214,479	✓						
Northwest area	Sediment	NW-04A	0-15	4/11/2015	697,277	1,214,316	✓						
Northwest area	Sediment	NW-04B	0-15	4/11/2015	697,263	1,214,342	✓						
Northwest area	Sediment	NW-04C	0-15	4/11/2015	697,253	1,214,362	✓						
Northwest area	Sediment	NW-04	0-15	4/11/2015	697,268	1,214,333	✓						
Northwest area	Sediment	NW-04A	15-30	4/11/2015	697,277	1,214,316	✓						
Northwest area	Sediment	NW-04B	15-30	4/11/2015	697,263	1,214,342	✓						
Northwest area	Sediment	NW-04C	15-30	4/11/2015	697,253	1,214,362	✓						
Northwest area	Sediment	NW-04	15-30	4/11/2015	697,268	1,214,333	✓						
Northwest area	Sediment	NW-04A	30-45	4/10/2015	697,277	1,214,316	✓						
Northwest area	Sediment	NW-04B	30-45	4/10/2015	697,263	1,214,342	✓						
Northwest area	Sediment	NW-04C	30-45	4/10/2015	697,253	1,214,362	✓						
Northwest area	Sediment	NW-04	30-45	4/10/2015	697,268	1,214,333	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A8 Site locations for soil samples collected and analyzed, Southeast Area, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Southeast area	Soil	SE-01A	0-30	4/11/2015	700,155	1,212,975	✓						
Southeast area	Soil	SE-01B	0-30	4/11/2015	700,049	1,212,973	✓						
Southeast area	Soil	SE-01C	0-30	4/11/2015	699,942	1,212,953	✓						
Southeast area	Soil	SE-01	0-30	4/11/2015	700,045	1,212,966	✓						
Southeast area	Soil	SE-01A	30-60	4/11/2015	700,155	1,212,975	✓						
Southeast area	Soil	SE-01B	30-60	4/11/2015	700,049	1,212,973	✓						
Southeast area	Soil	SE-01C	30-60	4/11/2015	699,942	1,212,953	✓						
Southeast area	Soil	SE-01	30-60	4/11/2015	700,045	1,212,966	✓						
Southeast area	Soil	SE-02A	0-30	4/10/2015	699,987	1,212,632	✓						
Southeast area	Soil	SE-02B	0-30	4/10/2015	699,904	1,212,454	✓						
Southeast area	Soil	SE-02C	0-30	4/10/2015	699,896	1,212,334	✓						
Southeast area	Soil	SE-02	0-30	4/10/2015	699,941	1,212,510	✓						
Southeast area	Soil	SE-02A	30-60	4/10/2015	699,987	1,212,632	✓						
Southeast area	Soil	SE-02B	30-60	4/10/2015	699,904	1,212,454	✓						
Southeast area	Soil	SE-02C	30-60	4/10/2015	699,896	1,212,334	✓						
Southeast area	Soil	SE-02	30-60	4/10/2015	699,941	1,212,510	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

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Table A9 Site locations for sediment samples collected and analyzed, Bien Hung Lake and Gate 2 Lake, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID[2]	Media	Sub-DU[1]	Depth (cm)	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	698,995	1,211,337	✓	✓	✓	✓	✓	✓	
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	698,604	1,211,834	✓	✓	✓	✓	✓	✓	
Gate 2 lake	Sediment	G2L-01A	15-30	4/13/2015	698,630	1,211,835	✓						
Gate 2 lake	Sediment	G2L-01B	15-30	4/13/2015	698,606	1,211,836	✓						
Gate 2 lake	Sediment	G2L-01C	15-30	4/13/2015	698,581	1,211,830	✓						
Gate 2 lake	Sediment	G2L-01	15-30	4/13/2015	698,604	1,211,834	✓						
Gate 2 lake	Sediment	G2L-01A	30-45	4/13/2015	698,630	1,211,835	✓						
Gate 2 lake	Sediment	G2L-01B	30-45	4/13/2015	698,606	1,211,836	✓						
Gate 2 lake	Sediment	G2L-01C	30-45	4/13/2015	698,581	1,211,830	✓						
Gate 2 lake	Sediment	G2L-01	30-45	4/13/2015	698,604	1,211,834	✓						

* ***Notes*** :

- DU: decision unit
- cm: centimeter
- ID: identification
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

[2] Gate 2 Lake and Bien Hung Lake are located outside of the Airbase.

Table A10 Site locations for biota samples collected and analyzed, Bien Hoa Airbase, Vietnam, 2014-2015

Site ID	Sub-DU	Media	Species	Tissue type	Collection date	Northing	Easting	Dioxins/Furan
Pacer Ivy area	PI-20	Fish	Tilapia	Muscle	3/18/2015	697,165	1,213,239	✓
Pacer Ivy	PI-20	Fish	Tilapia	Fat	3/18/2015	697,165	1,213,239	✓
Pacer Ivy	PI-20	Snail	Snail	Whole snail	3/18/2015	697,165	1,213,239	✓
Z1 area	Z1-09	Fish	Tilapia	Whole fish	3/19/2015	699,142	1,211,942	✓
Northeast area	NE-07	Fish	Tilapia	Fat	3/17/2015	700,401	1,214,332	✓
Northeast area	NE-08	Fish	Tilapia	Muscle	3/17/2015	700,909	1,213,730	✓
Northeast area	NE-08	Fish	Tilapia	Fat	3/17/2015	700,909	1,213,730	✓
Northeast area	NE-08	Fish	Tilapia	Eggs	3/17/2015	700,909	1,213,730	✓
Northeast area	NE-10	Fish	Tilapia	Whole fish	3/16/2015	700,378	1,213,442	✓
Northeast area	NE-12	Fish	Tilapia	Muscle	3/16/2015	700,511	1,213,584	✓
Northeast area	NE-12	Fish	Tilapia	Eggs	3/16/2015	700,511	1,213,584	✓
Northeast area	NE-15	Fish	Tilapia	Muscle	3/16/2015	700,445	1,213,692	✓
Northeast area	NE-15	Fish	Tilapia	Fat	3/16/2015	700,445	1,213,692	✓
Northwest area	NW-02	Fish	Tilapia	Muscle	3/17/2015	697,398	1,214,262	✓
Northwest area	NW-02	Fish	Tilapia	Fat	3/17/2015	697,398	1,214,262	✓
Northwest area	NW-04	Fish	Tilapia	Muscle	3/17/2015	697,268	1,214,333	✓
Northwest area	NW-04	Fish	Tilapia	Fat	3/17/2015	697,268	1,214,333	✓
Northwest area	NW-04	Fish	Tilapia	Eggs	3/17/2015	697,268	1,214,333	✓
Northwest area	NW-04	Snail	Snail	Whole snail	3/17/2015	697,268	1,214,333	✓
Bien Hung Lake	BHL-01	Fish	Tilapia	Muscle	3/26/2015	698,995	1,211,337	✓
Bien Hung Lake	BHL-01	Fish	Tilapia	Fat	3/26/2015	698,995	1,211,337	✓
Bien Hung Lake	BHL-01	Fish	Tilapia	Eggs	3/26/2015	698,995	1,211,337	✓

* ***Notes*** :

- DU: decision unit
- ID: identification

Table A11 Site locations for groundwater samples collected and analyzed, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID[1]	Type	Media	Collection date	Northing	Easting	Dioxins/Furan	VOCs	SVOCs	Herbicides	Metals	PCBs	Physical properties
MW-01	Filtered	Groundwater	4/14/2015	1,212,519	699,180	✓						
MW-01	Unfiltered	Groundwater	4/14/2015	1,212,519	699,180	✓	✓	✓	✓	✓	✓	
MW-02	Filtered	Groundwater	4/14/2015	1,212,413	698,863	✓						
MW-02	Unfiltered	Groundwater	4/14/2015	1,212,413	698,863	✓	✓	✓	✓	✓	✓	
MW-03	Filtered	Groundwater	4/15/2015	1,212,434	699,050	✓						
MW-03	Unfiltered	Groundwater	4/15/2015	1,212,434	699,050	✓	✓	✓	✓	✓	✓	
MW-04	Filtered	Groundwater	4/15/2015	1,212,324	698,968	✓						
MW-04	Unfiltered	Groundwater	4/15/2015	1,212,324	698,968	✓	✓	✓	✓	✓	✓	
MW-05	Filtered	Groundwater	4/14/2015	1,212,501	698,031	✓						
MW-05	Unfiltered	Groundwater	4/14/2015	1,212,501	698,031	✓	✓	✓	✓	✓	✓	
MW-06	Filtered	Groundwater	4/14/2015	1,213,242	697,298	✓						
MW-06	Unfiltered	Groundwater	4/14/2015	1,213,242	697,298	✓	✓	✓	✓	✓	✓	
Offsite well #1	Unfiltered	Groundwater	4/14/2015	1,212,253	697,724	✓			✓			
Offsite well #2	Unfiltered	Groundwater	4/14/2015	1,212,767	696,810	✓			✓			
Offsite well #3	Unfiltered	Groundwater	4/14/2015	1,216,673	699,829	✓			✓			
Offsite well #4	Unfiltered	Groundwater	4/14/2015	1,214,361	701,000	✓			✓			
Offsite well #5	Unfiltered	Groundwater	4/14/2015	1,212,076	700,904	✓			✓			
Offsite well #6	Unfiltered	Groundwater	4/14/2015	1,211,871	699,125	✓			✓			
Water tower	Pre-treatment	Groundwater	4/14/2015	1,212,870	698,341	✓			✓			
Water tower	Post-treatment	Groundwater	4/14/2015	1,212,870	698,341	✓	✓	✓	✓	✓	✓	

* ***Notes***:

- DU: decision unit
- #: number
- ID: identification
- MW: monitoring well
- PCBs: polychlorinated biphenyls
- SVOCs: semi-volatile organic compounds
- VOCs: volatile organic compounds

[1] MW-01 through MW-06 are existing onsite monitoring wells

Table A12 MND-approved dioxin limits, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	DU	Media	MND-Approved landuse	Dioxin limit (ppt TEQ)
Pacer Ivy area	PI-01	Soil	Industrial	1,200
Pacer Ivy area	PI-02	Soil	Industrial	1,200
Pacer Ivy area	PI-03	Soil	Industrial	1,200
Pacer Ivy area	PI-04	Soil	Industrial	1,200
Pacer Ivy area	PI-05	Soil	Industrial	1,200
Pacer Ivy area	PI-06	Soil	Industrial	1,200
Pacer Ivy area	PI-07	Soil	Industrial	1,200
Pacer Ivy area	PI-08	Soil	Industrial	1,200
Pacer Ivy area	PI-09	Soil	Industrial	1,200
Pacer Ivy area	PI-10	Soil	Urban residential	300
Pacer Ivy area	PI-11	Soil	Urban residential	300
Pacer Ivy area	PI-12	Soil	Urban residential	300
Pacer Ivy area	PI-13	Soil	Urban residential	300
Pacer Ivy area	PI-14	Soil	Urban residential	300
Pacer Ivy area	PI-15	Sediment	Sediment	150
Pacer Ivy area	PI-16	Sediment	Sediment	150
Pacer Ivy area	PI-17	Sediment	Sediment	150
Pacer Ivy area	PI-18	Sediment	Sediment	150
Pacer Ivy area	PI-19	Sediment	Sediment	150
Pacer Ivy area	PI-20	Sediment	Sediment	150
Pacer Ivy area	PI-21	Sediment	Sediment	150
Southwest area	SW-01	Soil	Urban residential	300
Southwest area	SW-02	Soil	Urban residential	300
Southwest area	SW-03	Soil	Urban residential	300
Southwest area	SW-04	Soil	Urban residential	300
Southwest area	SW-06	Soil	Urban residential	300
Southwest area	SW-07	Soil	Urban residential	300
Southwest area	SW-08	Soil	Urban residential	300
Z1 area	Z1-01-Landfill	Soil	Industrial	1,200
Z1 area	Z1-02	Soil	Urban residential	300
Z1 area	Z1-03	Soil	Urban residential	300
Z1 area	Z1-04	Soil	Industrial	1,200
Z1 area	Z1-05	Soil	Urban residential	300
Z1 area	Z1-06	Soil	Urban residential	300
Z1 area	Z1-07	Soil	Urban residential	300
Z1 area	Z1-08	Soil	Urban residential	300
Z1 area	Z1-09	Sediment	Sediment	150
Z1 area	Z1-10	Sediment	Sediment	150

Table A12 (Cont'd.)

Site ID	DU	Media	MND-Approved landuse	Dioxin limit (ppt TEQ)
Z1 area	Z1-11	Soil	Urban residential	300
Z1 area	Z1-12	Soil	Industrial	1,200
Z1 area	Z1-13	Soil	Urban residential	300
Z1 area	Z1-16	Soil	Urban residential	300
Z1 area	Z1-17	Soil	Industrial	1,200
Z1 taxiway area	ZT-01	Soil	Industrial	1,200
Z1 taxiway area	ZT-02	Soil	Industrial	1,200
Z1 taxiway area	ZT-04	Soil	Industrial	1,200
Z1 taxiway area	ZT-05	Soil	Industrial	1,200
Z1 taxiway area	ZT-06	Soil	Industrial	1,200
Z1 taxiway area	ZT-07	Soil	Industrial	1,200
Northwest area	NW-01	Sediment	Sediment	150
Northwest area	NW-02	Sediment	Sediment	150
Northwest area	NW-03	Sediment	Sediment	150
Northwest area	NW-04	Sediment	Sediment	150
North forest area	NF-01	Soil	Forest land and perennial tree land	100
North forest area	NF-02	Soil	Forest land and perennial tree land	100
North forest area	NF-03	Soil	Forest land and perennial tree land	100
North forest area	NF-04	Soil	Forest land and perennial tree land	100
Northeast area	NE-01	Soil	Industrial	1,200
Northeast area	NE-02	Soil	Industrial	1,200
Northeast area	NE-03	Soil	Industrial	1,200
Northeast area	NE-04	Soil	Industrial	1,200
Northeast area	NE-05	Soil	Industrial	1,200
Northeast area	NE-06	Sediment	Sediment	150
Northeast area	NE-07	Sediment	Sediment	150
Northeast area	NE-08	Sediment	Sediment	150
Northeast area	NE-09	Sediment	Sediment	150
Northeast area	NE-10	Sediment	Sediment	150
Northeast area	NE-11	Sediment	Sediment	150
Northeast area	NE-12	Sediment	Sediment	150
Northeast area	NE-13	Sediment	Sediment	150
Northeast area	NE-14	Sediment	Sediment	150
Northeast area	NE-15	Sediment	Sediment	150

Table A12 (Cont'd.)

Site ID	DU	Media	MND-Approved landuse	Dioxin limit (ppt TEQ)
Southeast area	SE-01	Soil	Urban residential	300
Southeast area	SE-02	Soil	Urban residential	300
Bien Hung lake	BHL-01	Sediment	Sediment	150
Gate 2 lake	G2L-01	Sediment	Sediment	150

* ***Notes*** :

- DU: decision unit
- MND: Ministry of Defense
- ID: identification
- ppt: part per trillion
- TEQ: dioxin toxicity equivalence

Table A13 Soil and sediment dioxin concentrations, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Bien Hung Lake	Sediment	BHL-01	0-15	4/14/2015	150	83.0
Gate 2 Lake	Sediment	G2L-01	0-15	4/11/2015	150	**166**
Gate 2 Lake	Sediment	G2L-01	15-30	4/13/2015	150	100
Gate 2 Lake	Sediment	G2L-01	30-45	4/13/2015	150	56.5
Northeast area	Soil	NE-01	0-30	4/10/2015	1,200	10.6
Northeast area	Soil	NE-01	30-60	4/9/2015	1,200	3.78
Northeast area	Soil	NE-02A	0-30	11/29/2014	1,200	981
Northeast area	Soil	NE-02B	0-30	11/29/2014	1,200	542
Northeast area	Soil	NE-02C	0-30	11/25/2014	1,200	1,020
Northeast area	Soil	NE-02	0-30	11/29/2014	1,200	794
Northeast area	Soil	NE-02	30-60	12/1/2014	1,200	63.3
Northeast area	Soil	NE-03	0-30	4/11/2015	1,200	34.7
Northeast area	Soil	NE-03	30-60	4/11/2015	1,200	20.5
Northeast area	Soil	NE-04A	0-30	4/11/2015	1,200	666
Northeast area	Soil	NE-04B	0-30	4/11/2015	1,200	706
Northeast area	Soil	NE-04C	0-30	4/11/2015	1,200	236
Northeast area	Soil	NE-04	0-30	4/11/2015	1,200	595
Northeast area	Soil	NE-04	30-60	4/13/2015	1,200	354.8
Northeast area	Soil	NE-05	0-30	12/4/2014	1,200	74.7
Northeast area	Soil	NE-05	30-60	12/4/2014	1,200	40.9
Northeast area	Sediment	NE-06	0-15	4/13/2015	150	71.5
Northeast area	Sediment	NE-06	15-30	4/9/2015	150	44.8
Northeast area	Sediment	NE-06	30-45	4/10/2015	150	74.5
Northeast area	Sediment	NE-07	0-15	4/9/2015	150	**1,300**
Northeast area	Sediment	NE-07	15-30	4/9/2015	150	**765**
Northeast area	Sediment	NE-07	30-45	4/9/2015	150	54.0
Northeast area	Sediment	NE-08A	0-15	4/7/2015	150	**223**
Northeast area	Sediment	NE-08B	0-15	4/7/2015	150	**215**
Northeast area	Sediment	NE-08C	0-15	4/7/2015	150	48.8
Northeast area	Sediment	NE-08	0-15	4/7/2015	150	**179**
Northeast area	Sediment	NE-08A	15-30	4/7/2015	150	**157**
Northeast area	Sediment	NE-08B	15-30	4/7/2015	150	**265**
Northeast area	Sediment	NE-08C	15-30	4/7/2015	150	52.7
Northeast area	Sediment	NE-08	15-30	4/7/2015	150	**202**
Northeast area	Sediment	NE-08A	30-45	4/7/2015	150	**217**
Northeast area	Sediment	NE-08B	30-45	4/7/2015	150	122
Northeast area	Sediment	NE-08C	30-45	4/7/2015	150	39.9
Northeast area	Sediment	NE-08	30-45	4/7/2015	150	128
Northeast area	Sediment	NE-09	0-15	3/25/2015	150	**448**
Northeast area	Sediment	NE-09	15-30	3/24/2015	150	**334**
Northeast area	Sediment	NE-09	30-45	3/23/2015	150	**216**

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Northeast area	Sediment	NE-10	0-15	4/10/2015	150	26.9
Northeast area	Sediment	NE-10	15-30	4/8/2015	150	33.7
Northeast area	Sediment	NE-10	30-45	4/10/2015	150	49.0
Northeast area	Sediment	NE-11	0-15	4/4/2015	150	124.7
Northeast area	Sediment	NE-11	15-30	4/4/2015	150	**366.8**
Northeast area	Sediment	NE-11	30-45	4/4/2015	150	**174.0**
Northeast area	Sediment	NE-12A	0-15	4/3/2015	150	**259**
Northeast area	Sediment	NE-12B	0-15	4/3/2015	150	**148**
Northeast area	Sediment	NE-12C	0-15	4/3/2015	150	133
Northeast area	Sediment	NE-12	0-15	4/3/2015	150	**185**
Northeast area	Sediment	NE-12	15-30	4/9/2015	150	64.5
Northeast area	Sediment	NE-12	30-45	4/9/2015	150	47.1
Northeast area	Sediment	NE-13	0-15	4/9/2015	150	77.6
Northeast area	Sediment	NE-13	15-30	4/9/2015	150	89.7
Northeast area	Sediment	NE-13	30-45	4/6/2015	150	63.9
Northeast area	Sediment	NE-14	0-15	4/1/2015	150	35.8
Northeast area	Sediment	NE-14	15-30	4/1/2015	150	39.2
Northeast area	Sediment	NE-14	30-45	4/3/2015	150	34.8
Northeast area	Sediment	NE-15A	0-15	3/23/2015	150	50.0
Northeast area	Sediment	NE-15B	0-15	3/23/2015	150	127
Northeast area	Sediment	NE-15C	0-15	3/23/2015	150	**225**
Northeast area	Sediment	NE-15	0-15	3/23/2015	150	**154**
Northeast area	Sediment	NE-15	15-30	3/21/2015	150	24.6
Northeast area	Sediment	NE-15	30-45	3/21/2015	150	9.81
North forest area	Soil	NF-01	0-30	11/28/2014	100	35.5
North forest area	Soil	NF-01	30-60	11/28/2014	100	6.27
North forest area	Soil	NF-02	0-30	11/27/2014	100	60.0
North forest area	Soil	NF-02	30-60	11/27/2014	100	4.02
North forest area	Soil	NF-03	0-30	11/28/2014	100	19.0
North forest area	Soil	NF-03	30-60	11/28/2014	100	1.00
North forest area	Soil	NF-04A	0-30	11/25/2014	100	**349**
North forest area	Soil	NF-04B	0-30	11/25/2014	100	**125**
North forest area	Soil	NF-04C	0-30	11/25/2014	100	20.1
North forest area	Soil	NF-04	0-30	12/1/2014	100	**171**
North forest area	Soil	NF-04A	30-60	11/24/2014	100	**465**
North forest area	Soil	NF-04B	30-60	11/25/2014	100	21.4
North forest area	Soil	NF-04C	30-60	11/25/2014	100	25.9
North forest area	Soil	NF-04	30-60	12/1/2014	100	**159**
Northwest area	Sediment	NW-01	0-15	4/13/2015	150	96.8
Northwest area	Sediment	NW-01	15-30	4/13/2015	150	104

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Northwest area	Sediment	NW-01	30-45	4/13/2015	150	69.7
Northwest area	Sediment	NW-02	0-15	4/13/2015	150	72.4
Northwest area	Sediment	NW-02	15-30	4/13/2015	150	46.5
Northwest area	Sediment	NW-02	30-45	4/13/2015	150	23.7
Northwest area	Sediment	NW-03A	0-15	4/11/2015	150	4.11
Northwest area	Sediment	NW-03B	0-15	4/11/2015	150	16.8
Northwest area	Sediment	NW-03C	0-15	4/11/2015	150	**385**
Northwest area	Sediment	NW-03	0-15	4/11/2015	150	**155**
Northwest area	Sediment	NW-03A	15-30	4/11/2015	150	0.766
Northwest area	Sediment	NW-03B	15-30	4/11/2015	150	6.71
Northwest area	Sediment	NW-03C	15-30	4/11/2015	150	**587**
Northwest area	Sediment	NW-03	15-30	4/11/2015	150	**177**
Northwest area	Sediment	NW-03A	30-45	4/9/2015	150	0.742
Northwest area	Sediment	NW-03B	30-45	4/9/2015	150	4.87
Northwest area	Sediment	NW-03C	30-45	4/9/2015	150	**644**
Northwest area	Sediment	NW-03	30-45	4/9/2015	150	**194**
Northwest area	Sediment	NW-04A	0-15	4/11/2015	150	**477**
Northwest area	Sediment	NW-04B	0-15	4/11/2015	150	82.6
Northwest area	Sediment	NW-04C	0-15	4/11/2015	150	34.6
Northwest area	Sediment	NW-04	0-15	4/11/2015	150	**199**
Northwest area	Sediment	NW-04A	15-30	4/11/2015	150	**262**
Northwest area	Sediment	NW-04B	15-30	4/11/2015	150	32.7
Northwest area	Sediment	NW-04C	15-30	4/11/2015	150	37.6
Northwest area	Sediment	NW-04	15-30	4/11/2015	150	108
Northwest area	Sediment	NW-04	30-45	4/10/2015	150	37.0
Pacer Ivy area	Soil	PI-01	0-30	4/13/2015	1,200	183.5
Pacer Ivy area	Soil	PI-01	30-60	4/13/2015	1,200	174.6
Pacer Ivy area	Soil	PI-01	60-90	4/14/2015	1,200	39.5
Pacer Ivy area	Soil	PI-01A	90-120	4/14/2015	1,200	0.986
Pacer Ivy area	Soil	PI-01B	90-120	4/14/2015	1,200	0.813
Pacer Ivy area	Soil	PI-01C	90-120	4/14/2015	1,200	29.8
Pacer Ivy area	Soil	PI-01	90-120	4/14/2015	1,200	12.4
Pacer Ivy area	Soil	PI-01A	150-180	4/14/2015	1,200	21.0
Pacer Ivy area	Soil	PI-01B	150-180	4/14/2015	1,200	17.1
Pacer Ivy area	Soil	PI-01C	150-180	4/14/2015	1,200	30.3
Pacer Ivy area	Soil	PI-01	150-180	4/14/2015	1,200	23.2
Pacer Ivy area	Soil	PI-01	210-240	4/14/2015	1,200	4.66
Pacer Ivy area	Soil	PI-01	270-300	4/14/2015	1,200	2.33
Pacer Ivy area	Soil	PI-02	0-30	11/24/2014	1,200	**9,230**
Pacer Ivy area	Soil	PI-02	30-60	11/21/2014	1,200	**11,400**
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	1,200	**3,160**

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Pacer Ivy area	Soil	PI-02A	90-120	11/16/2014	1,200	**2,280**
Pacer Ivy area	Soil	PI-02B	90-120	11/17/2014	1,200	**6,610**
Pacer Ivy area	Soil	PI-02C	90-120	11/18/2014	1,200	66.2
Pacer Ivy area	Soil	PI-02	90-120	11/24/2014	1,200	**2,900**
Pacer Ivy area	Soil	PI-02A	150-180	11/16/2014	1,200	782
Pacer Ivy area	Soil	PI-02B	150-180	11/17/2014	1,200	**1,320**
Pacer Ivy area	Soil	PI-02C	150-180	11/18/2014	1,200	101
Pacer Ivy area	Soil	PI-02	150-180	11/29/2014	1,200	733
Pacer Ivy area	Soil	PI-02A	240-270	11/16/2014	1,200	**1,920**
Pacer Ivy area	Soil	PI-02B	240-270	11/17/2014	1,200	**1,120**
Pacer Ivy area	Soil	PI-02C	240-270	11/18/2014	1,200	68.3
Pacer Ivy area	Soil	PI-02	240-270	12/1/2014	1,200	**1,120**
Pacer Ivy area	Soil	PI-02	270-300	11/27/2014	1,200	566
Pacer Ivy area	Soil	PI-03	0-30	3/24/2015	1,200	23.7
Pacer Ivy area	Soil	PI-03	30-60	4/4/2015	1,200	9.96
Pacer Ivy area	Soil	PI-03	60-90	3/27/2015	1,200	3.42
Pacer Ivy area	Soil	PI-03	90-120	4/4/2015	1,200	0.913
Pacer Ivy area	Soil	PI-03	120-150	3/25/2015	1,200	0.728
Pacer Ivy area	Soil	PI-04	0-30	4/8/2015	1,200	243
Pacer Ivy area	Soil	PI-04	30-60	4/8/2015	1,200	166
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	1,200	14.1
Pacer Ivy area	Soil	PI-04C	90-120	4/9/2015	1,200	0.773
Pacer Ivy area	Soil	PI-04	90-120	4/9/2015	1,200	21.1
Pacer Ivy area	Soil	PI-04	120-150	4/9/2015	1,200	119
Pacer Ivy area	Soil	PI-05	0-30	3/21/2015	1,200	259
Pacer Ivy area	Soil	PI-05	30-60	4/6/2015	1,200	193
Pacer Ivy area	Soil	PI-05	60-90	4/7/2015	1,200	158
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	1,200	246
Pacer Ivy area	Soil	PI-06	30-60	11/18/2014	1,200	261
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	1,200	15.1
Pacer Ivy area	Soil	PI-07	30-60	11/25/2014	1,200	6.91
Pacer Ivy area	Soil	PI-07	60-90	11/26/2014	1,200	3.77
Pacer Ivy area	Soil	PI-08A	0-30	3/26/2015	1,200	**3,040**
Pacer Ivy area	Soil	PI-08B	0-30	3/26/2015	1,200	536
Pacer Ivy area	Soil	PI-08C	0-30	3/26/2015	1,200	864
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	1,200	**2,573**
Pacer Ivy area	Soil	PI-08	30-60	4/8/2015	1,200	377
Pacer Ivy area	Soil	PI-08	60-90	4/2/2015	1,200	253
Pacer Ivy area	Soil	PI-09	0-30	3/24/2015	1,200	372
Pacer Ivy area	Soil	PI-09	30-60	3/24/2015	1,200	139
Pacer Ivy area	Soil	PI-09	60-90	3/25/2015	1,200	69.0

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Pacer Ivy area	Soil	PI-10A	0-30	3/20/2015	300	**316**
Pacer Ivy area	Soil	PI-10B	0-30	3/20/2015	300	**395**
Pacer Ivy area	Soil	PI-10C	0-30	3/20/2015	300	**2,220**
Pacer Ivy area	Soil	PI-10	0-30	3/20/2015	300	**639**
Pacer Ivy area	Soil	PI-10A	30-60	3/19/2015	300	118
Pacer Ivy area	Soil	PI-10B	30-60	3/19/2015	300	79.1
Pacer Ivy area	Soil	PI-10C	30-60	3/19/2015	300	153
Pacer Ivy area	Soil	PI-10	30-60	3/19/2015	300	117
Pacer Ivy area	Soil	PI-10A	60-90	3/19/2015	300	80.7
Pacer Ivy area	Soil	PI-10B	60-90	3/19/2015	300	39.1
Pacer Ivy area	Soil	PI-10C	60-90	3/19/2015	300	11.7
Pacer Ivy area	Soil	PI-10	60-90	3/19/2015	300	54.5
Pacer Ivy area	Soil	PI-11	0-30	4/6/2015	300	221
Pacer Ivy area	Soil	PI-11	30-60	3/25/2015	300	32.6
Pacer Ivy area	Soil	PI-11	60-90	3/24/2015	300	36.3
Pacer Ivy area	Soil	PI-12A	0-30	3/21/2015	300	**1,290**
Pacer Ivy area	Soil	PI-12B	0-30	3/21/2015	300	**2,870**
Pacer Ivy area	Soil	PI-12C	0-30	3/21/2015	300	**2,340**
Pacer Ivy area	Soil	PI-12	0-30	3/21/2015	300	**2,170**
Pacer Ivy area	Soil	PI-12A	30-60	4/2/2015	300	175
Pacer Ivy area	Soil	PI-12B	30-60	4/2/2015	300	**759**
Pacer Ivy area	Soil	PI-12C	30-60	4/2/2015	300	**1,000**
Pacer Ivy area	Soil	PI-12	30-60	4/2/2015	300	**560**
Pacer Ivy area	Soil	PI-12A	60-90	4/1/2015	300	40.0
Pacer Ivy area	Soil	PI-12B	60-90	4/1/2015	300	207
Pacer Ivy area	Soil	PI-12C	60-90	4/1/2015	300	**656**
Pacer Ivy area	Soil	PI-12	60-90	4/1/2015	300	**288**
Pacer Ivy area	Soil	PI-13A	0-30	11/12/2014	300	**299**
Pacer Ivy area	Soil	PI-13B	0-30	11/11/2014	300	20.9
Pacer Ivy area	Soil	PI-13C	0-30	11/12/2014	300	22.1
Pacer Ivy area	Soil	PI-13	0-30	11/17/2014	300	266.3
Pacer Ivy area	Soil	PI-13	30-60	11/17/2014	300	73.7
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	300	48.1
Pacer Ivy area	Soil	PI-14	30-60	11/21/2014	300	5.01
Pacer Ivy area	Sediment	PI-15A	0-15	3/27/2015	150	**693**
Pacer Ivy area	Sediment	PI-15B	0-15	3/27/2015	150	**3,370**
Pacer Ivy area	Sediment	PI-15C	0-15	3/27/2015	150	**2,180**
Pacer Ivy area	Sediment	PI-15	0-15	3/27/2015	150	**1,910**
Pacer Ivy area	Sediment	PI-15A	15-30	4/2/2015	150	**801**
Pacer Ivy area	Sediment	PI-15B	15-30	4/2/2015	150	**1,240**
Pacer Ivy area	Sediment	PI-15C	15-30	4/2/2015	150	**2,750**
Pacer Ivy area	Sediment	PI-15	15-30	4/2/2015	150	**1,360**

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Pacer Ivy area	Sediment	PI-15A	30-45	3/26/2015	150	**809**
Pacer Ivy area	Sediment	PI-15B	30-45	3/26/2015	150	**1,250**
Pacer Ivy area	Sediment	PI-15C	30-45	3/26/2015	150	**3,320**
Pacer Ivy area	Sediment	PI-15	30-45	3/26/2015	150	**1,670**
Pacer Ivy area	Sediment	PI-16A	0-15	3/26/2015	150	**211**
Pacer Ivy area	Sediment	PI-16B	0-15	3/26/2015	150	**171**
Pacer Ivy area	Sediment	PI-16C	0-15	3/26/2015	150	**889**
Pacer Ivy area	Sediment	PI-16	0-15	3/26/2015	150	**395**
Pacer Ivy area	Sediment	PI-16A	15-30	4/3/2015	150	**164**
Pacer Ivy area	Sediment	PI-16B	15-30	4/3/2015	150	**212**
Pacer Ivy area	Sediment	PI-16C	15-30	4/3/2015	150	**1,120**
Pacer Ivy area	Sediment	PI-16	15-30	4/3/2015	150	**403**
Pacer Ivy area	Sediment	PI-16A	30-45	4/1/2015	150	**321**
Pacer Ivy area	Sediment	PI-16B	30-45	4/1/2015	150	102
Pacer Ivy area	Sediment	PI-16C	30-45	4/1/2015	150	**947**
Pacer Ivy area	Sediment	PI-16	30-45	4/1/2015	150	**276**
Pacer Ivy area	Sediment	PI-17A	0-15	3/27/2015	150	**318**
Pacer Ivy area	Sediment	PI-17B	0-15	3/27/2015	150	**1,300**
Pacer Ivy area	Sediment	PI-17C	0-15	3/27/2015	150	16.2
Pacer Ivy area	Sediment	PI-17	0-15	3/27/2015	150	**431**
Pacer Ivy area	Sediment	PI-17A	15-30	3/25/2015	150	**370**
Pacer Ivy area	Sediment	PI-17B	15-30	3/25/2015	150	**613**
Pacer Ivy area	Sediment	PI-17C	15-30	3/25/2015	150	4.09
Pacer Ivy area	Sediment	PI-17	15-30	3/25/2015	150	**264**
Pacer Ivy area	Sediment	PI-17A	30-45	3/26/2015	150	**267**
Pacer Ivy area	Sediment	PI-17B	30-45	3/26/2015	150	**506**
Pacer Ivy area	Sediment	PI-17C	30-45	3/26/2015	150	2.34
Pacer Ivy area	Sediment	PI-17	30-45	3/26/2015	150	**172**
Pacer Ivy area	Sediment	PI-18	0-15	3/23/2015	150	**1,080**
Pacer Ivy area	Sediment	PI-18	15-30	3/24/2015	150	**349**
Pacer Ivy area	Sediment	PI-18A	30-45	3/25/2015	150	**146**
Pacer Ivy area	Sediment	PI-18B	30-45	3/25/2015	150	**149**
Pacer Ivy area	Sediment	PI-18C	30-45	3/25/2015	150	**179**
Pacer Ivy area	Sediment	PI-18	30-45	3/25/2015	150	**169**
Pacer Ivy area	Sediment	PI-19	0-15	4/6/2015	150	34.1
Pacer Ivy area	Sediment	PI-19	15-30	4/6/2015	150	18.3
Pacer Ivy area	Sediment	PI-19	30-45	4/6/2015	150	8.01
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	150	**3,080**
Pacer Ivy area	Sediment	PI-20	15-30	3/20/2015	150	**5,410**
Pacer Ivy area	Sediment	PI-20	30-45	3/25/2015	150	**3,820**

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Pacer Ivy area	Sediment	PI-21	0-15	4/3/2015	150	26.6
Pacer Ivy area	Sediment	PI-21	15-30	4/1/2015	150	18.4
Pacer Ivy area	Sediment	PI-21	30-45	4/3/2015	150	69.1
Southeast area	Soil	SE-01	0-30	4/11/2015	300	36.9
Southeast area	Soil	SE-01	30-60	4/11/2015	300	34.5
Southeast area	Soil	SE-02	0-30	4/10/2015	300	64.5
Southeast area	Soil	SE-02	30-60	4/10/2015	300	31.8
Southwest area	Soil	SW-01A	0-30	11/6/2014	300	**20,000**
Southwest area	Soil	SW-01B	0-30	11/10/2014	300	**21,800**
Southwest area	Soil	SW-01C	0-30	11/10/2014	300	**1,240**
Southwest area	Soil	SW-01	0-30	11/13/2014	300	**10,900**
Southwest area	Soil	SW-01A	30-60	11/10/2014	300	**111,000**
Southwest area	Soil	SW-01B	30-60	11/11/2014	300	**26,600**
Southwest area	Soil	SW-01C	30-60	11/11/2014	300	**359**
Southwest area	Soil	SW-01	30-60	11/15/2014	300	**41,000**
Southwest area	Soil	SW-01A	60-90	11/10/2014	300	**13,800**
Southwest area	Soil	SW-01B	60-90	11/10/2014	300	**499**
Southwest area	Soil	SW-01C	60-90	11/11/2014	300	25.6
Southwest area	Soil	SW-01	60-90	11/15/2014	300	**4,880**
Southwest area	Soil	SW-01	90-120	11/17/2014	300	62.0
Southwest area	Soil	SW-01A	120-150	11/10/2014	300	**2,680**
Southwest area	Soil	SW-01B	120-150	11/10/2014	300	**1,230**
Southwest area	Soil	SW-01C	120-150	11/11/2014	300	14.2
Southwest area	Soil	SW-01	120-150	11/17/2014	300	**1,370**
Southwest area	Soil	SW-02A	0-30	11/10/2014	300	**7,880.0**
Southwest area	Soil	SW-02B	0-30	11/11/2014	300	170.0
Southwest area	Soil	SW-02C	0-30	11/11/2014	300	115.0
Southwest area	Soil	SW-02	0-30	11/15/2014	300	**2,560.0**
Southwest area	Soil	SW-02A	30-60	11/10/2014	300	**831.0**
Southwest area	Soil	SW-02B	30-60	11/11/2014	300	**311.0**
Southwest area	Soil	SW-02C	30-60	11/11/2014	300	12.7
Southwest area	Soil	SW-02	30-60	11/15/2014	300	**332.0**
Southwest area	Soil	SW-02	60-90	11/15/2014	300	71.6
Southwest area	Soil	SW-03A	0-30	11/10/2014	300	**1,880**
Southwest area	Soil	SW-03B	0-30	11/10/2014	300	**641**
Southwest area	Soil	SW-03C	0-30	11/10/2014	300	142
Southwest area	Soil	SW-03	0-30	11/15/2014	300	**746**
Southwest area	Soil	SW-03A	30-60	11/10/2014	300	**1,680**
Southwest area	Soil	SW-03B	30-60	11/10/2014	300	114
Southwest area	Soil	SW-03C	30-60	11/10/2014	300	10.1
Southwest area	Soil	SW-03	30-60	11/15/2014	300	**550**

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Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Southwest area	Soil	SW-03A	60-90	11/10/2014	300	**1,180**
Southwest area	Soil	SW-03B	60-90	11/10/2014	300	38.4
Southwest area	Soil	SW-03C	60-90	11/10/2014	300	6.81
Southwest area	Soil	SW-03	60-90	11/15/2014	300	**445**
Southwest area	Soil	SW-04	0-30	11/19/2014	300	41.4
Southwest area	Soil	SW-04	30-60	11/21/2014	300	15.0
Southwest area	Soil	SW-04	60-90	11/21/2014	300	12.2
Southwest area	Soil	SW-06A	0-30	11/6/2014	300	57.3
Southwest area	Soil	SW-06B	0-30	11/7/2014	300	52.4
Southwest area	Soil	SW-06C	0-30	11/7/2014	300	71.0
Southwest area	Soil	SW-06	0-30	11/12/2014	300	62.8
Southwest area	Soil	SW-06	30-60	11/13/2014	300	20.1
Southwest area	Soil	SW-06	60-90	11/14/2014	300	49.2
Southwest area	Soil	SW-07A	0-30	11/13/2014	300	**674**
Southwest area	Soil	SW-07B	0-30	11/13/2014	300	**311**
Southwest area	Soil	SW-07C	0-30	11/13/2014	300	210
Southwest area	Soil	SW-07	0-30	11/15/2014	300	**406**
Southwest area	Soil	SW-07A	30-60	11/13/2014	300	231
Southwest area	Soil	SW-07B	30-60	11/13/2014	300	192
Southwest area	Soil	SW-07C	30-60	11/13/2014	300	81.4
Southwest area	Soil	SW-07	30-60	11/17/2014	300	169
Southwest area	Soil	SW-07A	60-90	11/13/2014	300	219
Southwest area	Soil	SW-07B	60-90	11/12/2014	300	168
Southwest area	Soil	SW-07C	60-90	11/13/2014	300	64.5
Southwest area	Soil	SW-07	60-90	11/17/2014	300	129
Southwest area	Soil	SW-08	0-30	11/18/2014	300	60.8
Southwest area	Soil	SW-08A	30-60	11/14/2014	300	149.0
Southwest area	Soil	SW-08B	30-60	11/14/2014	300	216
Southwest area	Soil	SW-08C	30-60	11/14/2014	300	44.4
Southwest area	Soil	SW-08	30-60	11/18/2014	300	171
Southwest area	Soil	SW-08	60-90	11/18/2014	300	40.7
Z1 area	Soil	Z1-01-BIO	0-100	4/14/2015	1,200	3.00
Z1 area	Soil	Z1-01-Landfill	0-100	4/14/2015	1,200	**1,510**
Z1 area	Soil	Z1-02A	0-30	3/25/2015	300	**865**
Z1 area	Soil	Z1-02B	0-30	3/25/2015	300	162
Z1 area	Soil	Z1-02C	0-30	3/25/2015	300	28.4
Z1 area	Soil	Z1-02	0-30	3/25/2015	300	**333**
Z1 area	Soil	Z1-02A	60-90	3/24/2015	300	**452**
Z1 area	Soil	Z1-02B	60-90	3/24/2015	300	82.4
Z1 area	Soil	Z1-02C	60-90	3/24/2015	300	44.9
Z1 area	Soil	Z1-02	60-90	3/24/2015	300	206

Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Z1 area	Soil	Z1-02	120-150	4/3/2015	300	20.8
Z1 area	Soil	Z1-02	180-210	4/4/2015	300	25.8
Z1 area	Soil	Z1-02	240-270	4/4/2015	300	34.2
Z1 area	Soil	Z1-02	300-330	4/6/2015	300	25.6
Z1 area	Soil	Z1-02	360-390	4/6/2015	300	33.2
Z1 area	Soil	Z1-03	0-30	12/3/2014	300	**512.1**
Z1 area	Soil	Z1-03A	60-90	11/27/2014	300	86.5
Z1 area	Soil	Z1-03B	60-90	11/27/2014	300	95.8
Z1 area	Soil	Z1-03C	60-90	11/27/2014	300	3.25
Z1 area	Soil	Z1-03	60-90	12/2/2014	300	90.5
Z1 area	Soil	Z1-03	120-150	12/2/2014	300	5.6
Z1 area	Soil	Z1-03	180-210	12/2/2014	300	4.03
Z1 area	Soil	Z1-03	240-270	12/2/2014	300	0.702
Z1 area	Soil	Z1-03	300-330	12/4/2014	300	0.728
Z1 area	Soil	Z1-03	360-390	12/4/2014	300	3.08
Z1 area	Soil	Z1-04	0-30	12/3/2014	1,200	49.9
Z1 area	Soil	Z1-04	60-90	11/29/2014	1,200	7.30
Z1 area	Soil	Z1-04	120-150	12/1/2014	1,200	7.53
Z1 area	Soil	Z1-04	180-210	12/1/2014	1,200	9.41
Z1 area	Soil	Z1-04	240-270	11/29/2014	1,200	4.17
Z1 area	Soil	Z1-04	300-330	12/1/2014	1,200	10.8
Z1 area	Soil	Z1-04	360-390	12/3/2014	1,200	4.26
Z1 area	Soil	Z1-05	0-30	12/4/2014	300	48.2
Z1 area	Soil	Z1-05	30-60	12/4/2014	300	11.3
Z1 area	Soil	Z1-05	60-90	12/4/2014	300	4.00
Z1 area	Soil	Z1-06A	0-30	3/18/2015	300	**325**
Z1 area	Soil	Z1-06B	0-30	3/18/2015	300	152
Z1 area	Soil	Z1-06C	0-30	3/18/2015	300	237
Z1 area	Soil	Z1-06	0-30	3/18/2015	300	205
Z1 area	Soil	Z1-06	30-60	3/18/2015	300	12.8
Z1 area	Soil	Z1-06	60-90	3/20/2015	300	31.7
Z1 area	Soil	Z1-06	120-150	4/3/2015	300	14.0
Z1 area	Soil	Z1-06	180-210	4/2/2015	300	16.4
Z1 area	Soil	Z1-07A	0-30	4/10/2015	300	129
Z1 area	Soil	Z1-07B	0-30	4/10/2015	300	184
Z1 area	Soil	Z1-07C	0-30	4/10/2015	300	175
Z1 area	Soil	Z1-07	0-30	4/10/2015	300	168
Z1 area	Soil	Z1-07A	30-60	4/9/2015	300	233
Z1 area	Soil	Z1-07B	30-60	4/9/2015	300	53.5
Z1 area	Soil	Z1-07C	30-60	4/9/2015	300	**438**
Z1 area	Soil	Z1-07	30-60	4/9/2015	300	**274**

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Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Z1 area	Soil	Z1-07	60-90	4/7/2015	300	13.9
Z1 area	Soil	Z1-07	120-150	4/7/2015	300	8.92
Z1 area	Soil	Z1-07	180-210	4/7/2015	300	4.06
Z1 area	Soil	Z1-08A	0-30	11/19/2014	300	104.0
Z1 area	Soil	Z1-08B	0-30	11/20/2014	300	16.1
Z1 area	Soil	Z1-08C	0-30	11/20/2014	300	10.3
Z1 area	Soil	Z1-08	0-30	11/25/2014	300	107
Z1 area	Soil	Z1-08	30-60	11/26/2014	300	17.4
Z1 area	Soil	Z1-08	60-90	11/26/2014	300	18.5
Z1 area	Sediment	Z1-09	0-15	4/8/2015	150	**413**
Z1 area	Sediment	Z1-09	15-30	4/8/2015	150	**260**
Z1 area	Sediment	Z1-09	30-45	4/8/2015	150	**444**
Z1 area	Sediment	Z1-10	0-15	4/10/2015	150	**1,494.6**
Z1 area	Sediment	Z1-10	15-30	4/11/2015	150	**1,578.8**
Z1 area	Sediment	Z1-10	30-45	4/13/2015	150	**244.8**
Z1 area	Soil	Z1-11A	0-30	11/26/2014	300	151
Z1 area	Soil	Z1-11B	0-30	11/27/2014	300	75.7
Z1 area	Soil	Z1-11C	0-30	11/27/2014	300	49.9
Z1 area	Soil	Z1-11	0-30	12/1/2014	300	93.9
Z1 area	Soil	Z1-11	30-60	12/2/2014	300	31.1
Z1 area	Soil	Z1-11	60-90	12/3/2014	300	8.88
Z1 area	Soil	Z1-12	0-30	4/14/2015	1,200	7.18
Z1 area	Soil	Z1-12	30-60	4/13/2015	1,200	3.47
Z1 area	Soil	Z1-13A	0-30	12/2/2014	300	90.8
Z1 area	Soil	Z1-13B	0-30	12/2/2014	300	85.0
Z1 area	Soil	Z1-13C	0-30	12/3/2014	300	47.8
Z1 area	Soil	Z1-13	0-30	12/4/2014	300	103.2
Z1 area	Soil	Z1-13	30-60	12/4/2014	300	20.5
Z1 area	Soil	Z1-13	60-90	12/4/2014	300	7.82
Z1 area	Soil	Z1-16A	0-30	4/10/2015	300	150
Z1 area	Soil	Z1-16B	0-30	4/10/2015	300	**900**
Z1 area	Soil	Z1-16C	0-30	4/10/2015	300	130
Z1 area	Soil	Z1-16	0-30	4/10/2015	300	**435.6**
Z1 area	Soil	Z1-16	30-60	4/10/2015	300	222.2
Z1 area	Soil	Z1-16	60-90	4/10/2015	300	91.4
Z1 area	Soil	Z1-16	120-150	4/10/2015	300	21.2
Z1 area	Soil	Z1-16	180-210	4/9/2015	300	14.6
Z1 area	Soil	Z1-17	0-30	4/13/2015	1,200	13.6
Z1 area	Soil	Z1-17	60-90	4/11/2015	1,200	4.08
Z1 area	Soil	Z1-17	120-150	4/13/2015	1,200	2.1
Z1 area	Soil	Z1-17	180-210	4/13/2015	1,200	6.47

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Table A13 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	Total TEQ (ppt dry weight) (ND=1/2 DL)
Z1 area	Soil	Z1-17	240-270	4/14/2015	1,200	0.697
Z1 area	Soil	Z1-17	300-330	4/13/2015	1,200	1.93
Z1 area	Soil	Z1-17	360-390	4/13/2015	1,200	0.697
Z1 taxiway area	Soil	ZT-01	0-30	4/11/2015	1,200	48.8
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	1,200	4.59
Z1 taxiway area	Soil	ZT-01	60-90	4/11/2015	1,200	64.7
Z1 taxiway area	Soil	ZT-01	120-150	4/11/2015	1,200	43.6
Z1 taxiway area	Soil	ZT-02A	0-30	11/27/2014	1,200	312
Z1 taxiway area	Soil	ZT-02B	0-30	11/27/2014	1,200	**3,440**
Z1 taxiway area	Soil	ZT-02C	0-30	11/27/2014	1,200	178
Z1 taxiway area	Soil	ZT-02	0-30	12/1/2014	1,200	1,080
Z1 taxiway area	Soil	ZT-02A	30-60	11/27/2014	1,200	73.2
Z1 taxiway area	Soil	ZT-02B	30-60	11/27/2014	1,200	429
Z1 taxiway area	Soil	ZT-02C	30-60	11/27/2014	1,200	46.9
Z1 taxiway area	Soil	ZT-02	30-60	12/2/2014	1,200	181
Z1 taxiway area	Soil	ZT-02	60-90	12/2/2014	1,200	86.1
Z1 taxiway area	Soil	ZT-04	0-30	12/2/2014	1,200	15.3
Z1 taxiway area	Soil	ZT-04	30-60	12/3/2014	1,200	6.24
Z1 taxiway area	Soil	ZT-04	60-90	12/4/2014	1,200	1.32
Z1 taxiway area	Soil	ZT-05	0-30	12/2/2014	1,200	10.5
Z1 taxiway area	Soil	ZT-05	30-60	12/2/2014	1,200	1.18
Z1 taxiway area	Soil	ZT-05	60-90	12/4/2014	1,200	2.02
Z1 taxiway area	Soil	ZT-06	0-30	12/4/2014	1,200	23.8
Z1 taxiway area	Soil	ZT-06	30-60	12/4/2014	1,200	4.93
Z1 taxiway area	Soil	ZT-06	60-90	12/4/2014	1,200	0.939
Z1 taxiway area	Soil	ZT-07	0-30	4/13/2015	1,200	86.4
Z1 taxiway area	Soil	ZT-07	30-60	4/13/2015	1,200	40.6
Z1 taxiway area	Soil	ZT-07	60-90	4/10/2015	1,200	9.42
Z1 taxiway area	Soil	ZT-07	120-150	4/10/2015	1,200	0.785

* ***Notes***:

- cm: centimeter
- DL: detection limit
- DU: decision unit
- ID: identification
- ND: non-detect
- ppt: part per trillion
- TEQ: dioxin toxicity equivalence
- **RED**: exceeding the action level

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

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Table A14 Concentrations of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in soil samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Northeast area	Soil	NE-01	0-30	4/10/2015	1,200	7.64	10.4	4.39	20.9	180	1,010	0.0617	6.66	7.74	9.4	14.7	8.47	10.6	72%
Northeast area	Soil	NE-01	30-60	4/9/2015	1,200	2.65	4.44	1.25	5.81	45.9	242	0.0400	3.95	2.20	1.89	5.33	3.98	3.78	70%
Northeast area	Soil	NE-02A	0-30	11/29/2014	1,200	952	1,080	159	106	29.7	97.8	2.27	216	180	22.2	ND	3.11	981	97%
Northeast area	Soil	NE-02B	0-30	11/29/2014	1,200	505	607	97.0	74.9	38.7	144	2.85	212	189	18.0	4.16	4.48	542	93%
Northeast area	Soil	NE-02C	0-30	11/25/2014	1,200	989	1,080	101	65.5	79.2	316	2.38	169	142	12.6	8.24	8.18	1,020	97%
Northeast area	Soil	NE-02	0-30	11/29/2014	1,200	762	876	162	98.5	53.9	186	30.6	224	182	23.6	9.13	4.38	794	96%
Northeast area	Soil	NE-02	30-60	12/1/2014	1,200	62.3	79.0	18.7	8.88	4.09	30.4	0.372	37.3	23.9	2.28	0.967	2.03	63.3	98%
Northeast area	Soil	NE-03	0-30	4/11/2015	1,200	32.8	38.7	4.46	15.2	83.5	406	0.363	18.7	21.1	9.08	6.52	11.6	34.7	95%
Northeast area	Soil	NE-03	30-60	4/11/2015	1,200	19.6	24.8	2.79	3.29	ND	193	0.240	14.4	14.5	ND	ND	4.25	20.5	96%
Northeast area	Soil	NE-04A	0-30	4/11/2015	1,200	615	835	181	93.7	64.8	237	4.52	390	274	37.0	13.7	7.73	666	92%
Northeast area	Soil	NE-04B	0-30	4/11/2015	1,200	674	802	115	79.5	48.0	214	3.10	170	163	28.2	10.3	6.28	706	95%
Northeast area	Soil	NE-04C	0-30	4/11/2015	1,200	224	265	44.0	35.0	95.2	404	0.121	65.5	58.5	15.7	11.0	13.3	236	95%
Northeast area	Soil	NE-04	0-30	4/11/2015	1,200	549	651	117	64.1	72.2	302	2.85	192	143	23.8	14.7	7.84	595.0	92%
Northeast area	Soil	NE-04	30-60	4/13/2015	1,200	116	144	27.0	19.9	17.3	151	0.825	44.9	34.5	1.55	6.40	4.68	354.8	33%
Northeast area	Soil	NE-05	0-30	12/4/2014	1,200	59.5	69.5	21.7	95.0	593	1,960	0.378	32.0	42.1	56.8	73.6	30.9	74.7	80%
Northeast area	Soil	NE-05	30-60	12/4/2014	1,200	34.5	43.4	9.35	46.9	330	1,320	0.211	16.5	23.5	34.9	46.9	25.2	40.9	84%
North forest area	Soil	NF-01	0-30	11/28/2014	100	23.6	26.0	4.06	13.3	81.9	307	0.199	9.14	8.20	7.93	12.3	9.45	35.5	66%
North forest area	Soil	NF-01	30-60	11/28/2014	100	5.67	5.67	ND	0.885	7.56	71.5	0.0329	0.980	1.12	ND	1.07	2.15	6.27	90%
North forest area	Soil	NF-02	0-30	11/27/2014	100	56.9	64.0	1.20	38.2	185	571	0.511	18.3	28.4	21.3	22.4	14.8	60.0	95%
North forest area	Soil	NF-02	30-60	11/27/2014	100	3.43	3.43	0.453	ND	15.2	119	0.0301	0.489	ND	0.513	0.902	1.40	4.02	85%
North forest area	Soil	NF-03	0-30	11/28/2014	100	17.9	20.3	2.32	7.52	79.9	276	0.0214	7.57	5.78	6.93	10.1	8.42	19.0	94%
North forest area	Soil	NF-03	30-60	11/28/2014	100	0.212	ND	0.439	0.808	29.3	187	0.0212	ND	0.996	1.26	2.57	4.07	1.00	21%
North forest area	Soil	NF-04A	0-30	11/25/2014	100	339	410	49.6	61.2	132	450	1.01	112	111	32.8	20.4	11.1	**349**	97%
North forest area	Soil	NF-04B	0-30	11/25/2014	100	112	153	48.3	46.0	75.4	354	1.24	93.3	95.3	21.4	15.9	10.5	**125**	90%
North forest area	Soil	NF-04C	0-30	11/25/2014	100	17.3	23.1	9.83	16.7	71.3	342	0.190	10.3	14.0	7.17	9.39	7.18	20.1	86%
North forest area	Soil	NF-04	0-30	12/1/2014	100	163	202	36.0	44.0	110	334	0.916	85.3	74.7	19.8	15.0	9.60	**171**	95%
North forest area	Soil	NF-04A	30-60	11/24/2014	100	457	538	60.8	51.9	52.5	177	0.491	138	116	28.1	12.8	4.96	**464**	98%
North forest area	Soil	NF-04B	30-60	11/25/2014	100	17.4	31.0	18.2	11.7	22.7	143	0.360	29.5	19.2	3.47	5.02	3.03	21.4	81%
North forest area	Soil	NF-04C	30-60	11/25/2014	100	24.9	32.2	3.59	8.76	21.3	163	0.228	16.6	13.7	3.58	3.08	2.23	25.9	96%
North forest area	Soil	NF-04	30-60	12/1/2014	100	155	184	20.2	20.8	39.3	186	0.356	48.3	35.9	11.2	3.37	3.21	**159**	97%
Pacer Ivy area	Soil	PI-01	0-30	4/13/2015	1,200	87.3	97.8	20.7	35.4	92.0	311	0.752	36.1	31.4	10.4	4.63	5.89	183.5	48%
Pacer Ivy area	Soil	PI-01	30-60	4/13/2015	1,200	15.7	19.8	4.53	7.27	10.1	83.4	0.121	2.45	4.53	1.70	1.50	1.46	174.6	9%
Pacer Ivy area	Soil	PI-01	60-90	4/14/2015	1,200	38.9	46.6	2.38	7.58	20.2	117	0.201	7.39	3.94	1.14	ND	0.955	39.5	98%
Pacer Ivy area	Soil	PI-01A	90-120	4/14/2015	1,200	0.202	ND	ND	ND	34.7	138	0.0202	ND	ND	ND	ND	1.84	0.986	20%
Pacer Ivy area	Soil	PI-01B	90-120	4/14/2015	1,200	0.222	ND	ND	ND	ND	31.6	0.0223	2.25	ND	ND	ND	0.769	0.813	27%
Pacer Ivy area	Soil	PI-01C	90-120	4/14/2015	1,200	28.7	32.1	1.54	7.88	22.3	148	0.477	6.96	3.01	0.473	0.997	1.34	29.8	96%
Pacer Ivy area	Soil	PI-01	90-120	4/14/2015	1,200	12.0	12.5	0.422	3.89	13.8	86.8	0.131	2.45	2.06	0.309	ND	0.594	12.4	97%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Pacer Ivy area	Soil	PI-01A	150-180	4/14/2015	1,200	20.3	20.3	ND	3.16	17.0	71.4	0.0212	0.523	ND	ND	0.629	1.75	21.0	97%
Pacer Ivy area	Soil	PI-01B	150-180	4/14/2015	1,200	16.6	16.7	ND	ND	1.33	15.0	0.0225	7.03	3.64	0.655	ND	1.30	17.1	97%
Pacer Ivy area	Soil	PI-01C	150-180	4/14/2015	1,200	29.1	30.8	0.552	7.02	27.6	134	0.534	8.37	2.13	0.447	0.746	1.61	30.3	96%
Pacer Ivy area	Soil	PI-01	150-180	4/14/2015	1,200	22.5	25.2	1.39	5.88	13.9	66.8	0.232	6.15	2.73	0.489	0.260	0.347	23.2	97%
Pacer Ivy area	Soil	PI-01	210-240	4/14/2015	1,200	3.90	3.90	ND	3.67	19.4	87.3	0.0262	1.36	ND	ND	ND	ND	4.66	84%
Pacer Ivy area	Soil	PI-01	270-300	4/14/2015	1,200	1.36	2.00	ND	5.09	27.2	103	0.0225	1.68	ND	ND	ND	ND	2.33	58%
Pacer Ivy area	Soil	PI-02	0-30	11/24/2014	1,200	9,130	9,750	463	703	607	1,110	23.2	2,010	1,800	257	71.1	33.9	**9,230**	99%
Pacer Ivy area	Soil	PI-02	30-60	11/21/2014	1,200	11,300	12,200	623	846	723	1,150	41.5	3,140	2,360	339	78.2	30.7	**11,400**	99%
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	1,200	3,120	3,350	219	276	254	603	12.8	830	688	105	25.2	11.8	**3,160**	99%
Pacer Ivy area	Soil	PI-02A	90-120	11/16/2014	1,200	2,230	2,590	364	543	408	598	4.31	831	762	167	99.8	45.6	**2,280**	98%
Pacer Ivy area	Soil	PI-02B	90-120	11/17/2014	1,200	6,540	6,970	203	217	152	338	41.3	1,880	1,410	160.0	8.64	10.3	**6,610**	99%
Pacer Ivy area	Soil	PI-02C	90-120	11/18/2014	1,200	63.6	65.1	ND	3.08	34.2	124	0.564	17.9	6.75	9.35	7.61	5.92	66.2	96%
Pacer Ivy area	Soil	PI-02	90-120	11/24/2014	1,200	2,860	3,150	260	313	210	349	14.7	1,020	820	120	33.0	10.1	**2,900**	99%
Pacer Ivy area	Soil	PI-02A	150-180	11/16/2014	1,200	768	797	58.7	95.7	99.6	267	4.11	229	218	16.4	19.7	15.7	782	98%
Pacer Ivy area	Soil	PI-02B	150-180	11/17/2014	1,200	1,320	1,350	ND	8.90	37.9	108	0.0214	49.7	15.3	5.37	1.72	3.12	**1,320**	100%
Pacer Ivy area	Soil	PI-02C	150-180	11/18/2014	1,200	99.9	102	ND	ND	5.56	37.6	0.277	6.73	13.5	ND	1.92	2.29	101	99%
Pacer Ivy area	Soil	PI-02	150-180	11/29/2014	1,200	727	755	35.4	47.9	60.8	167	1.50	135	106	13.6	4.38	5.27	733	99%
Pacer Ivy area	Soil	PI-02A	240-270	11/16/2014	1,200	1,880	2,040	297	323	216	389	6.78	506	480	57.6	22.6	15.1	**1,920**	98%
Pacer Ivy area	Soil	PI-02B	240-270	11/17/2014	1,200	1,110	1,160	35.4	45.8	65.5	216	3.18	195	154	22.7	5.76	3.15	**1,120**	99%
Pacer Ivy area	Soil	PI-02C	240-270	11/18/2014	1,200	66.0	73.1	5.33	10.1	24.5	87.1	0.499	40.8	29.3	2.82	1.90	1.21	68.3	97%
Pacer Ivy area	Soil	PI-02	240-270	12/1/2014	1,200	1,100	1,180	104	107	104	221	3.39	282	239	28.2	12.0	6.76	**1,120**	98%
Pacer Ivy area	Soil	PI-02	270-300	11/27/2014	1,200	560	589	36.1	39.1	56.5	151	1.64	120	106	14.1	6.02	3.90	566	99%
Pacer Ivy area	Soil	PI-03	0-30	3/24/2015	1,200	19.3	22.9	8.63	35.6	213	858	0.344	15.1	14.0	18.1	21.8	13.4	23.7	81%
Pacer Ivy area	Soil	PI-03	30-60	4/4/2015	1,200	9.09	10.6	1.76	6.76	30.6	145	0.117	2.87	2.76	1.92	2.72	2.26	9.96	91%
Pacer Ivy area	Soil	PI-03	60-90	3/27/2015	1,200	2.66	2.96	0.413	5.62	64.8	422	0.00745	0.565	2.12	6.13	6.00	1.50	3.42	78%
Pacer Ivy area	Soil	PI-03	90-120	4/4/2015	1,200	0.211	ND	ND	2.22	6.18	78.8	0.0481	1.05	ND	ND	ND	1.15	0.913	23%
Pacer Ivy area	Soil	PI-03	120-150	3/25/2015	1,200	0.207	ND	ND	1.38	11.0	69.3	0.0207	ND	ND	ND	0.448	0.509	0.728	28%
Pacer Ivy area	Soil	PI-04	0-30	4/8/2015	1,200	225	268	58.6	49.9	125	688	0.910	60.9	67.4	18.5	19.1	13.9	243	93%
Pacer Ivy area	Soil	PI-04	30-60	4/8/2015	1,200	161	180	17.9	23.6	69.8	222	0.270	27.7	25.7	5.83	7.06	5.70	166	97%
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	1,200	13.7	15.7	1.29	4.79	19.2	130	0.00805	1.91	3.48	0.376	2.10	2.02	14.1	97%
Pacer Ivy area	Soil	PI-04C	90-120	4/9/2015	1,200	0.209	ND	ND	2.12	15.9	171	0.0209	1.65	ND	ND	ND	0.670	0.773	27%
Pacer Ivy area	Soil	PI-04	90-120	4/9/2015	1,200	20.5	20.5	1.08	4.16	28.0	178	0.0148	3.2	0.452	ND	0.989	1.78	21.1	97%
Pacer Ivy area	Soil	PI-04	120-150	4/9/2015	1,200	117	124	2.05	16.3	61.5	284	0.128	11.6	6.49	0.675	2.67	2.41	119	98%
Pacer Ivy area	Soil	PI-05	0-30	3/21/2015	1,200	244	275	37.4	108	484	2,350	1.32	82.1	84.9	59.6	86.3	67.5	259	94%
Pacer Ivy area	Soil	PI-05	30-60	4/6/2015	1,200	179	205	32.7	98.3	512	2,490	1.07	76.1	77.1	57.5	87.5	68.6	193	93%
Pacer Ivy area	Soil	PI-05	60-90	4/7/2015	1,200	147	163	21.3	63.8	286	1,470	0.891	80.2	81.1	41.8	50.6	40.0	158	93%
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	1,200	233	255	33.6	83.0	324	1,140	1.59	80.1	93.2	41.8	36.1	27.6	245	95%
Pacer Ivy area	Soil	PI-06	30-60	11/18/2014	1,200	257	276	8.37	23.9	72.5	249	0.472	52.9	39.3	4.81	7.88	5.74	261	98%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	1,200	13.1	13.9	2.52	12.0	74.3	388	0.131	9.04	8.53	7.75	9.04	6.87	15.1	87%
Pacer Ivy area	Soil	PI-07	30-60	11/25/2014	1,200	5.82	6.42	1.31	6.30	29.6	165	0.0493	7.95	3.39	1.79	4.34	3.10	6.91	84%
Pacer Ivy area	Soil	PI-07	60-90	11/26/2014	1,200	3.23	3.23	ND	1.03	14.6	136	0.0197	0.543	0.398	0.554	ND	2.67	3.77	86%
Pacer Ivy area	Soil	PI-08A	0-30	3/26/2015	1,200	2,840	3,700	1,330	2,740	3,320	3,540	11.3	808	738	148	120	72.2	**3,040**	93%
Pacer Ivy area	Soil	PI-08B	0-30	3/26/2015	1,200	485	658	265	228	260	1,650	4.24	292	233	34.9	27.6	32.7	536	90%
Pacer Ivy area	Soil	PI-08C	0-30	3/26/2015	1,200	729	1,180	573	274	153	820	6.73	580	481	48.6	9.35	8.38	864	84%
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	1,200	1,340	1,830	831	1,160	1,300	2,220	7.68	542	523	89.8	58.2	47.5	**2,573**	52%
Pacer Ivy area	Soil	PI-08	30-60	4/8/2015	1,200	357	431	131	221	246	812	1.93	103	95.1	14.8	10.5	7.25	377	95%
Pacer Ivy area	Soil	PI-08	60-90	4/2/2015	1,200	235	305	102	147	195	785	1.19	72.0	71.9	13.6	8.64	6.25	253	93%
Pacer Ivy area	Soil	PI-09	0-30	3/24/2015	1,200	353	405	77.2	135	534	1,910	3.23	119	102	55.1	89.2	65.1	372	95%
Pacer Ivy area	Soil	PI-09	30-60	3/24/2015	1,200	131	149	26.5	49.3	224	820	1.43	49.9	40.4	29.5	37.8	23.1	139	94%
Pacer Ivy area	Soil	PI-09	60-90	3/25/2015	1,200	64.9	74.2	1.03	17.7	126	459	1.0	33.0	19.1	15.5	18.9	9.38	69.0	94%
Pacer Ivy area	Soil	PI-10A	0-30	3/20/2015	300	284	363	94.7	82.5	237	698	3.17	252	267	151	105	20.6	**316**	90%
Pacer Ivy area	Soil	PI-10B	0-30	3/20/2015	300	378	445	41.5	35.1	116	412	5.19	188	159	9.65	15.6	9.35	**395**	96%
Pacer Ivy area	Soil	PI-10C	0-30	3/20/2015	300	2,150	2,440	244	194	154	505	14.2	737	606	67.8	27.4	14.7	**2,220**	97%
Pacer Ivy area	Soil	PI-10	0-30	3/20/2015	300	606	710	116	97.6	157	490	5.96	284	270	89.8	56.4	16.4	**637**	95%
Pacer Ivy area	Soil	PI-10A	30-60	3/19/2015	300	100	127	32.6	47.1	140	376	1.71	125	163	129	88.4	20.3	118	85%
Pacer Ivy area	Soil	PI-10B	30-60	3/19/2015	300	75.0	86.3	9.43	12.1	31.4	121	1.01	29.0	34.2	2.34	3.59	2.71	79.1	95%
Pacer Ivy area	Soil	PI-10C	30-60	3/19/2015	300	147	171	16.5	25.4	25.0	104	0.0221	46.6	45.1	3.92	3.64	3.04	153	96%
Pacer Ivy area	Soil	PI-10	30-60	3/19/2015	300	109	131	29.1	31.2	56.8	185	1.22	68.5	75.1	39.9	24.8	5.52	117	93%
Pacer Ivy area	Soil	PI-10A	60-90	3/19/2015	300	54.2	114	58.3	94.2	130	226	1.36	232	272	256	137	22.5	80.7	67%
Pacer Ivy area	Soil	PI-10B	60-90	3/19/2015	300	36.9	39.2	1.64	3.10	24.1	79.3	0.551	15.6	ND	0.566	1.34	1.75	39.1	94%
Pacer Ivy area	Soil	PI-10C	60-90	3/19/2015	300	11.2	11.7	ND	1.30	3.22	25.4	0.0215	3.23	4.01	ND	0.526	ND	11.7	96%
Pacer Ivy area	Soil	PI-10	60-90	3/19/2015	300	42.5	75.4	33.0	29.1	61.8	136	0.972	136	127	110	74.8	11.4	54.5	78%
Pacer Ivy area	Soil	PI-11	0-30	4/6/2015	300	203	247	91.6	95.3	78.1	517	1.46	105	88.5	18.0	10.3	8.74	221	92%
Pacer Ivy area	Soil	PI-11	30-60	3/25/2015	300	30.8	34.5	6.20	15.1	72.1	682	0.314	17.2	0.780	2.44	4.97	4.57	32.6	94%
Pacer Ivy area	Soil	PI-11	60-90	3/24/2015	300	34.8	45.6	8.62	22.0	81.3	772	0.363	16.1	11.0	3.04	6.42	4.29	36.3	96%
Pacer Ivy area	Soil	PI-12A	0-30	3/21/2015	300	1,210	1,530	659	928	877	1,640	8.13	462	431	41.5	40.0	30.9	**1,290**	94%
Pacer Ivy area	Soil	PI-12B	0-30	3/21/2015	300	2,700	3,520	1,430	1,870	1,640	2,390	16.4	992	854	106	75.6	41.0	**2,870**	94%
Pacer Ivy area	Soil	PI-12C	0-30	3/21/2015	300	2,170	2,900	1,250	1,940	2,170	2,620	12.2	888	854	113	38.9	48.9	**2,340**	93%
Pacer Ivy area	Soil	PI-12	0-30	3/21/2015	300	2,030	2,670	1,110	1,610	1,520	2,280	13.4	727	706	127	72	38.1	**2,170**	94%
Pacer Ivy area	Soil	PI-12A	30-60	4/2/2015	300	160	200	78.6	171	227	847	0.972	54.8	41.2	13.0	9.31	6.99	175	91%
Pacer Ivy area	Soil	PI-12B	30-60	4/2/2015	300	726	955	291	336	339	1,250	2.68	174	149	37.8	23.0	19.0	**759**	96%
Pacer Ivy area	Soil	PI-12C	30-60	4/2/2015	300	930	1,290	578	758	697	1,360	5.24	333	248	53.7	31.1	21.2	**1,000**	93%
Pacer Ivy area	Soil	PI-12	30-60	4/2/2015	300	521	704	238	428	388	1,090	3.85	183	116	11.8	ND	14.3	**560**	93%
Pacer Ivy area	Soil	PI-12A	60-90	4/1/2015	300	36.2	41.0	11.8	36.9	69.6	597	0.197	15.2	10.9	2.08	0.789	2.16	40.0	91%
Pacer Ivy area	Soil	PI-12B	60-90	4/1/2015	300	194	257	89.3	143	190	918	0.874	65.4	54.4	6.05	8.54	7.77	207	94%
Pacer Ivy area	Soil	PI-12C	60-90	4/1/2015	300	611	808	302	503	613	1,100	2.92	204	164	33.9	23.0	17.1	**656**	93%
Pacer Ivy area	Soil	PI-12	60-90	4/1/2015	300	278	307	43.1	245	321	864	0.0212	105	84.0	0.462	7.52	7.19	**288**	97%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Pacer Ivy area	Soil	PI-13A	0-30	11/12/2014	300	219	259	125	711	4,020	17,500	1.96	112	252	445	545	323	**299**	73%
Pacer Ivy area	Soil	PI-13B	0-30	11/11/2014	300	18.5	20.3	1.60	21.3	149	813	0.0786	3.33	8.75	13.3	20.9	18.8	20.9	89%
Pacer Ivy area	Soil	PI-13C	0-30	11/12/2014	300	14.4	17.4	4.51	50.6	535	2,080	0.222	19.3	20.9	31.8	75.2	74.5	22.1	65%
Pacer Ivy area	Soil	PI-13	0-30	11/17/2014	300	74.4	87.3	53.1	335	1,540	5,920	0.717	40.6	76.9	135	166	114	266.3	28%
Pacer Ivy area	Soil	PI-13	30-60	11/17/2014	300	50.0	55.9	17.5	183	2,030	6,700	0.484	53.8	58.1	75.8	166	124	73.7	68%
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	300	8.29	23.5	50.4	314	1,630	5,140	1.92	110	138	204	263	184	48.1	17%
Pacer Ivy area	Soil	PI-14	30-60	11/21/2014	300	0.131	1.66	4.41	34.1	216	906	0.0159	25.0	27.2	36.8	44.9	34.1	5.01	3%
Southeast area	Soil	SE-01	0-30	4/11/2015	300	8.60	17.4	31.8	231	1,630	8,290	0.115	14.0	62.3	181	213	126	36.9	0.2
Southeast area	Soil	SE-01	30-60	4/11/2015	300	19.2	23.9	19.6	109	849	4,360	0.160	4.12	44.2	75.4	109	56.5	34.5	56%
Southeast area	Soil	SE-02	0-30	4/10/2015	300	55.1	63.2	20.0	48.5	274	1,140	0.449	22.5	36.6	38.4	45.8	40.1	64.5	85%
Southeast area	Soil	SE-02	30-60	4/10/2015	300	27.0	29.0	3.51	38.3	196	836	0.184	9.41	9.32	5.70	32.1	25.2	31.7	85%
Southwest area	Soil	SW-01A	0-30	11/6/2014	300	19,900	20,400	123	100	195	615	6.02	1,580	971	111	39.7	24.4	**20,000**	100%
Southwest area	Soil	SW-01B	0-30	11/10/2014	300	21,700	22,200	143	90.3	431	1,340	17.6	2,940	970	81.4	68.7	56.2	**21,800**	100%
Southwest area	Soil	SW-01C	0-30	11/10/2014	300	1,230	1,250	5.72	75.0	330	1,210	0.0910	33.4	36.9	41.5	62.6	32.5	**1,240**	99%
Southwest area	Soil	SW-01	0-30	11/13/2014	300	10,900	11,200	126	123	344	1,110	7.86	1,370	647	101	56.4	36.9	**10,900**	100%
Southwest area	Soil	SW-01A	30-60	11/10/2014	300	111,000	113,000	314	160	116	341	11.7	9,000	4,690	346	22.3	28.9	**111,000**	100%
Southwest area	Soil	SW-01B	30-60	11/11/2014	300	26,600	27,200	84.1	46.3	460	1,510	14.2	2,900	974	72.7	72.8	63.6	**26,600**	100%
Southwest area	Soil	SW-01C	30-60	11/11/2014	300	357	366	ND	12.2	67.0	415	0.401	3.46	16.8	8.65	14.2	9.59	**359**	99%
Southwest area	Soil	SW-01	30-60	11/15/2014	300	40,900	41,900	156	88.4	205	675	11.3	4,070	1,940	210	47.4	33.8	**41,000**	100%
Southwest area	Soil	SW-01A	60-90	11/10/2014	300	13,800	14,200	46.7	29.8	25.3	94.7	1.14	1,120	501	41.5	8.63	5.51	**13,800**	100%
Southwest area	Soil	SW-01B	60-90	11/10/2014	300	497	510	ND	3.86	33.8	202	0.353	52.8	16.8	2.78	15.0	19.8	**499**	100%
Southwest area	Soil	SW-01C	60-90	11/11/2014	300	24.0	24.0	ND	ND	19.3	109	0.0565	ND	ND	ND	1.85	2.29	25.6	94%
Southwest area	Soil	SW-01	60-90	11/15/2014	300	4,880	5,020	ND	8.30	31.4	138	0.684	447	214	27.9	10.2	12.6	**4,880**	100%
Southwest area	Soil	SW-01	90-120	11/17/2014	300	61.2	61.2	ND	2.13	15.8	113	0.0351	48.9	ND	1.28	4.17	5.24	62.0	99%
Southwest area	Soil	SW-01A	120-150	11/10/2014	300	2,680	2,750	12.4	9.79	24.9	148	0.270	216	107	11.0	12.1	14.9	**2,680**	100%
Southwest area	Soil	SW-01B	120-150	11/10/2014	300	1,230	1,270	4.11	5.44	32.7	183	0.528	81.8	38.3	1.38	3.91	5.18	**1,230**	100%
Southwest area	Soil	SW-01C	120-150	11/11/2014	300	13.6	13.6	ND	0.544	12.3	90.3	0.0225	ND	ND	ND	2.02	1.32	14.2	96%
Southwest area	Soil	SW-01	120-150	11/17/2014	300	1,370	1,410	4.28	1.75	16.2	127	0.265	100	52.9	5.04	8.59	11.4	**1,370**	100%
Southwest area	Soil	SW-02A	0-30	11/10/2014	300	7,710	8,240	280	518	1,800	4,980	67.2	7,230	4,310	244	216	154	**7,880**	98%
Southwest area	Soil	SW-02B	0-30	11/11/2014	300	163	183	4.26	81.4	489	1,770	0.140	49.5	48.9	52.5	136	88.5	170	96%
Southwest area	Soil	SW-02C	0-30	11/11/2014	300	110	110	5.77	24.5	148	637	0.0850	13.9	9.09	6.68	13.4	16.4	115	96%
Southwest area	Soil	SW-02	0-30	11/15/2014	300	2,480	2,690	159	298	1,120	2,930	33.5	3,520	2,040	169	151	96.2	**2,560**	97%
Southwest area	Soil	SW-02A	30-60	11/10/2014	300	825	848	15.8	44.9	219	934	2.19	194	137	21.5	42.9	36.2	**830**	99%
Southwest area	Soil	SW-02B	30-60	11/11/2014	300	310	319	2.65	9.85	17.3	166	0.379	7.35	7.76	4.90	11.7	7.82	**311**	100%
Southwest area	Soil	SW-02C	30-60	11/11/2014	300	11.6	15.0	0.605	7.27	68.8	250	0.0488	6.01	4.57	4.42	14.9	11.6	12.7	91%
Southwest area	Soil	SW-02	30-60	11/15/2014	300	328	341	8.54	23.0	99.0	433.0	0.775	61.5	40.1	10.7	21.8	15.3	**332**	99%
Southwest area	Soil	SW-02	60-90	11/15/2014	300	70.0	72.8	0.791	9.15	50.1	228	0.468	67.1	22.7	4.25	10.7	8.41	71.6	98%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Southwest area	Soil	SW-03A	0-30	11/10/2014	300	1,850	1,930	105	210	752	3,180	2.83	221	244	140	187	129	1,880	98%
Southwest area	Soil	SW-03B	0-30	11/10/2014	300	613	660	71.3	171	932	3,610	1.49	106	119	119	180	106	641	96%
Southwest area	Soil	SW-03C	0-30	11/10/2014	300	123	158	56.0	131	614	1.0	0.599	53.6	55.2	46.7	72.0	44.7	142	87%
Southwest area	Soil	SW-03	0-30	11/15/2014	300	722	771	64.4	160	734	2,880	1.55	114	122	89.0	141	118	746	97%
Southwest area	Soil	SW-03A	30-60	11/10/2014	300	1,650	1,720	65.5	165	730	3,500	1.53	153	171	143	180	103	1,680	98%
Southwest area	Soil	SW-03B	30-60	11/10/2014	300	101	106	8.73	34.6	820	7,500	0.184	3.43	14.6	16.8	237	679	114	89%
Southwest area	Soil	SW-03C	30-60	11/10/2014	300	9.14	9.80	0.956	3.30	54.5	314	0.0214	1.18	ND	4.48	12.6	14.6	10.1	90%
Southwest area	Soil	SW-03	30-60	11/15/2014	300	541	561	11.0	57.8	240	1,160	0.562	42.4	51.9	45.8	57.3	31.8	550	98%
Southwest area	Soil	SW-03A	60-90	11/10/2014	300	1,160	1,250	61.5	132	323	1,370	1.09	148	95.6	53.1	64.4	35.8	1,180	98%
Southwest area	Soil	SW-03B	60-90	11/10/2014	300	36.5	36.5	1.89	32.3	150	531	0.0221	4.19	3.24	5.43	20.2	14.5	38.4	95%
Southwest area	Soil	SW-03C	60-90	11/10/2014	300	5.88	5.88	ND	3.95	49.4	278	0.0223	ND	ND	1.36	3.62	5.32	6.81	86%
Southwest area	Soil	SW-03	60-90	11/15/2014	300	441	468	12.3	67.0	168	762	0.474	65.1	48.6	29.0	33.4	28.8	445	99%
Southwest area	Soil	SW-04	0-30	11/19/2014	300	28.4	32.6	20.9	93.8	531	2,240	0.268	30.1	30.0	82.4	165	143	41.4	69%
Southwest area	Soil	SW-04	30-60	11/21/2014	300	10.8	16.0	6.58	43.8	261	970	0.0232	16.0	11.5	28.6	72.9	57.9	15.0	72%
Southwest area	Soil	SW-04	60-90	11/21/2014	300	8.51	11.0	4.76	23.9	214	1,150	0.0214	5.73	8.57	29.5	84.1	77.7	12.2	70%
Southwest area	Soil	SW-06A	0-30	11/6/2014	300	49.3	69.7	17.1	23.1	372	1,320	0.363	61.0	51.8	17.2	41.7	34.6	57.3	86%
Southwest area	Soil	SW-06B	0-30	11/7/2014	300	48.2	53.1	4.16	19.9	195	756	0.267	13.4	4.86	6.74	28.6	30.6	52.4	92%
Southwest area	Soil	SW-06C	0-30	11/7/2014	300	56.3	71.1	15.1	90.5	783	3,780	0.328	59.6	27.2	49.0	139	153	71.0	79%
Southwest area	Soil	SW-06	0-30	11/12/2014	300	53.0	77.3	33.3	74.3	396	1,570	0.394	49.8	47.4	41.4	66.9	57.6	62.8	84%
Southwest area	Soil	SW-06	30-60	11/13/2014	300	13.3	16.8	5.72	41.0	428	1,820	0.115	10.8	10.0	24.4	64.0	71.2	20.1	66%
Southwest area	Soil	SW-06	60-90	11/14/2014	300	40.9	43.1	11.1	40.6	403	1,520	0.183	28.0	40.5	33.7	66.5	82.4	49.2	83%
Southwest area	Soil	SW-07A	0-30	11/13/2014	300	656	709	43.5	115	641	3,620	0.727	108	104	79.0	103	68.8	674	97%
Southwest area	Soil	SW-07B	0-30	11/13/2014	300	302	332	31.7	61.1	302	1,120	0.707	44.4	54.6	28.6	43.9	28.0	311	97%
Southwest area	Soil	SW-07C	0-30	11/13/2014	300	171	193	75.2	229	1,710	5,920	3.04	113	175	125	212	140	210	81%
Southwest area	Soil	SW-07	0-30	11/15/2014	300	383	418	53.4	154	916	3,380	1.63	95.0	121	86.2	121	80.3	406	94%
Southwest area	Soil	SW-07A	30-60	11/13/2014	300	227	237	7.58	27.8	154	789	0.0211	24.2	24.1	18.2	21.5	17.1	231	98%
Southwest area	Soil	SW-07B	30-60	11/13/2014	300	187	201	10.4	29.5	154	529	0.0218	25.8	23.7	11.9	17.5	13.2	192	97%
Southwest area	Soil	SW-07C	30-60	11/13/2014	300	67.4	84.2	20.3	89.7	903	3,010	0.613	25.0	31.5	45.4	99.2	58.0	81.4	83%
Southwest area	Soil	SW-07	30-60	11/17/2014	300	161	173	14.1	45.6	400	1,470	0.340	25.9	27.7	25.3	45.4	28.8	169	95%
Southwest area	Soil	SW-07A	60-90	11/13/2014	300	214	217	4.58	27.8	207	1,130	0.233	21.4	21.1	18.7	34.3	23.4	219	98%
Southwest area	Soil	SW-07B	60-90	11/12/2014	300	162	178	7.94	34.0	330	1,230	0.366	25.6	22.0	13.1	22.9	19.3	168	96%
Southwest area	Soil	SW-07C	60-90	11/13/2014	300	57.5	62.3	4.65	29.6	224	743	1.06	25.4	28.6	14.8	31.4	18.7	64.5	89%
Southwest area	Soil	SW-07	60-90	11/17/2014	300	124	134	9.18	27.4	204	822	0.377	26.6	20.4	15.7	29.1	21.1	129	96%
Southwest area	Soil	SW-08	0-30	11/18/2014	300	30.4	44.6	44.2	270	2,160	7,870	0.310	46.6	94.4	205	387	279	60.8	50%
Southwest area	Soil	SW-08A	30-60	11/14/2014	300	125	143	28.6	173	1,040	4,290	1.29	54.1	90.5	126	196	158	149	84%
Southwest area	Soil	SW-08B	30-60	11/14/2014	300	190	210	35.4	214	1,650	6,260	0.0453	53.9	94.8	176	272	208	216	88%
Southwest area	Soil	SW-08C	30-60	11/14/2014	300	22.9	28.6	12.7	154	1,270	5,110	0.195	12.4	47.6	118	197	158	44.4	52%
Southwest area	Soil	SW-08	30-60	11/18/2014	300	150	166	29.6	185	1,490	6,570	0.561	48.3	82.6	139	270	213	171	88%
Southwest area	Soil	SW-08	60-90	11/18/2014	300	32.7	37.6	4.53	61.2	508	2,030	0.0204	9.52	19.7	38.8	75.4	64.4	40.7	80%

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Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Z1 area	Soil	Z1-01-BIO	0-100	4/14/2015	1,200	2.36	2.37	ND	1.19	ND	150	0.0209	ND	ND	ND	ND	0.899	3.00	79%
Z1 area	Soil	Z1-01-Landfill	0-100	4/14/2015	1,200	1,480	1,580	73.2	86.0	246	1,030	1.43	301	234	78.4	20.2	19.6	1,510	98%
Z1 area	Soil	Z1-02A	0-30	3/25/2015	300	834	921	93.6	88.5	186	635	2.58	193	207	40.6	27.4	16.5	865	96%
Z1 area	Soil	Z1-02B	0-30	3/25/2015	300	161	162	ND	2.40	60.9	344	0.133	1.78	15.0	0.437	8.04	7.50	162	99%
Z1 area	Soil	Z1-02C	0-30	3/25/2015	300	27.7	28.9	1.13	1.24	41.5	226	0.0208	0.646	1.68	1.53	2.79	4.48	28.4	98%
Z1 area	Soil	Z1-02	0-30	3/25/2015	300	322	349	33.3	41.9	104	447	1.04	61.8	62.0	18.1	12.2	9.68	333	97%
Z1 area	Soil	Z1-02A	60-90	3/24/2015	300	445	471	23.6	31.7	66.0	247	0.493	55.4	53.8	11.0	9.75	5.27	452	98%
Z1 area	Soil	Z1-02B	60-90	3/24/2015	300	81.1	85.5	3.49	7.20	29.7	151	0.0202	8.35	10.3	4.25	3.48	2.05	82.4	98%
Z1 area	Soil	Z1-02C	60-90	3/24/2015	300	44.0	46.0	1.52	4.33	16.1	124	0.0209	6.07	6.54	1.61	2.11	1.60	44.9	98%
Z1 area	Soil	Z1-02	60-90	3/24/2015	300	202	216	11.7	17.9	46.00	216	0.212	26.4	23.8	6.99	5.91	3.54	206	98%
Z1 area	Soil	Z1-02	120-150	4/3/2015	300	20.2	21.3	0.811	2.06	8.00	44.7	0.0366	3.06	2.02	0.330	0.815	0.484	20.8	97%
Z1 area	Soil	Z1-02	180-210	4/4/2015	300	25.1	27.8	2.42	3.92	15.4	72.8	0.0983	4.85	5.76	0.825	1.98	1.35	25.8	97%
Z1 area	Soil	Z1-02	240-270	4/4/2015	300	33.2	34.6	1.55	2.32	3.35	33.0	0.00990	2.89	3.91	ND	0.906	0.856	34.2	97%
Z1 area	Soil	Z1-02	300-330	4/6/2015	300	24.8	25.2	0.988	2.01	8.14	34.3	0.0456	2.17	ND	ND	ND	0.758	25.6	97%
Z1 area	Soil	Z1-02	360-390	4/6/2015	300	32.2	33.9	1.10	2.62	8.56	40.6	0.021	2.34	ND	ND	0.691	1.24	33.2	97%
Z1 area	Soil	Z1-03	0-30	12/3/2014	300	49.7	53.4	ND	11.3	73.2	412	0.0487	12.4	8.6	4.77	15.3	13.8	512.1	10%
Z1 area	Soil	Z1-03A	60-90	11/27/2014	300	85.0	91.7	6.67	9.03	16.8	98.0	0.0200	16.3	12.4	2.42	3.26	2.41	86.5	98%
Z1 area	Soil	Z1-03B	60-90	11/27/2014	300	92.1	104	9.20	11.3	35.4	158	0.0209	15.3	14.5	8.00	9.50	5.60	95.8	96%
Z1 area	Soil	Z1-03C	60-90	11/27/2014	300	2.18	2.84	1.23	1.47	12.3	56.3	0.0218	ND	0.653	1.00	2.58	1.43	3.25	67%
Z1 area	Soil	Z1-03	60-90	12/2/2014	300	81.0	88.5	5.05	8.43	18.2	82.6	0.0720	21.8	12.2	1.53	4.12	2.83	90.5	90%
Z1 area	Soil	Z1-03	120-150	12/2/2014	300	3.21	3.80	ND	1.68	8.40	41.5	0.000222	0.911	0.607	ND	ND	ND	5.6	57%
Z1 area	Soil	Z1-03	180-210	12/2/2014	300	3.54	3.54	ND	ND	2.05	18.1	0.0214	ND	0.446	ND	ND	ND	4.03	88%
Z1 area	Soil	Z1-03	240-270	12/2/2014	300	2.17	ND	ND	ND	1.32	18.7	0.0217	ND	ND	ND	ND	ND	0.702	309%
Z1 area	Soil	Z1-03	300-330	12/4/2014	300	0.226	ND	ND	ND	2.68	15.9	0.0226	ND	ND	ND	ND	ND	0.728	31%
Z1 area	Soil	Z1-03	360-390	12/4/2014	300	2.59	2.59	ND	ND	4.33	23.1	0.0213	ND	ND	ND	ND	0.438	3.08	84%
Z1 area	Soil	Z1-04	0-30	12/3/2014	1,200	45.3	49.5	10.7	17.7	74.4	380	0.123	19.1	23.0	18.4	15.7	12.5	49.9	91%
Z1 area	Soil	Z1-04	60-90	11/29/2014	1,200	6.08	6.75	1.41	0.735	6.13	54.6	0.0228	1.37	1.44	ND	0.802	2.04	7.30	83%
Z1 area	Soil	Z1-04	120-150	12/1/2014	1,200	5.61	7.67	1.25	1.48	6.62	46.5	0.0221	0.703	2.13	2.45	1.39	4.56	7.53	75%
Z1 area	Soil	Z1-04	180-210	12/1/2014	1,200	8.88	8.88	ND	ND	8.46	52.9	0.0221	ND	ND	ND	ND	1.46	9.41	94%
Z1 area	Soil	Z1-04	240-270	11/29/2014	1,200	3.65	3.65	ND	ND	4.73	45.0	0.0223	ND	0.683	ND	ND	0.652	4.17	88%
Z1 area	Soil	Z1-04	300-330	12/1/2014	1,200	10.3	10.7	ND	0.433	2.51	43.5	0.0212	ND	0.81	ND	ND	0.543	10.8	95%
Z1 area	Soil	Z1-04	360-390	12/3/2014	1,200	3.78	3.78	ND	ND	4.18	41.7	0.0208	ND	0.537	ND	ND	0.478	4.26	89%
Z1 area	Soil	Z1-05	0-30	12/4/2014	300	41.8	46.3	8.92	42.8	348.0	1,130	0.267	17.8	23.1	23.1	36.0	26.0	48.2	87%
Z1 area	Soil	Z1-05	30-60	12/4/2014	300	8.50	11.3	2.90	16.1	113	433	0.815	9.43	11.5	16.5	20.5	10.2	11.3	75%
Z1 area	Soil	Z1-05	60-90	12/4/2014	300	3.09	3.09	ND	6.07	34.6	134	0.0225	1.15	1.96	ND	4.62	3.67	4.00	77%
Z1 area	Soil	Z1-06A	0-30	3/18/2015	300	303	341	50.3	20.4	81.7	312	1.62	111	146	24.8	6.71	8.41	325	93%
Z1 area	Soil	Z1-06B	0-30	3/18/2015	300	140	160	28.7	22.8	16.0	149	1.10	65.3	74.9	12.0	4.49	5.99	152	92%
Z1 area	Soil	Z1-06C	0-30	3/18/2015	300	226	238	32.2	37.7	67.9	225	0.375	48.6	57.2	26.3	10.4	5.60	237	95%
Z1 area	Soil	Z1-06	0-30	3/18/2015	300	192	214	35.0	32.9	54.5	209	1.04	62.0	80.4	18.5	7.80	5.53	205	94%

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Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight) 2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	PCDF (ppt TEQ; ND = 1/2 DL) (dry weight) 2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF	Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
Z1 area	Soil	Z1-06	30-60	3/18/2015	300	11.7	14.4	2.70	4.50	8.3	47.7	0.110	4.20	4.94	1.30	ND	0.895	12.8	91%
Z1 area	Soil	Z1-06	60-90	3/20/2015	300	30.1	34.5	5.37	6.47	5.89	63.4	0.133	7.38	12.0	3.02	1.73	1.13	31.7	95%
Z1 area	Soil	Z1-06	120-150	4/3/2015	300	12.2	13.8	2.96	ND	6.45	38.6	0.0201	4.13	6.38	1.02	0.695	0.820	14.0	87%
Z1 area	Soil	Z1-06	180-210	4/2/2015	300	15.9	16.8	0.608	1.75	5.86	35.9	0.0212	4.21	5.14	0.567	ND	0.692	16.4	97%
Z1 area	Soil	Z1-07A	0-30	4/10/2015	300	120	148	35.7	65.5	470	2,130	0.854	80.0	72.4	77.7	102	50.9	129	93%
Z1 area	Soil	Z1-07B	0-30	4/10/2015	300	170	193	26.1	74.0	484	2,200	0.684	64.4	62.5	83.9	170	134	184	92%
Z1 area	Soil	Z1-07C	0-30	4/10/2015	300	165	182	24.6	67.7	258	1,080	0.0202	43.9	56.6	37.4	23.1	36.8	175	94%
Z1 area	Soil	Z1-07	0-30	4/10/2015	300	153	174	35.0	82.6	414	1,960	0.650	57.1	67.4	77.4	123	91.0	168	91%
Z1 area	Soil	Z1-07A	30-60	4/9/2015	300	226	241	14.5	22.9	82.6	270	0.921	52.3	59.1	18.6	16.9	11.3	233	97%
Z1 area	Soil	Z1-07B	30-60	4/9/2015	300	48.8	53.7	4.23	39.6	329	1,460	0.0	15.4	18.6	41.8	103	96.5	53.5	91%
Z1 area	Soil	Z1-07C	30-60	4/9/2015	300	429	457	33.3	61.6	87.4	234	0.0208	82.5	90.2	23.6	14.9	11.1	438	98%
Z1 area	Soil	Z1-07	30-60	4/9/2015	300	265	283	27.4	49.7	153	641	0.722	60.2	68.7	36.3	50.5	40.1	274	97%
Z1 area	Soil	Z1-07	60-90	4/7/2015	300	10.2	11.8	4.11	24.3	177	953	0.0677	3.69	12.8	29.0	58.9	52.9	13.9	73%
Z1 area	Soil	Z1-07	120-150	4/7/2015	300	8.38	8.37	ND	ND	12.3	50.1	0.0207	1.90	2.26	0.592	2.73	2.42	8.92	94%
Z1 area	Soil	Z1-07	180-210	4/7/2015	300	3.36	3.36	ND	1.66	21.2	102	0.0207	ND	2.21	4.32	4.99	2.10	4.06	83%
Z1 area	Soil	Z1-08A	0-30	11/19/2014	300	3.02	5.87	11.6	383	6,770	35,100	0.220	13.1	195	809	1,060	357	104	3%
Z1 area	Soil	Z1-08B	0-30	11/20/2014	300	8.47	11.4	11.8	49.4	271	1,180	0.0220	6.61	7.78	28.8	54.8	52.6	16.1	53%
Z1 area	Soil	Z1-08C	0-30	11/20/2014	300	3.79	6.03	4.00	40.7	308	1,370	0.0214	4.63	15.0	54.9	90.9	58.0	10.3	37%
Z1 area	Soil	Z1-08	0-30	11/25/2014	300	9.46	25.2	53.0	259	3,410	20,900	0.620	29.9	170	457	531	238	107	9%
Z1 area	Soil	Z1-08	30-60	11/26/2014	300	4.82	4.8	2.64	62.3	818	4,520	0.100	7.01	33.5	120	135	70.7	17.4	28%
Z1 area	Soil	Z1-08	60-90	11/26/2014	300	10.6	10.6	1.35	41.8	551	2,990	0.0273	9.80	20.3	65.9	84.2	47.4	18.5	57%
Z1 area	Soil	Z1-11A	0-30	11/26/2014	300	128	157	32.1	173	1,240	4,570	1.29	111	88.6	89.3	164	125	151	85%
Z1 area	Soil	Z1-11B	0-30	11/27/2014	300	62.4	68.1	20.2	115	695	2,340	0.488	24.2	36.8	51.4	88.7	62.4	75.7	82%
Z1 area	Soil	Z1-11C	0-30	11/27/2014	300	33.1	37.9	18.6	127	925	3,650	0.0220	17.0	33.3	87.7	182	137	49.9	66%
Z1 area	Soil	Z1-11	0-30	12/1/2014	300	78.4	92.8	32.3	136	926	3,470	0.698	47.7	58.0	77.1	172	118	93.9	83%
Z1 area	Soil	Z1-11	30-60	12/2/2014	300	23.5	27.3	10.0	61.4	532	2,010	0.150	11.4	19.7	59.2	147	153	31.1	76%
Z1 area	Soil	Z1-11	60-90	12/3/2014	300	7.16	7.16	ND	ND	144	761	0.0214	3.05	5.86	0.695	42.2	40.2	8.88	81%
Z1 area	Soil	Z1-12	0-30	4/14/2015	1,200	3.84	4.47	3.33	28.7	197	1,130	0.0775	3.80	10.8	21.5	39.6	36.8	7.18	53%
Z1 area	Soil	Z1-12	30-60	4/13/2015	1,200	2.20	2.65	1.18	11.9	109	599	0.0389	2.99	4.42	12.9	27.1	29.0	3.47	63%
Z1 area	Soil	Z1-13A	0-30	12/2/2014	300	81.6	90.3	14.5	81.7	584	2,060	0.667	30.8	40.8	52.7	81.3	51.5	90.8	90%
Z1 area	Soil	Z1-13B	0-30	12/2/2014	300	72.7	80.0	16.0	84.4	751	2,850	0.309	19.0	28.2	60.1	99.2	61.5	85.0	86%
Z1 area	Soil	Z1-13C	0-30	12/3/2014	300	38.7	43.8	10.7	78.4	469	1,710	0.202	13.3	19.8	41.2	79.0	52.5	47.8	81%
Z1 area	Soil	Z1-13	0-30	12/4/2014	300	55.6	61.5	19.2	85.8	596	2,040	0.356	22.1	27.9	50.9	85.5	53.1	103.2	54%
Z1 area	Soil	Z1-13	30-60	12/4/2014	300	17.3	19.7	2.79	24.5	163	618	0.0278	5.42	9.42	14.6	24.4	16.4	20.5	84%
Z1 area	Soil	Z1-13	60-90	12/4/2014	300	6.60	6.60	0.454	8.08	99.4	520	0.0194	0.453	2.47	0.615	14.8	9.87	7.82	84%
Z1 area	Soil	Z1-16A	0-30	4/10/2015	300	148	160	5.69	20.6	41.9	165	0.834	42.4	57.7	11.1	5.24	5.35	150	99%
Z1 area	Soil	Z1-16B	0-30	4/10/2015	300	847	984	155	83.0	45.1	131	5.27	366	371	20.9	3.24	3.49	900	94%
Z1 area	Soil	Z1-16C	0-30	4/10/2015	300	115	139	37.5	40.7	59.1	173	1.16	147	62.0	5.74	7.80	3.64	130	88%
Z1 area	Soil	Z1-16	0-30	4/10/2015	300	352	409	60.5	43.3	43.2	157	2.48	154	145	14.6	6.98	3.95	435.6	81%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Z1 area	Soil	Z1-16	30-60	4/10/2015	300	20.8	23.7	3.34	3.61	5.52	28.9	0.147	9.29	9.23	1.39	0.762	0.530	222.2	9%
Z1 area	Soil	Z1-16	60-90	4/10/2015	300	86.5	97.3	14.4	8.51	5.15	24.2	0.517	30.7	27.6	2.23	0.472	0.417	91.4	95%
Z1 area	Soil	Z1-16	120-150	4/10/2015	300	19.7	21.4	3.33	0.672	1.57	19.6	0.117	5.67	5.74	ND	ND	0.491	21.2	93%
Z1 area	Soil	Z1-16	180-210	4/9/2015	300	13.6	15.7	2.01	1.21	3.01	23.1	0.0845	3.92	4.94	0.172	0.191	0.220	14.6	93%
Z1 area	Soil	Z1-17	0-30	4/13/2015	1,200	12.9	22.2	1.36	5.55	47.8	317	0.0567	4.13	3.29	5.16	9.95	5.70	13.6	95%
Z1 area	Soil	Z1-17	60-90	4/11/2015	1,200	3.87	4.13	ND	ND	3.81	27.3	0.0246	0.823	0.276	ND	0.226	0.300	4.08	95%
Z1 area	Soil	Z1-17	120-150	4/13/2015	1,200	1.92	1.92	ND	0.153	1.80	17.8	0.00735	0.379	0.356	ND	ND	ND	2.10	91%
Z1 area	Soil	Z1-17	180-210	4/13/2015	1,200	5.98	5.98	ND	1.88	ND	30.4	0.0214	ND	ND	ND	ND	0.465	6.47	92%
Z1 area	Soil	Z1-17	240-270	4/14/2015	1,200	0.219	ND	1.02	ND	1.43	21.7	0.0219	ND	ND	ND	ND	0.481	0.697	31%
Z1 area	Soil	Z1-17	300-330	4/13/2015	1,200	1.42	1.42	ND	ND	ND	30.1	0.0223	ND	ND	ND	ND	ND	1.93	74%
Z1 area	Soil	Z1-17	360-390	4/13/2015	1,200	0.216	ND	ND	ND	2.66	18.4	0.0216	ND	0.541	ND	ND	ND	0.697	31%
Z1 taxiway area	Soil	ZT-01	0-30	4/11/2015	1,200	44.3	48.5	8.04	20.4	137	842	0.147	10.8	19.6	25.7	34.6	20.9	48.8	91%
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	1,200	4.28	4.49	ND	0.408	12.9	148	0.00730	0.580	1.26	0.509	0.869	1.47	4.59	93%
Z1 taxiway area	Soil	ZT-01	60-90	4/11/2015	1,200	63.7	67.2	4.07	5.34	49.3	322	0.094	9.47	9.14	3.77	4.85	11.5	64.7	98%
Z1 taxiway area	Soil	ZT-01	120-150	4/11/2015	1,200	41.4	43.6	3.13	11.0	78.1	509	0.104	7.61	3.24	6.76	19.3	18.0	43.6	95%
Z1 taxiway area	Soil	ZT-02A	0-30	11/27/2014	1,200	299	330	40.4	96.1	276	859	0.367	84.8	97.6	40.8	42.9	30.0	312	96%
Z1 taxiway area	Soil	ZT-02B	0-30	11/27/2014	1,200	3,390	3,720	124	92.2	221	1,080	3.22	788	504	63.9	26.5	41.1	**3,440**	99%
Z1 taxiway area	Soil	ZT-02C	0-30	11/27/2014	1,200	168	179	7.71	21.7	200	932	0.467	52.0	60.8	27.8	25.9	34.6	178	94%
Z1 taxiway area	Soil	ZT-02	0-30	12/1/2014	1,200	1,060	1,180	69.9	94.0	236	923	1.4	287	215	52.8	43.5	31.9	**1,080**	98%
Z1 taxiway area	Soil	ZT-02A	30-60	11/27/2014	1,200	68.4	74.6	7.64	22.8	123	382	0.116	23.7	34.9	4.91	25.9	13.7	73.2	93%
Z1 taxiway area	Soil	ZT-02B	30-60	11/27/2014	1,200	421	467	31.3	20.1	56.3	278	0.638	130	83.7	14.4	12.1	8.57	429	98%
Z1 taxiway area	Soil	ZT-02C	30-60	11/27/2014	1,200	44.7	48.6	6.31	5.96	53.2	367	0.0207	9.37	11.3	5.46	3.94	7.33	46.9	95%
Z1 taxiway area	Soil	ZT-02	30-60	12/2/2014	1,200	176	195	16.0	23.4	74.6	361	0.374	69.4	47.3	14.5	14.2	9.52	181	97%
Z1 taxiway area	Soil	ZT-02	60-90	12/2/2014	1,200	82.9	94.1	9.34	13.8	49.6	269	0.185	28.5	29.2	7.81	10.1	6.22	86.1	96%
Z1 taxiway area	Soil	ZT-04	0-30	12/2/2014	1,200	8.71	11.4	7.63	60.7	425	1,820	0.127	16.6	17.3	41.4	89.9	72.9	15.3	57%
Z1 taxiway area	Soil	ZT-04	30-60	12/3/2014	1,200	4.71	5.12	ND	10.1	110	588	0.0200	0.663	3.66	10.1	23.5	21.3	6.24	75%
Z1 taxiway area	Soil	ZT-04	60-90	12/4/2014	1,200	0.207	ND	0.444	6.60	67.8	430	0.0207	ND	1.89	5.48	15.0	12.7	1.32	16%
Z1 taxiway area	Soil	ZT-05	0-30	12/2/2014	1,200	3.83	4.29	4.02	46.4	374	1,680	0.0212	3.88	15.4	69.6	139	88.5	10.5	36%
Z1 taxiway area	Soil	ZT-05	30-60	12/2/2014	1,200	0.205	ND	ND	4.35	53.2	393	0.0205	ND	2.31	2.64	8.65	5.64	1.18	17%
Z1 taxiway area	Soil	ZT-05	60-90	12/4/2014	1,200	0.206	ND	ND	8.41	98.4	598	0.0206	ND	4.25	13.7	26.6	17.8	2.02	10%
Z1 taxiway area	Soil	ZT-06	0-30	12/4/2014	1,200	18.1	21.8	9.20	43.4	256	1,210	0.182	15.7	21.9	35.5	45.9	28.0	23.8	76%
Z1 taxiway area	Soil	ZT-06	30-60	12/4/2014	1,200	3.58	4.10	0.722	6.83	59.8	308	0.0217	1.89	4.58	9.26	12.0	6.81	4.93	73%
Z1 taxiway area	Soil	ZT-06	60-90	12/4/2014	1,200	0.180	ND	ND	1.48	31.9	201	0.0180	ND	0.822	1.47	2.61	8.26	0.939	19%
Z1 taxiway area	Soil	ZT-07	0-30	4/13/2015	1,200	85.9	92.7	1.64	7.16	29.7	226	0.0561	8.78	9.81	3.28	3.91	2.76	86.4	99%
Z1 taxiway area	Soil	ZT-07	30-60	4/13/2015	1,200	40.2	42.7	ND	3.19	11.5	146	0.00955	2.87	1.93	1.19	0.574	1.01	40.6	99%
Z1 taxiway area	Soil	ZT-07	60-90	4/10/2015	1,200	8.53	8.53	0.498	ND	17.3	ND	0.0205	ND	ND	ND	ND	1.86	9.42	91%
Z1 taxiway area	Soil	ZT-07	120-150	4/10/2015	1,200	0.201	ND	ND	0.935	9.17	141	0.0201	ND	0.407	ND	ND	0.663	0.785	26%

Table A14 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		

* ***Notes*** :

- %: percent
- cm: centimeter
- DL: detection limit
- DU: decision unit
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppt: part per trillion
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A15 Concentrations of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Bien Hung Lake	Sediment	BHL-01	0-15	4/14/2015	150	64.4	103.0	47.6	184	736	4,090	1.98	105	72.6	79.7	116	111	83.0	78%
Gate 2 Lake	Sediment	G2L-01	0-15	4/11/2015	150	149	174	44.7	110	372	2,570	0.889	78.7	70.1	76.0	86.6	88.8	**166**	90%
Gate 2 Lake	Sediment	G2L-01	15-30	4/13/2015	150	91.8	105	13.9	56.5	272	1,350	0.405	40.0	36.8	26.5	46.1	36.9	100	92%
Gate 2 Lake	Sediment	G2L-01	30-45	4/13/2015	150	52.5	60.5	8.02	24.8	114	515	0.315	21.6	20.4	12.8	19.9	16.3	56.5	93%
Northeast area	Sediment	NE-06	0-15	4/13/2015	150	68.8	78.8	7.81	13.9	48.6	273	0.422	16.6	10.5	4.63	5.98	5.36	71.5	96%
Northeast area	Sediment	NE-06	15-30	4/9/2015	150	43.2	49.0	4.49	3.90	20.6	94.2	0.172	8.41	0.750	ND	3.18	1.48	44.8	96%
Northeast area	Sediment	NE-06	30-45	4/10/2015	150	73.7	79.6	1.53	6.31	8.54	71.4	0.148	5.28	ND	1.17	1.90	2.26	74.5	99%
Northeast area	Sediment	NE-07	0-15	4/9/2015	150	1,200	1,590	270	116	108	468	6.0	454	341	47.4	25.5	14.9	**1,300**	92%
Northeast area	Sediment	NE-07	15-30	4/9/2015	150	753	838	35.5	3.22	14.7	108	1.03	153	92.9	8.62	2.98	5.07	**765**	98%
Northeast area	Sediment	NE-07	30-45	4/9/2015	150	53.1	66.8	10.2	16.9	ND	80.1	0.0202	24.0	10.3	ND	ND	2.27	54.0	98%
Northeast area	Sediment	NE-08A	0-15	4/7/2015	150	218	254	31.4	40.7	162	833	2.27	148	106	34.4	35.3	19.7	**223**	98%
Northeast area	Sediment	NE-08B	0-15	4/7/2015	150	203	243	39.9	41.1	125	688	1.99	91.7	65.7	16.8	10.3	16.2	**215**	94%
Northeast area	Sediment	NE-08C	0-15	4/7/2015	150	43.9	48.4	9.14	13.3	144	776	0.714	31.6	5.54	12.2	23.2	15.6	48.8	90%
Northeast area	Sediment	NE-08	0-15	4/7/2015	150	167	209	40.5	43.7	144	791	1.74	101	79.8	28.8	29.7	19.2	**179**	93%
Northeast area	Sediment	NE-08A	15-30	4/7/2015	150	146	167	20.8	17.5	78.1	407	1.35	104	73.0	8.80	15.6	11.2	**157**	93%
Northeast area	Sediment	NE-08B	15-30	4/7/2015	150	260	323	36.4	51.0	205	807	1.97	119	81.5	21.7	22.5	14.2	**265**	98%
Northeast area	Sediment	NE-08C	15-30	4/7/2015	150	50.5	70.6	6.74	9.21	80.2	421	0.682	31.9	22.6	13.9	20.8	12.0	52.7	96%
Northeast area	Sediment	NE-08	15-30	4/7/2015	150	190	228	33.2	29.4	111	545	1.97	102	78.7	11.2	25.2	14.1	**202**	94%
Northeast area	Sediment	NE-08A	30-45	4/7/2015	150	213	265	11.1	7.49	71.2	287	2.54	216	135	13.3	7.37	8.3	**217**	98%
Northeast area	Sediment	NE-08B	30-45	4/7/2015	150	116	146	23.9	23.2	64.4	259	0.866	46.1	35.2	2.36	5.58	7.58	122	95%
Northeast area	Sediment	NE-08C	30-45	4/7/2015	150	37.8	37.8	5.33	6.13	ND	327	0.0288	10.8	12.1	3.13	17.8	8.18	39.9	95%
Northeast area	Sediment	NE-08	30-45	4/7/2015	150	126	162	15.9	14.9	53.1	238	1.42	99.2	61.4	4.99	10.7	5.27	128	98%
Northeast area	Sediment	NE-09	0-15	3/25/2015	150	429	502	68.9	86.0	237	448	3.91	189	217	49.1	32.0	19.4	**448**	96%
Northeast area	Sediment	NE-09	15-30	3/24/2015	150	329	383	36.6	55.9	153	458	2.09	134	164	33.7	20.0	10.9	**334**	99%
Northeast area	Sediment	NE-09	30-45	3/23/2015	150	210	251	20.1	18.3	59.3	202	1.22	87.8	82.8	17.3	8.46	3.46	**216**	97%
Northeast area	Sediment	NE-10	0-15	4/10/2015	150	20.9	31.5	7.24	45.0	253	1,220	0.284	16.3	20.5	32.2	41.2	29.9	26.9	78%
Northeast area	Sediment	NE-10	15-30	4/8/2015	150	26.2	30.8	5.26	51.4	290	1,500	0.0207	14.7	15.9	32.7	48.0	38.7	33.7	78%
Northeast area	Sediment	NE-10	30-45	4/10/2015	150	21.4	21.4	1.29	30.3	207	1,070	0.0203	12.5	5.37	2.91	30.6	25.4	49.0	44%
Northeast area	Sediment	NE-11	0-15	4/4/2015	150	70.6	89.6	28.4	115	624	2,830	1.07	43.7	51.5	62.2	81.1	52.5	124.7	57%
Northeast area	Sediment	NE-11	15-30	4/4/2015	150	323	364	35.6	170	988	4,130	1.49	85.2	90.1	93.5	110	64.1	**366.8**	88%
Northeast area	Sediment	NE-11	30-45	4/4/2015	150	121	152	43.0	246	2,080	9,920	1.57	64.3	66.7	102	121	66.2	**174.0**	70%
Northeast area	Sediment	NE-12A	0-15	4/3/2015	150	247	284	22.7	171	917	2,990	0.562	62.7	50.0	82.4	109	71.7	**259**	95%
Northeast area	Sediment	NE-12B	0-15	4/3/2015	150	133	144	22.7	133	685	2,830	1.03	56.0	56.3	73.9	101	62.3	**148**	90%
Northeast area	Sediment	NE-12C	0-15	4/3/2015	150	117	135	11.1	134	858	3,460	0.958	48.6	56.7	84.2	111	77.2	133	88%
Northeast area	Sediment	NE-12	0-15	4/3/2015	150	167	195	41.8	142	771	3,310	0.909	59.8	69.1	85.9	114	73.1	**185**	90%

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Table A15 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Northeast area	Sediment	NE-12	15-30	4/9/2015	150	58.7	65.2	7.91	62.8	306	1,520	0.416	30.1	18.6	21.7	41.4	29.0	64.5	91%
Northeast area	Sediment	NE-12	30-45	4/9/2015	150	44.8	53.4	1.19	11.4	148	682	0.281	36.3	14.3	17.3	8.98	13.1	47.1	95%
Northeast area	Sediment	NE-13	0-15	4/9/2015	150	63.7	82.2	30.6	112	635	2,770	0.473	45.5	59.9	74.7	107	71.6	77.6	82%
Northeast area	Sediment	NE-13	15-30	4/9/2015	150	78.2	94.7	12.9	117	706	2,740	0.556	44.0	61.6	90.2	123	66.1	89.7	87%
Northeast area	Sediment	NE-13	30-45	4/6/2015	150	54.6	65.5	7.56	64.4	426	1,910	0.369	25.2	39.4	51.1	73.7	50.5	63.9	85%
Northeast area	Sediment	NE-14	0-15	4/1/2015	150	31.3	39.0	9.64	32.0	181	908	0.201	17.3	21.4	23.0	36.2	25.4	35.8	87%
Northeast area	Sediment	NE-14	15-30	4/1/2015	150	34.6	42.5	7.54	28.8	187	961	0.261	12.0	20.2	24.3	35.8	23.8	39.2	88%
Northeast area	Sediment	NE-14	30-45	4/3/2015	150	29.8	36.4	6.95	39.6	211	928	0.247	11.6	16.9	28.4	37.0	25.9	34.8	86%
Northeast area	Sediment	NE-15A	0-15	3/23/2015	150	43.8	55.6	18.5	47.2	197	812	0.395	32.1	30.1	31.9	48.9	33.9	50.0	88%
Northeast area	Sediment	NE-15B	0-15	3/23/2015	150	113	143	38.1	94.1	407	1,770	0.903	70.2	68.8	70.3	108	63.1	127	89%
Northeast area	Sediment	NE-15C	0-15	3/23/2015	150	211	251	34.1	69.9	354	1,640	1.53	93.4	111	72.3	112	66.4	**225**	94%
Northeast area	Sediment	NE-15	0-15	3/23/2015	150	141	174	36.9	80.0	349	1,510	1.09	76.2	86.8	64.2	90.2	64.9	**154**	92%
Northeast area	Sediment	NE-15	15-30	3/21/2015	150	22.0	31.5	7.03	16.3	90.9	384	0.208	16.5	14.8	10.8	22.0	15.4	24.6	89%
Northeast area	Sediment	NE-15	30-45	3/21/2015	150	8.64	14.2	ND	6.68	41.9	190	0.0214	11.7	5.90	8.16	12.7	8.45	9.81	88%
Northwest area	Sediment	NW-01	0-15	4/13/2015	150	92.0	108	14.1	27.3	89.1	416	0.548	34.6	36.3	9.99	10.6	7.78	96.8	95%
Northwest area	Sediment	NW-01	15-30	4/13/2015	150	98.4	117	10.1	27.1	83.4	391	0.555	43.1	46.0	11.0	7.0	7.06	104	95%
Northwest area	Sediment	NW-01	30-45	4/13/2015	150	68.1	78.3	6.59	14.8	62.2	261	0.498	30.5	32.6	8.06	4.47	5.15	69.7	98%
Northwest area	Sediment	NW-02	0-15	4/13/2015	150	67.9	77.6	11.1	32.1	118	475	0.399	24.2	23.3	8.99	13.2	9.73	72.4	94%
Northwest area	Sediment	NW-02	15-30	4/13/2015	150	43.6	49.1	4.87	25.6	93.7	379	0.181	14.3	16.3	8.41	10.8	8.01	46.5	94%
Northwest area	Sediment	NW-02	30-45	4/13/2015	150	22.6	26.4	ND	7.90	49.6	214	0.134	5.67	7.42	3.06	4.29	4.14	23.7	95%
Northwest area	Sediment	NW-03A	0-15	4/11/2015	150	2.89	2.89	0.601	1.62	86.8	316	0.0391	2.02	1.07	1.72	3.79	5.86	4.11	70%
Northwest area	Sediment	NW-03B	0-15	4/11/2015	150	14.3	19.7	2.85	23.4	186	884	0.0454	19.1	8.10	5.23	28.9	26.9	16.8	85%
Northwest area	Sediment	NW-03C	0-15	4/11/2015	150	378	404	10.6	30.7	191	919	0.819	61.6	53.3	19.3	37.8	36.4	**385**	98%
Northwest area	Sediment	NW-03	0-15	4/11/2015	150	151	164	8.34	24.7	165	822	0.339	29.2	22.6	15.2	25.4	23.7	**155**	97%
Northwest area	Sediment	NW-03A	15-30	4/11/2015	150	0.212	ND	ND	ND	8.11	44.7	0.0212	0.645	ND	ND	0.540	1.26	0.766	28%
Northwest area	Sediment	NW-03B	15-30	4/11/2015	150	5.17	7.85	1.70	10.5	115	474	0.0559	11.5	0.671	7.14	16.3	13.6	6.71	77%
Northwest area	Sediment	NW-03C	15-30	4/11/2015	150	584	625	ND	11.7	129	610	0.738	61.1	63.6	18.1	12.4	27.0	**587**	99%
Northwest area	Sediment	NW-03	15-30	4/11/2015	150	174	187	6.64	12.7	78.3	312	0.229	28.3	25.6	8.24	11.8	9.70	**177**	98%
Northwest area	Sediment	NW-03A	30-45	4/9/2015	150	0.201	ND	ND	0.408	14.0	66.3	0.0201	0.429	ND	ND	2.41	3.50	0.742	27%
Northwest area	Sediment	NW-03B	30-45	4/9/2015	150	4.13	7.70	0.848	2.85	31.9	130	0.0204	8.5	0.831	3.06	5.47	5.41	4.87	85%
Northwest area	Sediment	NW-03C	30-45	4/9/2015	150	638	696	23.6	22.2	94.9	423	0.985	83.5	102	24.8	9.07	17.5	**644**	99%
Northwest area	Sediment	NW-03	30-45	4/9/2015	150	193	210	5.82	9.89	41.1	188	0.376	35.1	37.5	9.15	8.97	6.71	**194**	99%
Northwest area	Sediment	NW-04A	0-15	4/11/2015	150	470	504	42.9	84.9	163	848	3.61	121	111	26.5	23.5	17.7	**477**	99%
Northwest area	Sediment	NW-04B	0-15	4/11/2015	150	79.1	89.7	1.60	15.0	78.4	458	0.776	30.7	19.2	0.925	9.50	8.56	82.6	96%
Northwest area	Sediment	NW-04C	0-15	4/11/2015	150	31.9	34.1	1.03	20.6	98.9	617	0.270	14.9	8.33	2.28	5.08	10.9	34.6	92%
Northwest area	Sediment	NW-04	0-15	4/11/2015	150	192	209	28.5	47.9	120	702	1.57	48.4	41.9	14.2	13.4	13.4	**199**	96%

Table A15 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Northwest area	Sediment	NW-04A	15-30	4/11/2015	150	254	274	13.0	49.4	130	616	2.00	56.3	57.8	10.6	6.36	9.67	**262**	97%
Northwest area	Sediment	NW-04B	15-30	4/11/2015	150	31.7	32.7	4.52	5.26	24.7	238	0.326	7.48	8.89	1.43	1.67	3.07	32.7	97%
Northwest area	Sediment	NW-04C	15-30	4/11/2015	150	34.8	37.4	1.29	15.2	81.1	506	0.271	8.29	3.01	2.98	4.05	9.51	37.6	93%
Northwest area	Sediment	NW-04	15-30	4/11/2015	150	105	117	11.1	27.4	85.3	466	0.925	28.1	22.2	3.55	9.68	14.6	108	97%
Northwest area	Sediment	NW-04	30-45	4/10/2015	150	35.2	37.1	ND	18.4	54.8	370	0.318	6.10	8.75	1.24	3.15	2.10	37.0	95%
Pacer Ivy area	Sediment	PI-15A	0-15	3/27/2015	150	654	792	202	470	610	1,150	2.98	159	159	35.3	28.0	23.4	**693**	94%
Pacer Ivy area	Sediment	PI-15B	0-15	3/27/2015	150	3,220	3,920	884	1,980	2,820	3,370	9.67	652	620	142	104	86.9	**3,370**	96%
Pacer Ivy area	Sediment	PI-15C	0-15	3/27/2015	150	2,050	2,470	812	1,490	1,700	2,250	10.8	649	646	137	85.6	55.7	**2,180**	94%
Pacer Ivy area	Sediment	PI-15	0-15	3/27/2015	150	1,800	2,250	710	1,290	1,720	2,210	8.24	495	488	101	81.8	51.4	**1,910**	94%
Pacer Ivy area	Sediment	PI-15A	15-30	4/2/2015	150	750	917	269	659	888	1,440	3.06	183	146	31.6	16.3	35.6	**801**	94%
Pacer Ivy area	Sediment	PI-15B	15-30	4/2/2015	150	1,170	1,420	377	603	761	1,220	5.78	340	272	41.8	29.3	17.7	**1,240**	94%
Pacer Ivy area	Sediment	PI-15C	15-30	4/2/2015	150	2,610	3,120	898	1,670	2,130	2,770	14.2	883	783	172	109	55.0	**2,750**	95%
Pacer Ivy area	Sediment	PI-15	15-30	4/2/2015	150	1,310	1,580	383	1,000	1,210	1,700	9.36	449	372	ND	54.4	38.5	**1,360**	96%
Pacer Ivy area	Sediment	PI-15A	30-45	3/26/2015	150	770	924	229	487	655	1,150	3.77	159	150	21.9	21.1	20.0	**809**	95%
Pacer Ivy area	Sediment	PI-15B	30-45	3/26/2015	150	1,200	1,460	297	560	697	1,070	5.99	328	230	21.4	25.3	18.1	**1,250**	96%
Pacer Ivy area	Sediment	PI-15C	30-45	3/26/2015	150	3,160	3,790	1,030	1,620	2,030	2,570	18.4	1,010	972	147	112	74.3	**3,320**	95%
Pacer Ivy area	Sediment	PI-15	30-45	3/26/2015	150	1,620	1,950	200	983	1,190	1,860	12.7	574	460	3.65	29.4	38.1	**1,670**	97%
Pacer Ivy area	Sediment	PI-16A	0-15	3/26/2015	150	200	246	56.6	147	249	1,040	0.816	50.2	47.3	14.3	18.6	20.4	**211**	95%
Pacer Ivy area	Sediment	PI-16B	0-15	3/26/2015	150	160	203	46.7	146	270	1,200	0.703	41.8	38.8	8.53	13.9	16.3	**171**	94%
Pacer Ivy area	Sediment	PI-16C	0-15	3/26/2015	150	845	1,050	257	531	798	1,850	3.83	220	192	51.5	40.2	0.0	**889**	95%
Pacer Ivy area	Sediment	PI-16	0-15	3/26/2015	150	373	461	137	269	440	1,260	1.97	105	106	27.6	24.9	22.2	**395**	94%
Pacer Ivy area	Sediment	PI-16A	15-30	4/3/2015	150	158	192	37.0	117	208	765	0.621	39.4	41.0	8.92	13.0	14.5	**164**	96%
Pacer Ivy area	Sediment	PI-16B	15-30	4/3/2015	150	199	282	89.8	159	312	1,260	0.783	52.1	44.8	13.4	12.9	10.3	**212**	94%
Pacer Ivy area	Sediment	PI-16C	15-30	4/3/2015	150	1,070	1,300	310	674	906	1,710	4.30	256	231	49.9	38.1	31.6	**1,120**	96%
Pacer Ivy area	Sediment	PI-16	15-30	4/3/2015	150	381	475	114	268	416	1,320	1.90	105	95.0	7.63	21.5	21.0	**403**	95%
Pacer Ivy area	Sediment	PI-16A	30-45	4/1/2015	150	307	396	91.3	216	410	1,080	1.10	67.5	60.3	18.2	18.8	15.6	**321**	96%
Pacer Ivy area	Sediment	PI-16B	30-45	4/1/2015	150	96.3	154	37.8	101	286	1,210	0.0221	20.7	29.0	18.0	20.1	21.5	102	94%
Pacer Ivy area	Sediment	PI-16C	30-45	4/1/2015	150	902	1,100	266	533	769	1,530	3.67	220	199	43.9	34.1	24.4	**947**	95%
Pacer Ivy area	Sediment	PI-16	30-45	4/1/2015	150	262	346	79.6	207	353	1,200	1.48	63.9	66.6	17.4	18.5	21.1	**276**	95%
Pacer Ivy area	Sediment	PI-17A	0-15	3/27/2015	150	307	375	51.9	41.3	121	617	1.79	72.8	75.0	6.98	7.40	9.60	**318**	97%
Pacer Ivy area	Sediment	PI-17B	0-15	3/27/2015	150	1,260	1,490	305	327	395	1,060	7.68	365	312	41.1	12.2	13.7	**1,300**	97%
Pacer Ivy area	Sediment	PI-17C	0-15	3/27/2015	150	15.7	16.4	ND	ND	4.52	48.7	0.0207	2.71	3.19	ND	ND	0.947	16.2	97%
Pacer Ivy area	Sediment	PI-17	0-15	3/27/2015	150	418	489	84.2	98.4	137	527	2.50	108	98.4	16.2	9.86	7.40	**431**	97%
Pacer Ivy area	Sediment	PI-17A	15-30	3/25/2015	150	354	448	101	90.5	115	690	1.71	82.9	65.5	9.94	12.5	9.87	**370**	96%
Pacer Ivy area	Sediment	PI-17B	15-30	3/25/2015	150	589	708	165	209	232	972	3.25	139	92.9	19.8	10.2	7.31	**613**	96%
Pacer Ivy area	Sediment	PI-17C	15-30	3/25/2015	150	3.61	3.62	ND	ND	3.26	38.2	0.0416	ND	1.51	ND	0.440	1.65	4.09	88%
Pacer Ivy area	Sediment	PI-17	15-30	3/25/2015	150	260	318	66.3	85.4	46.6	467	1.98	81.1	57.2	4.99	2.73	4.38	**264**	98%

Table A15 (Cont'd.)

Site ID	Media	Sub-DU[1]	Depth (cm)	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (dry weight)						PCDF (ppt TEQ; ND = 1/2 DL) (dry weight)						Total TEQ (ppt TEQ; ND = 1/2 DL) (dry weight)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Pacer Ivy area	Sediment	PI-17A	30-45	3/26/2015	150	260	314	31.8	54.8	104	713	1.22	49.6	44.2	6.59	7.46	5.57	**267**	97%
Pacer Ivy area	Sediment	PI-17B	30-45	3/26/2015	150	490	592	50.3	134	197	985	2.33	110	82.4	11.4	8.76	7.48	**506**	97%
Pacer Ivy area	Sediment	PI-17C	30-45	3/26/2015	150	1.92	1.92	ND	ND	2.85	31.3	0.0191	ND	ND	ND	ND	0.644	2.34	82%
Pacer Ivy area	Sediment	PI-17	30-45	3/26/2015	150	171	205	ND	30.7	35.0	391	0.021	24.2	ND	ND	2.00	2.39	**172**	99%
Pacer Ivy area	Sediment	PI-18	0-15	3/23/2015	150	1,050	1,160	110	173	730	3,340	10.2	339	268	85.9	101	54.6	**1,080**	97%
Pacer Ivy area	Sediment	PI-18	15-30	3/24/2015	150	336	364	18.2	20.0	268	1,390	4.68	103	17.7	24.6	42.0	20.6	**349**	96%
Pacer Ivy area	Sediment	PI-18A	30-45	3/25/2015	150	139	154	5.87	29.3	261	1,010	2.48	68.1	35.7	20.4	39.2	19.1	**146**	95%
Pacer Ivy area	Sediment	PI-18B	30-45	3/25/2015	150	146	149	7.37	18.2	93.3	427	1.36	46.8	32.3	13.4	14.9	6.60	**149**	98%
Pacer Ivy area	Sediment	PI-18C	30-45	3/25/2015	150	171	185	11.3	45.3	212	855	3.40	81.8	33.3	12.4	29.8	14.5	**179**	96%
Pacer Ivy area	Sediment	PI-18	30-45	3/25/2015	150	161	161	19.0	ND	176	889	3.07	72.7	ND	7.14	ND	14.0	**169**	95%
Pacer Ivy area	Sediment	PI-19	0-15	4/6/2015	150	9.56	38.9	36.4	61.6	187	825	1.12	769	636	313	123	33.2	34.1	28%
Pacer Ivy area	Sediment	PI-19	15-30	4/6/2015	150	10.2	30.9	12.9	25.5	105	493	0.691	317	131	55.2	33.4	14.1	18.3	56%
Pacer Ivy area	Sediment	PI-19	30-45	4/6/2015	150	3.59	11.6	9.15	8.06	68.8	305	0.0915	64.5	55.1	37.9	27.5	16.3	8.01	45%
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	150	3,000	3,320	344	573	1,580	5,710	11.8	811	843	232	214	126	**3,080**	97%
Pacer Ivy area	Sediment	PI-20	15-30	3/20/2015	150	5,350	5,900	447	919	2,080	6,760	13.6	1,320	1,470	426	359	185	**5,410**	99%
Pacer Ivy area	Sediment	PI-20	30-45	3/25/2015	150	3,760	4,040	205	318	1,600	7,520	14.8	1,010	814	254	253	171	**3,820**	98%
Pacer Ivy area	Sediment	PI-21	0-15	4/3/2015	150	24.6	36.2	8.47	31.3	114	725	0.127	9.75	7.16	5.07	12.9	18.2	26.6	92%
Pacer Ivy area	Sediment	PI-21	15-30	4/1/2015	150	17.1	18.8	ND	28.6	57.0	732	0.142	2.97	3.58	3.53	8.16	13.0	18.4	93%
Pacer Ivy area	Sediment	PI-21	30-45	4/3/2015	150	64.3	106	34.4	72.9	174	778	0.0205	18.9	13.4	3.73	9.01	14.2	69.1	93%
Z1 area	Sediment	Z1-09	0-15	4/8/2015	150	394	436	45.3	82.5	258	977	2.65	111	96.3	35.3	37.5	31.2	**413**	95%
Z1 area	Sediment	Z1-09	15-30	4/8/2015	150	246	279	36.4	42.3	121	396	1.03	66.8	59.8	15.6	19.3	10.8	**260**	95%
Z1 area	Sediment	Z1-09	30-45	4/8/2015	150	432	471	39.5	46.9	94.9	335	1.16	86.2	93.2	22.2	14.2	8.83	**444**	97%
Z1 area	Sediment	Z1-10	0-15	4/10/2015	150	1,290	1,390	102	210	502	1,960	2.19	285	265	106	95.9	65.0	**1,494.6**	86%
Z1 area	Sediment	Z1-10	15-30	4/11/2015	150	466	502	33.5	67.2	153	592	0.178	109	108	34.1	32.5	21.0	**1,578.8**	30%
Z1 area	Sediment	Z1-10	30-45	4/13/2015	150	91.5	97.4	1.18	ND	20.2	175	0.153	17.6	17.9	2.10	9.61	7.42	**244.8**	37%

* ***Notes***:

- %: percent
- cm: centimeter
- DL: detection limit
- DU: decision unit
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppt: part per trillion
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A16 Concentrations of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in biota samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Sub-DU	Media	Species	Tissue type	Collection date	Action level (ppt TEQ)	PCDD (ppt TEQ; ND = 1/2 DL) (wet weight)						PCDF (ppt TEQ; ND = 1/2 DL) (wet weight)						TOTAL (ppt TEQ; ND = 1/2 DL) (wet weight)	% TCDD in TEQ
							2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
Pacer Ivy area	PI-20	Fish	Catfish	Muscle	3/18/2015	20	57.6	57.7	ND	0.0845	0.460	0.716	0.00285	0.686	ND	ND	ND	ND	57.7	100%
Pacer Ivy area	PI-20	Fish	Catfish	Fat	3/18/2015	20	3,500	3,510	36.8	36.6	22.1	13.9	3.38	40.1	17.6	3.60	1.51	ND	3,550	99%
Pacer Ivy area	PI-20	Snail	Snail	Whole snail	3/18/2015	20	66.2	74.3	12.6	21.8	38.7	93.6	0.978	30.0	19.1	4.90	2.40	2.03	69.5	95%
Z1 area	Z1-09	Fish	Talapia	Whole fish	3/19/2015	20	67.7	67.9	ND	0.0906	3.13	10.6	0.539	5.91	ND	0.470	ND	0.403	68.3	99%
Northeast area	NE-07	Fish	Talapia	Fat	3/17/2015	20	800	803	8.84	ND	ND	1.44	28.1	287	7.08	ND	ND	ND	837	96%
Northeast area	NE-08	Fish	Talapia	Muscle	3/17/2015	20	3.18	3.18	ND	ND	ND	0.198	0.144	1.45	ND	ND	ND	0.0657	3.38	94%
Northeast area	NE-08	Fish	Talapia	Fat	3/17/2015	20	133	133	1.54	ND	0.860	4.72	6.07	68.1	ND	ND	ND	ND	141	94%
Northeast area	NE-08	Fish	Talapia	Eggs	3/17/2015	20	62.3	63.5	ND	ND	0.346	2.35	2.71	29.5	0.955	ND	ND	0.112	65.2	96%
Northeast area	NE-10	Fish	Talapia	Whole fish	3/16/2015	20	1.27	1.57	ND	0.291	0.965	12.1	0.0841	1.02	0.179	ND	ND	0.328	1.43	89%
Northeast area	NE-12	Fish	Talapia	Muscle	3/16/2015	20	3.59	3.59	ND	ND	ND	0.288	0.00280	0.449	ND	ND	ND	ND	3.65	98%
Northeast area	NE-12	Fish	Talapia	Eggs	3/16/2015	20	226	226	2.42	2.17	6.34	14.9	3.80	39.6	3.49	0.769	0.226	0.000072	233	97%
Northeast area	NE-15	Fish	Bighead carp	Muscle	3/16/2015	20	33.3	33.3	ND	0.0713	ND	0.500	0.509	5.53	0.865	ND	ND	ND	33.9	98%
Northeast area	NE-15	Fish	Bighead carp	Fat	3/16/2015	20	1,400	1,420	17.5	1.47	5.84	241	24.2	277	41.1	3.87	0.643	ND	1,440	97%
Northwest area	NW-02	Fish	Basa	Muscle	3/17/2015	20	3.99	4.05	0.103	ND	0.178	0.173	0.00293	0.0660	ND	ND	ND	ND	4.13	97%
Northwest area	NW-02	Fish	Basa	Fat	3/17/2015	20	908	908	28.8	40.9	44.0	24.0	0.312	3.22	1.06	1.18	ND	0.857	942	96%
Northwest area	NW-04	Fish	Talapia	Muscle	3/17/2015	20	49.4	49.4	ND	ND	0.134	0.149	0.409	4.11	ND	ND	ND	ND	49.9	99%
Northwest area	NW-04	Fish	Talapia	Fat	3/17/2015	20	3,720	3,720	20.7	6.89	ND	7.04	34.1	353	12.8	0.612	ND	ND	3,770	99%
Northwest area	NW-04	Fish	Talapia	Eggs	3/17/2015	20	750	750	3.49	1.19	ND	3.45	6.47	66.6	1.09	0.128	ND	ND	760	99%
Northwest area	NW-04	Snail	Snail	Whole snail	3/17/2015	20	60.9	65.5	ND	3.14	5.52	14.4	0.411	14.7	8.57	0.932	0.413	0.325	61.6	99%
Bien Hung Lake	BHL-01	Fish	Talapia	Muscle	3/26/2015	20	0.684	0.7	ND	ND	ND	0.906	0.0290	0.398	ND	ND	ND	ND	0.773	88%
Bien Hung Lake	BHL-01	Fish	Talapia	Fat	3/26/2015	20	36.8	36.8	ND	ND	ND	2.15	2.91	36.6	2.31	ND	ND	ND	40.4	91%
Bien Hung Lake	BHL-01	Fish	Talapia	Eggs	3/26/2015	20	8.64	8.93	ND	ND	ND	0.552	0.675	6.88	0.484	ND	ND	ND	9.43	92%

* ***Notes*** :

- %: percent
- 999: exceeding the action level of 30 ppt TEQ
- DL: detection limit
- DU: decision unit
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppt: part per trillion
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

Table A17 Concentrations of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID[1]	Type	Media	Collection date	USEPA MCL (pg/L)	GVN Discharge Limit (pg/L)[2]	PCDD (pg/L) (ND=1/2 DL)						PCDF (pg/L) (ND=1/2 DL)						TOTAL (TEQ ND=1/2 DL) (pg/L)	% TCDD in TEQ
						2,3,7,8-TCDD	Total T4CDD	Total P5CDD	Total H6CDD	Total H7CDD	Total O8CDD	2,3,7,8-TCDF	Total T4CDF	Total P5CDF	Total H6CDF	Total H7CDF	Total O8CDF		
MW-01	Filtered	Groundwater	4/14/2015	30	10	0.253	ND	ND	ND	3.26	26.6	0.0253	ND	ND	ND	ND	1.15	0.836	30%
MW-01	Unfiltered	Groundwater	4/14/2015	30	10	0.270	0.895	ND	1.54	3.34	20.20	0.0270	ND	ND	ND	ND	ND	0.858	31%
MW-02	Filtered	Groundwater	4/14/2015	30	10	0.253	ND	ND	ND	1.49	9.30	0.0253	ND	ND	ND	0.812	ND	0.819	31%
MW-02	Unfiltered	Groundwater	4/14/2015	30	10	9.46	9.46	ND	ND	5.59	28.10	0.0252	ND	ND	ND	ND	ND	10.0	95%
MW-03	Filtered	Groundwater	4/15/2015	30	10	0.256	1.19	ND	2.76	14.0	61.9	0.0256	ND	ND	ND	1.15	ND	0.882	29%
MW-03	Unfiltered	Groundwater	4/15/2015	30	10	0.249	17.2	8.45	27.7	89.9	461	0.0249	ND	ND	ND	ND	ND	1.32	19%
MW-04	Filtered	Groundwater	4/15/2015	30	10	0.251	ND	ND	ND	1.55	7.53	0.0251	ND	ND	ND	ND	ND	0.807	31%
MW-04	Unfiltered	Groundwater	4/15/2015	30	10	0.259	1.06	ND	1.36	3.34	21.9	0.0259	0.851	ND	0.525	ND	0.793	0.849	31%
MW-05	Filtered	Groundwater	4/14/2015	30	10	17.3	21.4	ND	3.44	9.42	42.50	0.181	19.2	10.4	ND	0.540	0.754	18.0	96%
MW-05	Unfiltered	Groundwater	4/14/2015	30	10	222	255	20.6	31.0	174	555	1.91	250	115	8.76	9.86	7.78	235	94%
MW-06	Filtered	Groundwater	4/14/2015	30	10	19.8	21.7	1.03	2.78	23.3	89.70	0.152	13.4	6.17	0.551	0.963	2.08	21.4	93%
MW-06	Unfiltered	Groundwater	4/14/2015	30	10	55.8	60.9	5.09	11.3	72.1	290	0.440	46.9	28.0	2.94	6.63	4.25	58.8	95%
Offsite well #1	Unfiltered	Groundwater	4/14/2015	30	10	0.256	ND	ND	ND	1.26	5.26	0.0256	ND	ND	ND	ND	ND	0.819	31%
Offsite well #2	Unfiltered	Groundwater	4/14/2015	30	10	0.257	ND	ND	ND	0.649	4.04	0.0257	ND	ND	ND	ND	ND	0.813	32%
Offsite well #3	Unfiltered	Groundwater	4/14/2015	30	10	0.259	ND	ND	ND	1.63	2.24	0.0259	ND	ND	ND	0.525	ND	0.827	31%
Offsite well #4	Unfiltered	Groundwater	4/14/2015	30	10	0.256	ND	ND	ND	ND	1.19	0.0256	ND	ND	ND	ND	ND	0.809	32%
Offsite well #5	Unfiltered	Groundwater	4/14/2015	30	10	0.273	ND	ND	ND	ND	1.05	0.0273	2.03	ND	ND	ND	ND	0.863	32%
Offsite well #6	Unfiltered	Groundwater	4/14/2015	30	10	0.256	ND	ND	ND	8.99	18.70	0.0256	ND	ND	ND	ND	ND	0.876	29%
Airbase water supply tower	Pre-treatment	Groundwater	4/14/2015	30	10	0.257	ND	ND	ND	ND	0.785	0.0257	ND	ND	ND	ND	ND	0.811	32%
Airbase water supply tower	Post-treatment	Groundwater	4/14/2015	30	10	0.253	ND	ND	ND	ND	2.34	0.0253	ND	ND	ND	ND	ND	0.799	32%

* ***Notes***:

- %: percent
- **999**: exceeding the USEPA MCL of 30 pg/L TEQ
- **999**: exceeding the GVN Discharge Limit of 10 pg/L TEQ
- DL: detection limit
- DU: decision unit
- USEPA MCL: United States Environmental Proteciton Agency Maximum Contaminant Level
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppq: part per quadrillion
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

[1] MW-01 through MW-06 are existing onsite monitoring wells

[2] QCVN 40:2011/BTMNT - National Technical Regulation on Industrial Wastewater

Table A18 Concentration of PCDDs/PCDFs in groundwater samples, from Dekonta (2014).

Parameter	Unit	MW-01	MW-02	MW-03	MW-04	MW-05	MW-06a
1234678-HpCDD	pg/L	ND	<0.34	1	ND	0.58	1.5
1234678-HpCDF	pg/l	ND	ND	ND	ND	ND	ND
123478-HxCDD	pg/l	ND	ND	ND	ND	ND	ND
123478-HxCDF	pg/l	ND	ND	ND	ND	ND	ND
1234789-HpCDF	pg/l	ND	ND	ND	ND	ND	ND
123678-HxCDD	pg/l	ND	ND	ND	ND	ND	0.16
123678-HxCDF	pg/l	ND	ND	ND	ND	ND	ND
12378-PeCDD	pg/l	ND	ND	ND	ND	0.29	<0.0076
12378-PeCDF	pg/l	ND	ND	ND	ND	ND	ND
123789-HxCDD	pg/l	ND	ND	ND	ND	ND	ND
123789-HxCDF	pg/l	ND	ND	ND	ND	ND	ND
234678-HxCDF	pg/l	ND	ND	ND	ND	ND	ND
23478-PeCDF	pg/l	ND	ND	ND	ND	ND	ND
2378-TCDD	pg/l	0.34	3.00	ND	0.18	17	10
2378-TCDF	pg/l	0.25	0.41	ND	0.22	5.9	2.3
OCDD	pg/l	1.30	2.1	15	2.3	3.2	15
OCDF	pg/l	ND	ND	ND	ND	ND	n

* ***Notes*** :

- pg/L: picogram per liter
- ND: non-detect

Table A19 Historical concentrations in soil and sediment samples analyzed from Bien Hoa, Vietnam.

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and 10-80 Division (2006)	04VN011	Outside Airbase (W)	697,030	1,212,687	Sediment	0-10	0.304	1.19	26%
Hatfield and 10-80 Division (2006)	04VN013	Outside Airbase (W)	696,829	1,213,740	Soil	0-10	12.2	14.3	85%
Hatfield and 10-80 Division (2006)	04VN014	Outside Airbase (W)	698,858	1,211,444	Sediment	0-10	96.7	106	91%
Hatfield and 10-80 Division (2006)	05VN073	Outside Airbase (W)	696,791	1,214,022	Soil	0-10	18.8	22.6	83%
Hatfield and 10-80 Division (2006)	05VN074	Outside Airbase SW	698,302	1,211,815	Soil	0-10	279	287	97%
Hatfield and 10-80 Division (2006)	05VN077	Outside Airbase SW	698,275	1,211,651	Soil	0-10	27.1	39.4	69%
Hatfield and 10-80 Division (2006)	05VN078	Z1	699,223	1,211,898	Sediment	0-10	797	833	96%
Hatfield and 10-80 Division (2006)	05VN079	Z1	699,223	1,211,898	Sediment	0-10	224	234	96%
Hatfield and 10-80 Division (2006)	05VN080	Z1	699,223	1,211,898	Soil	0-10	284	294	97%
Hatfield and 10-80 Division (2006)	05VN081	Z1	699,157	1,211,899	Sediment	0-10	76.9	80.3	96%
Hatfield and 10-80 Division (2006)	05VN085	Outside Airbase (E)	700,957	1,213,468	Sediment	0-10	41.5	48.3	86%
Hatfield and 10-80 Division (2006)	05VN086	East quadrant	700,777	1,213,665	Sediment	0-10	40.6	48.7	83%
Hatfield and 10-80 Division (2006)	05VN087	NE Perimeter	700,961	1,213,566	Soil	0-10	257	267	96%
Hatfield and 10-80 Division (2006)	05VN088	Outside Airbase (E)	700,725	1,213,592	Sediment	0-10	82.8	101	82%
Hatfield and 10-80 Division (2006)	05VN089	NE Perimeter	700,725	1,213,592	Soil	0-10	392	424	92%
Hatfield and 10-80 Division (2006)	05VN094	Outside Airbase (SE)	701,583	1,211,234	Sediment	0-10	5.22	8.24	63%
Hatfield and 10-80 Division (2006)	05VN095	Outside Airbase (S)	698,907	1,211,511	Soil	0-10	208	224	93%
Hatfield and 10-80 Division (2006)	05VN096	Outside Airbase (SW)	696,581	1,211,855	Soil	0-10	0.596	2.76	22%
Hatfield and 10-80 Division (2006)	05VN097	Outside Airbase (SE)	700,978	1,211,889	Sediment	0-10	3.73	14.8	25%
Hatfield and 10-80 Division (2006)	05VN098	Outside Airbase (SE)	701,599	1,211,164	Sediment	0-10	0.969	3.26	30%
Hatfield and 10-80 Division (2006)	05VN101	Outside Airbase (SE)	701,698	1,210,987	Sediment	0-10	2.72	9.03	30%
Hatfield and 10-80 Division (2006)	05VN102	Outside Airbase (S)	698,852	1,211,444	Sediment	0-10	96	131	73%
Hatfield and 10-80 Division (2006)	05VN103	Outside Airbase (S)	698,933	1,211,416	Sediment	0-10	31.1	36	86%
Hatfield and VRTC (2009)	08VNBH067	SW Airbase	698,223	1,212,365	Soil	0-10	1890	1920	98%
Hatfield and VRTC (2009)	08VNBH068	SW Airbase	698,237	1,212,374	Soil	0-10	1376	1400	98%
Hatfield and VRTC (2009)	08VNBH071	SW Airbase	698,255	1,212,365	Soil	0-10	3640	5150	71%
Hatfield and VRTC (2009)	08VNBH072	SW Airbase	698,247	1,212,318	Soil	0-10	51.2	56.2	91%
Hatfield and VRTC (2009)	08VNBH074	SW Airbase	698,272	1,212,399	Soil	0-10	439.1	450	98%
Hatfield and VRTC (2009)	08VNBH076	SW Airbase	698,295	1,212,431	Soil	0-10	1529	1540	99%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and VRTC (2009)	08VNBH077	SW Airbase	698,324	1,212,452	Soil	0-10	70.5	74.0	95%
Hatfield and VRTC (2009)	08VNBH080	Z1	699,140	1,212,426	Soil	0-30	36770	37519	98%
Hatfield and VRTC (2009)	08VNBH080-2	Z1	699,140	1,212,426	Soil	30-60	144110	146094	99%
Hatfield and VRTC (2009)	08VNBH080-3	Z1	699,140	1,212,426	Soil	60-90	259140	262000	99%
Hatfield and VRTC (2009)	08VNBH080-4	Z1	699,140	1,212,426	Soil	90-120	215300	217000	99%
Hatfield and VRTC (2009)	08VNBH080-5	Z1	699,140	1,212,426	Soil	120-150	26233	26400	99%
Hatfield and VRTC (2009)	08VNBH080-6	Z1	699,140	1,212,426	Soil	150-180	OLR 184000	185000	NC
Hatfield and VRTC (2009)	08VNBH082	Z1	699,143	1,212,437	Soil	0-10	48597	49100	99%
Hatfield and VRTC (2009)	08VNBH083	Z1	699,138	1,212,446	Soil	0-10	99.7	109	91%
Hatfield and VRTC (2009)	08VNBH084	SW Airbase	698,220	1,212,401	Soil	0-10	65400	65500	100%
Hatfield and VRTC (2009)	08VNBH085	SW Airbase	698,205	1,212,378	Soil	0-10	1975	2000	99%
Hatfield and VRTC (2009)	08VNBH087	SW Airbase	698,240	1,212,391	Soil	0-10	427.5	440	97%
Hatfield and VRTC (2009)	08VNBH088	SW Airbase	698,225	1,212,381	Soil	0-10	71.5	78.3	91%
Hatfield and VRTC (2009)	08VNBH088-2	SW Airbase	698,225	1,212,381	Soil	10-30	15.9	19.0	84%
Hatfield and VRTC (2009)	08VNBH088-3	SW Airbase	698,225	1,212,381	Soil	30-60	NDR 12.6	3.47	NC
Hatfield and VRTC (2009)	08VNBH088-4	SW Airbase	698,225	1,212,381	Soil	60-90	3.4	5.41	63%
Hatfield and VRTC (2009)	08VNBH091	SW Airbase	698,191	1,212,357	Soil	0-10	213.5	245	87%
Hatfield and VRTC (2009)	08VNBH097	SW Airbase	698,035	1,212,248	Soil	0-10	9.5	12.8	74%
Hatfield and VRTC (2009)	08VNBH099	SW Airbase	698,155	1,212,431	Soil	0-10	131.5	140	94%
Hatfield and VRTC (2009)	08VNBH102	Pacer Ivy	697,321	1,213,207	Soil	0-10	29.2	80.3	36%
Hatfield and VRTC (2009)	08VNBH104	Pacer Ivy	697,293	1,213,228	Soil	0-10	2000	2040	98%
Hatfield and VRTC (2009)	08VNBH105	Pacer Ivy	697,305	1,213,310	Soil	0-10	22256	22796	98%
Hatfield and VRTC (2009)	08VNBH106	Pacer Ivy	697,317	1,213,175	Soil	0-10	140	147	95%
Hatfield and VRTC (2009)	08VNBH107	Pacer Ivy	697,350	1,213,178	Soil	0-10	489.4	556	88%
Hatfield and VRTC (2009)	08VNBH108	Pacer Ivy	697,344	1,213,167	Sediment	0-10	1030	1090	94%
Hatfield and VRTC (2009)	08VNBH109	Pacer Ivy	697,286	1,213,126	Sediment	0-10	2650	2780	95%
Hatfield and VRTC (2009)	08VNBH110	Pacer Ivy	697,290	1,213,178	Sediment	0-10	1400	1500	93%
Hatfield and VRTC (2009)	08VNBH111	Pacer Ivy	697,260	1,213,235	Sediment	0-10	5810	5970	97%
Hatfield and VRTC (2009)	08VNBH112	SW Airbase	698,197	1,212,349	Soil	0-10	30.4	42.8	71%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and VRTC (2009)	08VNBH113	Pacer Ivy	697,354	1,213,208	Soil	0-10	68.7	92.9	74%
Hatfield and VRTC (2009)	08VNBH114	Pacer Ivy	697,342	1,213,248	Soil	0-10	467.3	516	91%
Hatfield and VRTC (2009)	08VNBH115	Pacer Ivy	697,404	1,213,199	Soil	0-10	1.00	5.30	19%
Hatfield and VRTC (2009)	08VNBH116	Pacer Ivy	697,426	1,213,227	Soil	0-10	844	894	94%
Hatfield and VRTC (2009)	08VNBH119	Pacer Ivy	697,471	1,213,245	Soil	0-10	70.1	217	32%
Hatfield and VRTC (2009)	08VNBH120	Pacer Ivy	697,557	1,213,200	Soil	0-10	221	289	76%
Hatfield and VRTC (2009)	08VNBH122	Z1	698,942	1,212,342	Soil	0-10	194.2	223	87%
Hatfield and VRTC (2009)	08VNBH123	Z1	698,980	1,212,340	Soil	0-10	1310	1330	98%
Hatfield and VRTC (2009)	08VNBH124	Z1	699,000	1,212,346	Soil	0-10	387	395	98%
Hatfield and VRTC (2009)	08VNBH125	Z1	698,989	1,212,317	Soil	0-10	2013	2100	96%
Hatfield and VRTC (2009)	08VNBH126	Z1	698,996	1,212,301	Soil	0-10	71	74	96%
Hatfield and VRTC (2009)	08VNBH127	Z1	698,987	1,212,294	Soil	0-10	68.8	70.4	98%
Hatfield and VRTC (2009)	08VNBH128	Z1	699,017	1,212,269	Soil	0-10	850	879	97%
Hatfield and VRTC (2009)	08VNBH130	Z1	699,098	1,212,193	Soil	0-10	566.3	589	96%
Hatfield and VRTC (2009)	08VNBH132	Z1	699,187	1,212,167	Sediment	0-10	405	413	98%
Hatfield and VRTC (2009)	08VNBH134	Z1	698,938	1,212,152	Soil	0-10	41.1	48.3	85%
Hatfield and VRTC (2009)	08VNBH135	Z1	698,945	1,212,082	Soil	0-10	2620	2670	98%
Hatfield and VRTC (2009)	08VNBH136	Z1	698,937	1,212,046	Soil	0-10	67.4	72.9	92%
Hatfield and VRTC (2009)	08VNBH137	Z1	699,057	1,212,027	Soil	0-10	395.9	411	96%
Hatfield and VRTC (2009)	08VNBH138	Z1	699,108	1,212,011	Soil	0-10	19.6	22.4	88%
Hatfield and VRTC (2009)	08VNBH139	Z1	699,156	1,212,033	Soil	0-10	20	26.3	76%
Hatfield and VRTC (2009)	08VNBH141	Z1	699,049	1,212,302	Soil	0-10	742.2	753	99%
Hatfield and VRTC (2009)	08VNBH141-3	Z1	699,049	1,212,302	Soil	30-60	8236	8310	99%
Hatfield and VRTC (2009)	08VNBH141-6	Z1	699,049	1,212,302	Soil	120-150	11.8	22.2	53%
Hatfield and VRTC (2009)	08VNBH142	Z1	699,108	1,212,300	Soil	0-10	31.3	40.7	77%
Hatfield and VRTC (2009)	08VNBH143	Z1	699,151	1,212,319	Soil	0-10	84	113	74%
Hatfield and VRTC (2009)	08VNBH143-3	Z1	699,151	1,212,319	Soil	30-60	3.8	6.15	62%
Hatfield and VRTC (2009)	08VNBH145	Z1	699,275	1,212,325	Soil	0-10	81.8	94.4	87%
Hatfield and VRTC (2009)	08VNBH147	Z1	699,251	1,212,425	Soil	0-10	236.4	259	91%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and VRTC (2009)	08VNBH148	Z1	699,261	1,212,514	Soil	0-10	30	32	94%
Hatfield and VRTC (2009)	08VNBH149	Z1	699,306	1,212,304	Soil	0-10	94.3	106	89%
Hatfield and VRTC (2009)	08VNBH150	Z1	699,341	1,212,346	Soil	0-10	20	23	87%
Hatfield and VRTC (2009)	08VNBH153	Z1	699,235	1,212,191	Soil	0-10	737.8	757	97%
Hatfield and VRTC (2009)	08VNBH155	Z1	699,249	1,212,175	Sediment	0-10	2200	2240	98%
Hatfield and VRTC (2009)	08VNBH156	Z1	699,191	1,212,075	Sediment	0-10	15.2	20.9	73%
Hatfield and VRTC (2009)	08VNBH157	Z1	699,170	1,212,023	Sediment	0-10	1740	1790	97%
Hatfield and VRTC (2009)	08VNBH158	Z1	699,167	1,212,000	Sediment	0-10	18	22.0	82%
Hatfield and VRTC (2009)	08VNBH159	Z1	699,149	1,211,961	Sediment	0-10	727	756	96%
Hatfield and VRTC (2009)	08VNBH161	Z1	698,988	1,212,373	Soil	0-10	311.1	323	96%
Hatfield and VRTC (2009)	08VNBH162	Z1	698,596	1,212,083	Soil	0-10	393	443	89%
Hatfield and VRTC (2009)	08VNBH163	Z1	698,698	1,212,110	Soil	0-10	17.4	25.3	69%
Hatfield and VRTC (2009)	08VNBH166	Z1	698,896	1,212,233	Soil	0-10	80.9	98.0	83%
Hatfield and VRTC (2009)	08VNBH167	Z1	698,944	1,212,266	Soil	0-10	985	1000	99%
Hatfield and VRTC (2009)	08VNBH170	Z1	699,196	1,212,275	Soil	0-10	12395	13300	93%
Hatfield and Office 33 (2011)	10VNBH200	North quadrant	698,233	1,214,492	Soil	0-15	10.8	11.6	93%
Hatfield and Office 33 (2011)	10VNBH201	North quadrant	698,891	1,214,344	Soil	0-15	5.33	8.47	63%
Hatfield and Office 33 (2011)	10VNBH202	North quadrant	699,878	1,214,355	Soil	0-20	425	459	93%
Hatfield and Office 33 (2011)	10VNBH203	North quadrant	700,887	1,214,216	Soil	0-20	15.4	17.1	90%
Hatfield and Office 33 (2011)	10VNBH204	Outside Airbase (E)	701,073	1,213,812	Soil	0-15	333	347	96%
Hatfield and Office 33 (2011)	10VNBH205	East quadrant	700,637	1,213,628	Soil	0-20	39.2	48.5	81%
Hatfield and Office 33 (2011)	10VNBH206	East quadrant	700,634	1,213,768	Soil	0-20	32.7	36.6	89%
Hatfield and Office 33 (2011)	10VNBH208	East quadrant	700,426	1,213,658	Soil	0-10	996	1040	96%
Hatfield and Office 33 (2011)	10VNBH209	East quadrant	700,328	1,213,255	Soil	0-20	17.0	19.1	89%
Hatfield and Office 33 (2011)	10VNBH210	East quadrant	700,327	1,213,357	Soil	0-20	3.40	12.1	28%
Hatfield and Office 33 (2011)	10VNBH212	East quadrant	700,179	1,213,623	Soil	0-20	47.9	56.1	85%
Hatfield and Office 33 (2011)	10VNBH213	East quadrant	700,345	1,213,889	Soil	0-20	17.8	18.7	95%
Hatfield and Office 33 (2011)	10VNBH214	SW Airbase	698,303	1,212,248	Soil	0-20	62.7	110	57%
Hatfield and Office 33 (2011)	10VNBH215	SW Airbase	698,324	1,212,359	Soil	0-10	7.84	9.22	85%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and Office 33 (2011)	10VNBH216	SW Airbase	698,162	1,212,463	Soil	0-20	124	131	95%
Hatfield and Office 33 (2011)	10VNBH217	SW Airbase	698,121	1,212,590	Soil	0-10	33.8	41.1	82%
Hatfield and Office 33 (2011)	10VNBH218	SW Airbase	698,290	1,212,503	Soil	0-15	25.8	30.0	86%
Hatfield and Office 33 (2011)	10VNBH219	SW Airbase	697,999	1,212,702	Soil	0-15	21.5	47.4	45%
Hatfield and Office 33 (2011)	10VNBH220	Pacer Ivy	697,264	1,213,287	Soil	0-10	7530	7550	100%
Hatfield and Office 33 (2011)	10VNBH221	Pacer Ivy	697,255	1,213,333	Soil	0-10	3940	3990	99%
Hatfield and Office 33 (2011)	10VNBH222	Pacer Ivy	697,210	1,213,313	Soil	0-10	2620	2700	97%
Hatfield and Office 33 (2011)	10VNBH224	Pacer Ivy	697,317	1,213,424	Soil	0-10	1090	1120	97%
Hatfield and Office 33 (2011)	10VNBH225	Pacer Ivy	697,277	1,213,471	Soil	0-10	99.1	104	95%
Hatfield and Office 33 (2011)	10VNBH226	Pacer Ivy	697,339	1,213,543	Soil	0-15	5.81	7.13	81%
Hatfield and Office 33 (2011)	10VNBH227	Pacer Ivy	697,157	1,213,531	Soil	0-10	5.50	6.73	82%
Hatfield and Office 33 (2011)	10VNBH228	Pacer Ivy	697,128	1,213,639	Soil	0-10	49.4	56.4	88%
Hatfield and Office 33 (2011)	10VNBH229	Pacer Ivy	697,111	1,213,696	Soil	0-10	7.97	9.69	82%
Hatfield and Office 33 (2011)	10VNBH230	Pacer Ivy	697,054	1,213,475	Soil	0-15	83.9	86.7	97%
Hatfield and Office 33 (2011)	10VNBH231	Pacer Ivy	697,109	1,213,416	Soil	0-15	1300	1310	99%
Hatfield and Office 33 (2011)	10VNBH232	Pacer Ivy	697,008	1,213,577	Soil	0-10	62.4	65.8	95%
Hatfield and Office 33 (2011)	10VNBH233	Pacer Ivy	696,933	1,213,651	Soil	0-10	3000	3070	98%
Hatfield and Office 33 (2011)	10VNBH234	Pacer Ivy	696,965	1,213,714	Soil	0-15	1.87	2.79	67%
Hatfield and Office 33 (2011)	10VNBH235	Pacer Ivy	696,913	1,213,770	Soil	0-10	2.76	3.86	72%
Hatfield and Office 33 (2011)	10VNBH236	Pacer Ivy	696,901	1,213,905	Soil	0-10	336	346	97%
Hatfield and Office 33 (2011)	10VNBH237-2	Pacer Ivy	697,315	1,213,308	Soil	30-60	61400	61800	99%
Hatfield and Office 33 (2011)	10VNBH237-4	Pacer Ivy	697,315	1,213,308	Soil	60-90	30.9	34.2	90%
Hatfield and Office 33 (2011)	10VNBH237-6	Pacer Ivy	697,315	1,213,308	Soil	120-150	48.6	52.9	92%
Hatfield and Office 33 (2011)	10VNBH238	Pacer Ivy	697,195	1,213,030	Soil	0-10	0.264	0.836	32%
Hatfield and Office 33 (2011)	10VNBH239	Pacer Ivy	697,274	1,213,012	Soil	0-10	5.83	11.7	50%
Hatfield and Office 33 (2011)	10VNBH240-1	Pacer Ivy	697,317	1,213,371	Soil	0-30	2310	2340	99%
Hatfield and Office 33 (2011)	10VNBH240-3	Pacer Ivy	697,317	1,213,371	Soil	60-90	< 2.20	4.40	NC
Hatfield and Office 33 (2011)	10VNBH241	Z1	698,989	1,212,130	Soil	0-15	196	212	92%
Hatfield and Office 33 (2011)	10VNBH242	Z1	699,053	1,212,143	Soil	0-15	3130	3210	98%

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Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and Office 33 (2011)	10VNBH243	Z1	699,060	1,212,084	Soil	0-15	2540	2650	96%
Hatfield and Office 33 (2011)	10VNBH244	Z1	699,140	1,212,131	Soil	0-15	74.9	88.000	85%
Hatfield and Office 33 (2011)	10VNBH245-1	Z1	699,166	1,212,194	Soil	0-30	7.66	9.75	79%
Hatfield and Office 33 (2011)	10VNBH245-3	Z1	699,166	1,212,194	Soil	60-90	< 0.921	1.46	NC
Hatfield and Office 33 (2011)	10VNBH246-3	Z1	699,267	1,212,327	Soil	60-90	NDR 1.69	1.53	NC
Hatfield and Office 33 (2011)	10VNBH246-5	Z1	699,267	1,212,327	Soil	120-150	< 0.986	1.56	NC
Hatfield and Office 33 (2011)	10VNBH247	Z1	699,130	1,212,537	Soil	0-10	93.7	113	83%
Hatfield and Office 33 (2011)	10VNBH248	Z1	699,242	1,212,224	Soil	0-10	4.83	6.24	77%
Hatfield and Office 33 (2011)	10VNBH250	Z1	699,421	1,212,468	Soil	0-10	28.3	34.8	81%
Hatfield and Office 33 (2011)	10VNBH251	Z1	698,625	1,212,117	Soil	0-10	225	237	95%
Hatfield and Office 33 (2011)	10VNBH400	North quadrant	696,889	1,214,049	Sediment	0-10	62.8	68.5	92%
Hatfield and Office 33 (2011)	10VNBH402	North quadrant	697,271	1,214,295	Sediment	0-10	362	372	97%
Hatfield and Office 33 (2011)	10VNBH403	North quadrant	700,214	1,214,362	Sediment	0-10	37.4	38.2	98%
Hatfield and Office 33 (2011)	10VNBH404	North quadrant	697,996	1,214,512	Sediment	0-10	4.90	5.66	87%
Hatfield and Office 33 (2011)	10VNBH406	North quadrant	700,442	1,214,351	Sediment	0-10	257	268	96%
Hatfield and Office 33 (2011)	10VNBH408	East quadrant	700,910	1,213,662	Sediment	0-10	11.6	12.3	94%
Hatfield and Office 33 (2011)	10VNBH410	East quadrant	700,347	1,213,652	Sediment	0-10	600	633	95%
Hatfield and Office 33 (2011)	10VNBH412	East quadrant	700,383	1,213,444	Sediment	0-10	5.11	6.00	85%
Hatfield and Office 33 (2011)	10VNBH413	Pacer Ivy	697,374	1,213,466	Sediment	0-10	665	675	99%
Hatfield and Office 33 (2011)	10VNBH416	Pacer Ivy	696,990	1,213,359	Sediment	0-10	30.9	32.1	96%
Hatfield and Office 33 (2011)	10VNBH419	Pacer Ivy	697,336	1,213,164	Sediment	0-10	586	605	97%
Hatfield and Office 33 (2011)	10VNBH421	Pacer Ivy	697,187	1,213,173	Sediment	0-10	605	628	96%
Hatfield and Office 33 (2011)	10VNBH422	Pacer Ivy	697,229	1,213,196	Sediment	0-10	1710	1770	97%
Hatfield and Office 33 (2011)	10VNBH423	Pacer Ivy	697,248	1,213,230	Sediment	0-10	605	622	97%
Hatfield and Office 33 (2011)	10VNBH424	Pacer Ivy	697,229	1,213,066	Sediment	0-10	50.0	2020	2%
Hatfield and Office 33 (2011)	10VNBH426	Z1	698,590	1,212,081	Sediment	0-10	111	125	89%
Hatfield and Office 33 (2011)	10VNBH427	Z1	699,344	1,212,211	Sediment	0-10	212	219	97%
Hatfield and Office 33 (2011)	10VNBH428	Z1	699,043	1,211,975	Sediment	0-10	33.9	39.8	85%
Hatfield and Office 33 (2011)	10VNBH429	Outside Airbase (S)	698,656	1,211,778	Sediment	0-10	24.3	26.9	90%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
Hatfield and Office 33 (2011)	10VNBH430	Outside Airbase (S)	699,009	1,211,337	Sediment	0-10	79.1	95.6	83%
VEA (2012)	11BH-A3	Pacer Ivy	696,900	1,213,445	Soil	0-10	3649	3980	92%
VEA (2012)	11BHA-AB4-2	Pacer Ivy	696,935	1,213,664	Soil	30-60	1785	1796	99%
VEA (2012)	11BH-AB1	Pacer Ivy	696,899	1,213,648	Soil	0-10	1673	1725	97%
VEA (2012)	11BH-AB4-1	Pacer Ivy	696,935	1,213,664	Soil	0-30	2662	2677	99%
VEA (2012)	11BH-AB5-1	Pacer Ivy	696,893	1,213,663	Soil	0-30	75.1	81.1	93%
VEA (2012)	11BH-AB5-2	Pacer Ivy	696,893	1,213,663	Soil	30-60	38.3	47.0	81%
VEA (2012)	11BH-B1	Pacer Ivy	696,957	1,213,587	Soil	0-10	417	430	97%
VEA (2012)	11BH-B2	Pacer Ivy	696,927	1,213,528	Soil	0-10	988	1020	97%
VEA (2012)	11BH-B3	Pacer Ivy	696,937	1,213,473	Soil	0-10	286	297	96%
VEA (2012)	11BH-B5	Pacer Ivy	696,952	1,213,366	Soil	0-10	3734	3972	94%
VEA (2012)	11BH-C2	Pacer Ivy	696,988	1,213,532	Soil	0-10	292	301	97%
VEA (2012)	11BH-C3-1	Pacer Ivy	696,906	1,213,519	Soil	0-10	2050	2103	97%
VEA (2012)	11BH-C3-2	Pacer Ivy	696,906	1,213,519	Soil	10-30	2132	2180	98%
VEA (2012)	11BH-C3-3	Pacer Ivy	696,906	1,213,519	Soil	30-60	299	302	99%
VEA (2012)	11BH-C3-4	Pacer Ivy	696,906	1,213,519	Soil	60-90	4.93	5.44	91%
VEA (2012)	11BH-C3-5	Pacer Ivy	696,906	1,213,519	Soil	90-120	4.19	5.21	80%
VEA (2012)	11BH-C3-6	Pacer Ivy	696,906	1,213,519	Soil	120-150	7.00	8.13	86%
VEA (2012)	11BH-C3-7	Pacer Ivy	696,906	1,213,519	Soil	>150	<1.33	1.22	NC
VEA (2012)	11BH-C4	Pacer Ivy	697,016	1,213,406	Soil	0-10	52.1	53.4	98%
VEA (2012)	11BH-C6	Pacer Ivy	697,004	1,213,308	Soil	0-10	253	285	89%
VEA (2012)	11BH-D1	Pacer Ivy	697,042	1,213,615	Soil	0-10	60.9	65.5	93%
VEA (2012)	11BH-D2	Pacer Ivy	697,033	1,213,535	Soil	0-10	30.7	31.6	97%
VEA (2012)	11BH-D4	Pacer Ivy	697,046	1,213,400	Soil	0-10	15.3	15.5	99%
VEA (2012)	11BH-D5	Pacer Ivy	697,016	1,213,351	Soil	0-10	1469	1507	97%
VEA (2012)	11BH-D55	Pacer Ivy	697,016	1,213,351	Soil	0-10	1419	1454	98%
VEA (2012)	11BH-DCH1	Pacer Ivy	697,426	1,213,470	Soil	0-10	2785	2872	97%
VEA (2012)	11BH-DCH10	Pacer Ivy	697,058	1,213,452	Soil	0-10	540	554	97%
VEA (2012)	11BH-DCH12	Pacer Ivy	696,964	1,213,486	Soil	0-10	19.2	19.9	96%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
VEA (2012)	11BH-DCH2	Pacer Ivy	697,480	1,213,467	Soil	0-10	1609	1670	96%
VEA (2012)	11BH-DCH22	Pacer Ivy	697,480	1,213,467	Soil	0-10	1199	1249	96%
VEA (2012)	11BH-DCH4-1	Pacer Ivy	697,586	1,213,471	Soil	0-10	207	220	94%
VEA (2012)	11BH-DCH4-2	Pacer Ivy	697,586	1,213,471	Soil	0-10	238	252	94%
VEA (2012)	11BH-DCH6	Pacer Ivy	697,684	1,213,471	Soil	0-10	457	486	94%
VEA (2012)	11BH-DCH7	Pacer Ivy	697,274	1,213,469	Soil	0-10	2171	2215	98%
VEA (2012)	11BH-DCH8	Pacer Ivy	697,237	1,213,490	Soil	0-10	6518	6681	98%
VEA (2012)	11BH-DCH9	Pacer Ivy	697,204	1,213,478	Soil	0-10	1260	1305	97%
VEA (2012)	11BH-E1	Pacer Ivy	697,094	1,213,585	Soil	0-10	9.97	11.1	90%
VEA (2012)	11BH-E10	Pacer Ivy	697,191	1,213,137	Soil	0-10	382	411	93%
VEA (2012)	11BH-E2	Pacer Ivy	697,085	1,213,526	Soil	0-10	40.0	49.9	80%
VEA (2012)	11BH-E3	Pacer Ivy	697,089	1,213,465	Soil	0-10	903	934	97%
VEA (2012)	11BH-E5	Pacer Ivy	697,098	1,213,363	Soil	0-10	7.33	7.59	97%
VEA (2012)	11BH-E6	Pacer Ivy	697,077	1,213,308	Soil	0-10	399	406	98%
VEA (2012)	11BH-E8	Pacer Ivy	697,087	1,213,194	Soil	0-10	221	417	53%
VEA (2012)	11BH-F3-1	Pacer Ivy	697,113	1,213,483	Soil	0-30	9.26	13.0	71%
VEA (2012)	11BH-F3-2	Pacer Ivy	697,113	1,213,483	Soil	30-60	15.7	16.2	97%
VEA (2012)	11BH-F3-3	Pacer Ivy	697,113	1,213,483	Soil	60-90	2.57	4.06	63%
VEA (2012)	11BH-F3-4	Pacer Ivy	697,113	1,213,483	Soil	90-120	4.28	4.56	94%
VEA (2012)	11BH-F4	Pacer Ivy	697,150	1,213,407	Soil	0-10	1401	1447	97%
VEA (2012)	11BH-F5	Pacer Ivy	697,195	1,213,370	Soil	0-10	20807	21196	98%
VEA (2012)	11BH-F6	Pacer Ivy	697,187	1,213,324	Soil	0-10	5092	5251	97%
VEA (2012)	11BH-G1	Pacer Ivy	697,158	1,213,591	Soil	0-10	165	177	93%
VEA (2012)	11BH-G2-1	Pacer Ivy	697,164	1,213,521	Soil	0-30	11.2	11.4	98%
VEA (2012)	11BH-G2-2	Pacer Ivy	697,164	1,213,521	Soil	30-60	4.94	5.00	99%
VEA (2012)	11BH-G2-3	Pacer Ivy	697,164	1,213,521	Soil	60-90	2.81	2.82	100%
VEA (2012)	11BH-G2-4	Pacer Ivy	697,164	1,213,521	Soil	90-120	1.69	2.01	84%
VEA (2012)	11BH-G2-5	Pacer Ivy	697,164	1,213,521	Soil	120-150	<1.33	0.118	NC
VEA (2012)	11BH-G2-6	Pacer Ivy	697,164	1,213,521	Soil	150-180	<1.33	2.04	NC

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
VEA (2012)	11BH-G3	Pacer Ivy	697,210	1,213,478	Soil	0-10	391	402	97%
VEA (2012)	11BH-G4	Pacer Ivy	697,213	1,213,419	Soil	0-10	799	823	97%
VEA (2012)	11BH-G6	Pacer Ivy	697,217	1,213,318	Soil	0-10	1166	1222	95%
VEA (2012)	11BH-G7	Pacer Ivy	697,233	1,213,248	Soil	0-10	3210	3479	92%
VEA (2012)	11BH-H1	Pacer Ivy	697,267	1,213,607	Soil	0-10	52.8	68.8	77%
VEA (2012)	11BH-H2	Pacer Ivy	697,240	1,213,530	Soil	0-10	9.97	10.3	97%
VEA (2012)	11BH-H21-1	Pacer Ivy	697,251	1,213,266	Soil	0-30	4875	5017	97%
VEA (2012)	11BH-H21-2	Pacer Ivy	697,251	1,213,266	Soil	30-60	9695	9883	98%
VEA (2012)	11BH-H22	Pacer Ivy	697,240	1,213,530	Soil	0-10	7.33	7.73	95%
VEA (2012)	11BH-H4-1	Pacer Ivy	697,274	1,213,404	Soil	0-30	1552	1600	97%
VEA (2012)	11BH-H4-2	Pacer Ivy	697,274	1,213,404	Soil	30-60	26.9	42.6	63%
VEA (2012)	11BH-H4-22	Pacer Ivy	697,274	1,213,404	Soil	30-60	9.22	10.8	85%
VEA (2012)	11BH-H4-3	Pacer Ivy	697,274	1,213,404	Soil	60-90	4.40	49.4	9%
VEA (2012)	11BH-H4-4	Pacer Ivy	697,274	1,213,404	Soil	90-120	51.7	60.2	86%
VEA (2012)	11BH-H4-5	Pacer Ivy	697,274	1,213,404	Soil	120-150	63.7	78.5	81%
VEA (2012)	11BH-H4-6	Pacer Ivy	697,274	1,213,404	Soil	150-180	94.3	94.3	100%
VEA (2012)	11BH-H4-7	Pacer Ivy	697,274	1,213,404	Soil	180-210	26.4	41.4	64%
VEA (2012)	11BH-H5	Pacer Ivy	697,265	1,213,371	Soil	0-10	9455	9685	98%
VEA (2012)	11BH-H6-1	Pacer Ivy	697,265	1,213,318	Soil	0-30	72856	73389	99%
VEA (2012)	11BH-H6-2	Pacer Ivy	697,265	1,213,318	Soil	30-60	108990	109791	99%
VEA (2012)	11BH-H6-3	Pacer Ivy	697,265	1,213,318	Soil	60-90	317087	318816	99%
VEA (2012)	11BH-H6-4	Pacer Ivy	697,265	1,213,318	Soil	90-120	183940	185142	99%
VEA (2012)	11BH-H6-44	Pacer Ivy	697,265	1,213,318	Soil	90-120	146776	147672	99%
VEA (2012)	11BH-H6-5-1	Pacer Ivy	697,265	1,213,318	Soil	120-150	19560	19692	99%
VEA (2012)	11BH-H6-5-2	Pacer Ivy	697,265	1,213,318	Soil	120-150	21076	21205	99%
VEA (2012)	11BH-H6-6	Pacer Ivy	697,265	1,213,318	Soil	150-180	8087	8129	99%
VEA (2012)	11BH-K11	Pacer Ivy	697,337	1,213,033	Soil	0-10	637	682	93%
VEA (2012)	11BH-K3-1	Pacer Ivy	697,307	1,213,475	Soil	0-30	36.0	42.0	86%
VEA (2012)	11BH-K3-2	Pacer Ivy	697,307	1,213,475	Soil	30-60	6.72	6.73	100%

Table A19 (Cont'd.)

Sampling Program	Sample ID	Location	Easting	Northing	Media	Depth (cm)	2,3,7,8 TCDD (ppt dry weight) (ND = 1/2 DL)	ppt TEQ (dry weight) (ND = 1/2 DL) (WHO 2005)	TCDD as % of TEQ
VEA (2012)	11BH-K3-3	Pacer Ivy	697,307	1,213,475	Soil	60-90	8.35	8.72	96%
VEA (2012)	11BH-K3-4	Pacer Ivy	697,307	1,213,475	Soil	90-120	1.46	1.46	100%
VEA (2012)	11BH-K3-5	Pacer Ivy	697,307	1,213,475	Soil	120-150	3.34	3.35	100%
VEA (2012)	11BH-K7-1	Pacer Ivy	697,323	1,213,291	Soil	0-30	949368	962559	99%
VEA (2012)	11BH-K7-2	Pacer Ivy	697,323	1,213,291	Soil	30-60	388807	392669	99%
VEA (2012)	11BH-K7-3	Pacer Ivy	697,323	1,213,291	Soil	60-90	209	210	100%
VEA (2012)	11BH-K7-33	Pacer Ivy	697,323	1,213,291	Soil	60-90	375	375	100%
VEA (2012)	11BH-K7-4	Pacer Ivy	697,323	1,213,291	Soil	90-120	465	466	100%
VEA (2012)	11BH-K7-5	Pacer Ivy	697,323	1,213,291	Soil	120-150	243	243	100%
VEA (2012)	11BH-K7-6	Pacer Ivy	697,323	1,213,291	Soil	150-180	6.68	6.68	100%
VEA (2012)	11BH-K7-7	Pacer Ivy	697,323	1,213,291	Soil	180-210	139	145	96%
VEA (2012)	11BH-K7-8	Pacer Ivy	697,323	1,213,291	Soil	210-240	7567	7611	99%
VEA (2012)	11BH-K8	Pacer Ivy	697,309	1,213,208	Soil	0-10	1041	1123	93%
VEA (2012)	11BH-L12	Pacer Ivy	697,395	1,213,003	Soil	0-10	446	484	92%
VEA (2012)	11BH-L13	Pacer Ivy	697,425	1,212,972	Soil	0-10	1689	1790	94%
VEA (2012)	11BH-M12	Pacer Ivy	697,477	1,213,052	Soil	0-10	19.9	22.4	89%
VEA (2012)	11BH-M13	Pacer Ivy	697,516	1,213,019	Soil	0-10	14.0	22.0	64%

* ***Notes*** :

Source: Hatfield and 10-80 Division 2006, Hatfield and Office 33 2010, Hatfield and Office 33 2011, Vietnam Environment Administration (VEA) 2012.

Laboratory reports were used to populate 2,3,7,8 TCDD and TEQ data from Hatfield and 10-80 Division 2006, Hatfield and Office 33 2010, and Hatfield and Office 33 2011.

Laboratory reports and Table 5 used to populate 2,3,7,8 TCDD and TEQ from VEA 2012.

VEA 2012 reports ND=0.

- ID: identification
- cm: centimeter
- %: percent
- TCDD: tetrachlorodibenzodioxin
- ND: non-detect
- DL: detection limit
- ppt: parts per trillion
- WHO: World Health Organization
- TEQ: dioxin toxicity equivalence
- W: West
- SW: Southwest
- E: East
- SE: Southeast
- NC: Not calculated
- NDR: Peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND.
- "<" = less than the detection limit; number following this symbol represents the detection limit.
- OLR: exceeds calibrated linear range, dilution data shown

Table A20 Historical dioxin concentrations in blood serum and breast milk samples analyzed from Bien Hoa, Vietnam.

Sample ID	Media	Sex	Age	2,3,7,8 TCDD	% Lipid	TEQ (WHO 2005)	TCDD as % of TEQ
10VNBH600	Blood Serum	M	45	27.8	0.86	41.5	67%
10VNBH601	Blood Serum	F	46	58	0.86	76.6	76%
10VNBH602	Blood Serum	M	48	42.1	0.94	58.8	72%
10VNBH603	Blood Serum	M	47	137	0.87	145	94%
10VNBH604	Blood Serum	M	42	1040	0.81	1080	96%
10VNBH605	Blood Serum	M	47	37.7	1.10	49.0	77%
10VNBH606	Blood Serum	M	50	92.8	0.89	111	84%
10VNBH607	Blood Serum	M	47	40.9	1.10	50.7	81%
10VNBH608	Blood Serum	M	48	29.9	0.90	37.9	79%
10VNBH609	Blood Serum	M	48	17.6	0.78	31.2	56%
10VNBH610	Blood Serum	M	46	13.7	0.63	19.3	71%
10VNBH611	Blood Serum	M	45	56.5	0.82	70.2	80%
10VNBH612	Blood Serum	M	47	79.0	0.90	104	76%
10VNBH613	Blood Serum	M	48	53.3	1.50	73.2	73%
10VNBH614	Blood Serum	M	43	327	0.90	347	94%
10VNBH615	Blood Serum	M	46	42.8	1.0	63.9	67%
10VNBH616	Blood Serum	M	48	45.9	1.10	61.3	75%
10VNBH617	Blood Serum	M	47	322	0.71	343	94%
10VNBH618	Blood Serum	M	45	67.8	0.98	83.3	81%
10VNBH619	Blood Serum	M	46	38.9	0.80	49.7	78%
10VNBH620	Blood Serum	M	48	32.4	0.70	45.7	71%
10VNBH621	Blood Serum	M	45	95.8	1.20	110	87%
10VNBH622	Blood Serum	M	48	274	0.71	303	90%
10VNBH623	Blood Serum	M	47	67.7	0.89	82.4	82%
10VNBH624	Blood Serum	M	45	72.1	0.64	87.8	82%
10VNBH625	Blood Serum	M	46	44.1	1.20	57.5	77%
10VNBH626	Blood Serum	F	46	31.9	0.76	35.8	89%
10VNBH627	Blood Serum	M	48	71.0	0.52	89.0	80%
10VNBH628	Blood Serum	M	53	159	0.73	173	92%
10VNBH629	Blood Serum	F	61	160	1.10	179	89%
10VNBH630	Blood Serum	M	45	85.4	0.80	90.8	94%
10VNBH631	Blood Serum	M	50	49.5	1.10	59.9	83%
10VNBH632	Blood Serum	M	48	211	1.50	230	92%
10VNBH633	Blood Serum	M	49	1970	0.89	2020	98%
10VNBH634	Blood Serum	M	45	87.0	0.64	93.1	93%
10VNBH635	Blood Serum	M	47	67.1	1.70	74.7	90%

Table A20 (Cont'd.)

Sample ID	Media	Sex	Age	2,3,7,8 TCDD	% Lipid	TEQ (WHO 2005)	TCDD as % of TEQ
10VNBH636	Blood Serum	M	48	161	0.67	183	88%
10VNBH637	Blood Serum	F	38	1130	0.51	1150	98%
10VNBH638	Blood Serum	M	48	28.1	0.80	44.1	64%
10VNBH639	Blood Serum	F	47	102	0.77	121	84%
10VNBH640	Blood Serum	M	48	34.4	0.73	46.7	74%
10VNBH641	Blood Serum	M	48	119	0.85	138	86%
10VNBH800	Breast Milk	F	34	8.21	9.61	12.8	64%
10VNBH801	Breast Milk	F	27	2.39	6.14	7.54	32%
10VNBH802	Breast Milk	F	30	1.48	5.70	6.53	23%
10VNBH804	Breast Milk	F	21	22.5	4.25	28.6	79%
10VNBH805	Breast Milk	F	39	< 12.3	3.68	13.7	NC
10VNBH806	Breast Milk	F	21	< 0.246	3.58	1.55	NC
10VNBH807	Breast Milk	F	28	2.94	1.97	13.0	23%
10VNBH808	Breast Milk	F	28	3.11	2.51	5.58	56%
10VNBH809	Breast Milk	F	25	2.45	3.96	7.39	33%
10VNBH810	Breast Milk	F	29	9.85	1.96	14.0	70%
10VNBH811	Breast Milk	F	24	NDR 1.64	6.04	3.49	NC
10VNBH814	Breast Milk	F	27	13.8	3.46	31.8	43%
10VNBH816	Breast Milk	F	23	1.37	3.64	5.86	23%
10VNBH817	Breast Milk	F	27	< 0.815	1.24	2.99	NC
10VNBH818	Breast Milk	F	34	10.2	4.03	13.5	76%
10VNBH819	Breast Milk	F	38	1.72	1.86	6.25	28%
10VNBH820	Breast Milk	F	25	3.20	4.70	6.78	47%
10VNBH821	Breast Milk	F	24	0.773	11.9	6.32	12%
10VNBH803	Breast Milk	F	29	30.3	2.52	39.6	77%
10VNBH812	Breast Milk	F	26	8.99	2.69	12.7	71%
10VNBH813	Breast Milk	F	34	2.27	4.19	5.87	39%
10VNBH815	Breast Milk	F	28	2.31	1.99	9.83	23%

* ***Notes*** :

Source: Hatfield 2011. Laboratory reports were used to populate 2,3,7,8 TCDD and TEQ data.

- ND = Not detected; for "Total TEQ" calculations, if ND, 1/2 detection level was used.
- NDR = Peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND.
- NC = Not calculated.
- F: Female
- M: Male
- WHO: World Health Organization
- TEQ: dioxin toxicity equivalence
- TCDD: tetrachlorodibenzodioxin
- ID: identification
- %: percent

Table A21 Historical concentrations in biota samples analyzed from Bien Hoa, Vietnam.

Site ID	Sample ID	Collection Date	Species and Media	2,3,7,8 TCDD	TEQ (WHO 2005)	TCDD as % of TEQ
BH Market	10VNBH512	2010	Muscle	NDR 0.0862	0.0782	NC
BH Market	10VNBH513	2010	Fat	2.51	4.54	55%
BH Market	10VNBH514	2010	Muscle	NDR 0.117	0.0856	NC
BH Market	10VNBH515	2010	Fat	3.29	5.9	56%
East quadrant	10VNBH500	2010	Muscle	1.4	1.49	94%
East quadrant	10VNBH501	2010	Fat	73.3	76	96%
East quadrant	10VNBH502	2010	Muscle	14.4	14.8	97%
East quadrant	10VNBH503	2010	Fat	1620	1680	96%
North quadrant	10VNBH504	2010	Muscle	25.4	25.9	98%
North quadrant	10VNBH505	2010	Fat	2410	2460	98%
Outside Airbase (S)	10VNBH518	2010	Muscle	1.25	1.35	93%
Outside Airbase (S)	10VNBH519	2010	Fat	86.7	91.8	94%
Outside Airbase (S)	10VNBH507	2010	Muscle	32.7	33.2	98%
Outside Airbase (S)	10VNBH508	2010	Fat	1490	1520	98%
Pacer Ivy	10VNBH509	2010	Muscle	31.2	31.5	99%
Pacer Ivy	10VNBH510	2010	Fat	3990	4040	99%
Pacer Ivy	10VNBH521	2010	Whole Fish	618	622	99%
Pacer Ivy	10VNBH521	2010	Whole Fish	621	625	99%
Z1	10VNBH516	2010	Fish/Muscle	18.6	18.9	98%
Z1	10VNBH517	2010	Fish/Fat	1410	1440	98%
Z1	10VNBH522	2010	Fish/Whole	94.7	96.5	98%

Notes:

Source: Hatfield 2011. Laboratory reports were used to populate 2,3,7,8 TCDD and TEQ data.

- "<": less than the detection limit; number following this symbol represents the detection limit.
- NDR: peak detected but did not meet quantification criteria; number following this flag represents the
- NC: Not calculated as NDR values of TCDD are considered "0".
- ID: identification
- BH: Bien Hoa
- S: South
- TCDD: tetrachlorodibenzodioxin
- WHO: World Health Organization
- TEQ: dioxin toxicity equivalence
- %: percent
- NDR: Peak detected but did not meet quantification criteria; for 'Total TEQ' calculations, NDR was treated as ND.

Table A22 Historical concentrations in groundwater samples analyzed from Bien Hoa, Vietnam.

Sample ID	Northing	Easting	Media	Depth (m)	2,3,7,8 TCDD	TEQ Lowerbound	TEQ Upperbound	TCDD as % of Upperbound TEQ
MW-01	699,007	1,212,654	Groundwater	10.37	0.34	0.37	0.47	72.34
MW-02	698,863	1,212,413	Groundwater	8.88	3	3.1	3.2	93.8
MW-03	699,050	1,212,434	Groundwater	8.65	n.d	0.025	0.16	n.d
MW-04	698,968	1,212,324	Groundwater	7.51	0.18	0.2	0.31	58.06
MW-05	698,031	1,212,501	Groundwater	10.58	17	18	18	94
MW-06a	697,149	1,213,254	Groundwater	5.74	10	10	10	100

* ***Notes*** :

Source: Dekonta 2014.

- ID: identification
- m: meter
- TCDD: tetrachlorodibenzodioxin
- TEQ: dioxin toxicity equivalence
- %: percent
- ND: non-detect

Table A23 Relative percent differences of field versus laboratory duplicate samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sub-DU[1]	Depth (cm)	Sample type	Media	Concentration (ppt dry weight) (ND = 1/2 DL)					RPD (%)				
				2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL TEQ	2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL
G2L-01	30-45	Field sample	Sediment	52.5	515	3.15	16.3	56.5	15.0%	26.6%	10.5%	9.9%	11.8%
G2L-01 (dup)	30-45	Lab duplicate	Sediment	61.0	673	3.50	18.0	63.6					
NE-02A	0-30	Field sample	Soil	952	97.8	22.7	3.11	980	0.3%	8.8%	1.8%	7.7%	0.4%
NE-02A (dup)	0-30	Lab duplicate	Soil	949	89.6	22.3	2.88	976					
NE-05-T2	0-30	Field sample	Soil	17.7	3,580	1.98	55.3	30.9	0.6%	14.7%	5.7%	7.9%	7.0%
NE-05-T2 (dup)	0-30	Lab duplicate	Soil	17.8	3,090	1.87	51.1	28.8					
NE-10-T2	15-30	Field sample	Sediment	27.3	1,540	2.67	37.5	32.0	0.7%	0.7%	36.4%	2.2%	2.9%
NE-10-T2 (dup)	15-30	Lab duplicate	Sediment	27.1	1,530	3.86	36.7	31.1					
NE-15	0-15	Field sample	Sediment	141	1,510	10.9	64.9	154	5.8%	0.7%	11.4%	3.0%	5.3%
NE-15 (dup)	0-15	Lab duplicate	Sediment	133	1,500	9.72	63.0	146					
NF-04	0-30	Field sample	Soil	163	334	9.16	9.6	171	6.3%	8.8%	11.9%	13.6%	9.2%
NF-04 (dup)	0-30	Lab duplicate	Soil	153	306	8.13	11.0	156					
NF-04C	0-30	Field sample	Soil	17.3	342	1.90	7.18	20.1	9.7%	0.3%	1.6%	13.2%	7.2%
NF-04C (dup)	0-30	Lab duplicate	Soil	15.7	341	1.87	6.29	18.7					
NW-02	0-15	Field sample	Sediment	67.9	475	3.99	9.73	72.4	4.4%	3.2%	18.6%	12.2%	4.8%
NW-02 (dup)	0-15	Lab duplicate	Sediment	65.0	460	3.31	8.61	69.0					
PI-01	90-120	Field sample	Soil	12.0	86.8	1.31	0.594	12.4	8.8%	23.6%	19.9%	16.1%	9.2%
PI-01 (dup)	90-120	Lab duplicate	Soil	13.1	110	1.60	0.698	13.6					
PI-01-T2	0-30	Field sample	Soil	117	308	8.99	8.98	124	4.4%	10.2%	6.5%	0.7%	5.0%
PI-01-T2 (dup)	0-30	Lab duplicate	Soil	112	278	8.42	9.04	118					
PI-08	60-90	Field sample	Soil	235	785	11.9	6.25	253	10.1%	3.3%	24.4%	7.7%	8.7%
PI-08 (dup)	60-90	Lab duplicate	Soil	260	811	15.2	6.75	276					
PI-08-T2	0-30	Field sample	Soil	2,250	2,590	110	59.6	2,430	12.8%	20.9%	7.5%	27.9%	12.7%
PI-08-T2 (dup)	0-30	Lab duplicate	Soil	1,980	2,100	102	45.0	2,140					
PI-09	30-60	Field sample	Soil	131	820	14.3	23.1	139	5.5%	18.1%	0.0%	12.2%	5.2%
PI-09 (dup)	30-60	Lab duplicate	Soil	124	983	14.3	26.1	132					
PI-21	15-30	Field sample	Sediment	17.1	732	1.42	13.0	18.4	0.6%	3.3%	2.8%	29.7%	0.5%
PI-21 (dup)	15-30	Lab duplicate	Sediment	17.2	708	1.46	9.64	18.3					
SE-01	30-60	Field sample	Soil	19.2	4,360	1.60	56.5	34.5	18.8%	5.4%	19.2%	1.1%	108.0%
SE-01 (dup)	30-60	Lab duplicate	Soil	15.9	4,130	1.94	57.1	10.3					
SW-01	120-150	Field sample	Soil	1,370	127	2.65	11.4	1,370	2.2%	28.4%	14.4%	43.5%	2.2%
SW-01 (dup)	120-150	Lab duplicate	Soil	1,340	169	3.06	7.33	1,340					

Table A23 (Cont'd.)

Sub-DU[1]	Depth (cm)	Sample type	Media	Concentration (ppt dry weight) (ND = 1/2 DL)					RPD (%)				
				2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL TEQ	2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL
SW-07	60-90	Field sample	Soil	124	822	3.77	21.1	129	12.1%	4.6%	12.9%	1.4%	11.7%
SW-07 (dup)	60-90	Lab duplicate	Soil	140	785	4.29	20.8	145					
Z1-02	360-390	Field sample	Soil	32.2	40.6	0.777	1.24	33.2	4.8%	9.5%	50.6%	27.5%	3.6%
Z1-02 (dup)	360-390	Lab duplicate	Soil	33.8	36.9	0.463	0.940	34.4					
Z1-03-T1	0-30	Field sample	Soil	453	474	13.7	12.5	461	53.8%	30.1%	45.4%	26.4%	53.4%
Z1-03-T1 (dup)	0-30	Lab duplicate	Soil	786	642	8.63	16.3	797					
Z1-03-T2	0-30	Field sample	Soil	87.0	803	2.50	12.7	107	23.4%	52.2%	22.1%	76.4%	10.6%
Z1-03-T2 (dup)	0-30	Lab duplicate	Soil	110	1,370	3.12	28.4	119					
Z1-03-T2	60-90	Field sample	Soil	24.1	117	ND	ND	25.1	57.8%	17.2%	NA	NA	54.8%
Z1-03-T2 (dup)	60-90	Lab duplicate	Soil	13.3	98.5	ND	1.25	14.3					
Z1-04	360-390	Field sample	Soil	3.78	41.7	ND	0.478	4.26	26.0%	6.2%	NA	NA	143.3%
Z1-04 (dup)	360-390	Lab duplicate	Soil	2.91	39.2	ND	ND	0.703					
Z1-08C	0-30	Field sample	Soil	3.79	1,370	ND	58.0	10.3	0.8%	5.0%	NA	14.5%	3.8%
Z1-08C (dup)	0-30	Lab duplicate	Soil	3.76	1,440	0.432	67.1	10.7					
Z1-09	0-15	Field sample	Sediment	394	977	26.5	31.2	413	7.3%	35.6%	4.1%	12.3%	7.0%
Z1-09 (dup)	0-15	Lab duplicate	Sediment	424	1,400	27.6	35.3	443					
Z1-16C	0-30	Field sample	Soil	115	173	11.6	3.64	130	6.7%	9.9%	11.9%	41.6%	3.8%
Z1-16C (dup)	0-30	Lab duplicate	Soil	123	191	10.3	5.55	135					
ZT-02	60-90	Field sample	Soil	82.9	269	1.85	6.22	86.1	2.4%	29.5%	25.5%	31.1%	1.8%
ZT-02 (dup)	60-90	Lab duplicate	Soil	80.9	362	2.39	8.51	84.6					
PI-16A	15-30	Field sample	Sediment	158	765	6.21	14.5	164	1.3%	3.2%	6.7%	12.5%	1.2%
PI-16A (dup)	15-30	Duplicate	Sediment	156	790	6.64	12.8	166					
PI-12A	60-90	Field sample	Soil	36.2	597	1.97	2.16	40.0	34.7%	9.7%	44.0%	1.4%	37.4%
PI-12A (dup)	60-90	Duplicate	Soil	25.5	658	1.26	2.13	27.4					
NW-03C	30-45	Field sample	Sediment	638	423	9.85	17.5	644	19.8%	20.6%	21.1%	20.8%	20.4%
NW-03C (dup)	30-45	Duplicate	Sediment	523	344	7.97	14.2	525					
Z1-03B	60-90	Field sample	Soil	92.1	158	0.432	5.60	95.8	11.2%	17.2%	2.1%	18.8%	10.1%
Z1-03B (dup)	60-90	Duplicate	Soil	103.0	133	0.441	4.64	106					
SW-08B	30-60	Field sample	Soil	190	6260	7.97	208	216	12.9%	4.2%	20.8%	9.2%	9.2%
SW-08B (dup)	30-60	Duplicate	Soil	167	6530	6.47	228	197					

Table A23 (Cont'd.)

Sub-DU[1]	Depth (cm)	Sample type	Media	Concentration (ppt dry weight) (ND = 1/2 DL)					RPD (%)				
				2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL TEQ	2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL

* ***Notes*** :

- %: percent
- cm: centimeter
- DL: detection limit
- DU: decision unit
- dup: duplicate sample
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppt: part per trillion
- RPD: relative percent difference
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

[1] A, B, and C denote the 3 sub-samples within each DU. Those without such designations are MIS samples.

Table A24 Relative percent differences of field versus field split samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sub-DU	Depth (cm)	Sample type	Media	Concentration (ppt dry weight) (ND=1/2 DL)					RPD (%)				
				2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL TEQ	2,3,7,8-TCDD	OCDD	2,3,7,8-TCDF	OCDF	TOTAL TEQ
NE-01	0-30	Field sample	Soil	7.64	1,010	0.0617	8.47	10.6	5.0%	4.2%	15.4%	11.3%	3.8%
NE-01S	0-30	Split sample	Soil	7.27	968	0.0529	9.48	10.2					
NE-04-T2	30-60	Field sample	Soil	314	126	0.0211	3.48	329	1.9%	57.2%	194.3%	23.6%	2.1%
NE-04S-T2	30-60	Split sample	Soil	320	227	1.47	4.41	336					
NE-07	0-15	Field sample	Sediment	1,200	468	6.0	14.9	1,300	0.0%	19.7%	11.0%	0.7%	3.1%
NE-07S	0-15	Split sample	Sediment	1,200	384	6.70	14.8	1,260					
NE-11	0-15	Field sample	Sediment	70.6	2,830	1.07	52.5	124.7	0.6%	2.1%	7.9%	1.5%	40.4%
NE-11S	0-15	Split sample	Sediment	70.2	2,770	0.989	51.7	82.8					
NW-02	0-15	Field sample	Sediment	67.9	475	0.399	9.73	72.4	2.7%	11.3%	20.4%	4.2%	3.7%
NW-02S	0-15	Split sample	Sediment	66.1	424	0.325	9.33	69.8					
PI-01	0-30	Field sample	Soil	87.3	311	0.752	5.89	183.5	0.7%	16.7%	10.2%	2.7%	65.8%
PI-01S	0-30	Split sample	Soil	86.7	263	0.679	6.05	92.7					
PI-01-T1	30-60	Field sample	Soil	144	260	1.28	6.93	149	6.7%	1.2%	181.4%	6.4%	6.5%
PI-01S-T1	30-60	Split sample	Soil	154	257	0.0625	6.50	159					
PI-03	0-30	Field sample	Soil	19.3	858	0.344	13.4	23.7	26.1%	24.7%	5.1%	36.6%	20.5%
PI-03S	0-30	Split sample	Soil	25.1	1,100	0.362	19.4	29.1					
PI-15	0-15	Field sample	Sediment	1,800	2,210	8.24	51.4	1,910	16.8%	1.8%	0.9%	12.2%	15.9%
PI-15S	0-15	Split sample	Sediment	2,130	2,250	8.17	58.1	2,240					
SW-06	0-30	Field sample	Soil	53.0	1,570	0.394	57.6	62.8	21.3%	15.8%	36.3%	8.0%	16.9%
SW-06S	0-30	Split sample	Soil	42.8	1,840	0.273	62.4	53.0					
Z1-01-Landfill	0-100	Field sample	Soil	1,480	1,030	1.43	19.6	1,510	0.0%	25.4%	8.8%	1.0%	0.0%
Z1-01S-Landfill	0-100	Split sample	Soil	1,480	798	1.31	19.4	1,510					
Z1-05	0-30	Field sample	Soil	41.8	1,130	0.267	26.0	48.2	10.2%	3.5%	6.9%	3.8%	8.5%
Z1-05S	0-30	Split sample	Soil	46.3	1,170	0.286	27.0	52.5					
Z1-17	120-150	Field sample	Soil	1.92	17.8	0.00735	ND	2.10	9.4%	8.1%	1.4%	NA	8.2%
Z1-17S	120-150	Split sample	Soil	2.11	19.3	0.00745	0.233	2.28					
Z1-17	240-270	Field sample	Soil	0.219	21.7	0.0219	0.481	0.697	162.4%	2.7%	98.5%	11.4%	93.5%
Z1-17S	240-270	Split sample	Soil	2.11	22.3	0.00745	0.539	1.92					
ZT-07	0-30	Field sample	Soil	85.9	226	0.0561	2.76	86.4	5.9%	2.2%	89.9%	11.6%	5.8%
ZT-07S	0-30	Split sample	Soil	81.0	231	0.0213	3.10	81.5					

* **Notes**:

- %: percent
- cm: centimeter
- DL: detection limit
- DU: decision unit
- dup: duplicate sample
- H6CDD: total hexachlorodibenzodioxins
- H6CDF: total hexachlorodibenzofurans
- H7CDD: total heptachlorodibenzodioxins
- H7CDF: total heptachlorodibenzofurans
- ID: identification
- ND: non-detect
- O8CDD: total octachlorodibenzodioxins
- O8CDF: total octachlorodibenzofurans
- P5CDD: total pentachlorodibenzodioxins
- P5CDF: total pentachlorodibenzofurans
- PCDD: polychlorinated dibenzodioxins
- PCDF: polychlorinated dibenzofurans
- ppt: part per trillion
- RPD: relative percent difference
- T4CDD: total tetrachlorodibenzodioxins
- T4CDF: total tetrachlorodibenzofurans
- TCDD: tetrachlorodibenzodioxin
- TCDF: tetrachlorodibenzofuran
- TEQ: dioxin toxicity equivalence

Table A25 95% upper confidence limit calculations for triplicate samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sample ID	Sub-DU	Depth (cm)	Media	TOTAL (TEQ ND=1/2 DL)	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
14BH-Z1-03-0-30	Z1-03	0-30	Soil	52.9	207	180.9814	2.91999	512.1
14BH-Z1-03-T1-0-30	Z1-03-T1	0-30	Soil	461				
14BH- Z1-03-T2-0-30	Z1-03-T2	0-30	Soil	107				
14BH-Z1-03-60-90	Z1-03	60-90	Soil	83.2	46	26.6664	2.91999	90.5
14BH-Z1-03-T1 60-90	Z1-03-T1	60-90	Soil	28.3				
14BH-Z1-03-T2 60-90	Z1-03-T2	60-90	Soil	25.1				
14BH-Z1-03-120-150	Z1-03	120-150	Soil	4.05	4	0.7746	2.91999	5.6
14BH-Z1-03-T1 120-150	Z1-03-T1	120-150	Soil	5.34				
14BH-Z1-03-T2 120-150	Z1-03-T2	120-150	Soil	3.49				
14BH-Z1-13 0-30	Z1-13	0-30	Soil	65.2	82	12.2880	2.91999	103.2
14BH-Z1-13-T1 0-30	Z1-13-T1	0-30	Soil	89.4				
14BH-Z1-13-T2 0-30	Z1-13-T2	0-30	Soil	92.8				
14BH-NE-05 0-30	NE-05	0-30	Soil	69.8	46	16.9306	2.91999	74.7
14BH-NE5-T1-0-30	NE-05-T1	0-30	Soil	37.9				
14BH-NE5-T2-0-30	NE-05-T2	0-30	Soil	30.9				
14BH-NF-01 0-30	NF-01	0-30	Soil	25.2	30	3.3360	2.91999	35.5
14BH-NF-01-T1-0-30	NF-01-T1	0-30	Soil	32.8				
14BH-NF-01-T2-0-30	NF-01-T2	0-30	Soil	31.6				
14BH-SW4-0-30	SW-04	0-30	Soil	40.1	36	2.9428	2.91999	41.4
14BH-SW-04-T1-0-30	SW-04-T1	0-30	Soil	32.9				
14BH-SW-04-T2-0-30	SW-04-T2	0-30	Soil	36.2				
14BH-PI-13 0-30	PI-13	0-30	Soil	107	173	55.1382	2.91999	266.3
14BH-PI-13 -T1-0-30	PI-13-T1	0-30	Soil	242				
14BH-PI-13 -T2-0-30	PI-13-T2	0-30	Soil	171				

Table A25 95% upper confidence limit calculations for triplicate samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sample ID	Sub-DU	Depth (cm)	Media	TOTAL (TEQ ND=1/2 DL)	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
15BH-NE-04-0-30	NE-04	0-30	Soil	579	549	27.2764	2.91999	595.0
15BH-NE-04-T1-0-30	NE-04-T1	0-30	Soil	513				
15BH-NE-04-T2-0-30	NE-04-T2	0-30	Soil	555				
15BH-NE-04-30-60	NE-04	30-60	Soil	124	195	94.8086	2.91999	354.8
15BH-NE-04-T1-30-60	NE-04-T1	30-60	Soil	132				
15BH-NE-04-T2-30-60	NE-04-T2	30-60	Soil	329				
15BH-NE-10-0-15	NE-10	0-15	Sediment	25.2	22	3.0880	2.91999	26.9
15BH-NE-10-T1-0-15	NE-10-T1	0-15	Sediment	17.7				
15BH-NE-10-T2-0-15	NE-10-T2	0-15	Sediment	22.3				
15BH-NE-10-15-30	NE-10	15-30	Sediment	30.7	32	1.0209	2.91999	33.7
15BH-NE-10-T1-15-30	NE-10-T1	15-30	Sediment	33.2				
15BH-NE-10-T2-15-30	NE-10-T2	15-30	Sediment	32.0				
15BH-NE-10-30-45	NE-10	30-45	Sediment	24.8	35	8.3731	2.91999	49.0
15BH-NE-10-T1-30-45	NE-10-T1	30-45	Sediment	45.3				
15BH-NE-10-T2-30-45	NE-10-T2	30-45	Sediment	34.5				
15BH-NE-11-0-15	NE-11	0-15	Sediment	83.3	109	9.2783	2.91999	124.7
15BH-NE-11-T1-0-15	NE-11-T1	0-15	Sediment	96.3				
15BH-NE-11-T2-0-15	NE-11-T2	0-15	Sediment	113				
15BH-NE-11-15-30	NE-11	15-30	Sediment	338	188	105.8689	2.91999	366.8
15BH-NE-11-T1-15-30	NE-11-T1	15-30	Sediment	117				
15BH-NE-11-T2-15-30	NE-11-T2	15-30	Sediment	110				
15BH-NE-11-30-45	NE-11	30-45	Sediment	148	137	21.7613	2.91999	174.0
15BH-NE-11-T1-30-45	NE-11-T1	30-45	Sediment	157				
15BH-NE-11-T2-30-45	NE-11-T2	30-45	Sediment	107				

Table A25 95% upper confidence limit calculations for triplicate samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sample ID	Sub-DU	Depth (cm)	Media	TOTAL (TEQ ND=1/2 DL)	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)
15BH-PI-01-0-30	PI-01	0-30	Soil	92.4	151	19.4822	2.91999	183.5
15BH-PI-01-T1-0-30	PI-01-T1	0-30	Soil	158				
15BH-PI-01-T2-0-30	PI-01-T2	0-30	Soil	124				
15BH-PI-01-30-60	PI-01	30-60	Soil	17.5	84	53.6961	2.91999	174.6
15BH-PI-01-T1-30-60	PI-01-T1	30-60	Soil	149				
15BH-PI-01-T2-30-60	PI-01-T2	30-60	Soil	85.6				
15BH-PI-08-0-30	PI-08	0-30	Soil	1470	1,903	397.4362	2.91999	2573.4
15BH-PI-08-T1-0-30	PI-08-T1	0-30	Soil	1810				
15BH-PI-08-T2-0-30	PI-08-T2	0-30	Soil	2430				
15BH-Z1-10-0-15	Z1-10	0-15	Sediment	1320	1,074	249.4634	2.91999	1494.6
15BH-Z1-10-T1-0-15	Z1-10-T1	0-15	Sediment	1170				
15BH-Z1-10-T2-0-15	Z1-10-T2	0-15	Sediment	732				
15BH-Z1-10-15-30	Z1-10	15-30	Sediment	474	900	402.4279	2.91999	1578.8
15BH-Z1-10-T1-15-30	Z1-10-T1	15-30	Sediment	1440				
15BH-Z1-10-T2-15-30	Z1-10-T2	15-30	Sediment	787				
15BH-Z1-10-30-45	Z1-10	30-45	Sediment	93.5	124	71.5747	2.91999	244.8
15BH-Z1-10-T1-30-45	Z1-10-T1	30-45	Sediment	223				
15BH-Z1-10-T2-30-45	Z1-10-T2	30-45	Sediment	55.9				
15BH-Z1-16-0-30	Z1-16	0-30	Soil	375	329	63.4157	2.91999	435.6
15BH-Z1-16-T1-0-30	Z1-16-T1	0-30	Soil	372				
15BH-Z1-16-T2-0-30	Z1-16-T2	0-30	Soil	239				
15BH-Z1-16-30-60	Z1-16	30-60	Soil	22.4	112	65.0961	2.91999	222.2
15BH-Z1-16-T1-30-60	Z1-16-T1	30-60	Soil	141				
15BH-Z1-16-T2-30-60	Z1-16-T2	30-60	Soil	174				

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Table A25 95% upper confidence limit calculations for triplicate samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Sample ID	Sub-DU	Depth (cm)	Media	TOTAL (TEQ ND=1/2 DL)	Average (ppt TEQ)	Stdev (ppt TEQ)	t-value	95% UCL (ppt TEQ)

* ***Notes*** **:**

- %: percent
- cm: centimeter
- DL: detection limit
- DU: decision unit
- ID: identification
- ND: non-detect
- ppt: part per trillion
- stdev: standard deviation
- TEQ: dioxin toxicity equivalence
- UCL: upper confidence limit

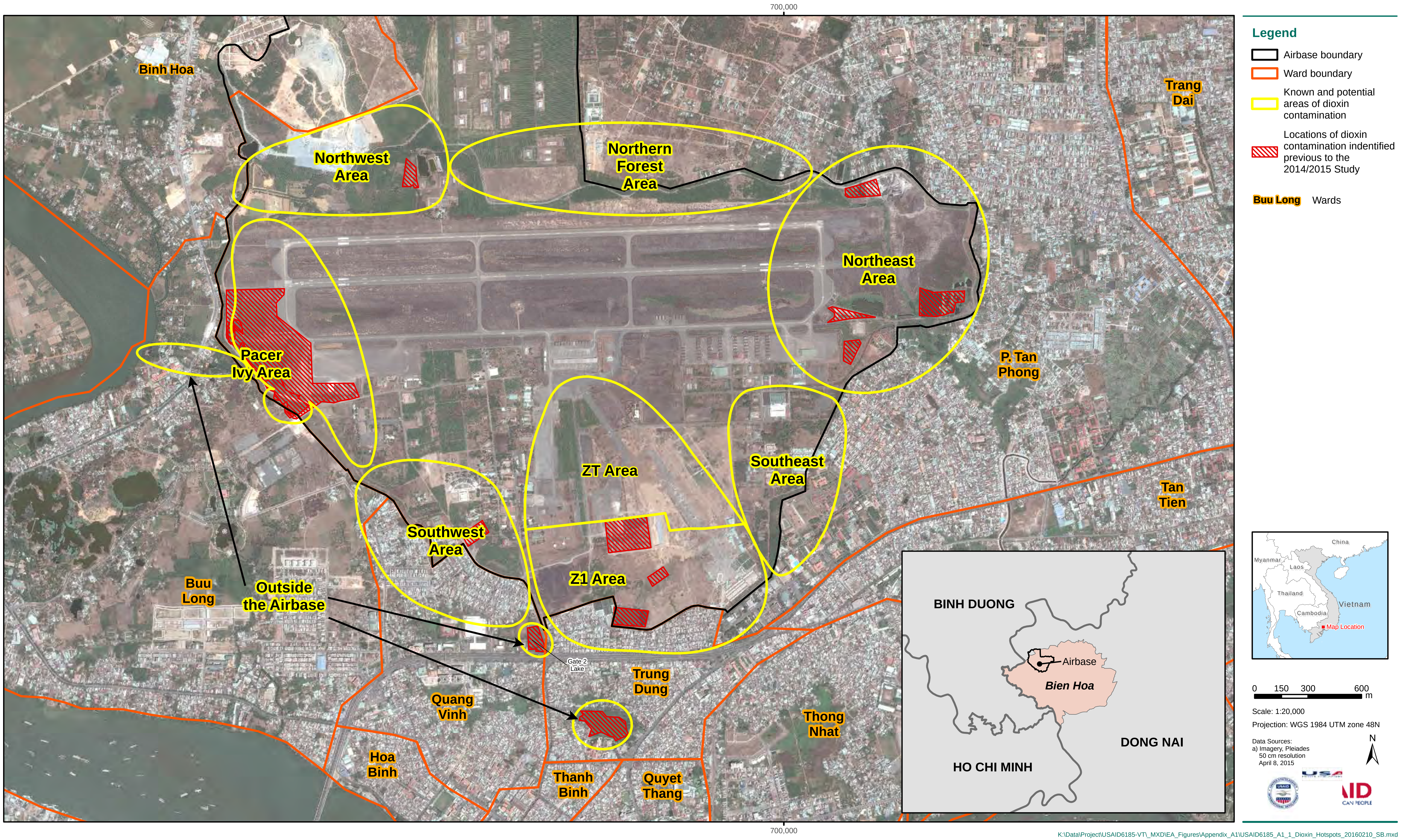
Table A26 Rinsate blank results, Bien Hoa Airbase, Vietnam, 2014-2015.

Rinsate blank collection location	Concentration (pg/L)	
	2,3,7,8-TCDD	TOTAL (TEQ ND=1/2 DL)
NE-04	1.41	2.01
NE-05	5.43	6.12
NW-02	ND	0.967
PI-01	ND	0.844
PI-02	96.7	97.6
PI-07	ND	0.893
SW-01	ND	0.847
SW-03	ND	0.936
SW-07	ND	0.906
Z1-04	ND	1.16
Z1-05	7.92	9.96
Z1-09	ND	0.862
Z1-13	ND	0.948
Z1-16	2.68	3.26
ZT-07	ND	0.844

* ***Notes*** **:**

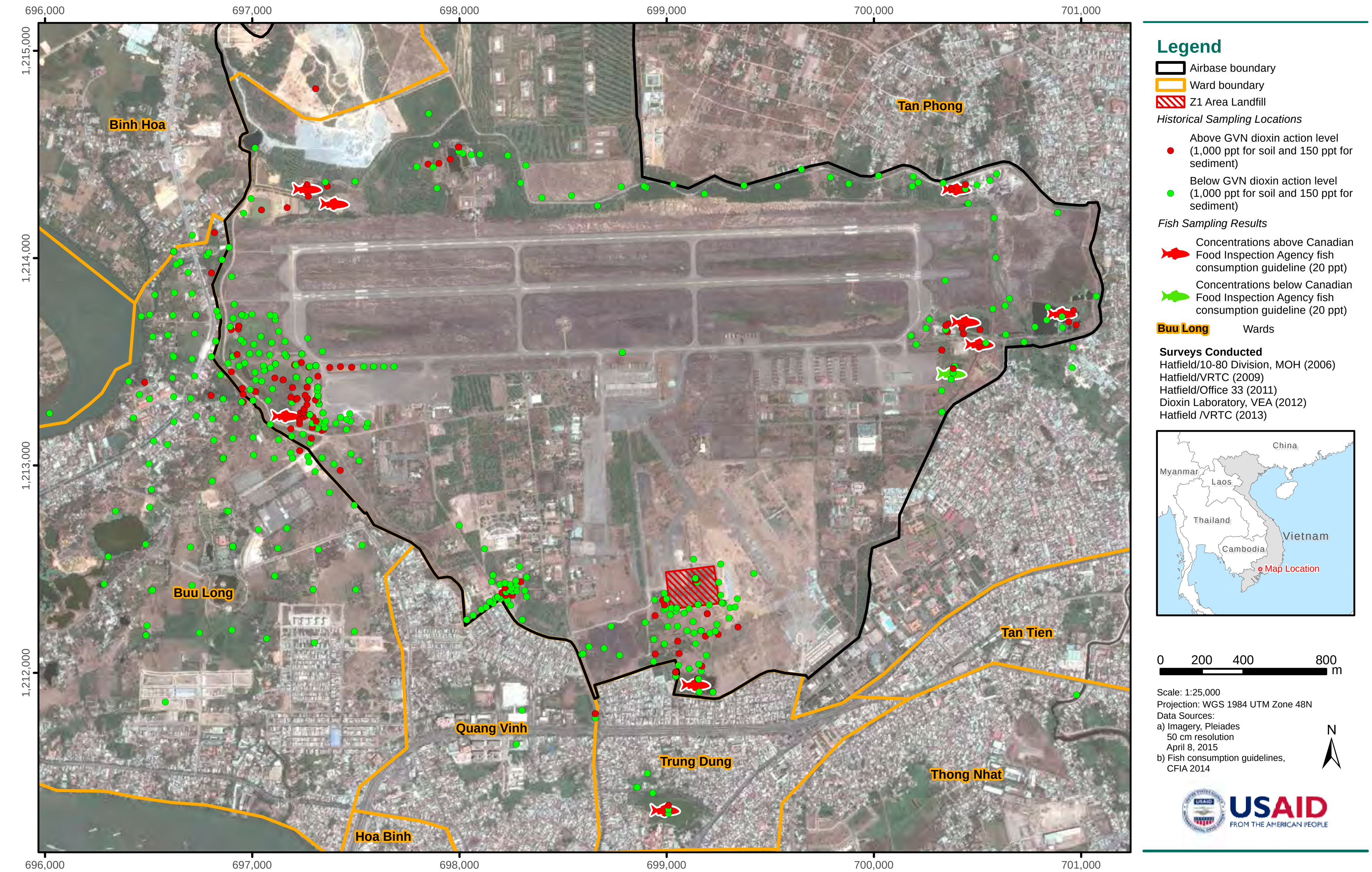
- DL: detection limit
- ID: identification
- ND: non-detect
- pg/L: picogram per liter
- TCDD: tetrachlorodibenzodioxin
- TEQ: dioxin toxicity equivalence

FIGURE A1.1 AREAS OF KNOWN AND POTENTIAL DIOXIN CONTAMINATION, BIEN HOA AIRBASE, VIETNAM



K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_1_Dioxin_Hotspots_20160210_SB.mxd

FIGURE A1.2 RESULTS OF HISTORICAL DIOXIN SAMPLING PROGRAM CONDUCTED AT BIEN HOA AIRBASE, VIETNAM FROM 1990 TO 2013



K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_2_Historical_Sampling_20160210_SB.mxd

FIGURE A1.3 2014/2015 DECISION UNITS AND SUB-DECISION UNITS FOR ENVIRONMENTAL REMEDIATION AT BIEN HOA AIRBASE, VIETNAM

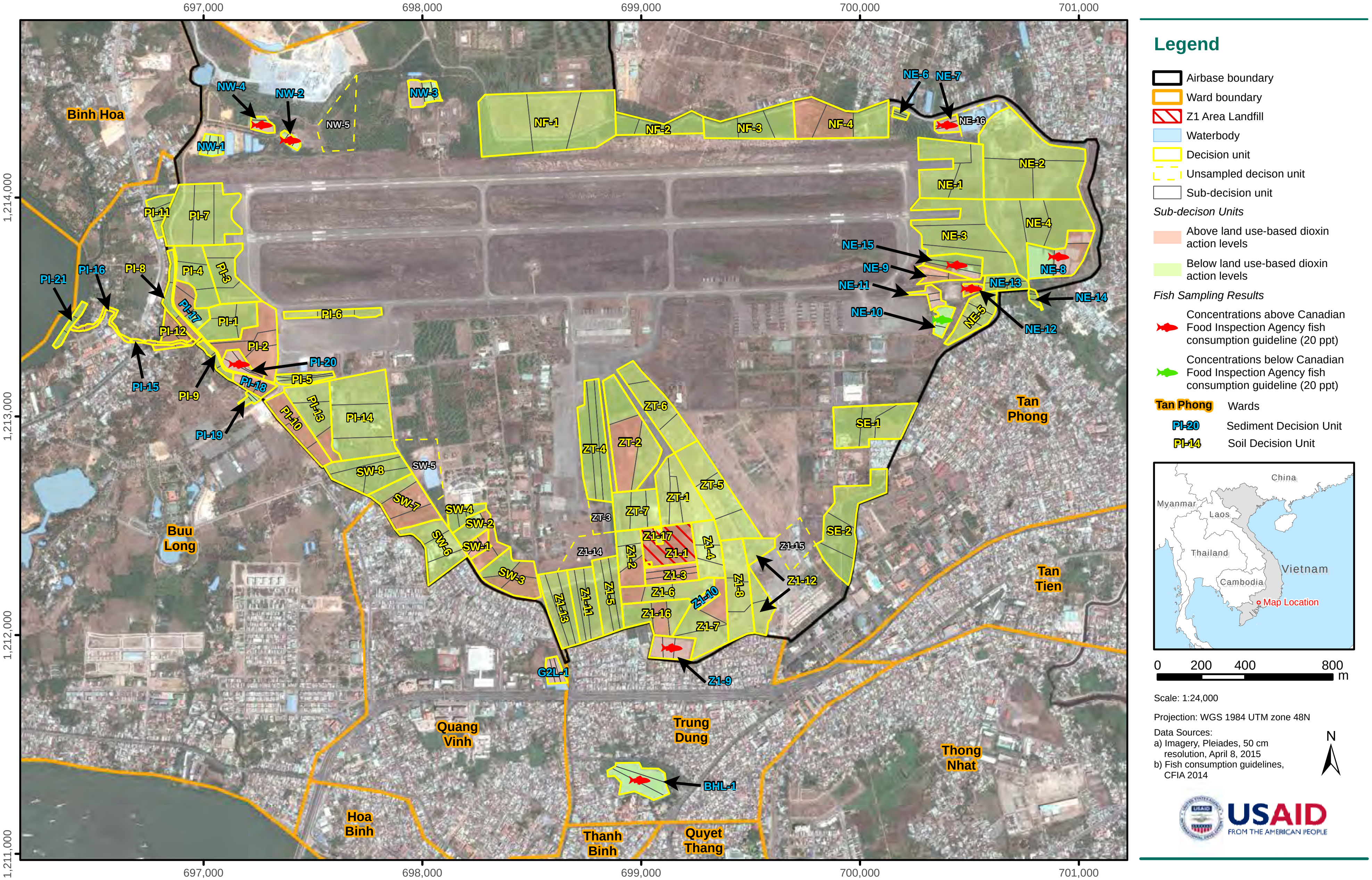


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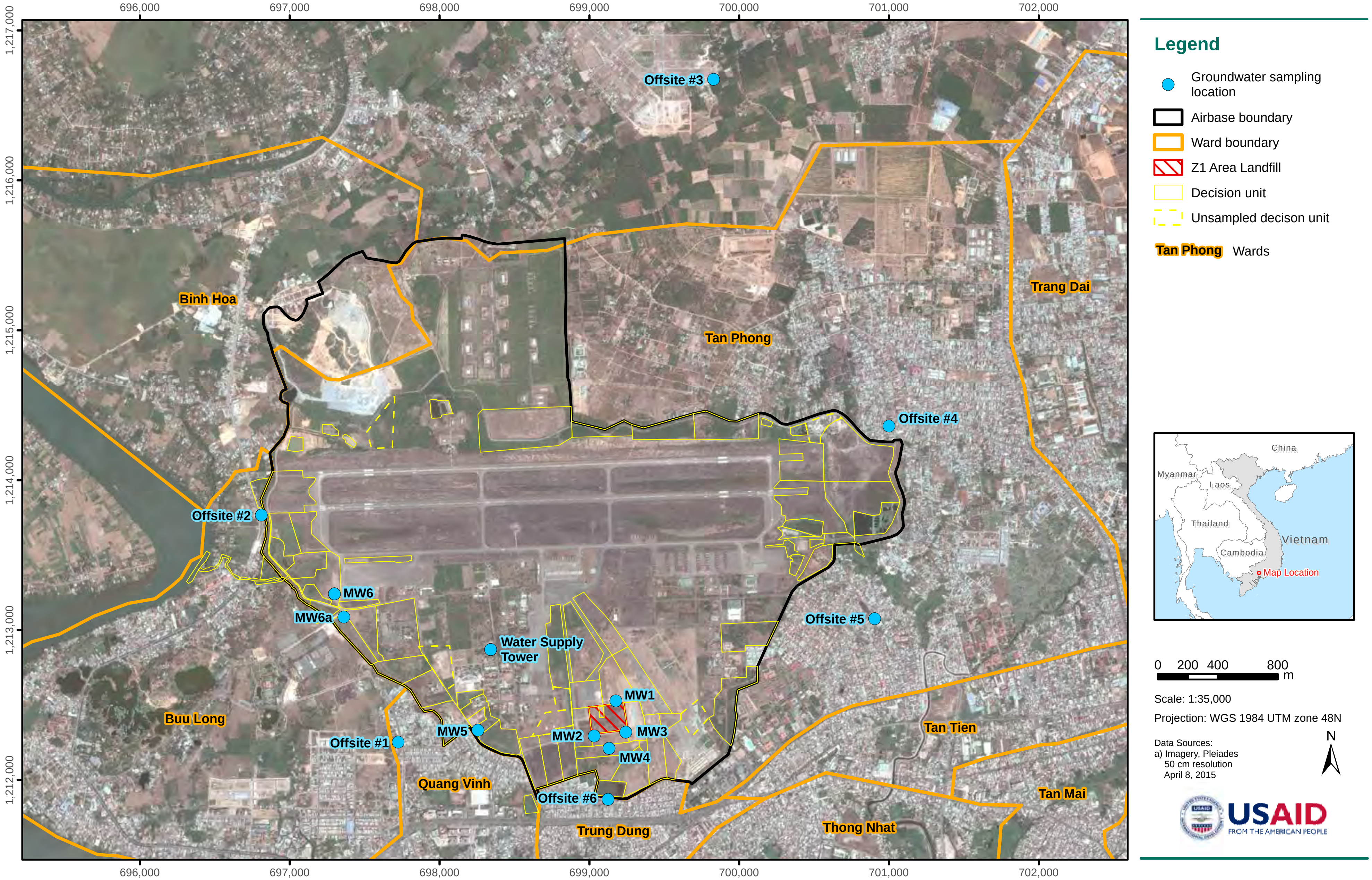
FIGURE A1.4 2014/2015 MIS SAMPLING LOCATIONS, BIEN HOA AIRBASE, VIETNAM

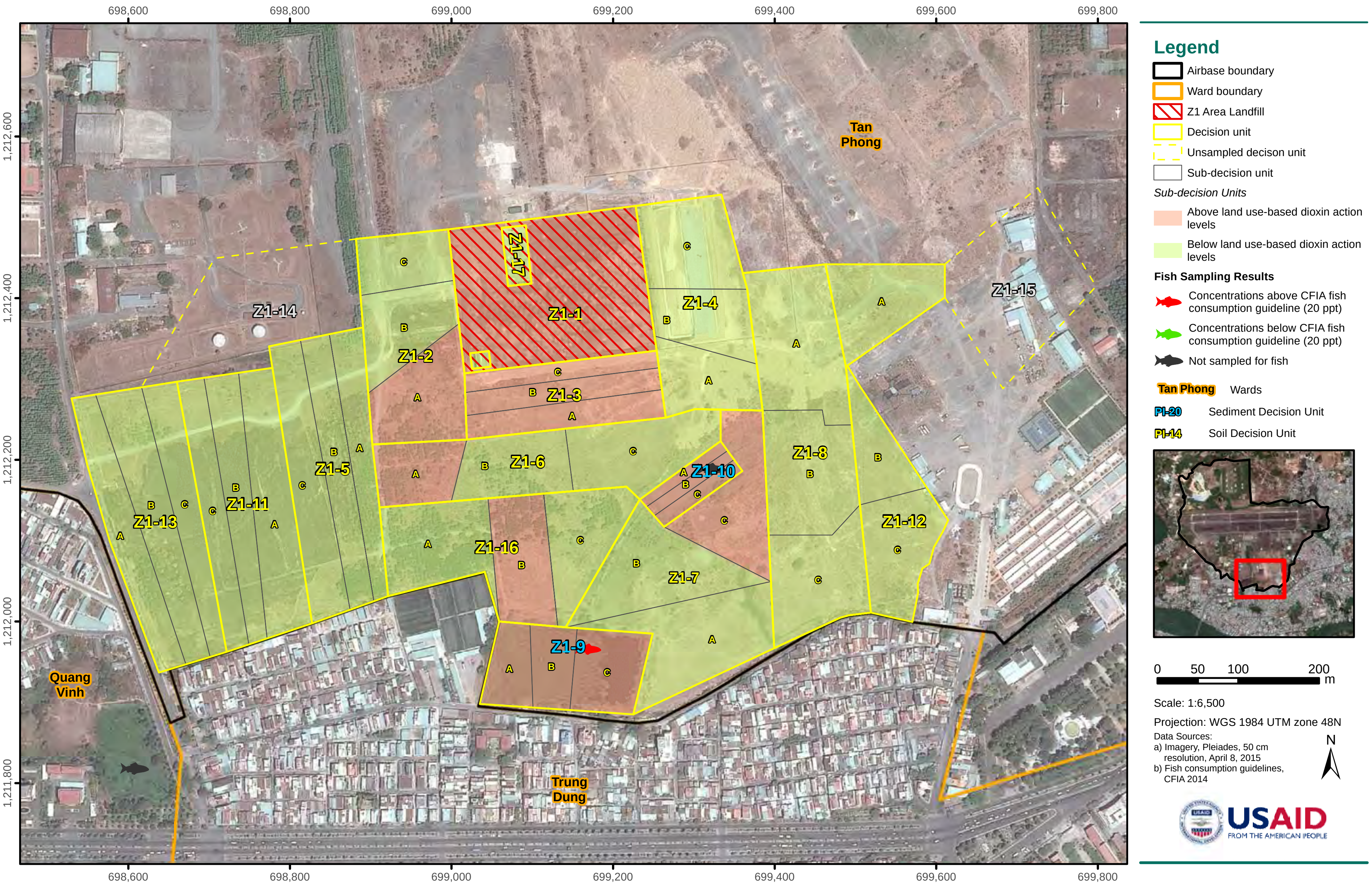
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_4_Bien_Hoa_MIS_Sampling_20160210_SB.mxd

FIGURE A1.5 2014/2015 GROUNDWATER SAMPLING LOCATIONS AT BIEN HOA AIRBASE, VIETNAM



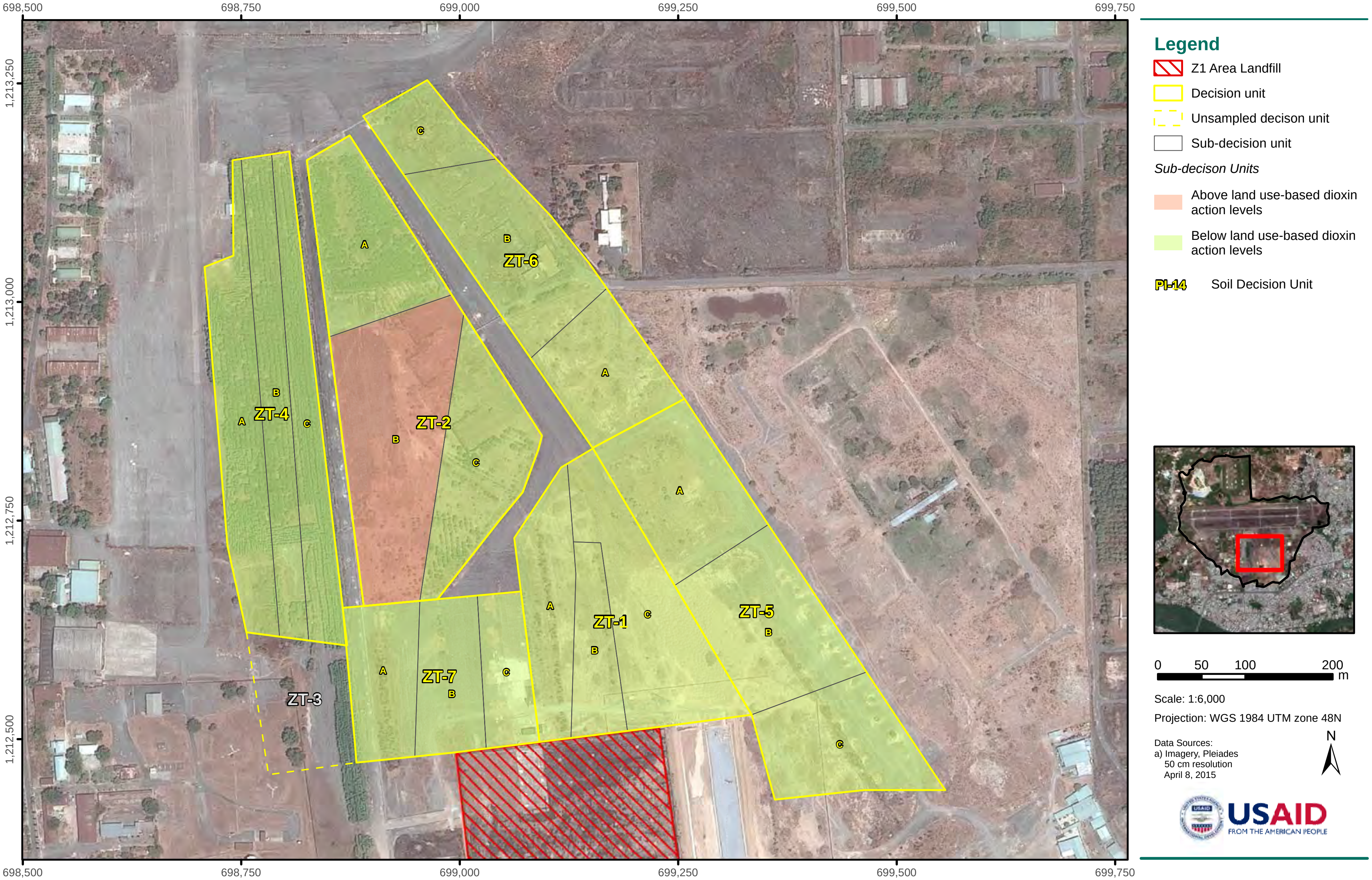
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_5_GroundwaterSampling_20160210_SB.mxd

FIGURE A1.6 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS - Z1 AREA, BIEN HOA AIRBASE, VIETNAM



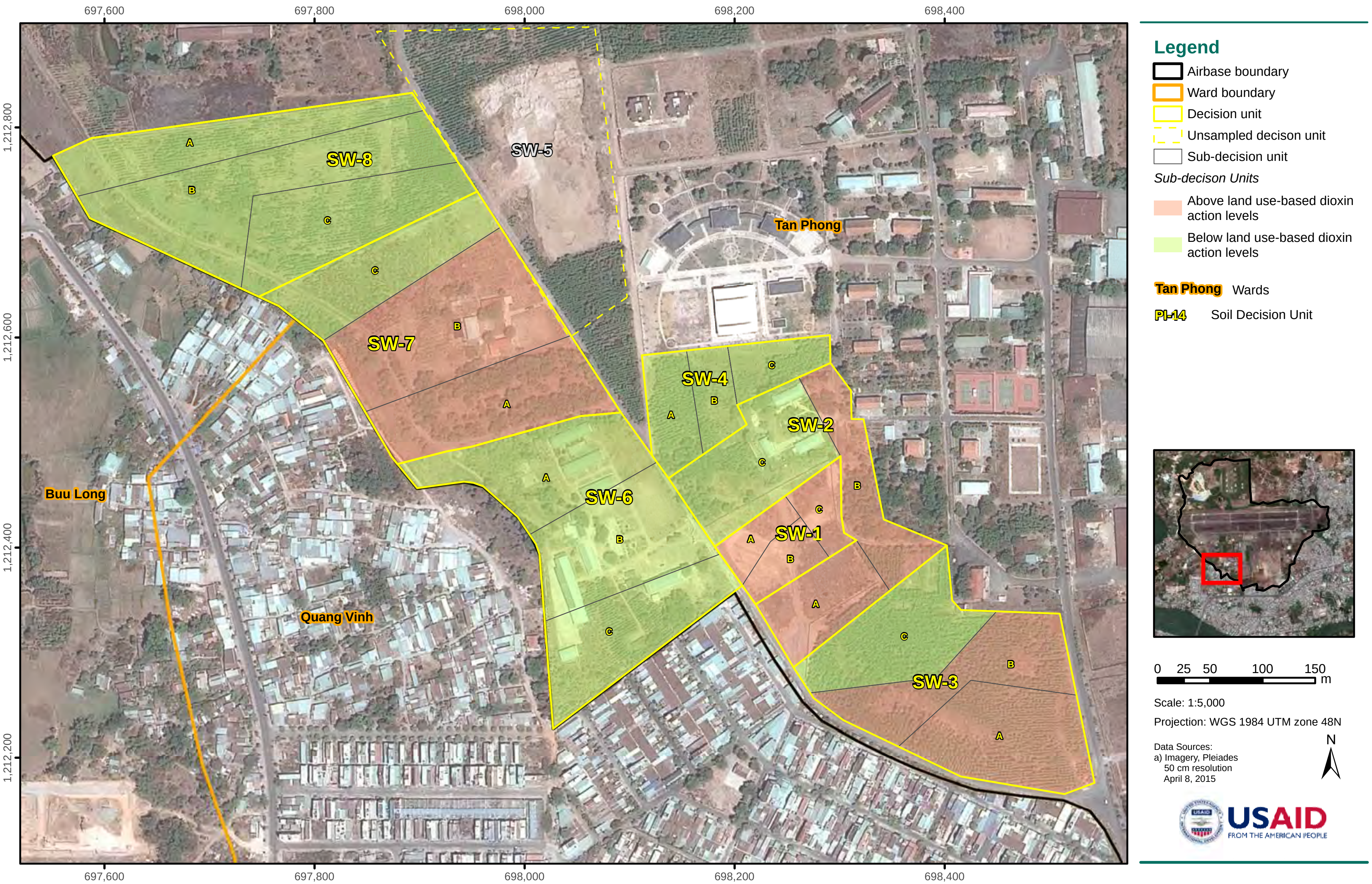
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_6_Z1_Sampling_20160210_SB.mxd

FIGURE A1.7 2014/2015 SOIL SAMPLING RESULTS - ZT AREA, BIEN HOA AIRBASE, VIETNAM



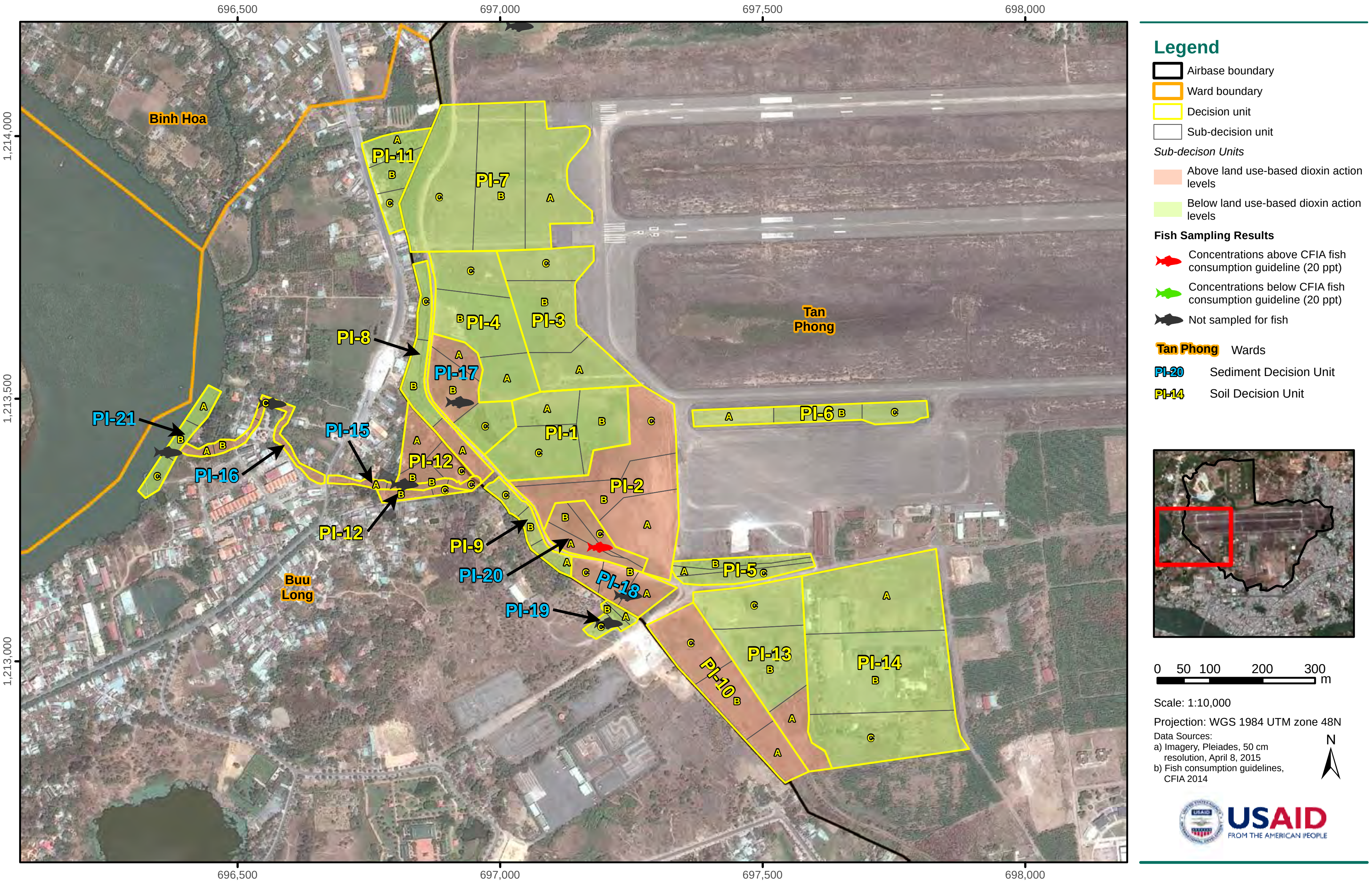
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_7_ZT_Sampling_20160210_SB.mxd

FIGURE A1.8 2014/2015 SOIL SAMPLING RESULTS - SOUTHWEST AREA, BIEN HOA AIRBASE, VIETNAM



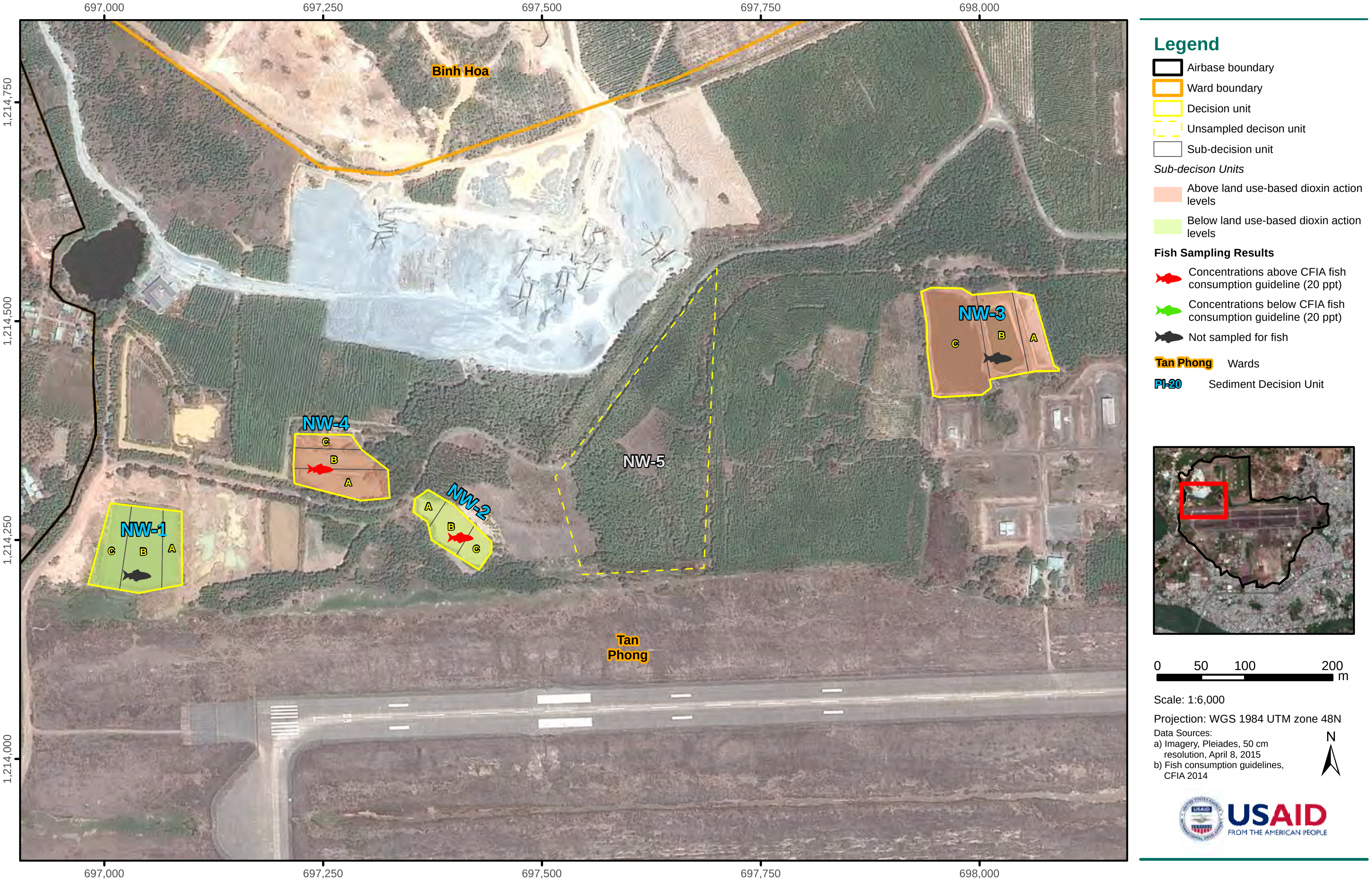
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_8_Southwest_Sampling_20160210_SB.mxd

FIGURE A1.9 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS - PACER IVY AREA, BIEN HOA AIRBASE, VIETNAM



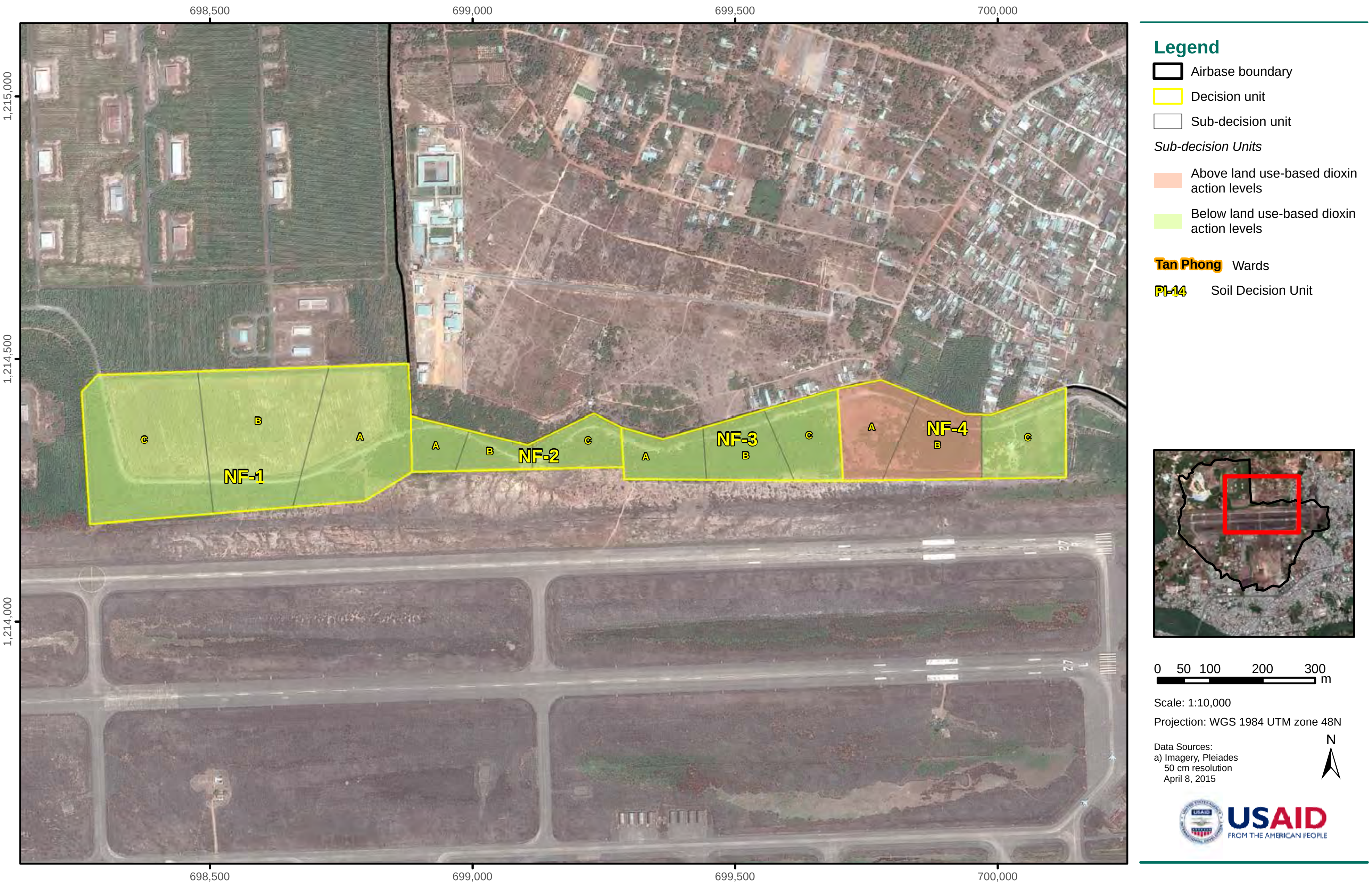
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_9_PacerIvy_Sampling_20160210_SB.mxd

FIGURE A1.10 2014/2015 SEDIMENT SAMPLING RESULTS - NORTHWEST AREA, BIEN HOA AIRBASE, VIETNAM



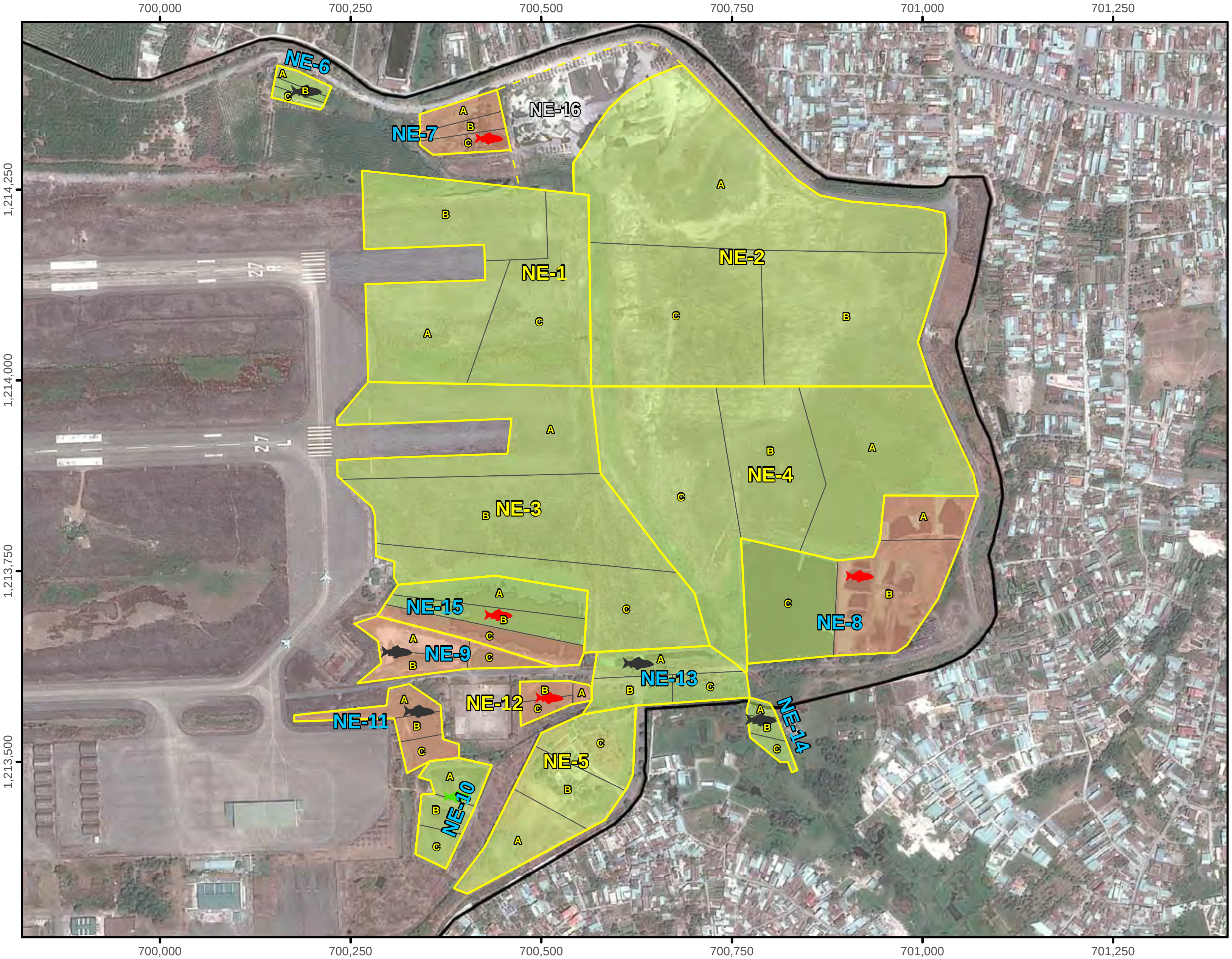
K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_10_Northwest_Sampling_20160210_SB.mxd

FIGURE A1.11 2014/2015 SOIL SAMPLING RESULTS - NORTHERN FOREST AREA, BIEN HOA AIRBASE, VIETNAM



K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_11_NorthernForest_Sampling_20160210_SB.mxd

FIGURE A1.12 2014/2015 SOIL AND SEDIMENT SAMPLING RESULTS - NORTHEAST AREA, BIEN HOA AIRBASE, VIETNAM



Legend

- Airbase boundary
- Decision unit
- Unsampled decison unit
- Sub-decision unit

Sub-decison Units

- Above land use-based dioxin action levels
- Below land use-based dioxin action levels

Fish Sampling Results

- Concentrations above CFIA fish consumption guideline (20 ppt)
- Concentrations below CFIA fish consumption guideline (20 ppt)
- Not sampled for fish

- PI-20 Sediment Decision Unit
- PI-14 Soil Decision Unit

0 50 100 200 m

Scale: 1:7,500

Projection: WGS 1984 UTM zone 48N

Data Sources:
a) Imagery, Pleiades, 50 cm resolution, April 8, 2015
b) Fish consumption guidelines, CFIA 2014

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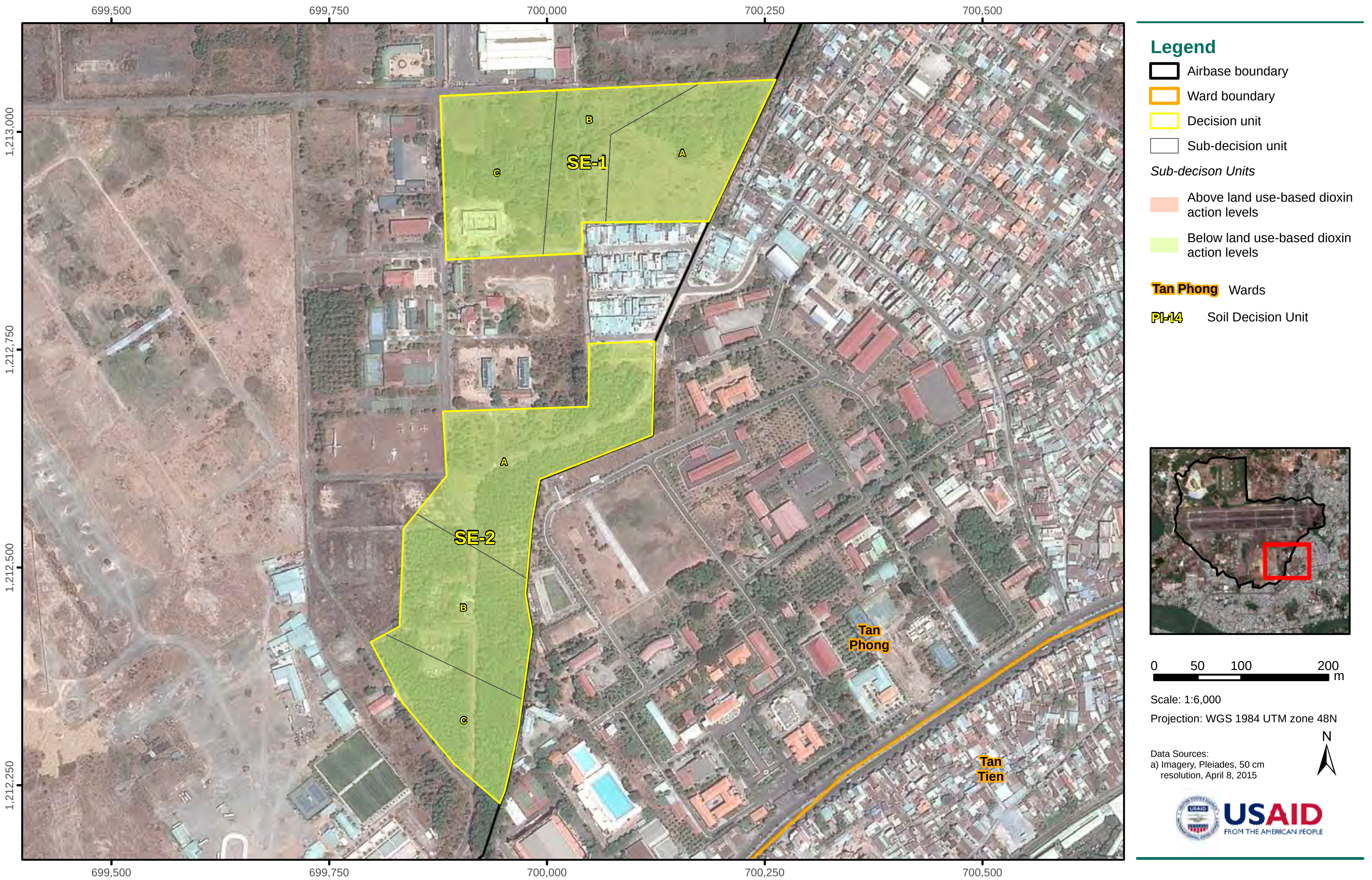
FIGURE A1.13 2014/2015 SOIL SAMPLING RESULTS - SOUTHEAST AREA, BIEN HOA AIRBASE, VIETNAM



K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_13_Southeast_Sampling_20160210_SB.mxd

FIGURE A1.14 2014/2015 SEDIMENT SAMPLING RESULTS - GATE 2 LAKE AND BIEN HUNG LAKE, BIEN HOA AIRBASE, VIETNAM

Legend

- Airbase boundary
- Ward boundary
- Decision unit
- Sub-decision unit

Sub-decison Units

- Above land use-based dioxin action levels
- Below land use-based dioxin action levels

Fish Sampling Results

- Concentrations above CFIA fish consumption guideline (20 ppt)
- Concentrations below CFIA fish consumption guideline (20 ppt)
- Not sampled for fish

0 25 50 100 150 m

Scale: 1:5,000

Projection: WGS 1984 UTM zone 48N

Data Sources:
a) Imagery, Pleiades, 50 cm resolution, April 8, 2015
b) Fish consumption guidelines, CFIA 2014

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K:\Data\Project\USAID6185-VT_MXD\EA_Figures\Appendix_A1\USAID6185_A1_14_OutsideBase_Sampling_20160210_SB.mxd

APPENDIX B

VOLUME ESTIMATES

Table B-1: Volume Estimate Calculation for Z1 Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-01 (Landfill)	MIS	0-100	150	40,457	1,510.0	Industrial	1200	1020	60,685	-	60,685	20,228	80,913
Soil	Z1-02A	Sub	0-30	30	12,382	865.0	Urban residential	300	255	3,715	-	3,715	-	3,715
Soil	Z1-02B	Sub	0-30	30	10,354	162.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	0-30	30	7,738	28.4	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	0-30	30	30,474	333.0	Urban residential	300	255	3,715	-	3,715	-	3,715
Soil	Z1-02A		30-60	30	12,382		Urban residential	300	255	-	-	-	3,715	3,715
Soil	Z1-02B		30-60	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		30-60	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		30-60	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	3,715	3,715
Soil	Z1-02A	Sub	60-90	30	12,382	452.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	60-90	30	10,354	82.5	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	60-90	30	7,738	44.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	60-90	30	30,474	206.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A		90-120	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B		90-120	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		90-120	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		90-120	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A	Sub	120-150	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	120-150	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	120-150	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	120-150	30	30,474	20.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A		150-180	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B		150-180	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		150-180	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		150-180	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A	Sub	180-210	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	180-210	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	180-210	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	180-210	30	30,474	25.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A		210-240	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B		210-240	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		210-240	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		210-240	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A	Sub	240-270	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	240-270	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	240-270	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	240-270	30	30,474	34.3	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A		270-300	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B		270-300	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		270-300	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		270-300	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-02A	Sub	300-330	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	300-330	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	300-330	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	300-330	30	30,474	25.6	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A		330-360	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B		330-360	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C		330-360	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02		330-360	30	30,474	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-02A	Sub	360-390	30	12,382		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02B	Sub	360-390	30	10,354		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02C	Sub	360-390	30	7,738		Urban residential	300	255	-	-	-	-	-
Soil	Z1-02	MIS	360-390	30	30,474	33.2	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	0-30	30	7,960		Urban residential	300	255	2,388	-	2,388	-	2,388
Soil	Z1-03B	Sub	0-30	30	6,789		Urban residential	300	255	2,037	-	2,037	-	2,037
Soil	Z1-03C	Sub	0-30	30	5,404		Urban residential	300	255	1,621	-	1,621	-	1,621
Soil	Z1-03	MIS	0-30	30	20,153	512.1	Urban residential	300	255	6,046	-	6,046	-	6,046
Soil	Z1-03A		30-60	30	7,960		Urban residential	300	255	-	-	-	2,388	2,388
Soil	Z1-03B		30-60	30	6,789		Urban residential	300	255	-	-	-	2,037	2,037
Soil	Z1-03C		30-60	30	5,404		Urban residential	300	255	-	-	-	1,621	1,621
Soil	Z1-03		30-60	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	6,046	6,046
Soil	Z1-03A	Sub	60-90	30	7,960	86.6	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	60-90	30	6,789	95.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	60-90	30	5,404	3.3	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	60-90	30	20,153	90.5	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A		90-120	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B		90-120	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C		90-120	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03		90-120	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	120-150	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	120-150	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	120-150	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	120-150	30	20,153	5.6	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A		150-180	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B		150-180	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C		150-180	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03		150-180	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	180-210	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	180-210	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	180-210	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	180-210	30	20,153	4.1	Urban residential	300	255	-	-	-	-	-

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-03A		210-240	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B		210-240	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C		210-240	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03		210-240	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	240-270	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	240-270	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	240-270	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	240-270	30	20,153	0.7	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A		270-300	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B		270-300	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C		270-300	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03		270-300	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	300-330	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	300-330	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	300-330	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	300-330	30	20,153	0.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A		330-360	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B		330-360	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C		330-360	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03		330-360	30	20,153	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-03A	Sub	360-390	30	7,960		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03B	Sub	360-390	30	6,789		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03C	Sub	360-390	30	5,404		Urban residential	300	255	-	-	-	-	-
Soil	Z1-03	MIS	360-390	30	20,153	3.1	Urban residential	300	255	-	-	-	-	-
Soil	Z1-04A	Sub	0-30	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	0-30	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	0-30	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	0-30	30	31,089	50.0	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		30-60	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		30-60	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		30-60	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		30-60	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A	Sub	60-90	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	60-90	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	60-90	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	60-90	30	31,089	7.4	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		90-120	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		90-120	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		90-120	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		90-120	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-04A	Sub	120-150	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	120-150	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	120-150	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	120-150	30	31,089	7.6	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		150-180	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		150-180	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		150-180	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		150-180	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A	Sub	180-210	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	180-210	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	180-210	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	180-210	30	31,089	9.5	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		210-240	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		210-240	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		210-240	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		210-240	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A	Sub	240-270	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	240-270	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	240-270	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	240-270	30	31,089	4.2	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		270-300	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		270-300	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		270-300	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		270-300	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A	Sub	300-330	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	300-330	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	300-330	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	300-330	30	31,089	10.8	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A		330-360	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B		330-360	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C		330-360	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04		330-360	30	31,089	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04A	Sub	360-390	30	9,128		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04B	Sub	360-390	30	9,254		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04C	Sub	360-390	30	12,707		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-04	MIS	360-390	30	31,089	4.3	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-05A	Sub	0-30	30	9,889		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05B	Sub	0-30	30	11,351		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05C	Sub	0-30	30	15,251		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05	MIS	0-30	30	36,491	48.2	Urban residential	300	255	-	-	-	-	-

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-05A	Sub	30-60	30	9,889		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05B	Sub	30-60	30	11,351		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05C	Sub	30-60	30	15,251		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05	MIS	30-60	30	36,491	11.4	Urban residential	300	255	-	-	-	-	-
Soil	Z1-05A	Sub	60-90	30	9,889		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05B	Sub	60-90	30	11,351		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05C	Sub	60-90	30	15,251		Urban residential	300	255	-	-	-	-	-
Soil	Z1-05	MIS	60-90	30	36,491	4.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A	Sub	0-30	30	7,909	325.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B	Sub	0-30	30	10,418	152.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C	Sub	0-30	30	14,045	237.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06	MIS	0-30	30	32,372	205.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A	Sub	30-60	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B	Sub	30-60	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C	Sub	30-60	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06	MIS	30-60	30	32,372	12.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A	Sub	60-90	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B	Sub	60-90	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C	Sub	60-90	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06	MIS	60-90	30	32,372	31.7	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A		90-120	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B		90-120	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C		90-120	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06		90-120	30	32,372	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A	Sub	120-150	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B	Sub	120-150	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C	Sub	120-150	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06	MIS	120-150	30	32,372	14.1	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A		150-180	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B		150-180	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C		150-180	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06		150-180	30	32,372	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-06A	Sub	180-210	30	7,909		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06B	Sub	180-210	30	10,418		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06C	Sub	180-210	30	14,045		Urban residential	300	255	-	-	-	-	-
Soil	Z1-06	MIS	180-210	30	32,372	16.4	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07A	Sub	0-30	30	17,939	129.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B	Sub	0-30	30	16,254	184.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C	Sub	0-30	30	13,363	175.0	Urban residential	300	255	4,009	-	4,009	-	4,009
Soil	Z1-07	MIS	0-30	30	47,556	168.0	Urban residential	300	255	4,009	-	4,009	-	4,009
Soil	Z1-07A	Sub	30-60	30	17,939	233.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B	Sub	30-60	30	16,254	53.5	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C	Sub	30-60	30	13,363	438.0	Urban residential	300	255	4,009	-	4,009	-	4,009
Soil	Z1-07	MIS	30-60	30	47,556	274.0	Urban residential	300	255	4,009	-	4,009	-	4,009

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-07A	Sub	60-90	30	17,939		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B	Sub	60-90	30	16,254		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C	Sub	60-90	30	13,363		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07	MIS	60-90	30	47,556	13.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07A		90-120	30	17,939		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B		90-120	30	16,254		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C		90-120	30	13,363		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07		90-120	30	47,556	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07A	Sub	120-150	30	17,939		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B	Sub	120-150	30	16,254		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C	Sub	120-150	30	13,363		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07	MIS	120-150	30	47,556	9.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07A		150-180	30	17,939		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B		150-180	30	16,254		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C		150-180	30	13,363		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07		150-180	30	47,556	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-07A	Sub	180-210	30	17,939		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07B	Sub	180-210	30	16,254		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07C	Sub	180-210	30	13,363		Urban residential	300	255	-	-	-	-	-
Soil	Z1-07	MIS	180-210	30	47,556	4.1	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08A	Sub	0-30	30	19,726	104.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08B	Sub	0-30	30	15,692	16.1	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08C	Sub	0-30	30	14,345	10.3	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08	MIS	0-30	30	49,763	107.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08A	Sub	30-60	30	19,726		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08B	Sub	30-60	30	15,692		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08C	Sub	30-60	30	14,345		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08	MIS	30-60	30	49,763	17.7	Urban residential	300	255	-	-	-	-	-
Soil	Z1-08A	Sub	60-90	30	19,726		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08B	Sub	60-90	30	15,692		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08C	Sub	60-90	30	14,345		Urban residential	300	255	-	-	-	-	-
Soil	Z1-08	MIS	60-90	30	49,763	18.5	Urban residential	300	255	-	-	-	-	-
Sediment	Z1-09A	Sub	0-15	15	5,367		Sediment	150	127.5	805	-	805	-	805
Sediment	Z1-09B	Sub	0-15	15	5,336		Sediment	150	127.5	800	-	800	-	800
Sediment	Z1-09C	Sub	0-15	15	8,752		Sediment	150	127.5	1,313	-	1,313	-	1,313
Sediment	Z1-09	MIS	0-15	15	19,456	413.0	Sediment	150	127.5	2,918	-	2,918	-	2,918
Sediment	Z1-09A	Sub	15-30	15	5,367		Sediment	150	127.5	805	-	805	-	805
Sediment	Z1-09B	Sub	15-30	15	5,336		Sediment	150	127.5	800	-	800	-	800
Sediment	Z1-09C	Sub	15-30	15	8,752		Sediment	150	127.5	1,313	-	1,313	-	1,313
Sediment	Z1-09	MIS	15-30	15	19,456	260.0	Sediment	150	127.5	2,918	-	2,918	-	2,918
Sediment	Z1-09A	Sub	30-45	15	5,367		Sediment	150	127.5	805	1,502	2,308	805	3,113
Sediment	Z1-09B	Sub	30-45	15	5,336		Sediment	150	127.5	800	1,494	2,294	800	3,094
Sediment	Z1-09C	Sub	30-45	15	8,752		Sediment	150	127.5	1,313	2,450	3,763	1,313	5,076
Sediment	Z1-09	MIS	30-45	15	19,456	444.0	Sediment	150	127.5	2,918	5,446	8,364	2,918	11,283

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	Z1-10A	Sub	0-15	15	1,653		Sediment	150	127.5	248	-	248	-	248
Sediment	Z1-10B	Sub	0-15	15	1,711		Sediment	150	127.5	257	-	257	-	257
Sediment	Z1-10C	Sub	0-15	15	2,142		Sediment	150	127.5	321	-	321	-	321
Sediment	Z1-10	MIS	0-15	15	5,506	1,494.6	Sediment	150	127.5	826	-	826	-	826
Sediment	Z1-10A	Sub	15-30	15	1,653		Sediment	150	127.5	248	-	248	-	248
Sediment	Z1-10B	Sub	15-30	15	1,711		Sediment	150	127.5	257	-	257	-	257
Sediment	Z1-10C	Sub	15-30	15	2,142		Sediment	150	127.5	321	-	321	-	321
Sediment	Z1-10	MIS	15-30	15	5,506	1,578.8	Sediment	150	127.5	826	-	826	-	826
Sediment	Z1-10A	Sub	30-45	15	1,653		Sediment	150	127.5	248	344	592	248	840
Sediment	Z1-10B	Sub	30-45	15	1,711		Sediment	150	127.5	257	356	612	257	869
Sediment	Z1-10C	Sub	30-45	15	2,142		Sediment	150	127.5	321	445	767	321	1,088
Sediment	Z1-10	MIS	30-45	15	5,506	244.8	Sediment	150	127.5	826	1,144	1,970	826	2,796
Soil	Z1-11A	Sub	0-30	30	16,201	151.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-11B	Sub	0-30	30	11,119	75.7	Urban residential	300	255	-	-	-	-	-
Soil	Z1-11C	Sub	0-30	30	10,493	49.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-11	MIS	0-30	30	37,813	93.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-11A	Sub	30-60	30	16,201		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11B	Sub	30-60	30	11,119		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11C	Sub	30-60	30	10,493		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11	MIS	30-60	30	37,813	31.1	Urban residential	300	255	-	-	-	-	-
Soil	Z1-11A	Sub	60-90	30	16,201		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11B	Sub	60-90	30	11,119		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11C	Sub	60-90	30	10,493		Urban residential	300	255	-	-	-	-	-
Soil	Z1-11	MIS	60-90	30	37,813	8.9	Urban residential	300	255	-	-	-	-	-
Soil	Z1-12A	Sub	0-30	30	11,852		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12B	Sub	0-30	30	7,390		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12C	Sub	0-30	30	11,966		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12	MIS	0-30	30	31,208	7.2	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12A	Sub	30-60	30	11,852		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12B	Sub	30-60	30	7,390		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12C	Sub	30-60	30	11,966		Industrial	1200	1020	-	-	-	-	-
Soil	Z1-12	MIS	30-60	30	31,208	3.5	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-13A	Sub	0-30	30	13,188	90.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-13B	Sub	0-30	30	15,413	85.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-13C	Sub	0-30	30	11,209	47.8	Urban residential	300	255	-	-	-	-	-
Soil	Z1-13	MIS	0-30	30	39,811	103.2	Urban residential	300	255	-	-	-	-	-
Soil	Z1-13A	Sub	30-60	30	13,188		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13B	Sub	30-60	30	15,413		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13C	Sub	30-60	30	11,209		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13	MIS	30-60	30	39,811	20.5	Urban residential	300	255	-	-	-	-	-
Soil	Z1-13A	Sub	60-90	30	13,188		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13B	Sub	60-90	30	15,413		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13C	Sub	60-90	30	11,209		Urban residential	300	255	-	-	-	-	-
Soil	Z1-13	MIS	60-90	30	39,811	7.8	Urban residential	300	255	-	-	-	-	-

Table B-1: Volume Estimate Calculation for Z1 Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	Z1-16A	Sub	0-30	30	13,717	150.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B	Sub	0-30	30	11,199	901.0	Urban residential	300	255	3,360	-	3,360	-	3,360
Soil	Z1-16C	Sub	0-30	30	11,420	130.0	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16	MIS	0-30	30	36,336	435.6	Urban residential	300	255	3,360	-	3,360	-	3,360
Soil	Z1-16A	Sub	30-60	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B	Sub	30-60	30	11,199		Urban residential	300	255	-	-	-	3,360	3,360
Soil	Z1-16C	Sub	30-60	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16	MIS	30-60	30	36,336	222.2	Urban residential	300	255	-	-	-	3,360	3,360
Soil	Z1-16A	Sub	60-90	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B	Sub	60-90	30	11,199		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16C	Sub	60-90	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16	MIS	60-90	30	36,336	91.6	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16A		90-120	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B		90-120	30	11,199		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16C		90-120	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16		90-120	30	36,336	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16A	Sub	120-150	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B	Sub	120-150	30	11,199		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16C	Sub	120-150	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16	MIS	120-150	30	36,336	21.2	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16A		150-180	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B		150-180	30	11,199		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16C		150-180	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16		150-180	30	36,336	Not Sampled[2]	Urban residential	300	255	-	-	-	-	-
Soil	Z1-16A	Sub	180-210	30	13,717		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16B	Sub	180-210	30	11,199		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16C	Sub	180-210	30	11,420		Urban residential	300	255	-	-	-	-	-
Soil	Z1-16	MIS	180-210	30	36,336	14.6	Urban residential	300	255	-	-	-	-	-
Soil	Z1-17	MIS	0-30	30	2,147	13.6	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	60-90	30	2,147	4.1	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	120-150	30	2,147	2.1	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	180-210	30	2,147	6.5	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	240-270	30	2,147	0.7	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	300-330	30	2,147	2.0	Industrial	1200	1020	-	-	-	-	-
Soil	Z1-17	MIS	360-390	30	2,147	0.7	Industrial	1200	1020	-	-	-	-	-
									Totals	**93,056**	**6,590**	**99,646**	**37,093**	**136,739**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

2 Samples were not collected at this depth interval. This depth is shown for volume estimating purposes.

Table B-2: Volume Estimate Calculation for ZT Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	ZT-01A	Sub	0-30	30	15,387		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01B	Sub	0-30	30	10,201		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01C	Sub	0-30	30	27,066		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01	MIS	0-30	30	52,655	48.8	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01A	Sub	30-60	30	15,387		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01B	Sub	30-60	30	10,201		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01C	Sub	30-60	30	27,066		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01	MIS	30-60	30	52,655	4.6	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01A	Sub	60-90	30	15,387		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01B	Sub	60-90	30	10,201		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01C	Sub	60-90	30	27,066		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01	MIS	60-90	30	52,655	64.7	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01A		90-120	30	15,387		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01B		90-120	30	10,201		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01C		90-120	30	27,066		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01		90-120	30	52,655	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01A	Sub	120-150	30	15,387		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01B	Sub	120-150	30	10,201		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01C	Sub	120-150	30	27,066		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-01	MIS	120-150	30	52,655	43.6	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02A	Sub	0-30	30	20,872	312.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02B	Sub	0-30	30	36,415	3,440.0	Industrial	1200	1020	10,925	-	10,925	-	10,925
Soil	ZT-02C	Sub	0-30	30	21,755	178.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02	MIS	0-30	30	79,042	1,080.0	Industrial	1200	1020	10,925	-	10,925	-	10,925
Soil	ZT-02A	Sub	30-60	30	20,872	73.2	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02B	Sub	30-60	30	36,415	429.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02C	Sub	30-60	30	21,755	46.9	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02	MIS	30-60	30	79,042	181.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02A	Sub	60-90	30	20,872		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02B	Sub	60-90	30	36,415		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02C	Sub	60-90	30	21,755		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-02	MIS	60-90	30	79,042	86.1	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04A	Sub	0-30	30	22,825		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04B	Sub	0-30	30	18,881		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04C	Sub	0-30	30	17,918		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04	MIS	0-30	30	59,624	15.3	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04A	Sub	30-60	30	22,825		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04B	Sub	30-60	30	18,881		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04C	Sub	30-60	30	17,918		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04	MIS	30-60	30	59,624	6.2	Industrial	1200	1020	-	-	-	-	-

Table B-2: Volume Estimate Calculation for ZT Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	ZT-04A	Sub	60-90	30	22,825		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04B	Sub	60-90	30	18,881		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04C	Sub	60-90	30	17,918		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-04	MIS	60-90	30	59,624	1.3	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05A	Sub	0-30	30	21,954		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05B	Sub	0-30	30	24,801		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05C	Sub	0-30	30	20,165		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05	MIS	0-30	30	66,920	10.5	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05A	Sub	30-60	30	21,954		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05B	Sub	30-60	30	24,801		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05C	Sub	30-60	30	20,165		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05	MIS	30-60	30	66,920	1.2	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05A	Sub	60-90	30	21,954		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05B	Sub	60-90	30	24,801		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05C	Sub	60-90	30	20,165		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-05	MIS	60-90	30	66,920	2.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06A	Sub	0-30	30	16,448		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06B	Sub	0-30	30	24,515		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06C	Sub	0-30	30	8,757		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06	MIS	0-30	30	49,720	23.8	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06A	Sub	30-60	30	16,448		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06B	Sub	30-60	30	24,515		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06C	Sub	30-60	30	8,757		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06	MIS	30-60	30	49,720	5.0	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06A	Sub	60-90	30	16,448		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06B	Sub	60-90	30	24,515		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06C	Sub	60-90	30	8,757		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-06	MIS	60-90	30	49,720	0.9	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07A	Sub	0-30	30	13,772		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07B	Sub	0-30	30	13,054		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07C	Sub	0-30	30	9,735		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07	MIS	0-30	30	36,561	86.4	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07A	Sub	30-60	30	13,772		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07B	Sub	30-60	30	13,054		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07C	Sub	30-60	30	9,735		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07	MIS	30-60	30	36,561	40.6	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07A	Sub	60-90	30	13,772		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07B	Sub	60-90	30	13,054		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07C	Sub	60-90	30	9,735		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07	MIS	60-90	30	36,561	9.4	Industrial	1200	1020	-	-	-	-	-

Table B-2: Volume Estimate Calculation for ZT Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	ZT-07A		90-120	30	13,772		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07B		90-120	30	13,054		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07C		90-120	30	9,735		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07		90-120	30	36,561	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07A	Sub	120-150	30	13,772		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07B	Sub	120-150	30	13,054		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07C	Sub	120-150	30	9,735		Industrial	1200	1020	-	-	-	-	-
Soil	ZT-07	MIS	120-150	30	36,561	0.8	Industrial	1200	1020	-	-	-	-	-
									Totals	**10,925**	**-**	**10,925**	**-**	**10,925**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

2 Samples were not collected at this depth interval. This depth is shown for volume estimating purposes.

Table B-3: Volume Estimate Calculation for Southwest Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	SW-01A	Sub	0-30	30	2,627	20,000.0	Urban residential	300	255	788	-	788	-	788
Soil	SW-01B	Sub	0-30	30	3,153	21,800.0	Urban residential	300	255	946	-	946	-	946
Soil	SW-01C	Sub	0-30	30	3,012	1,240.0	Urban residential	300	255	904	-	904	-	904
Soil	SW-01	MIS	0-30	30	8,793	10,900.0	Urban residential	300	255	2,638	-	2,638	-	2,638
Soil	SW-01A	Sub	30-60	30	2,627	111,000.0	Urban residential	300	255	788	-	788	-	788
Soil	SW-01B	Sub	30-60	30	3,153	26,600.0	Urban residential	300	255	946	-	946	-	946
Soil	SW-01C	Sub	30-60	30	3,012	359.0	Urban residential	300	255	904	-	904	-	904
Soil	SW-01	MIS	30-60	30	8,793	41,000.0	Urban residential	300	255	2,638	-	2,638	-	2,638
Soil	SW-01A	Sub	60-90	30	2,627	13,800.0	Urban residential	300	255	788	-	788	-	788
Soil	SW-01B	Sub	60-90	30	3,153	499.0	Urban residential	300	255	946	-	946	-	946
Soil	SW-01C	Sub	60-90	30	3,012	25.7	Urban residential	300	255	-	-	-	-	-
Soil	SW-01	MIS	60-90	30	8,793	4,880.0	Urban residential	300	255	1,734	-	1,734	-	1,734
Soil	SW-01A	Sub	90-120	30	2,627		Urban residential	300	255	788	-	788	-	788
Soil	SW-01B	Sub	90-120	30	3,153		Urban residential	300	255	946	-	946	-	946
Soil	SW-01C	Sub	90-120	30	3,012		Urban residential	300	255	-	-	-	-	-
Soil	SW-01	MIS	90-120	30	8,793	62.0	Urban residential	300	255	1,734	-	1,734	-	1,734
Soil	SW-01A	Sub	120-150	30	2,627	2,680.0	Urban residential	300	255	788	2,555	3,343	-	3,343
Soil	SW-01B	Sub	120-150	30	3,153	1,230.0	Urban residential	300	255	946	3,066	4,012	-	4,012
Soil	SW-01C	Sub	120-150	30	3,012	14.2	Urban residential	300	255	-	-	-	-	-
Soil	SW-01	MIS	120-150	30	8,793	1,370.0	Urban residential	300	255	1,734	5,622	7,356	-	7,356
Soil	SW-02A	Sub	0-30	30	7,338	7,880.0	Urban residential	300	255	2,202	-	2,202	-	2,202
Soil	SW-02B	Sub	0-30	30	8,468	170.0	Urban residential	300	255	2,540	-	2,540	-	2,540
Soil	SW-02C	Sub	0-30	30	12,612	115.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-02	MIS	0-30	30	28,418	2,560.0	Urban residential	300	255	4,742	-	4,742	-	4,742
Soil	SW-02A	Sub	30-60	30	7,338	831.0	Urban residential	300	255	2,202	-	2,202	-	2,202
Soil	SW-02B	Sub	30-60	30	8,468	311.0	Urban residential	300	255	2,540	-	2,540	-	2,540
Soil	SW-02C	Sub	30-60	30	12,612	12.7	Urban residential	300	255	-	-	-	-	-
Soil	SW-02	MIS	30-60	30	28,418	332.0	Urban residential	300	255	4,742	-	4,742	-	4,742
Soil	SW-02A	Sub	60-90	30	7,338		Urban residential	300	255	-	-	-	-	-
Soil	SW-02B	Sub	60-90	30	8,468		Urban residential	300	255	-	-	-	-	-
Soil	SW-02C	Sub	60-90	30	12,612		Urban residential	300	255	-	-	-	-	-
Soil	SW-02	MIS	60-90	30	28,418	71.6	Urban residential	300	255	-	-	-	-	-
Soil	SW-03A	Sub	0-30	30	13,572	1,880.0	Urban residential	300	255	4,072	-	4,072	-	4,072
Soil	SW-03B	Sub	0-30	30	12,018	642.0	Urban residential	300	255	3,605	-	3,605	-	3,605
Soil	SW-03C	Sub	0-30	30	12,254	142.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-03	MIS	0-30	30	37,844	746.0	Urban residential	300	255	7,677	-	7,677	-	7,677
Soil	SW-03A	Sub	30-60	30	13,572	1,680.0	Urban residential	300	255	4,072	-	4,072	-	4,072
Soil	SW-03B	Sub	30-60	30	12,018	114.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-03C	Sub	30-60	30	12,254	10.1	Urban residential	300	255	-	-	-	-	-
Soil	SW-03	MIS	30-60	30	37,844	550.0	Urban residential	300	255	4,072	-	4,072	-	4,072
Soil	SW-03A	Sub	60-90	30	13,572	1,180.0	Urban residential	300	255	4,072	8,759	12,830	-	12,830
Soil	SW-03B	Sub	60-90	30	12,018	38.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-03C	Sub	60-90	30	12,254	6.8	Urban residential	300	255	-	-	-	-	-
Soil	SW-03	MIS	60-90	30	37,844	445.0	Urban residential	300	255	4,072	8,759	12,830	-	12,830

Table B-3: Volume Estimate Calculation for Southwest Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	SW-04A	Sub	0-30	30	4,998		Urban residential	300	255	-	-	-	-	-
Soil	SW-04B	Sub	0-30	30	3,612		Urban residential	300	255	-	-	-	-	-
Soil	SW-04C	Sub	0-30	30	3,974		Urban residential	300	255	-	-	-	-	-
Soil	SW-04	MIS	0-30	30	12,583	41.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-04A	Sub	30-60	30	4,998		Urban residential	300	255	-	-	-	-	-
Soil	SW-04B	Sub	30-60	30	3,612		Urban residential	300	255	-	-	-	-	-
Soil	SW-04C	Sub	30-60	30	3,974		Urban residential	300	255	-	-	-	-	-
Soil	SW-04	MIS	30-60	30	12,583	15.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-04A	Sub	60-90	30	4,998		Urban residential	300	255	-	-	-	-	-
Soil	SW-04B	Sub	60-90	30	3,612		Urban residential	300	255	-	-	-	-	-
Soil	SW-04C	Sub	60-90	30	3,974		Urban residential	300	255	-	-	-	-	-
Soil	SW-04	MIS	60-90	30	12,583	12.2	Urban residential	300	255	-	-	-	-	-
Soil	SW-06A	Sub	0-30	30	13,762	57.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-06B	Sub	0-30	30	14,477	52.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-06C	Sub	0-30	30	12,923	71.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-06	MIS	0-30	30	41,162	62.9	Urban residential	300	255	-	-	-	-	-
Soil	SW-06A	Sub	30-60	30	13,762		Urban residential	300	255	-	-	-	-	-
Soil	SW-06B	Sub	30-60	30	14,477		Urban residential	300	255	-	-	-	-	-
Soil	SW-06C	Sub	30-60	30	12,923		Urban residential	300	255	-	-	-	-	-
Soil	SW-06	MIS	30-60	30	41,162	20.1	Urban residential	300	255	-	-	-	-	-
Soil	SW-06A	Sub	60-90	30	13,762		Urban residential	300	255	-	-	-	-	-
Soil	SW-06B	Sub	60-90	30	14,477		Urban residential	300	255	-	-	-	-	-
Soil	SW-06C	Sub	60-90	30	12,923		Urban residential	300	255	-	-	-	-	-
Soil	SW-06	MIS	60-90	30	41,162	49.3	Urban residential	300	255	-	-	-	-	-
Soil	SW-07A	Sub	0-30	30	14,543	674.0	Urban residential	300	255	4,363	-	4,363	-	4,363
Soil	SW-07B	Sub	0-30	30	20,388	311.0	Urban residential	300	255	6,116	-	6,116	-	6,116
Soil	SW-07C	Sub	0-30	30	11,335	210.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-07	MIS	0-30	30	46,266	406.0	Urban residential	300	255	10,479	-	10,479	-	10,479
Soil	SW-07A	Sub	30-60	30	14,543	231.0	Urban residential	300	255	-	-	-	4,363	4,363
Soil	SW-07B	Sub	30-60	30	20,388	192.0	Urban residential	300	255	-	-	-	6,116	6,116
Soil	SW-07C	Sub	30-60	30	11,335	81.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-07	MIS	30-60	30	46,266	169.0	Urban residential	300	255	-	-	-	10,479	10,479
Soil	SW-07A	Sub	60-90	30	14,543	219.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-07B	Sub	60-90	30	20,388	168.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-07C	Sub	60-90	30	11,335	64.6	Urban residential	300	255	-	-	-	-	-
Soil	SW-07	MIS	60-90	30	46,266	129.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-08A	Sub	0-30	30	12,282		Urban residential	300	255	-	-	-	-	-
Soil	SW-08B	Sub	0-30	30	20,581		Urban residential	300	255	-	-	-	-	-
Soil	SW-08C	Sub	0-30	30	14,065		Urban residential	300	255	-	-	-	-	-
Soil	SW-08	MIS	0-30	30	46,927	60.8	Urban residential	300	255	-	-	-	-	-
Soil	SW-08A	Sub	30-60	30	12,282	149.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-08B	Sub	30-60	30	20,581	216.0	Urban residential	300	255	-	-	-	-	-
Soil	SW-08C	Sub	30-60	30	14,065	44.4	Urban residential	300	255	-	-	-	-	-
Soil	SW-08	MIS	30-60	30	46,927	171.0	Urban residential	300	255	-	-	-	-	-

Table B-3: Volume Estimate Calculation for Southwest Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	SW-08A	Sub	60-90	30	12,282		Urban residential	300	255	-	-	-	-	-
Soil	SW-08B	Sub	60-90	30	20,581		Urban residential	300	255	-	-	-	-	-
Soil	SW-08C	Sub	60-90	30	14,065		Urban residential	300	255	-	-	-	-	-
Soil	SW-08	MIS	60-90	30	46,927	40.7	Urban residential	300	255	-	-	-	-	-
									Totals	**46,261**	**14,380**	**60,641**	**10,479**	**71,120**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

Table B-4: Volume Estimate Calculation for Pacer Ivy Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-01A	Sub	0-30	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	0-30	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	0-30	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	0-30	30	35,177	183.5	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	30-60	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	30-60	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	30-60	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	30-60	30	35,177	174.6	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	60-90	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	60-90	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	60-90	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	60-90	30	35,177	39.5	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	90-120	30	7,583	1.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	90-120	30	11,798	0.9	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	90-120	30	15,797	29.8	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	90-120	30	35,177	12.4	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A		120-150	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B		120-150	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C		120-150	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01		120-150	30	35,177	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	150-180	30	7,583	21.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	150-180	30	11,798	17.1	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	150-180	30	15,797	30.3	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	150-180	30	35,177	23.2	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A		180-210	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B		180-210	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C		180-210	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01		180-210	30	35,177	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	210-240	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	210-240	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	210-240	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	210-240	30	35,177	4.7	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A		240-270	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B		240-270	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C		240-270	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01		240-270	30	35,177	Not Sampled[2]	Industrial	1200	1020	-	-	-	-	-
Soil	PI-01A	Sub	270-300	30	7,583		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01B	Sub	270-300	30	11,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01C	Sub	270-300	30	15,797		Industrial	1200	1020	-	-	-	-	-
Soil	PI-01	MIS	270-300	30	35,177	2.4	Industrial	1200	1020	-	-	-	-	-
Soil	PI-02A	Sub	0-30	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	0-30	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	0-30	30	17,080		Industrial	1200	1020	5,124	-	5,124	-	5,124
Soil	PI-02	MIS	0-30	30	50,212	9,230.0	Industrial	1200	1020	15,064	-	15,064	-	15,064

Table B-4: Volume Estimate Calculation for Pacer Ivy Area **(Continued)**

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-02A	Sub	30-60	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	30-60	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	30-60	30	17,080		Industrial	1200	1020	5,124	-	5,124	-	5,124
Soil	PI-02	MIS	30-60	30	50,212	11,400.0	Industrial	1200	1020	15,064	-	15,064	-	15,064
Soil	PI-02A	Sub	60-90	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	60-90	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	60-90	30	17,080		Industrial	1200	1020	5,124	-	5,124	-	5,124
Soil	PI-02	MIS	60-90	30	50,212	3,160.0	Industrial	1200	1020	15,064	-	15,064	-	15,064
Soil	PI-02A	Sub	90-120	30	16,759	2,280.0	Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	90-120	30	16,372	6,620.0	Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	90-120	30	17,080	66.8	Industrial	1200	1020	-	-	-	-	-
Soil	PI-02	MIS	90-120	30	50,212	2,900.0	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A		120-150	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B		120-150	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C		120-150	30	17,080		Industrial	1200	1020	-	-	-	-	-
Soil	PI-02		120-150	30	50,212	Not Sampled[2]	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A	Sub	150-180	30	16,759	782.0	Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	150-180	30	16,372	1,320.0	Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	150-180	30	17,080	101.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-02	MIS	150-180	30	50,212	733.0	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A		180-210	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B		180-210	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C		180-210	30	17,080		Industrial	1200	1020	-	-	-	-	-
Soil	PI-02		180-210	30	50,212	Not Sampled[2]	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A		210-240	30	16,759		Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B		210-240	30	16,372		Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C		210-240	30	17,080		Industrial	1200	1020	-	-	-	-	-
Soil	PI-02		210-240	30	50,212	Not Sampled[2]	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A	Sub	240-270	30	16,759	1,920.0	Industrial	1200	1020	5,028	-	5,028	-	5,028
Soil	PI-02B	Sub	240-270	30	16,372	1,120.0	Industrial	1200	1020	4,912	-	4,912	-	4,912
Soil	PI-02C	Sub	240-270	30	17,080	68.3	Industrial	1200	1020	-	-	-	-	-
Soil	PI-02	MIS	240-270	30	50,212	1,120.0	Industrial	1200	1020	9,940	-	9,940	-	9,940
Soil	PI-02A	Sub	270-300	30	16,759		Industrial	1200	1020	-	-	-	5,028	5,028
Soil	PI-02B	Sub	270-300	30	16,372		Industrial	1200	1020	-	-	-	4,912	4,912
Soil	PI-02C	Sub	270-300	30	17,080		Industrial	1200	1020	-	-	-	-	-
Soil	PI-02	MIS	270-300	30	50,212	566.0	Industrial	1200	1020	-	-	-	9,940	9,940
Soil	PI-03A	Sub	0-30	30	13,073		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03B	Sub	0-30	30	15,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03C	Sub	0-30	30	10,165		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03	MIS	0-30	30	39,036	23.7	Industrial	1200	1020	-	-	-	-	-
Soil	PI-03A	Sub	30-60	30	13,073		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03B	Sub	30-60	30	15,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03C	Sub	30-60	30	10,165		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03	MIS	30-60	30	39,036	10.0	Industrial	1200	1020	-	-	-	-	-

Table B-4: Volume Estimate Calculation for Pacer Ivy Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-03A	Sub	60-90	30	13,073		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03B	Sub	60-90	30	15,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03C	Sub	60-90	30	10,165		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03	MIS	60-90	30	39,036	3.4	Industrial	1200	1020	-	-	-	-	-
Soil	PI-03A	Sub	90-120	30	13,073		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03B	Sub	90-120	30	15,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03C	Sub	90-120	30	10,165		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03	MIS	90-120	30	39,036	0.9	Industrial	1200	1020	-	-	-	-	-
Soil	PI-03A	Sub	120-150	30	13,073		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03B	Sub	120-150	30	15,798		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03C	Sub	120-150	30	10,165		Industrial	1200	1020	-	-	-	-	-
Soil	PI-03	MIS	120-150	30	39,036	0.8	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04A	Sub	0-30	30	8,845		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04B	Sub	0-30	30	16,816		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04C	Sub	0-30	30	10,653		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04	MIS	0-30	30	36,314	243.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04A	Sub	30-60	30	8,845		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04B	Sub	30-60	30	16,816		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04C	Sub	30-60	30	10,653		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04	MIS	30-60	30	36,314	166.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04A	Sub	60-90	30	8,845		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04B	Sub	60-90	30	16,816		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04C	Sub	60-90	30	10,653		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04	MIS	60-90	30	36,314	14.1	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04A	Sub	90-120	30	8,845		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04B	Sub	90-120	30	16,816		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04C	Sub	90-120	30	10,653	0.8	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04	MIS	90-120	30	36,314	21.2	Industrial	1200	1020	-	-	-	-	-
Soil	PI-04A	Sub	120-150	30	8,845		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04B	Sub	120-150	30	16,816		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04C	Sub	120-150	30	10,653		Industrial	1200	1020	-	-	-	-	-
Soil	PI-04	MIS	120-150	30	36,314	119.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-05A	Sub	0-30	30	2,689		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05B	Sub	0-30	30	3,591		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05C	Sub	0-30	30	4,898		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05	MIS	0-30	30	11,177	259.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-05A	Sub	30-60	30	2,689		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05B	Sub	30-60	30	3,591		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05C	Sub	30-60	30	4,898		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05	MIS	30-60	30	11,177	193.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-05A	Sub	60-90	30	2,689		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05B	Sub	60-90	30	3,591		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05C	Sub	60-90	30	4,898		Industrial	1200	1020	-	-	-	-	-
Soil	PI-05	MIS	60-90	30	11,177	158.0	Industrial	1200	1020	-	-	-	-	-

Table B-4: Volume Estimate Calculation for Pacer Ivy Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-06A	Sub	0-30	30	4,779		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06B	Sub	0-30	30	5,233		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06C	Sub	0-30	30	4,737		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06	MIS	0-30	30	14,749	246.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-06A	Sub	30-60	30	4,779		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06B	Sub	30-60	30	5,233		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06C	Sub	30-60	30	4,737		Industrial	1200	1020	-	-	-	-	-
Soil	PI-06	MIS	30-60	30	14,749	261.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-07A	Sub	0-30	30	23,078		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07B	Sub	0-30	30	26,343		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07C	Sub	0-30	30	32,265		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07	MIS	0-30	30	81,687	15.2	Industrial	1200	1020	-	-	-	-	-
Soil	PI-07A	Sub	30-60	30	23,078		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07B	Sub	30-60	30	26,343		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07C	Sub	30-60	30	32,265		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07	MIS	30-60	30	81,687	7.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-07A	Sub	60-90	30	23,078		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07B	Sub	60-90	30	26,343		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07C	Sub	60-90	30	32,265		Industrial	1200	1020	-	-	-	-	-
Soil	PI-07	MIS	60-90	30	81,687	3.8	Industrial	1200	1020	-	-	-	-	-
Soil	PI-08A	Sub	0-30	30	4,306	3,040.0	Industrial	1200	1020	1,292	-	1,292	-	1,292
Soil	PI-08B	Sub	0-30	30	5,876	537.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-08C	Sub	0-30	30	3,647	864.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-08	MIS	0-30	30	13,829	2,573.4	Industrial	1200	1020	1,292	-	1,292	-	1,292
Soil	PI-08A	Sub	30-60	30	4,306		Industrial	1200	1020	-	-	-	1,292	1,292
Soil	PI-08B	Sub	30-60	30	5,876		Industrial	1200	1020	-	-	-	-	-
Soil	PI-08C	Sub	30-60	30	3,647		Industrial	1200	1020	-	-	-	-	-
Soil	PI-08	MIS	30-60	30	13,829	377.0	Industrial	1200	1020	-	-	-	1,292	1,292
Soil	PI-08A	Sub	60-90	30	4,306		Industrial	1200	1020	-	-	-	-	-
Soil	PI-08B	Sub	60-90	30	5,876		Industrial	1200	1020	-	-	-	-	-
Soil	PI-08C	Sub	60-90	30	3,647		Industrial	1200	1020	-	-	-	-	-
Soil	PI-08	MIS	60-90	30	13,829	253.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-09A	Sub	0-30	30	2,348		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09B	Sub	0-30	30	1,861		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09C	Sub	0-30	30	2,548		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09	MIS	0-30	30	6,757	372.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-09A	Sub	30-60	30	2,348		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09B	Sub	30-60	30	1,861		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09C	Sub	30-60	30	2,548		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09	MIS	30-60	30	6,757	139.0	Industrial	1200	1020	-	-	-	-	-
Soil	PI-09A	Sub	60-90	30	2,348		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09B	Sub	60-90	30	1,861		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09C	Sub	60-90	30	2,548		Industrial	1200	1020	-	-	-	-	-
Soil	PI-09	MIS	60-90	30	6,757	69.0	Industrial	1200	1020	-	-	-	-	-

Table B-4: Volume Estimate Calculation for Pacer Ivy Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-10A	Sub	0-30	30	6,545	318.0	Urban residential	300	255	1,964	-	1,964	-	1,964
Soil	PI-10B	Sub	0-30	30	10,685	395.0	Urban residential	300	255	3,205	-	3,205	-	3,205
Soil	PI-10C	Sub	0-30	30	13,080	2,220.0	Urban residential	300	255	3,924	-	3,924	-	3,924
Soil	PI-10	MIS	0-30	30	30,310	639.0	Urban residential	300	255	9,093	-	9,093	-	9,093
Soil	PI-10A	Sub	30-60	30	6,545	121.0	Urban residential	300	255	-	-	-	-	-
Soil	PI-10B	Sub	30-60	30	10,685	79.2	Urban residential	300	255	-	-	-	-	-
Soil	PI-10C	Sub	30-60	30	13,080	153.0	Urban residential	300	255	-	-	-	3,924	3,924
Soil	PI-10	MIS	30-60	30	30,310	118.0	Urban residential	300	255	-	-	-	3,924	3,924
Soil	PI-10A	Sub	60-90	30	6,545	84.5	Urban residential	300	255	-	-	-	-	-
Soil	PI-10B	Sub	60-90	30	10,685	39.1	Urban residential	300	255	-	-	-	-	-
Soil	PI-10C	Sub	60-90	30	13,080	11.7	Urban residential	300	255	-	-	-	-	-
Soil	PI-10	MIS	60-90	30	30,310	56.2	Urban residential	300	255	-	-	-	-	-
Soil	PI-11A	Sub	0-30	30	5,312		Urban residential	300	255	-	-	-	-	-
Soil	PI-11B	Sub	0-30	30	4,992		Urban residential	300	255	-	-	-	-	-
Soil	PI-11C	Sub	0-30	30	2,897		Urban residential	300	255	-	-	-	-	-
Soil	PI-11	MIS	0-30	30	13,201	221.0	Urban residential	300	255	-	-	-	-	-
Soil	PI-11A	Sub	30-60	30	5,312		Urban residential	300	255	-	-	-	-	-
Soil	PI-11B	Sub	30-60	30	4,992		Urban residential	300	255	-	-	-	-	-
Soil	PI-11C	Sub	30-60	30	2,897		Urban residential	300	255	-	-	-	-	-
Soil	PI-11	MIS	30-60	30	13,201	32.7	Urban residential	300	255	-	-	-	-	-
Soil	PI-11A	Sub	60-90	30	5,312		Urban residential	300	255	-	-	-	-	-
Soil	PI-11B	Sub	60-90	30	4,992		Urban residential	300	255	-	-	-	-	-
Soil	PI-11C	Sub	60-90	30	2,897		Urban residential	300	255	-	-	-	-	-
Soil	PI-11	MIS	60-90	30	13,201	36.3	Urban residential	300	255	-	-	-	-	-
Soil	PI-12A	Sub	0-30	30	5,667	1,290.0	Urban residential	300	255	1,700	-	1,700	-	1,700
Soil	PI-12B	Sub	0-30	30	4,414	2,870.0	Urban residential	300	255	1,324	-	1,324	-	1,324
Soil	PI-12C	Sub	0-30	30	4,401	2,340.0	Urban residential	300	255	1,320	-	1,320	-	1,320
Soil	PI-12	MIS	0-30	30	14,482	2,170.0	Urban residential	300	255	4,345	-	4,345	-	4,345
Soil	PI-12A	Sub	30-60	30	5,667	175.0	Urban residential	300	255	-	-	-	1,700	1,700
Soil	PI-12B	Sub	30-60	30	4,414	759.0	Urban residential	300	255	1,324	-	1,324	-	1,324
Soil	PI-12C	Sub	30-60	30	4,401	1,000.0	Urban residential	300	255	1,320	-	1,320	-	1,320
Soil	PI-12	MIS	30-60	30	14,482	560.0	Urban residential	300	255	2,645	-	2,645	1,700	4,345
Soil	PI-12A	Sub	60-90	30	5,667	40.0	Urban residential	300	255	-	-	-	-	-
Soil	PI-12B	Sub	60-90	30	4,414	207.0	Urban residential	300	255	-	-	-	1,324	1,324
Soil	PI-12C	Sub	60-90	30	4,401	656.0	Urban residential	300	255	1,320	2,118	3,438	-	3,438
Soil	PI-12	MIS	60-90	30	14,482	288.0	Urban residential	300	255	1,320	2,118	3,438	1,324	4,762
Soil	PI-13A	Sub	0-30	30	8,038	299.0	Urban residential	300	255	2,411	-	2,411	-	2,411
Soil	PI-13B	Sub	0-30	30	18,674	20.9	Urban residential	300	255	-	-	-	-	-
Soil	PI-13C	Sub	0-30	30	16,007	22.1	Urban residential	300	255	-	-	-	-	-
Soil	PI-13	MIS	0-30	30	42,719	266.3	Urban residential	300	255	2,411	-	2,411	-	2,411
Soil	PI-13A	Sub	30-60	30	8,038		Urban residential	300	255	-	-	-	-	-
Soil	PI-13B	Sub	30-60	30	18,674		Urban residential	300	255	-	-	-	-	-
Soil	PI-13C	Sub	30-60	30	16,007		Urban residential	300	255	-	-	-	-	-
Soil	PI-13	MIS	30-60	30	42,719	73.7	Urban residential	300	255	-	-	-	-	-

Table B-4: Volume Estimate Calculation for Pacer Ivy Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	PI-14A	Sub	0-30	30	35,106		Urban residential	300	255	-	-	-	-	-
Soil	PI-14B	Sub	0-30	30	41,787		Urban residential	300	255	-	-	-	-	-
Soil	PI-14C	Sub	0-30	30	24,984		Urban residential	300	255	-	-	-	-	-
Soil	PI-14	MIS	0-30	30	101,876	50.0	Urban residential	300	255	-	-	-	-	-
Soil	PI-14A	Sub	30-60	30	35,106		Urban residential	300	255	-	-	-	-	-
Soil	PI-14B	Sub	30-60	30	41,787		Urban residential	300	255	-	-	-	-	-
Soil	PI-14C	Sub	30-60	30	24,984		Urban residential	300	255	-	-	-	-	-
Soil	PI-14	MIS	30-60	30	101,876	5.7	Urban residential	300	255	-	-	-	-	-
Sediment	PI-15A	Sub	0-15	15	1,564	693.0	Sediment	150	127.5	235	-	235	-	235
Sediment	PI-15B	Sub	0-15	15	1,435	3,370.0	Sediment	150	127.5	215	-	215	-	215
Sediment	PI-15C	Sub	0-15	15	1,060	2,180.0	Sediment	150	127.5	159	-	159	-	159
Sediment	PI-15	MIS	0-15	15	4,059	1,910.0	Sediment	150	127.5	609	-	609	-	609
Sediment	PI-15A	Sub	15-30	15	1,564	801.0	Sediment	150	127.5	235	-	235	-	235
Sediment	PI-15B	Sub	15-30	15	1,435	1,240.0	Sediment	150	127.5	215	-	215	-	215
Sediment	PI-15C	Sub	15-30	15	1,060	2,750.0	Sediment	150	127.5	159	-	159	-	159
Sediment	PI-15	MIS	15-30	15	4,059	1,360.0	Sediment	150	127.5	609	-	609	-	609
Sediment	PI-15A	Sub	30-45	15	1,564	809.0	Sediment	150	127.5	235	1,197	1,431	235	1,666
Sediment	PI-15B	Sub	30-45	15	1,435	1,250.0	Sediment	150	127.5	215	1,098	1,314	215	1,529
Sediment	PI-15C	Sub	30-45	15	1,060	3,320.0	Sediment	150	127.5	159	811	970	159	1,129
Sediment	PI-15	MIS	30-45	15	4,059	1,670.0	Sediment	150	127.5	609	3,107	3,715	609	4,324
Sediment	PI-16A	Sub	0-15	15	1,169	211.0	Sediment	150	127.5	175	-	175	-	175
Sediment	PI-16B	Sub	0-15	15	1,677	171.0	Sediment	150	127.5	252	-	252	-	252
Sediment	PI-16C	Sub	0-15	15	3,641	889.0	Sediment	150	127.5	546	-	546	-	546
Sediment	PI-16	MIS	0-15	15	6,487	395.0	Sediment	150	127.5	973	-	973	-	973
Sediment	PI-16A	Sub	15-30	15	1,169	164.0	Sediment	150	127.5	175	-	175	-	175
Sediment	PI-16B	Sub	15-30	15	1,677	212.0	Sediment	150	127.5	252	-	252	-	252
Sediment	PI-16C	Sub	15-30	15	3,641	1,120.0	Sediment	150	127.5	546	-	546	-	546
Sediment	PI-16	MIS	15-30	15	6,487	403.0	Sediment	150	127.5	973	-	973	-	973
Sediment	PI-16A	Sub	30-45	15	1,169	321.0	Sediment	150	127.5	175	478	653	175	829
Sediment	PI-16B	Sub	30-45	15	1,677	102.0	Sediment	150	127.5	-	-	-	503	503
Sediment	PI-16C	Sub	30-45	15	3,641	947.0	Sediment	150	127.5	546	1,488	2,034	546	2,580
Sediment	PI-16	MIS	30-45	15	6,487	276.0	Sediment	150	127.5	721	1,966	2,688	1,225	3,912
Sediment	PI-17A	Sub	0-15	15	4,083	318.0	Sediment	150	127.5	612	-	612	-	612
Sediment	PI-17B	Sub	0-15	15	8,852	1,300.0	Sediment	150	127.5	1,328	-	1,328	-	1,328
Sediment	PI-17C	Sub	0-15	15	7,545	16.2	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-17	MIS	0-15	15	20,480	431.0	Sediment	150	127.5	1,940	-	1,940	-	1,940
Sediment	PI-17A	Sub	15-30	15	4,083	370.0	Sediment	150	127.5	612	-	612	-	612
Sediment	PI-17B	Sub	15-30	15	8,852	613.0	Sediment	150	127.5	1,328	-	1,328	-	1,328
Sediment	PI-17C	Sub	15-30	15	7,545	4.1	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-17	MIS	15-30	15	20,480	265.0	Sediment	150	127.5	1,940	-	1,940	-	1,940
Sediment	PI-17A	Sub	30-45	15	4,083	267.0	Sediment	150	127.5	612	1,220	1,832	612	2,445
Sediment	PI-17B	Sub	30-45	15	8,852	506.0	Sediment	150	127.5	1,328	2,645	3,973	1,328	5,301
Sediment	PI-17C	Sub	30-45	15	7,545	2.4	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-17	MIS	30-45	15	20,480	172.0	Sediment	150	127.5	1,940	3,865	5,806	1,940	7,746

Table B-4: Volume Estimate Calculation for Pacer Ivy Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	PI-18A	Sub	0-15	15	4,983		Sediment	150	127.5	747	-	747	-	747
Sediment	PI-18B	Sub	0-15	15	3,952		Sediment	150	127.5	593	-	593	-	593
Sediment	PI-18C	Sub	0-15	15	3,024		Sediment	150	127.5	454	-	454	-	454
Sediment	PI-18	MIS	0-15	15	11,959	1,080.0	Sediment	150	127.5	1,794	-	1,794	-	1,794
Sediment	PI-18A	Sub	15-30	15	4,983		Sediment	150	127.5	747	-	747	-	747
Sediment	PI-18B	Sub	15-30	15	3,952		Sediment	150	127.5	593	-	593	-	593
Sediment	PI-18C	Sub	15-30	15	3,024		Sediment	150	127.5	454	-	454	-	454
Sediment	PI-18	MIS	15-30	15	11,959	349.0	Sediment	150	127.5	1,794	-	1,794	-	1,794
Sediment	PI-18A	Sub	30-45	15	4,983	146.0	Sediment	150	127.5	747	886	1,633	747	2,380
Sediment	PI-18B	Sub	30-45	15	3,952	150.0	Sediment	150	127.5	593	702	1,295	593	1,888
Sediment	PI-18C	Sub	30-45	15	3,024	179.0	Sediment	150	127.5	454	538	991	454	1,445
Sediment	PI-18	MIS	30-45	15	11,959	169.0	Sediment	150	127.5	1,794	2,125	3,919	1,794	5,713
Sediment	PI-19A	Sub	0-15	15	910		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19B	Sub	0-15	15	1,023		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19C	Sub	0-15	15	1,662		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19	MIS	0-15	15	3,595	40.1	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19A	Sub	15-30	15	910		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19B	Sub	15-30	15	1,023		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19C	Sub	15-30	15	1,662		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19	MIS	15-30	15	3,595	20.7	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19A	Sub	30-45	15	910		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19B	Sub	30-45	15	1,023		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19C	Sub	30-45	15	1,662		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-19	MIS	30-45	15	3,595	8.8	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-20A	Sub	0-15	15	4,489		Sediment	150	127.5	673	-	673	-	673
Sediment	PI-20B	Sub	0-15	15	3,735		Sediment	150	127.5	560	-	560	-	560
Sediment	PI-20C	Sub	0-15	15	3,868		Sediment	150	127.5	580	-	580	-	580
Sediment	PI-20	MIS	0-15	15	12,092	3,080.0	Sediment	150	127.5	1,814	-	1,814	-	1,814
Sediment	PI-20A	Sub	15-30	15	4,489		Sediment	150	127.5	673	-	673	-	673
Sediment	PI-20B	Sub	15-30	15	3,735		Sediment	150	127.5	560	-	560	-	560
Sediment	PI-20C	Sub	15-30	15	3,868		Sediment	150	127.5	580	-	580	-	580
Sediment	PI-20	MIS	15-30	15	12,092	5,410.0	Sediment	150	127.5	1,814	-	1,814	-	1,814
Sediment	PI-20A	Sub	30-45	15	4,489		Sediment	150	127.5	673	3,686	4,359	673	5,033
Sediment	PI-20B	Sub	30-45	15	3,735		Sediment	150	127.5	560	3,066	3,627	560	4,187
Sediment	PI-20C	Sub	30-45	15	3,868		Sediment	150	127.5	580	3,176	3,756	580	4,337
Sediment	PI-20	MIS	30-45	15	12,092	3,820.0	Sediment	150	127.5	1,814	9,928	11,742	1,814	13,556
Sediment	PI-21A	Sub	0-15	15	2,348		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21B	Sub	0-15	15	2,020		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21C	Sub	0-15	15	2,408		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21	MIS	0-15	15	6,777	26.6	Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21A	Sub	15-30	15	2,348		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21B	Sub	15-30	15	2,020		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21C	Sub	15-30	15	2,408		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21	MIS	15-30	15	6,777	18.4	Sediment	150	127.5	-	-	-	-	-

Table B-4: Volume Estimate Calculation for Pacer Ivy Area **(Continued)**

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	PI-21A	Sub	30-45	15	2,348		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21B	Sub	30-45	15	2,020		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21C	Sub	30-45	15	2,408		Sediment	150	127.5	-	-	-	-	-
Sediment	PI-21	MIS	30-45	15	6,777	69.1	Sediment	150	127.5	-	-	-	-	-
									Totals	**147,072**	**23,110**	**170,181**	**25,561**	**195,742**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

2 Samples were not collected at this depth interval. This depth is shown for volume estimating purposes.

Table B-5: Volume Estimate Calculation for Northwest Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	NW-01A	Sub	0-15	15	1,941		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01B	Sub	0-15	15	4,031		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01C	Sub	0-15	15	2,923		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01	MIS	0-15	15	8,895	96.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01A	Sub	15-30	15	1,941		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01B	Sub	15-30	15	4,031		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01C	Sub	15-30	15	2,923		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01	MIS	15-30	15	8,895	104.0	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01A	Sub	30-45	15	1,941		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01B	Sub	30-45	15	4,031		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01C	Sub	30-45	15	2,923		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-01	MIS	30-45	15	8,895	69.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02A	Sub	0-15	15	876		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02B	Sub	0-15	15	1,850		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02C	Sub	0-15	15	1,145		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02	MIS	0-15	15	3,871	72.4	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02A	Sub	15-30	15	876		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02B	Sub	15-30	15	1,850		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02C	Sub	15-30	15	1,145		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02	MIS	15-30	15	3,871	46.6	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02A	Sub	30-45	15	876		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02B	Sub	30-45	15	1,850		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02C	Sub	30-45	15	1,145		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-02	MIS	30-45	15	3,871	23.7	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03A	Sub	0-15	15	2,445	4.1	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03B	Sub	0-15	15	4,128	16.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03C	Sub	0-15	15	7,810	385.0	Sediment	150	127.5	1,172	-	1,172	-	1,172
Sediment	NW-03	MIS	0-15	15	14,383	155.0	Sediment	150	127.5	1,172	-	1,172	-	1,172
Sediment	NW-03A	Sub	15-30	15	2,445	0.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03B	Sub	15-30	15	4,128	6.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03C	Sub	15-30	15	7,810	587.0	Sediment	150	127.5	1,172	-	1,172	-	1,172
Sediment	NW-03	MIS	15-30	15	14,383	177.0	Sediment	150	127.5	1,172	-	1,172	-	1,172
Sediment	NW-03A	Sub	30-45	15	2,445	0.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-03B	Sub	30-45	15	4,128	4.9	Sediment	150	127.5	-	-	-	619	619
Sediment	NW-03C	Sub	30-45	15	7,810	644.0	Sediment	150	127.5	1,172	2,633	3,804	1,172	4,976
Sediment	NW-03	MIS	30-45	15	14,383	194.0	Sediment	150	127.5	1,172	2,633	3,804	1,172	4,976
Sediment	NW-04A	Sub	0-15	15	3,087	477.0	Sediment	150	127.5	463	-	463	-	463
Sediment	NW-04B	Sub	0-15	15	2,123	82.6	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04C	Sub	0-15	15	1,144	34.6	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04	MIS	0-15	15	6,354	199.0	Sediment	150	127.5	463	-	463	-	463
Sediment	NW-04A	Sub	15-30	15	3,087	262.0	Sediment	150	127.5	-	-	-	463	463
Sediment	NW-04B	Sub	15-30	15	2,123	32.7	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04C	Sub	15-30	15	1,144	37.6	Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04	MIS	15-30	15	6,354	108.0	Sediment	150	127.5	-	-	-	463	463

Table B-5: Volume Estimate Calculation for Northwest Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	NW-04A	Sub	30-45	15	3,087		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04B	Sub	30-45	15	2,123		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04C	Sub	30-45	15	1,144		Sediment	150	127.5	-	-	-	-	-
Sediment	NW-04	MIS	30-45	15	6,354	37.0	Sediment	150	127.5	-	-	-	-	-
									Totals	**3,978**	**2,633**	**6,611**	**1,635**	**8,245**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

Table B-6: Volume Estimate Calculation for Northern Forest Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	NF-01A	Sub	0-30	30	47,187		Forest land	100	85	-	-	-	-	-
Soil	NF-01B	Sub	0-30	30	53,824		Forest land	100	85	-	-	-	-	-
Soil	NF-01C	Sub	0-30	30	63,411		Forest land	100	85	-	-	-	-	-
Soil	NF-01	MIS	0-30	30	164,421	35.5	Forest land	100	85	-	-	-	-	-
Soil	NF-01A	Sub	30-60	30	47,187		Forest land	100	85	-	-	-	-	-
Soil	NF-01B	Sub	30-60	30	53,824		Forest land	100	85	-	-	-	-	-
Soil	NF-01C	Sub	30-60	30	63,411		Forest land	100	85	-	-	-	-	-
Soil	NF-01	MIS	30-60	30	164,421	6.3	Forest land	100	85	-	-	-	-	-
Soil	NF-02A	Sub	0-30	30	8,964		Forest land	100	85	-	-	-	-	-
Soil	NF-02B	Sub	0-30	30	8,233		Forest land	100	85	-	-	-	-	-
Soil	NF-02C	Sub	0-30	30	13,789		Forest land	100	85	-	-	-	-	-
Soil	NF-02	MIS	0-30	30	30,986	60.0	Forest land	100	85	-	-	-	-	-
Soil	NF-02A	Sub	30-60	30	8,964		Forest land	100	85	-	-	-	-	-
Soil	NF-02B	Sub	30-60	30	8,233		Forest land	100	85	-	-	-	-	-
Soil	NF-02C	Sub	30-60	30	13,789		Forest land	100	85	-	-	-	-	-
Soil	NF-02	MIS	30-60	30	30,986	4.0	Forest land	100	85	-	-	-	-	-
Soil	NF-03A	Sub	0-30	30	13,638		Forest land	100	85	-	-	-	-	-
Soil	NF-03B	Sub	0-30	30	17,021		Forest land	100	85	-	-	-	-	-
Soil	NF-03C	Sub	0-30	30	18,695		Forest land	100	85	-	-	-	-	-
Soil	NF-03	MIS	0-30	30	49,353	19.0	Forest land	100	85	-	-	-	-	-
Soil	NF-03A	Sub	30-60	30	13,638		Forest land	100	85	-	-	-	-	-
Soil	NF-03B	Sub	30-60	30	17,021		Forest land	100	85	-	-	-	-	-
Soil	NF-03C	Sub	30-60	30	18,695		Forest land	100	85	-	-	-	-	-
Soil	NF-03	MIS	30-60	30	49,353	1.0	Forest land	100	85	-	-	-	-	-
Soil	NF-04A	Sub	0-30	30	21,293	349.0	Forest land	100	85	6,388	-	6,388	-	6,388
Soil	NF-04B	Sub	0-30	30	21,881	125.0	Forest land	100	85	6,564	-	6,564	-	6,564
Soil	NF-04C	Sub	0-30	30	22,867	20.2	Forest land	100	85	-	-	-	-	-
Soil	NF-04	MIS	0-30	30	66,041	171.0	Forest land	100	85	12,952	-	12,952	-	12,952
Soil	NF-04A	Sub	30-60	30	21,293	465.0	Forest land	100	85	6,388	14,941	21,328	-	21,328
Soil	NF-04B	Sub	30-60	30	21,881	21.4	Forest land	100	85	-	-	-	-	-
Soil	NF-04C	Sub	30-60	30	22,867	26.0	Forest land	100	85	-	-	-	-	-
Soil	NF-04	MIS	30-60	30	66,041	159.0	Forest land	100	85	6,388	14,941	21,328	-	21,328
									Totals	**19,340**	**14,941**	**34,280**	**-**	**34,280**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

Table B-7: Volume Estimate Calcuation for Northeast Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	NE-01A	Sub	0-30	30	21,230		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01B	Sub	0-30	30	22,279		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01C	Sub	0-30	30	26,931		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01	MIS	0-30	30	70,440	10.6	Industrial	1200	1020	-	-	-	-	-
Soil	NE-01A	Sub	30-60	30	21,230		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01B	Sub	30-60	30	22,279		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01C	Sub	30-60	30	26,931		Industrial	1200	1020	-	-	-	-	-
Soil	NE-01	MIS	30-60	30	70,440	3.8	Industrial	1200	1020	-	-	-	-	-
Soil	NE-02A	Sub	0-30	30	63,702	981.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-02B	Sub	0-30	30	38,733	542.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-02C	Sub	0-30	30	41,476	1,020.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-02	MIS	0-30	30	143,912	795.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-02A	Sub	30-60	30	63,702		Industrial	1200	1020	-	-	-	-	-
Soil	NE-02B	Sub	30-60	30	38,733		Industrial	1200	1020	-	-	-	-	-
Soil	NE-02C	Sub	30-60	30	41,476		Industrial	1200	1020	-	-	-	-	-
Soil	NE-02	MIS	30-60	30	143,912	63.4	Industrial	1200	1020	-	-	-	-	-
Soil	NE-03A	Sub	0-30	30	29,984		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03B	Sub	0-30	30	37,212		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03C	Sub	0-30	30	24,928		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03	MIS	0-30	30	92,123	34.8	Industrial	1200	1020	-	-	-	-	-
Soil	NE-03A	Sub	30-60	30	29,984		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03B	Sub	30-60	30	37,212		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03C	Sub	30-60	30	24,928		Industrial	1200	1020	-	-	-	-	-
Soil	NE-03	MIS	30-60	30	92,123	20.7	Industrial	1200	1020	-	-	-	-	-
Soil	NE-04A	Sub	0-30	30	34,532	666.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-04B	Sub	0-30	30	22,951	706.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-04C	Sub	0-30	30	42,676	236.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-04	MIS	0-30	30	100,159	595.0	Industrial	1200	1020	-	-	-	-	-
Soil	NE-04A	Sub	30-60	30	34,532		Industrial	1200	1020	-	-	-	-	-
Soil	NE-04B	Sub	30-60	30	22,951		Industrial	1200	1020	-	-	-	-	-
Soil	NE-04C	Sub	30-60	30	42,676		Industrial	1200	1020	-	-	-	-	-
Soil	NE-04	MIS	30-60	30	100,159	354.8	Industrial	1200	1020	-	-	-	-	-
Soil	NE-05A	Sub	0-30	30	9,175		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05B	Sub	0-30	30	8,186		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05C	Sub	0-30	30	8,894		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05	MIS	0-30	30	26,255	74.7	Industrial	1200	1020	-	-	-	-	-
Soil	NE-05A	Sub	30-60	30	9,175		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05B	Sub	30-60	30	8,186		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05C	Sub	30-60	30	8,894		Industrial	1200	1020	-	-	-	-	-
Soil	NE-05	MIS	30-60	30	26,255	40.9	Industrial	1200	1020	-	-	-	-	-
Sediment	NE-06A	Sub	0-15	15	1,198		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06B	Sub	0-15	15	745		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06C	Sub	0-15	15	879		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06	MIS	0-15	15	2,822	71.5	Sediment	150	127.5	-	-	-	-	-

Table B-7: Volume Estimate Calcuation for Northeast Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	NE-06A	Sub	15-30	15	1,198		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06B	Sub	15-30	15	745		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06C	Sub	15-30	15	879		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06	MIS	15-30	15	2,822	44.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06A	Sub	30-45	15	1,198		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06B	Sub	30-45	15	745		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06C	Sub	30-45	15	879		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-06	MIS	30-45	15	2,822	74.5	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-07A	Sub	0-15	15	2,799		Sediment	150	127.5	420	-	420	-	420
Sediment	NE-07B	Sub	0-15	15	1,909		Sediment	150	127.5	286	-	286	-	286
Sediment	NE-07C	Sub	0-15	15	2,664		Sediment	150	127.5	400	-	400	-	400
Sediment	NE-07	MIS	0-15	15	7,372	1,300.0	Sediment	150	127.5	1,106	-	1,106	-	1,106
Sediment	NE-07A	Sub	15-30	15	2,799		Sediment	150	127.5	420	-	420	-	420
Sediment	NE-07B	Sub	15-30	15	1,909		Sediment	150	127.5	286	-	286	-	286
Sediment	NE-07C	Sub	15-30	15	2,664		Sediment	150	127.5	400	-	400	-	400
Sediment	NE-07	MIS	15-30	15	7,372	765.0	Sediment	150	127.5	1,106	-	1,106	-	1,106
Sediment	NE-07A	Sub	30-45	15	2,799		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-07B	Sub	30-45	15	1,909		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-07C	Sub	30-45	15	2,664		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-07	MIS	30-45	15	7,372	54.1	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-08A	Sub	0-15	15	6,608	223.0	Sediment	150	127.5	991	-	991	-	991
Sediment	NE-08B	Sub	0-15	15	18,187	215.0	Sediment	150	127.5	2,728	-	2,728	-	2,728
Sediment	NE-08C	Sub	0-15	15	17,333	48.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-08	MIS	0-15	15	42,128	179.0	Sediment	150	127.5	3,719	-	3,719	-	3,719
Sediment	NE-08A	Sub	15-30	15	6,608	157.0	Sediment	150	127.5	991	-	991	-	991
Sediment	NE-08B	Sub	15-30	15	18,187	265.0	Sediment	150	127.5	2,728	-	2,728	-	2,728
Sediment	NE-08C	Sub	15-30	15	17,333	52.7	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-08	MIS	15-30	15	42,128	202.0	Sediment	150	127.5	3,719	-	3,719	-	3,719
Sediment	NE-08A	Sub	30-45	15	6,608	217.0	Sediment	150	127.5	991	1,293	2,284	991	3,276
Sediment	NE-08B	Sub	30-45	15	18,187	122.0	Sediment	150	127.5	-	-	-	5,456	5,456
Sediment	NE-08C	Sub	30-45	15	17,333	39.9	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-08	MIS	30-45	15	42,128	128.0	Sediment	150	127.5	991	1,293	2,284	6,447	8,732
Sediment	NE-09A	Sub	0-15	15	4,520		Sediment	150	127.5	678	-	678	-	678
Sediment	NE-09B	Sub	0-15	15	3,440		Sediment	150	127.5	516	-	516	-	516
Sediment	NE-09C	Sub	0-15	15	2,181		Sediment	150	127.5	327	-	327	-	327
Sediment	NE-09	MIS	0-15	15	10,140	448.0	Sediment	150	127.5	1,521	-	1,521	-	1,521
Sediment	NE-09A	Sub	15-30	15	4,520		Sediment	150	127.5	678	-	678	-	678
Sediment	NE-09B	Sub	15-30	15	3,440		Sediment	150	127.5	516	-	516	-	516
Sediment	NE-09C	Sub	15-30	15	2,181		Sediment	150	127.5	327	-	327	-	327
Sediment	NE-09	MIS	15-30	15	10,140	334.0	Sediment	150	127.5	1,521	-	1,521	-	1,521
Sediment	NE-09A	Sub	30-45	15	4,520		Sediment	150	127.5	678	882	1,561	678	2,239
Sediment	NE-09B	Sub	30-45	15	3,440		Sediment	150	127.5	516	672	1,188	516	1,704
Sediment	NE-09C	Sub	30-45	15	2,181		Sediment	150	127.5	327	426	753	327	1,080
Sediment	NE-09	MIS	30-45	15	10,140	216.0	Sediment	150	127.5	1,521	1,980	3,501	1,521	5,022

Table B-7: Volume Estimate Calcuation for Northeast Area (Continued)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	NE-10A	Sub	0-15	15	3,871		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10B	Sub	0-15	15	2,748		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10C	Sub	0-15	15	2,229		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10	MIS	0-15	15	8,848	26.9	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10A	Sub	15-30	15	3,871		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10B	Sub	15-30	15	2,748		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10C	Sub	15-30	15	2,229		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10	MIS	15-30	15	8,848	33.7	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10A	Sub	30-45	15	3,871		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10B	Sub	30-45	15	2,748		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10C	Sub	30-45	15	2,229		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-10	MIS	30-45	15	8,848	49.0	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-11A	Sub	0-15	15	3,733		Sediment	150	127.5	560	-	560	-	560
Sediment	NE-11B	Sub	0-15	15	1,855		Sediment	150	127.5	278	-	278	-	278
Sediment	NE-11C	Sub	0-15	15	2,363		Sediment	150	127.5	354	-	354	-	354
Sediment	NE-11	MIS	0-15	15	7,950	124.7	Sediment	150	127.5	1,193	-	1,193	-	1,193
Sediment	NE-11A	Sub	15-30	15	3,733		Sediment	150	127.5	560	-	560	-	560
Sediment	NE-11B	Sub	15-30	15	1,855		Sediment	150	127.5	278	-	278	-	278
Sediment	NE-11C	Sub	15-30	15	2,363		Sediment	150	127.5	354	-	354	-	354
Sediment	NE-11	MIS	15-30	15	7,950	366.8	Sediment	150	127.5	1,193	-	1,193	-	1,193
Sediment	NE-11A	Sub	30-45	15	3,733		Sediment	150	127.5	560	654	1,214	560	1,774
Sediment	NE-11B	Sub	30-45	15	1,855		Sediment	150	127.5	278	325	603	278	881
Sediment	NE-11C	Sub	30-45	15	2,363		Sediment	150	127.5	354	414	768	354	1,123
Sediment	NE-11	MIS	30-45	15	7,950	174.0	Sediment	150	127.5	1,193	1,393	2,586	1,193	3,778
Sediment	NE-12A	Sub	0-15	15	596	259.0	Sediment	150	127.5	89	-	89	-	89
Sediment	NE-12B	Sub	0-15	15	1,581	148.0	Sediment	150	127.5	237	-	237	-	237
Sediment	NE-12C	Sub	0-15	15	1,462	133.0	Sediment	150	127.5	219	-	219	-	219
Sediment	NE-12	MIS	0-15	15	3,639	185.0	Sediment	150	127.5	546	-	546	-	546
Sediment	NE-12A	Sub	15-30	15	596		Sediment	150	127.5	-	-	-	89	89
Sediment	NE-12B	Sub	15-30	15	1,581		Sediment	150	127.5	-	-	-	237	237
Sediment	NE-12C	Sub	15-30	15	1,462		Sediment	150	127.5	-	-	-	219	219
Sediment	NE-12	MIS	15-30	15	3,639	64.5	Sediment	150	127.5	-	-	-	546	546
Sediment	NE-12A	Sub	30-45	15	596		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-12B	Sub	30-45	15	1,581		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-12C	Sub	30-45	15	1,462		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-12	MIS	30-45	15	3,639	47.1	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13A	Sub	0-15	15	6,077		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13B	Sub	0-15	15	4,308		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13C	Sub	0-15	15	3,572		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13	MIS	0-15	15	13,958	77.6	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13A	Sub	15-30	15	6,077		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13B	Sub	15-30	15	4,308		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13C	Sub	15-30	15	3,572		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13	MIS	15-30	15	13,958	89.7	Sediment	150	127.5	-	-	-	-	-

Table B-7: Volume Estimate Calcuation for Northeast Area **(Continued)**

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	NE-13A	Sub	30-45	15	6,077		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13B	Sub	30-45	15	4,308		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13C	Sub	30-45	15	3,572		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-13	MIS	30-45	15	13,958	63.9	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14A	Sub	0-15	15	726		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14B	Sub	0-15	15	1,124		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14C	Sub	0-15	15	1,151		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14	MIS	0-15	15	3,001	35.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14A	Sub	15-30	15	726		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14B	Sub	15-30	15	1,124		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14C	Sub	15-30	15	1,151		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14	MIS	15-30	15	3,001	39.2	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14A	Sub	30-45	15	726		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14B	Sub	30-45	15	1,124		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14C	Sub	30-45	15	1,151		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-14	MIS	30-45	15	3,001	34.8	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15A	Sub	0-15	15	8,350	50.1	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15B	Sub	0-15	15	6,477	127.0	Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15C	Sub	0-15	15	6,699	226.0	Sediment	150	127.5	1,005	-	1,005	-	1,005
Sediment	NE-15	MIS	0-15	15	21,526	154.0	Sediment	150	127.5	1,005	-	1,005	-	1,005
Sediment	NE-15A	Sub	15-30	15	8,350		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15B	Sub	15-30	15	6,477		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15C	Sub	15-30	15	6,699		Sediment	150	127.5	-	-	-	1,005	1,005
Sediment	NE-15	MIS	15-30	15	21,526	24.6	Sediment	150	127.5	-	-	-	1,005	1,005
Sediment	NE-15A	Sub	30-45	15	8,350		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15B	Sub	30-45	15	6,477		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15C	Sub	30-45	15	6,699		Sediment	150	127.5	-	-	-	-	-
Sediment	NE-15	MIS	30-45	15	21,526	9.8	Sediment	150	127.5	-	-	-	-	-
									Totals	**20,333**	**4,666**	**24,999**	**10,712**	**35,710**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

Table B-8: Volume Estimate Calculation for Southeast Area

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Soil	SE-01A	Sub	0-30	30	21,228		Urban residential	300	255	-	-	-	-	-
Soil	SE-01B	Sub	0-30	30	14,433		Urban residential	300	255	-	-	-	-	-
Soil	SE-01C	Sub	0-30	30	23,052		Urban residential	300	255	-	-	-	-	-
Soil	SE-01	MIS	0-30	30	58,712	36.9	Urban residential	300	255	-	-	-	-	-
Soil	SE-01A	Sub	30-60	30	21,228		Urban residential	300	255	-	-	-	-	-
Soil	SE-01B	Sub	30-60	30	14,433		Urban residential	300	255	-	-	-	-	-
Soil	SE-01C	Sub	30-60	30	23,052		Urban residential	300	255	-	-	-	-	-
Soil	SE-01	MIS	30-60	30	58,712	34.5	Urban residential	300	255	-	-	-	-	-
Soil	SE-02A	Sub	0-30	30	31,396		Urban residential	300	255	-	-	-	-	-
Soil	SE-02B	Sub	0-30	30	21,451		Urban residential	300	255	-	-	-	-	-
Soil	SE-02C	Sub	0-30	30	15,099		Urban residential	300	255	-	-	-	-	-
Soil	SE-02	MIS	0-30	30	67,946	64.5	Urban residential	300	255	-	-	-	-	-
Soil	SE-02A	Sub	30-60	30	31,396		Urban residential	300	255	-	-	-	-	-
Soil	SE-02B	Sub	30-60	30	21,451		Urban residential	300	255	-	-	-	-	-
Soil	SE-02C	Sub	30-60	30	15,099		Urban residential	300	255	-	-	-	-	-
Soil	SE-02	MIS	30-60	30	67,946	31.8	Urban residential	300	255	-	-	-	-	-
									Totals	-	-	-	-	-

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

Table B-9: Volume Estimate Calculation for Outside of Airbase (Gate 2 Lake and Bien Hung Lake)

Media	DU or Sub-DU	Sample Type	Sample Interval (cm)	Sample Interval Length (cm)	DU or Sub-DU Area (m2)	Dioxin Concentration (ppt TEQ) (TEQ ND=1/2 DL)	Landuse Type	Action Level (ppt TEQ)	Action Level with 15% CSF (ppt TEQ)	{A} Contaminated Volume with CSF (m3)	{B} Additional Volume due to Extra Depths, √ Ratio Method[1] (m3)	{C} Sub-Total Volume (m3) {A+ B}	{D} Contingency Volume (m3)	Total Volume (m3) {C + D}
Sediment	BHL-01	MIS	0-15	15	30,707	83.0	Sediment	150	127.5	-	-	-	-	-
Sediment	G2L-01	MIS	0-15	15	8,789	166.0	Sediment	150	127.5	1,318	-	1,318	-	1,318
Sediment	G2L-01A	Sub	15-30	15	2,804		Sediment	150	127.5	-	-	-	421	421
Sediment	G2L-01B	Sub	15-30	15	2,748		Sediment	150	127.5	-	-	-	412	412
Sediment	G2L-01C	Sub	15-30	15	3,237		Sediment	150	127.5	-	-	-	486	486
Sediment	G2L-01	MIS	15-30	15	8,789	100.0	Sediment	150	127.5	-	-	-	1,318	1,318
Sediment	G2L-01A	Sub	30-45	15	2,804		Sediment	150	127.5	-	-	-	-	-
Sediment	G2L-01B	Sub	30-45	15	2,748		Sediment	150	127.5	-	-	-	-	-
Sediment	G2L-01C	Sub	30-45	15	3,237		Sediment	150	127.5	-	-	-	-	-
Sediment	G2L-01	MIS	30-45	15	8,789	56.5	Sediment	150	127.5	-	-	-	-	-
									Totals	**1,318**	**-**	**1,318**	**1,318**	**2,637**

Abbreviations and Acronyms:

- %: percent
- √: square root
- cm: centimeter
- DL: detection limit
- DU: decision unit
- m^2: square meter
- m^3: cubic meter
- MIS: multi-increment sampling
- ND: non-detect
- ppt: part per trillion
- Sub: subsample
- TEQ: dioxin toxicity equivalence
- CSF: concentration safety factor

Notes:

1 The estimated additional volume would occur at depths below the deepest collected sample.

APPENDIX C

DESCRIPTION OF POTENTIALLY APPLICABLE TECHNOLOGIES/ STRATEGIES

Appendix C: Description of Potentially Applicable Technologies/Strategies

1 Introduction

As described in **Sections 4.1 and 4.2** of the Environmental Assessment (EA), multiple technologies and strategies were identified, considered, and then either screened out or retained during development of the remedial alternatives presented in **Sections 4.3**. This appendix describes all the technologies and strategies identified, and whether they were retained, and why. As noted in **Section 4.2**, three criteria were used to screen all the technologies/strategies, all of which had to be met for the strategy or technology to be retained:

- Has the technology or strategy demonstrated dioxin destruction or containment on a scale larger than a lab study, and from the range of concentrations measured in soils and sediments at the Airbase to below the range of required MND-approved dioxin limits? In other words, has the technology or strategy been demonstrated to be sufficiently mature to be applied at the Airbase? If a particular technology has not been demonstrated to treat or contain materials to below MND-approved dioxin limits, it should not receive the same consideration as a technology or strategy that has demonstrated maturity and applicability.
- Would full-scale costs be prohibitive, or not competitive with other comparable technologies? Technologies with available cost data, even if conceptual, were compared. Those without cost information or with only limited cost information, were assessed using professional judgment regarding expected cost drivers. For example, if a particular technology had significantly higher expected energy requirements versus another comparable technology that was already known to be effective, it was not retained. Additionally, if a particular technology required significant preprocessing and pretreatment prior to its application compared to others, it was not retained.
- Is the technology or strategy expected to be acceptable to Vietnamese stakeholders? This criterion is based solely on feedback from Government of Vietnam (GVN) stakeholders during early discussions regarding technology evaluation, or during past discussions. This includes technologies which GVN stakeholders have indicated are not expected to be sufficiently protective, or which would have significant waste streams that would require additional management.

Each technology or strategy is described further in the sections that follow. **Table C1** also lists the technologies and strategies identified for this screening step, as well as whether each was retained for more detailed evaluation. Where available and/or feasible, cost information, references, and project examples are listed for each technology or strategy. For technologies that have not been widely studied or tested, the amount of information available is more limited. For each technology or strategy that was screened out, the criterion for which it did not meet is identified.

2 Containment Technologies/Strategies

Four technologies and strategies that focus on containment and isolation of contaminated materials were identified for consideration. Each is described and evaluated in this section.

2.1 Passive Landfill

Placement of contaminated material in landfills is a common practice. Typically, hazardous waste must be in a secure landfill that is appropriately designed, constructed, and permitted. Such landfills are designed to hold contaminated materials over the life of the landfill, without allowing contamination to escape. The landfills are capped to minimize surface water infiltration, underlain with collection systems to allow appropriate management of leachate, and contained within layers of low-permeability clay, geosynthetic clay liner (GCL), polyethylene liners, and vegetative covers. Contaminated material remains in the landfill for the life of the landfill, during which institutional controls (ICs) and operation and maintenance (O&M) activities are required to inspect and maintain the landfill, and manage leachate and vegetative covers.

This is a mature and well-understood strategy/technology, has been used for dioxin-containing materials in full-scale applications in the past (including the Z1 Landfill at Bien Hoa and the landfill at Phu Cat in Vietnam). It was the originally proposed alternative at the Danang Airport remediation project prior to implementation of In-Pile Thermal Desorption (IPTD®)(USAID 2010). It is expected to be cost competitive with other containment technologies. It is expected to be acceptable to GVN. It was therefore retained for use in developing remedial alternatives.

2.2 Active Landfill

For the purposes of this evaluation, it is assumed that an Active Landfill would be constructed nearly the same as a standard (passive) landfill, with all the containment benefits provided by a typical landfill, but would also facilitate in-place biological degradation of the dioxin, thus reducing the long term risk. The containment provided within the landfill is advantageous, given biological treatment of dioxin is expected to be relatively slow. This technology has been closely evaluated in the past. An Active Landfill alternative was developed and evaluated as part of the Danang EA, despite concerns regarding unknown effectiveness (USAID 2010).

As summarized in the EA prepared for the Danang Airport remediation project, and as described in more detail in Field and Sierra-Alvarez (2008), dioxin bioremediation studies thus far have been confined to lab-scale experiments, which have shown mixed results. No studies available at the time of the Danang EA had demonstrated bioremediation of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) to below 1,000 parts per trillion (ppt) in soil and 150 ppt in sediment. In addition, neither the BEM (2007) report nor the United Nations Development Programme (UNDP) (2009b) report identified any documented studies in which biodegradation was shown to treat dioxins below GVN cleanup standards. The United States Environmental Protection Agency's (USEPA's) Technology Innovation Program website (USEPA 2015a) still notes:

> "Bioremediation is regarded as an attractive possibility for cleaning up dioxin-contaminated soil, but its real applicability and effectiveness is unknown. The following technical obstacles continue to limit the application of bioremediation: 1) only very specialized biological systems can be effective against the high toxicity, low volubility, and high absorptivity of dioxin; 2) a very stringent cleanup standard must be met; and 3) it may be difficult to find a microorganism that can effectively deactivate dioxins under the different conditions present at existing dioxin contaminated sites."

However, as part of the effort to develop the list of potential technologies and strategies that could be applied in an active landfill, a search of scientific literature was conducted to gather any new information regarding dioxin bioremediation. Studies described in the literature indicate progress, but still no successful bioremediation of 2,3,7,8-TCDD beyond the lab scale or over the range of concentrations required at the Airbase. For example, Chen and Wu (2013) reported biodegradation of near-fully and fully chlorinated dibenzo-p-dioxins and dibenzofurans, but observed stall at less-chlorinated congeners (e.g. TCDD).

Vietnamese scientists working at the Institute of Biotechnology (IBT) within the Vietnamese Academy of Science and Technology (VAST) have continued potentially promising lab-scale experiments, including metagenomics and metatranscriptomics to improve understanding of potential microbial populations and degradation mechanisms, and pilot scale testing at the existing Z1 Landfill. However, the amount of information available during development of this EA was not sufficient to address concerns regarding technology maturity and cost, and to our knowledge, no information has been published in a peer-reviewed journal. Significant questions remain regarding the Z1 Landfill pilot test, including the methods and materials used and how they could be implemented full-scale, the soil sampling methodology, the degradation mechanism, and the cost. Without this information, it is not possible to develop and then evaluate bioremediation as a complete stand-alone alternative.

As a result, the landfills presented and evaluated in this EA focus on passive technology. However, if there are advances in the bioremediation technology and the issues described above regarding demonstration of this technology are addressed, it would be possible to convert the passive landfill into an active landfill in the future. Therefore, this technology is retained for further consideration, but only as a potential add-on to passive landfills, and not for development as a stand-alone alternative. If the decision was made to convert to an active landfill, it would be necessary to consider additional factors such as bulking agents and volumetric expansion, conveyance piping for liquid injection, aeration, and/or vapor recovery, and access for interim soil sampling.

2.3 Capping-in-Place

This strategy includes construction of a durable physical isolation barrier over existing contaminated soils and/or sediments, thus preventing any further transport of contaminants to environmental receptors. This technology is used in the U.S. to prevent exposure to contaminated soils and sediments when other remedial options are not advantageous for implementability or cost reasons (ITRC 2003 and ITRC 2010). Caps can be constructed of materials like asphalt or concrete, the same materials used on top of a passive landfill, or clean sands and gravels and specialized engineered materials used for capping contaminated sediment in waterbodies. Soil caps are typically designed to shed water away from the contained material to prevent water from travelling through the material, and thus to prevent transport of contamination away from the cap via leachate. Sediment caps are designed to isolate and stabilize the material, thus preventing erosion and transport and contact with burrowing organisms. However, even more so than landfills, caps can require significant ICs to prevent damage, and ongoing O&M to maintain the landfill and prevent exposure. Capping is a mature technology, and expected to be cost effective versus other containment options. However, given the expected level of ongoing ICs and O&M required to maintain long-term protectiveness, it was indicated by GVN stakeholders that this technology will not be acceptable. This option was therefore not retained.

2.4 Solidification/Stabilization

Solidification/stabilization (S/S) is the process by which contaminated material is mixed with solidification and stabilization agents (cement, lime, fly ash, additives, and/or proprietary organophilic clays) to reduce leachability, erosion, and other contamination transport mechanisms. S/S is a common remedial technology in the U.S. to address very many sites with heavy metal contamination (USEPA 2009), and has also been used to address contamination with chlorinated solvents present as non-aqueous phase liquids (NAPL) (ITRC 2011). S/S has also been used to address dioxin contamination at the Selma Pressure Treating site in Selma, California, and the Standard Steel and Metal Salvage Yard site in Anchorage, Alaska. Given variability between sites, S/S typically requires treatability study testing to determine appropriate mix designs, optimal mixing strategies (e.g. pug mill, large-diameter auger, or rototilling), confirm appropriate stabilization and/or solidification of the material, and assess longer-term permanence, but is a mature technology. It is expected to be cost competitive with other containment approaches, and acceptable to GVN. This option was therefore retained.

3 Treatment Technologies

The following technologies or groups of technologies focus on destruction of dioxin in contaminated materials. Each is described and evaluated below.

3.1 Incineration

Incineration (oxidation) of dioxin-contaminated material is one of the most commonly used technologies (USEPA 2010) if not the most common (BEM 2007), having been applied from soils at more than 150 superfund sites. Detailed information for 22 of these projects are listed on EPA's Federal Remediation Technologies Roundtable website (USEPA 2015b). This technology uses high temperatures (870 to 1,200 degrees Celsius [°C]) to volatilize dioxin from contaminated soil and sediment, and then oxidize it in the gaseous phase (Mudhoo 2013). The incineration process uses a large quantity of fuel to generate the heat necessary to burn contaminated soil and sediment, and requires a complex treatment train that generates waste streams, but is able to treat very contaminated materials. Several incinerator types can successfully been used to destroy dioxin (BEM 2007), though rotary kiln incinerators have been most frequently utilized in the U.S. to remediate dioxin-contaminated soils at the Times Beach, Baird and McGuire, and Vertac Chemical sites (USEPA 1998a, USEPA 1998b, and 1998c). The Destruction efficiency (DE) for incinerators can be as high as 99.9999% for rotary kiln incinerators. Although the cost for treating soils via incineration is generally high, this is a mature technology and may be cost effective. It is expected to be acceptable to GVN and is therefore retained.

3.2 Thermal Desorption and Thermal Conductive Heating

Several technologies use thermal energy to volatilize and desorb dioxins from contaminated materials, and in some cases, induce chemical reactions that degrade dioxin. Some of these technologies could be used for complete treatment of contaminated soils and sediments, and some are only appropriate for pretreatment, wherein contamination is transferred to a different phase or media. During the screen process, all types of thermal technologies were evaluated.

3.2.1 Thermal Desorption for Pretreatment

Thermal desorption pretreatment involves the use of heat to volatilize and extract dioxins that are tightly bound to contaminated soils. Examples include the Matrix Constituent Separator (MCS) process used at Johnston Atoll and piloted at the Airbase (Cooke 2015), as well as other forms of thermal desorption used as part of other technologies described below: Plasma Arc and Pyrolysis processes, Base Catalyzed Desorption, Gas-Phase Chemical Reduction, and Copper-Mediated Destruction. As a pretreatment step, it is somewhat costly given the energy involved, but still widely applied given its performance.

MCS is an *ex situ* process that involves application of infrared heat to contaminated soils, followed by subsequent recovery of targeted chemical constituents, based on the principles of convection, conduction, radiant heating, air stripping, and vacuum extraction. As noted by Cooke (2015), the technology does not destroy or degrade dioxin, but does effectively desorb it from soils and sediments for further treatment in liquid and off-gas streams. During the pilot testing at the Airbase, it was demonstrated to be mature, having effectively reduced dioxin concentrations from above 15,000 ppt to below 2 ppt. Definitive cost data is not available, but may be below $500 per tonne, based on speculation by the vendor (Cooke 2015). Therefore, it is not known if it will be cost effective. Because it does not destroy dioxin, it was not selected for use in developing an alternative. However, it may still remain useful for pretreatment prior to incineration or some other off-gas treatment technology (e.g. thermal oxidizer and/or vapor-phase granular activated carbon [GAC]), or as a pretreatment step to one of the treatment methods listed herein that are limited to the aqueous phase. It could also be used to reduce volumes required in a containment-only alternative by transferring all the mass to a solid adsorbent like GAC. Condensate generated would require treatment also, likely with a process similar to the one described for *ex situ* TCH in **Section 4.4.6.1** above. Regardless, this technology may merit additional evaluation, even if it cannot be used as a standalone treatment technology.

3.2.2 *In Situ* Thermal Conductive Heating

As a destruction technology, or as removal step in combination with appropriate off-gas control technology, thermal treatment can also be successful. Thermal conductive heating (TCH) is one method to heat contaminated soils, and can be used to treat contamination both *in situ* and *ex situ*.

In situ thermal treatment via TCH is a very mature remediation technology, and has been commonly used in the U.S. (USEPA 2010). *In situ* TCH is most appropriate and feasible at sites where heat losses can be controlled or overcome with reasonable energy input into the subsurface. According to the vendor who implemented this technology for the Danang Airport remediation project and who also holds the U.S. patent for use of this technology, any soil thickness less than approximately 10 feet (approximately 3 meter [m]) would incur excessive heat losses. Heating over larger areas increases surface area for heat loss in both vertical directions. Also, it is critical to have a groundwater table that is not too shallow, or too close to the bottom of the contaminated volume targeted for heating and treatment. A groundwater table elevation of at least 5 feet, and preferably 10 feet, below the bottom of the material targeted for treatment is critical to avoid excessive conductive heat losses caused by wet soils.

After evaluation of the spatial extent of contamination and comparison against these requirements, it is clear that the Airbase does not meet these requirements. This is because contamination is present over wide areas but much smaller depth intervals, and so *in situ* heating would be very inefficient. Heat loss through the top of the volume being treated would could be minimized through the use of insulation, but only soil would be present on the underside of the volume being treated. Only one DU, PI-2, has dioxin contaminations in soils with a thickness approaching 10 feet (from 0 to 270 cm, or approximately 9 feet). These dimensions greatly increase the amount of surface area where heat loss would occur. For example, at PI-2, if the total amount of estimated contaminated soil, which is approximately 105,000 m^3, was treated in two *ex situ* TCH piles with similar proportions to the *ex situ* TCH piles used at Danang, it would have approximately two and half times less surface area than if the DU was treated *in situ*, in two phases. Additionally, groundwater is present at PI-2 at less than 15 feet (4.5 m) below ground surface, or less than 6 feet below the bottom of contamination. Given the small thickness, the larger surface area, and the proximity of groundwater to contamination, heat losses at the PI-2 would likely be excessive. Heat losses in other DUs with even less favorable conditions and geometries would certainly be even greater.

In addition to concerns regarding excessive heat loss, a very large protective layer to protect workers from heat and the heated soil from moisture and cooling would also be necessary. Other aspects of TCH are not conducive to large areas: off-gas treatment infrastructure and conveyance and electrical power would also need to be distributed over the entire area of each DU treated. Installation of vertical TCH infrastructure to necessary depths would be challenging in areas like PI-02, based on experience derived during the 2014/2015 sampling efforts.

Therefore, it is expected that the losses in efficiency and resulting costs would greatly increase. The amount of cost increase is difficult to quantify given it is not clear how the implementation challenges described above could overcome for most of the site, but it is expected that they would exceed the costs associated with excavation and hauling of the material to central treatment locations for *ex situ* TCH. For the same reasons, it is difficult to determine how fast remediation could proceed. While *in situ* TCH has been applied over very large areas in the past, it is not expected that any past *in situ* TCH application has ever had treatment dimensions similar to what would be necessary at the Airbase (i.e., very thin vertical interval at the surface). Therefore, *in situ* TCH was not retained, on the basis of both cost competitiveness and technology maturity.

3.2.2 *Ex Situ* Thermal Conductive Heating

Ex situ treatment was also evaluated. One example of successful use of *ex situ* TCH is the In Pile Thermal Desorption (IPTD®) system used at the Danang Airport remediation project (USAID 2015a and USAID 2015b), where soils were placed in an insulated and capped pile, and heated. This is the first full-scale implementation of *ex situ* TCH to address dioxin contamination. In these systems, dioxin mass is volatilized and extracted, or degraded in the pile via a combination of oxidation (if sufficient oxygen is present) or pyrolysis. Any extracted dioxin mass can then be removed from off-gas, condensate, and leachate by more conventional treatment technologies. This technology is mature and is expected to be cost effective, and was therefore retained.

3.3 Plasma Arc and Pyrolysis

This technology creates a thermal plasma field by applying a large electric current through an oxygen-deficient gas. The resistivity of the gas results in an increased temperature (3,000°C or higher). Depending on the type of system and the temperature reached, this technology can be used to pyrolyze waste material, producing a slag and gaseous end products, or at higher temperatures, to cause molecular dissociation that produces argon, carbon dioxide and water vapor and an aqueous solution of inorganic sodium salts (including sodium chloride, sodium bicarbonate and sodium fluoride) (UNDP 2009b). Although performance dioxin destruction data are not well reported, very high efficacy has been reported for many other persistent organic pollutants (POPs), and it is expected that dioxin removal would be similar (UNDP 2009b and BEM 2007). At least three versions of this technology and nine fixed-location commercial plants have been constructed (four in Japan, four in Australia, and one in the United Kingdom) (USEPA 2010). These technologies are mature and established. However, it is expected that these technologies would likely be expensive for full-scale treatment, based on proposals provided by one vendor who estimated costs for treatment of granular activated carbon (GAC) and non-aqueous phase liquids (NAPL) waste streams from the Danang Airport remediation project that indicated pilot scale costs could be approximately $4,000 per metric ton, including electrical power. This technology was therefore not retained for cost competitiveness reasons. It is expected that complete degradation of dioxin can be achieved at lower temperatures and at cheaper cost. For more concentrated wastes or contaminated treatment residuals, this technology may still be appropriate.

3.4 Mechano-Chemical Destruction (Ball Milling)

Mechano-Chemical Destruction (MCD), or ball milling technology, is a potentially chemical-free technology that employs mechanical energy to initiate chemical reactions. Soil crystal damage caused by the vibration leads to the formation of highly reactive free radicals, which react with organic molecules in the vicinity (including any organic contaminants) (UNDP 2009b and USEPA 2010). MCD treatment of a variety of recalcitrant compounds including pesticides, herbicides, polycyclic aromatic hydrocarbons, and dioxins has been demonstrated under both laboratory-scale and, to a limited extent, field-scale settings with minimal pre-treatment except for the drying of the contaminated materials. For example, MCD pilot studies were successfully performed for treatment of polychlorinated biphenyls, dichlorodiphenyltrichloroethane, and polyhalogenated pollutants in Norway and Germany in the later 1990's and early 2000's (Vijgen 2002a). In addition, this technology was employed to treat soil and sediment heavily contaminated with persistent organic compounds at the Fruitgrowers Chemical Company Site in Mapua, New Zealand with promising results (Parliamentary Commissioner for the Environment 2008).

The internationally patented MCD reactors consist of special hard-wearing cast rotors that make continuous contact with thousands of stainless steel balls to create continuous and repetitive particle collisions. A 2012 study demonstrating MCD technology utilizing several reactors in series was performed by UNDP (Cooke 2015) using soil from the Airbase using contaminated materials. Results from this technology demonstration indicated that treatment performance is sensitive to in-feed soil dioxin concentrations and that the claimed DE of 99.99% was not always satisfactorily met. However, system performance optimization is possible (Cooke 2015). The technology is expected to be potentially cost competitive and acceptable to GVN. It was therefore retained.

3.5 Base Catalyzed Desorption

Base-catalyzed desorption is a dechlorination process wherein dioxin is desorbed from contaminated soil and dewatered sediments using heat (approximately 326 to 500°C) and sodium bicarbonate. The resulting contaminated condensate, sodium hydroxide, a hydrocarbon (e.g. polyethylene glycol or a carrier oil), and other proprietary reagents are mixed, generating atomic hydrogen. The atomic hydrogen reacts with and displaces chlorine from organic compounds such as dioxin (BEM 2007 and Chen 1997). Pretreatment is required (maximum particle size is 50 mm), but has high DEs (99.99% or greater have been reported) (UNDP 2009b). This treatment technology is commercially licensed and mature. It is understood that this technology was successfully pilot tested for treatment of PCBs and pesticides at Warren County Landfill, North Carolina, and FCX Superfund Site, also in North Carolina, respectively (USEPA 2010). It has been used at two commercial plants in Australia, one in Mexico, and at short term projects in Australia, Spain, the U.S., and the Czech Republic, where full-scale treatment for polychlorinated dibenzo-p-dioxin (PCDD)/polychlorinated dibenzofuran (PCDF) contamination has been successful (Vijgen 2009a). However, the large quantity of waste associated with excess alkali and carbon would require management (landfilling, recycling, and/or reuse), which would increase costs beyond those reported by others. Most importantly, this technology was not acceptable to GVN during discussions conducted as part of the development of the EA for the Danang Airport remediation project, and is therefore not expected to acceptable here. This technology was therefore not retained.

3.6 Supercritical and Subcritical Water Treatment

Water in a supercritical state (above 374°C and 22 megapascals) can be used to facilitate oxidation of organics, and subcritical water (pressurized into a liquid above 100°C) can be used to extract dioxin from soils and sediments. For supercritical water, all particles must be smaller than 200 micron in size, and less than 20 percent organics. Supercritical water oxidation is capable of high throughput, and is a mature technology with commercial scale operations in Japan (UNDP 2009b), under U.S. Department of Defense (DOD) programs to destroy chemical weapons, and by other U.S.-based vendors (USEPA 2010). However, it requires high plant complexity and significant reagent quantities (oxygen or hydrogen peroxide). Subcritical water extraction has also been demonstrated (99.4% extraction at 350°C in 30 minutes [Hashimoto 2004]), and has been paired with reductive dechlorination with zero valent iron (ZVI) to achieve treatment (Kluyev 2002). However, both of these processes must be performed in the aqueous phase, which means all soil and sediment would have to be mixed with very large quantities of water to dissolve or suspend all solids requiring treatment. Additionally, the limits on organic loading mean that throughput into the treatment process would be slowed. Both supercritical and subcritical processes would require this significant pre-treatment step. Following treatment, the soils and sediments would have to be dewatered and dried, which would introduce significant effort and cost. For supercritical water treatment, limited information is available regarding waste streams and post-treatment requirements. Specific costs were not identified, but the amount of pre- and post-processing required to conduct this extraction and treatment in a liquid for this quantity of contaminated material would be very significant. All the soils and sediment would have to be fluidized to meet the requirements described above, and then dewatered prior to backfill or reuse. Water could likely be recycled to some extent, but would also likely require treatment to remove all residual soil particles. Therefore this technology was not retained because of high expected costs relative to other treatment technologies.

3.7 Vitrification

Vitrification uses large quantities of electric current to convert contaminated soil and sediment into a vitreous and crystalline material. During this process, materials are heated above 1,590°C, which degrades organic contaminants via pyrolysis and dechlorination reactions, or locks them into a matrix with no leachability (Mudhoo 2013, UNDP 2009b, BEM 2007, USEPA 2010). The process can be performed *in situ* or *ex situ*, although it is likely that only *ex situ* treatment would be appropriate for the

Airbase given the shallow soil depths and large areas, for the same reasons *in situ* TCH would be challenging. The technology is relatively mature, having been licensed in the U.S. and Australia (UNDP 2009b) and applied in the U.S. (often at U.S. Department of Energy sites to immobilize radioactive materials), Australia, and Japan (Vijgen 2002b and USEPA 2015c). However, during the development of the Danang Airport EA, no full-scale dioxin remediation projects were identified and no similar recent work has been identified since. Additionally, there have been instances in the past where vitrification has not been successful (UNDP 2009a). UNDP (2009b) reports that the technology has been developed as an *ex situ* system with 90 tons per day throughput, but that it remains very expensive due to energy requirements, estimated at approximately $700 per cubic meter (BEM 2007). It is expected that degradation of the dioxin can likely be achieved at lower temperatures (e.g. with incineration or *ex situ* TCH), and therefore lower expected costs. This process option was therefore not retained because of cost competitiveness with other treatment technologies.

3.8 Soil Washing/Liquefied Gas Extraction

Soil Washing and Liquefied Gas Extraction both work to separate contamination from the bulk soil matrix. Some versions of this technology works by segregating smaller diameter particles with higher organic fractions (e.g., silts and clays), which are more likely to contain dioxins and other organic contaminants, from larger particles with lesser organic fractions (e.g., sands and gravels). Other variations of this technology use the addition of a solvents such as ethanol to extract of dioxin from contaminated soil and sediments for separate treatment (CL:AIRE 2007 and Mudhoo 2013). Liquid solvents such as ethanol can be difficult to recycle from treated soil (Jonsson 2010). Liquefied gas extraction facilitates solvent removal from the soil after processing, as the treatment is done under pressure to liquefy the solvent temporarily, and is also more efficient (Saldana 2005). This technology has been demonstrated in the past and applied at multiple sites in several countries (CL:AIRE 2007 and USEPA 2015c). Specific information for 16 projects is listed on EPA's Federal Remediation Technologies Roundtable website (USEPA 2015c). However, the effectiveness of this technology is sensitive to solvent concentration and soil characteristics. Therefore, the process is not as effective with sediments and soils with high fractions of silts and clays, given the higher organic content (BEM 2007). It also requires treatment of wastewater generated before, during, and after the separation processes. Reported costs are approximately $125 per m^3 (BEM 2007). Given the high occurrence of silts and clays at the Airbase (Section 5.1.3 of the EA), it is not expected that this technology will be effective at the Airbase. Additionally, no full-scale applications of this technology are known to have addressed dioxins at concentrations similar to those at the Airbase. Therefore, this technology was not retained for use as a treatment technology in development of alternatives.

However, this technology may be useful to the project to minimize volumes requiring treatment or containment. Shimizu Corp offers a similar soil-washing and separation technology, which uses various separation techniques (screening, hydrocyclone, surfactants, flotation, flocculation, and GAC adsorption) to concentrate the dioxin into smaller volumes. Per documentation provided by Shimizu, their technology is similarly limited by soil type, and the technology is "relatively ineffective" if more than 40 to 50% of the soil has a diameter of less than 63 micrometers. Nine samples of approximately 12 kilogram (kg) of contaminated material from the Airbase was provided to Shimizu for testing. Preliminary performance data from this testing has been provided verbally. Eight of the samples were analyzed, and six were found to have a good range of concentrations (approximately 6,000 ppt to 80,000 ppt). Of these six samples, all had a strong correlation between low particle size and high dioxin concentrations; however one sample also had an additional larger particle size fraction with elevated dioxin concentrations. After the soil washing testing was completed, the separated soils with particles larger than 63 micrometers had at least 90% less dioxin, and approximately half had concentrations less than 1,000 ppt. These preliminary results indicate some significant promise for cost effective volume reduction, and some additional optimization is likely possible. However, some additional questions remain:

- The amount of potential volume reduction has not yet been quantified.
- It is not yet known what would be the maximum initial concentration that could be reduced to below 1,000 ppt (or whatever dioxin limit was more appropriate). It is likely that soil heterogeneity (as evidenced by the single sample that did not fully demonstrate the same correlation between particle size and dioxin concentration as the other five samples) would influence this technology significantly, and therefore may require greater post-implementation sampling to verify effectiveness compared to other technologies.
- The mass balance has not yet been finalized. Given this technology is non-destructive, it is necessary to confirm how dioxin mass moves through the system, so that waste streams can be managed appropriately. The washed dioxin mass (likely suspended solids in the washwater) would likely require dewatering before containment/treatment via some other technology, and the water would require treatment before discharge (or if possible, reuse in the process). It would be necessary to understand the extent of water treatment and solids dewatering that would need to occur, to confirm cost competitiveness (similar to other technologies in this Appendix that operate in the aqueous phase).

If it is successful at minimizing the amount of material with dioxin contamination in a cost competitive manner, it would be appropriate to evaluate the overall cost effectiveness of combining this technology with other treatment technologies that were capable of treating the resulting higher concentration of dioxin. The conceptual costs provided by Shimizu indicate a rough cost of approximately $160 per metric ton but it is not known if these costs include all necessary steps prior to the containment/treatment of the contaminated residuals via another technology.

3.9 Gas-Phase Chemical Reduction

This technology mixes hydrogen gas with chlorinated organic compounds, such as PCBs, at temperatures above 850°C and low pressure. This yields primarily methane and hydrogen chloride and minor amounts of other low molecular-weight hydrocarbons, including benzene (UNDP 2009b). This process has demonstrated effectiveness, with 99.9999% dioxin treatment reported (UNDP 2009b). The technology is mature, having been licensed and used for pilot-scale or full-scale work in several countries to treat PCBs, pesticides, and dioxins/furans (UNDP 2009b and USEPA 2010). It is understood that this has been applied to treat 1,000 tonnes of dioxin-contaminated waste at the General Motors of Canada Limited site in Canada, with a DE of >99.9995% (USEPA 2010). Other examples are previous use of this technology are also available (Vijgen 2009c). However, the plant has high reagent needs, low throughput, and high degree of complexity. Vijgen (2009b) estimated costs to treat chlorinated pesticides at $1,317 (for utilities, based on 2004 U.S. utility costs) and $222 (for labor) per tonne, or approximately $1,539 per tonne, or $1,026 per m^3 (assuming 1.5 tonnes per m^3), exclusive of the Contractor's overhead and profit, and capital and decommissioning costs. It is therefore not expected to be cost competitive with other options, and was not retained.

3.10 *In Situ* Bioremediation

In situ bioremediation relies on the same concepts as the Active Landfill described above, but the soil and sediment undergoing *in situ* treatment is not contained within a landfill. As such, the concerns described above for Active Landfills and by Field and Sierra-Alvarez (2008) are magnified, given the reduced degree of control over the *in situ* chemical and hydrogeological conditions. Given bioremediation is expected to be a slow process (UNDP 2009a), even if it was well demonstrated, this technology would present an additional degree of short-term exposure risk while dioxin was being degraded. Regardless, as described above, this potentially-promising technology has not been well demonstrated to be mature to treat existing concentrations at the Airbase to below MND-approved dioxin limits on any scale, and therefore it was not retained.

3.11 *Ex Situ* Chemical Reduction / Oxidation

This technology uses chemical oxidants or reductants to degrade organics such dioxin. Oxidation and reduction refer to a very broad range of chemical processes, and are therefore included implicitly, or has overlap, in several of the technologies listed herein. Therefore, this particular technology refers to any other chemical oxidation or reduction processes not described elsewhere, especially those oxidants and reductants used more typically for remediation. Oxidants added typically in remediation processes include potassium permanganate, persulfate, hydrogen peroxide (i.e. Fenton's reagent), and ozone (BEM 2007). A DE of 80% has been reported by Fenton's reagent for PCDD/Fs (Mariñosa 2007). The most common reductant mentioned in recent literature for dioxin treatment appeared to be ZVI. With the exception of ozone, most of these additives are added in a solution or slurry, and therefore processes must occur in the aqueous phase. This complicates soil and sediment treatment given the amount of pre- and post-processing that would be required. Furthermore, all oxidants are not compound-specific, and therefore in soils with high organic material (like silts and clays), reagent/additive costs would increase significantly as multiple applications, high dosages, and/or heavy mixing may be needed. This technology has also not been well demonstrated for full-scale use, and costs are expected to be high based on treatment of other compounds (BEM 2007). This technology was not retained for these reasons.

3.12 Advanced Oxidation

Advanced oxidation is an aqueous-phase treatment technology that is frequently used in the U.S. and elsewhere, and is similar to the chemical processes described in the previous section. Various oxidation techniques utilizing ultraviolet (UV) light, photolytic catalysts such as TiO_2, and/or varying oxidants (e.g. peroxide, ozone) can be used to oxidize aqueous-phase organic compounds, including dioxin (Mudhoo 2013). Complete degradation of 2-chlorordibenzo-p-dioxin and 2,7-dichlorodibenzo-p-dioxin have been demonstrated (Pelizetti 1998), but care is required to avoid creation of new PCDD/PCDF compounds depending on the concentrations of precursors and chloride (Vallejo 2015). This process is mature and demonstrated, but only for aqueous waste streams. Mixing significant quantities of soil into a water stream for treatment would reduce UV transmission (via turbidity and high suspended solids concentrations) and/or scavenge radicals (via high concentrations of dissolved or suspended organics), thus increasing the quantity of reagent required, the energy input required, and the residence time required (USEPA 2015d). The requirement that treatment be done in the aqueous phase would also require significant pre- and post-processing of soil, and further increase expected energy requirements, similar to technologies like Supercritical and Subcritical Water Treatment, described above in **Section**

3.6. Therefore, this technology was not retained because of low demonstrated maturity in addressing full-scale dioxin contamination in soil, and expected high cost.

3.13 Biological / Chemical Hybrids

Combined biological-chemical technologies have also been recently explored. Potential for degradation of 2,3,7,8-TCDD had been previously reported in lab-scale aqueous-phase slurry reactors (Kao 2000), where partial oxidation was followed by bioremediation. Bokare et al (2012) reported complete dechlorination of 2,3,7,8-TCDD to dibenzo-p-dioxin using a combination abiotic and biotic mechanisms: palladized iron nanoparticles (for initial reductive dechlorination) and subsequent oxidative biomineralization by *Sphingomonas wittichii RW1*. Although this is promising, it was performed in an ideal aqueous-phase lab-scale environment, and further investigation would be necessary before full-scale effectiveness, implementability, cost, and environmental impact could be evaluated.

Some related testing was performed at the Airbase under the UNDP project by HPC-Envirotec (Cooke 2015). Of five tests performed with biological-chemical hybrid treatment, only one demonstrated greater than 90% reduction, and it required multiple persulfate additions over a period of 6 months. The reduction-based tests were less successful. The final report indicated that the technology did not achieve the performance requirements. It therefore was not retained for further evaluation because of low demonstrated maturity in addressing full-scale dioxin contamination in soils.

3.14 Solvated Electron Technology

With this technology, a solvate electron solution is generated via dissolution of alkali or alkaline earth metals in anhydrous ammonia at room temperature and elevated pressure. The solvated electron solution is then placed in a cell with soil or sediment where it acts as a dehalogenating agent, degrading contaminants into metal salts and simple hydrocarbon compounds (Mudhoo 2013 and UNDP 2009b). The ammonia can be reused, but there is a treatment residue that requires disposal. High efficacy has been reported for some dioxins, but not for materials with high dioxin concentrations (UNDP 2009b). Throughput is small but scalable, but dioxin treatment has not been demonstrated on a large scale. Although the treated soil is primed for agriculture with high nitrogen concentrations from the ammonia bath (Mudhoo 2013), there also exist some significant concerns with H&S, given the anhydrous ammonia usage. This technology has been licensed by USEPA to treat PCBs (Vijgen 2002c), and reported throughputs are low (10 tonnes/day) (UNDP 2009b). No cost data was identified but given the limited throughput, costs would be expected to be relatively high. Given these concerns regarding cost and technology maturity in addressing full-scale dioxin contamination in soils and sediments, this technology was not retained.

3.15 Copper-Mediated Destruction

This technology is similar to Base Catalyzed Destruction, but instead of sodium hydroxide, copper is used to catalyze treatment of dioxin-contaminated solutions via hydrogenation and dechlorination. The process is preceded by thermal desorption at approximately 250°C over 2-4 hours. While claims have been made regarding high efficacy, previous assessments have not been able to identify evidence that the technology has been well proven at scale (UNDP 2009a and UNDP 2009b), and very little information was found regarding this technology. This technology was therefore not retained due to concerns regarding maturity in addressing full-scale dioxin contamination in soils and sediments.

3.16 *In Situ* Photolysis

This technology uses low-toxicity organic solvent (e.g. isooctane, hexane, cyclohexane), which is sprayed on the soils and sediments to facilitate movement of dioxin, similar to the soil washing technologies described above. As the solvent is allowed to volatilize, dioxin molecules are migrated upwards, where they can be photodegraded by ultraviolet rays from the sun (Kulkarni 2008, Balmer 2000, Goemans 2004, and Dougherty 1993). However, as described by Mudhoo (2013), given the process is limited by the convective transport to the surface, the process is limited with regard to the depth of treatment. Direct photolysis has been observed no deeper than 0.4 millimeters, as such facilitated dioxin transport to the surface by solvents is critical (Mudhoo 2013). Full-scale application would require spreading soils over large areas, and solvents over these large areas. As Mudhoo reports, significant effort has been undertaken to study this, but no large-scale tests or applications of this technology have been identified. Given the quantities of soil and sediment involved, this technology was determined to be insufficiently mature in addressing full-scale dioxin contamination in soils and sediments, and was not retained.

3.17 Steam Distillation

As reported by Kulkarni (2008), this technology utilizes microwave-based heating to reach temperatures under 100 degrees Celsius to generate steam and remove of organics from soils. Mino (2001) found that steam distillation was capable of removing 95% of 250 micrograms of 2,7-dichlorodibenzo-p-dioxin (DCDD) from 50 grams of soil. Very little information was found regarding this technology. It is not believed that this technology has been applied in any full-scale setting, and therefore it was not retained.

3.18 Radiolytic Degradation

This technology relies on high energy electron beams and gamma rays to ionize soil, using surfactants and water. The ionizing energy was able to achieve 92% reduction of 100 parts per billion of 2,3,7,8-TCDD likely via reductive dechlorination. While it is expected that such high energy reactions would be capable of degrading dioxin, results from application of other less energy-intensive approaches have demonstrated success. It is not believed that this technology has been applied in a full-scale setting, and very little information was found regarding this technology. Even if likely safety issues were addressed, it is expected to be very expensive, and therefore it was not retained because of high expected cost and concerns regarding maturity in addressing full-scale dioxin contamination.

3.19 Hydrothermal Treatment

This technology has been well demonstrated for treatment of fly ash and involves dissolution of contaminated material in sodium hydroxide and methanol solution at 300 degrees Celsius for 20 minutes. Reductions of 1,110 ng/g of total dioxins to 0.45 ng/g have been reported (Kulkarni 2008 and Ma 1997). However, this technology has not been applied full-scale to dioxin soil contamination, and very little information was found regarding this technology. It is not expected to be cost competitive given the pre- and post-processing necessary to get all the soils and sediment in and out of the aqueous phase (as described in **Section 3.6**). This technology was therefore not retained.

3.20 Non-Thermal Plasma

This technology uses strong electric fields to cause molecular disassociation, at non-elevated temperatures, and induce formation of radicals and degradation of dioxin (USEPA 2005). This process has some advantages over conventional technologies, and has been demonstrated by Zhou (2003) to achieve up to 81% degradation of 2,3,7,8-TCDD in fly ash, and up to 97% of total dioxin was reported removed from the flue gas of a Japanese incinerator (Oda 2006). USEPA (2005) notes that some construction has occurred to install non-thermal plasma in off-gas treatment system for other contaminants. However, it is not believed that this technology has been demonstrated to treat soils in a full-scale setting, and very little information was found regarding this technology. Therefore, it was not retained because of concerns regarding maturity in addressing full-scale dioxin contamination in soils and sediments.

3.21 Phytoremediation

Phytoremediation is the process by which biological plant growth and respiration induces remediation. In this context, phytoremediation would be the biologically induced dioxin removal from and/or degradation in soils and sediments. Per UNDP (2009b), this could even include other related processes such as releases of plant enzymes. Ultimately, this technology has not been demonstrated, and there remain concerns about the ability of plants to enact meaningful degradation at greater depths, concerns about performance in areas with high herbicide concentrations or soils with high concentrations, and several other concerns (UNDP 2009a, UNDP 2009b, BEM 2007, and USEPA 2010). The cost for this type of treatment would likely be low, but it would either be necessary to prove that dioxin was destroyed and not incorporated into the plant, or manage the waste stream of plant biota carefully to avoid release back into the environment. It is understood that a small pilot test is currently underway using Vetiver grass to remediate soils at the Airbase, but no performance data are available yet. Therefore, the technology was not retained because of concerns regarding maturity in addressing full-scale dioxin contamination in soils and sediments.

3.22 Mycoremediation

This technology is similar to phytoremediation, but relies on fungal growth instead of plant growth. Past reports indicate this technology's potential applicability is currently limited to low-concentration wastes only given destruction removal efficiencies of 50%, and it has a slow reaction rate (BEM 2007). Continuous monitoring is also required to verify fungal activity has not dropped and replacement of cultured fungi is not needed. Some limited pilot scale work has been done, but reactions are slow and costs may be high (approximately $\$250/m^3$) compared to other more effective and proven technologies (UNDP 2009a, UNDP 2009b, BEM 2007). Therefore, the technology was not retained because of high expected cost and concerns regarding maturity in addressing full-scale dioxin contamination from concentrations observed on the Airbase to below the MND-approved dioxin limits required.

4 Retained Technologies

The following technologies and strategies were retained for the Bien Hoa EA:

- **Landfills:** This commonly used containment strategy achieves containment of contaminated soil and sediment by isolating it from the surrounding environment using layers of clean fill, polyethylene liners, and low-permeability materials. Landfills were used to isolate contamination in the Z1 Area at the Airbase and at the Phu Cat Airbase.
- **Stabilization/Solidification:** Using this containment technology, contaminated material is mixed with stabilization agents (cement, lime, fly ash, additives, and/or proprietary organophilic clays) to reduce leachability, erosion, and other transport mechanisms.

- **Incineration:** High temperatures (870 to 1,200°C) generated by rotary kiln incinerators are commonly used to volatilize dioxin from contaminated soil and sediment, and then oxidize it in the gaseous phase.
- ***Ex Situ* TCH:** Soil is heated to approximately 300°C in an *ex situ* pile so that dioxin is either oxidized or pyrolyzed in the pile, or volatilized and extracted for further treatment as needed. An example of *ex situ* TCH is IPTD®, which was used at the Danang Airport remediation project.
- **MCD (also known as Ball Milling):** Vibration-induced soil crystal damage generates free radicals, which in turn can dechlorinate dioxin molecules and react with other organics.

Table C2 provides a summary of site characteristics where these technologies have been used in the U.S. and Vietnam.

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Table C1 Technologies Identified and Screening Results

Technology	Description	Screening Result
Containment Technologies		
Passive Landfill	Contaminated materials are placed in a landfill designed to contain hazardous waste.	Retained.
Active Landfill	Contaminated materials are placed in a standard landfill modified to allow bioremediation to occur.	Not retained as a primary technology; technology is not mature (bioremediation is not yet well demonstrated). However, additional testing may be helpful for this potential technology.
Capping	A durable isolation barrier is constructed over the top of contaminated material, and monitored.	Not retained; technology is not acceptable to GVN (because of protectiveness).
Solidification/Stabilization	Contaminated material is mixed with chemical agents to reduce leachability, erosion, and other transport mechanisms.	Retained.
Treatment Technologies		
Incineration	Contaminated materials are oxidized at high temperatures.	Retained.
In situ Thermal Conductive Heating (TCH)	*In situ* soils are heated to drive desorption and *in situ* oxidation/pyrolysis.	Not retained; technology is mature (demonstrated for full-scale remediation) given site geometry to other concerns and expected heat losses, and also not cost competitive.
Ex Situ Thermal Desorption	Soils and sediments are heated to drive desorption and treatment by other steps.	MCS may warrant additional consideration as a pretreatment step.
Ex Situ TCH	Dioxin in contaminated materials is thermally desorbed/oxidized/pyrolyzed in piles or treated in off-gas treatment equipment.	*Ex situ* TCH was retained.
Plasma Arc and Pyrolysis	Thermal plasma field is used to pyrolyze contaminated materials or dissociate into its atomic elements.	Not retained; technology is not expected to be cost competitive (high energy requirements).
Mechano-Chemical Destruction (Ball Milling)	Vibration of soils induces the formation of free radicals, which degrade organics such as dioxin.	Retained.

Technology	Description	Screening Result
Base Catalyzed Desorption	Following thermal desorption of contaminated materials, off-gas condensate is treated using sodium hydroxide and a hydrocarbon to dechlorinate dioxins.	Not retained; technology is not expected to be cost competitive or acceptable to GVN (because of large waste quantities).
Supercritical and Subcritical Water Treatment	Water in a supercritical state is used to oxidize organics, or water in a subcritical state is used to extract dioxins for further treatment.	Not retained; technology is not expected to be cost competitive because of pre-/post-processing requirements and throughput limitations.
Vitrification	Large quantities of electric current are used to convert contaminated materials into a vitreous and crystalline material.	Not retained; technology is not expected to be cost competitive (high energy requirements).
Soil Washing/Liquefied Gas Extraction	Solvent is added to extract dioxins from contaminated materials.	Not retained; technology is not mature (limited effectiveness with clays and silts). Preliminary testing by Shimizu may indicate potential value in combining with other technologies to reduce treatment volumes. Need to confirm dioxin mass balance and necessary post-washing treatment.
Gas-Phase Chemical Reduction	Hydrogen gas is mixed with contaminated materials at high temperatures to destroy dioxins and other organics.	Not retained; technology is not expected to be cost competitive (high reagent needs and low throughput).
In Situ Bioremediation	Liquid-phase amendments and/or specialized cultures are used to degrade dioxins *in situ*.	Not retained; technology is not mature (bioremediation is not yet well demonstrated and is expected to be especially difficult to implement *in situ*).
Ex Situ Chemical Reduction / Oxidation	Chemical reductants or oxidants are used to treat dioxins in contaminated materials.	Not retained; technology is not mature (not demonstrated for full-scale remediation) and is not expected to be cost effective.
Advanced Oxidation	Ultraviolet light, other oxidants, and/or catalysts are used to degrade dioxin and other organics in the aqueous phase.	Not retained; technology is not mature (not demonstrated for full-scale remediation) and is not expected to be cost competitive because of pre-/post-processing required to perform aqueous phase treatment.

Technology	**Description**	**Screening Result**
Biological / Chemical Hybrids	Oxidants and bioremediation are used in a phased manner to treat contaminated materials.	Not retained; technology is not mature (not demonstrated for full-scale remediation) based on pilot testing at the Airbase.
Solvated Electron Technology	Solvated electron solution is used to dehalogenate dioxins and other chlorinated organics.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive (low throughput).
Copper-Mediated Destruction	Following thermal desorption of contaminated materials, off-gas condensate is treated using copper as a catalyst to dechlorinate dioxins.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
In Situ Photolysis	Solvent is used to bring dioxin to the surface of *in situ* soils where it can be photodegraded.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
Steam Distillation	Steam is used to remove organics such as dioxin from soils.	Not retained; technology is not mature (not demonstrated). Very little information is available.
Radiolytic Degradation	High energy electron beams and gamma rays are used to ionize soil and destroy dioxins.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive (high energy requirements).
Hydrothermal Treatment	Contaminated materials are treated using heat and a solution of sodium hydroxide and methanol.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive.
Non-Thermal Plasma	Strong electrical fields are used to generate free radicals, which degrade dioxins and other organics.	Not retained; technology is not mature (not demonstrated for full-scale remediation).
Phytoremediation	Plant growth and activity is used to remove/destroy dioxins from/in soils.	Not retained; technology is not mature (not demonstrated for full-scale remediation). Pilot testing underway at Airbase using Vetiver grass.
Mycoremediation	Fungal growth and activity is used to destroy dioxins in soils.	Not retained; technology is not mature (not demonstrated) and is not expected to be cost competitive (especially compared to other more effective technologies).

Table C2 Characteristics of Selected Dioxin Sites in the United States and Vietnam

Site	Source	Maximum Dioxin Concentration (ppt)	Clean Up Goal	Material	Volume (Tons)	Treatment Technology	Cost (U.S. Dollars)	RI/FS	ROD	Remedial Action End Date
Times Beach (Missouri) (1)	Hexachlorophene production waste oil used for road dust control throughout Missouri	1,800,000	1,000 ppt for surface soils in residential settings; 10 ppt for soils above a depth of 1 foot; 20,000 ppt in commercial and industrial settings	Soil and debris	265,000	On site rotary kiln incineration	110,000,000	1984	1995	1997
Baird and McGuire (Holbrook, Massachusetts) (1)	Land disposal of chemical production wastes	270,000	None (Technology Based)	Soil and sediment	214,000	On site rotary kiln incineration	133,000,000	1986	1986	1996
Vertac (Jackson, Arkansas) (1)	Herbicide production	400,000	1 in a million lifetime risk of cancer for a 70 year exposure	Waste and soil	10,831	On site rotary kiln incineration	31,700,000	1978	1990	1994
Dow Chemical Site: Tittabawasee and Saginaw Rivers (Midland, Michigan) (2)	Chemical production wastewater discharge into surface water	1,600,000	90 ppt	Soil and sediment	83,000	Sediment capping and excavation				
Selma Pressure Treating (Selma, California) (5)	Wood treating	Unknown	1,000 ppt	Soil	10,000 m^3 or more	Stabilization/ Solidification	250 to 430 per m3	1988	1988	2005
Standard Steel and Metal Salvage Yard (Anchorage, Alaska) (6)	Improper chemical and waste recycling/ management	1,700	0.4 ppt (screening value only)	Soil	Unknown	Stabilization/ Solidification	Unknown	1996	1996	2002
Da Nang Airport (Vietnam)	Herbicide use	365,000	1,000 ppt soil 150 ppt sediment	Soil and sediment	145,000 (estimated)	Ex situ TCH	100,000,000			2018 (estimated)
Bien Hoa Airbase (Vietnam) (3)	Herbicide use	5,800,000 (4)	Varies based on land use for soil; 150 ppt sediment	Soil and sediment	408,500 to 495,300 m^3	Partial landfill (currently)				
		70,000 (for testing only)[7]	1,000 ppt (for testing only)	Soil	100 (test)	MCD	Unknown			
Phu Cat (Vietnam)[3]	Herbicide use	238,000	1,000 ppt soil 150 ppt sediment	Soil and sediment	3,450 (estimate)	Landfill				

Notes:

1. USEPA Office Technology Innovation. 2005. EPA-542-R-05-006. http://www.clu-in.org/pops.
2. USEPA Region 5 Cleanup Sites. https://www3.epa.gov/region5/cleanup/dowchemical/.
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APPENDIX D

PRELIMINARY ESTIMATED OVERALL COSTS FOR ALTERNATIVES

Appendix D: Preliminary Estimated Overall Costs for Alternatives

Introduction

Identification and evaluation of potential costs for project alternatives is integral to the evaluation process to help determine the best project approach to address the Airbase. The project alternative costs presented in this Environmental Assessment (EA) were developed in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, EPA 540-R-00-002 (July 2000). Although the EA process is distinct from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility study (FS) process, the objectives and intent as well as project concept development for this EA are sufficiently similar to the CERCLA process to warrant use of this guidance.

At the alternatives evaluation stage, the design for the project alternatives are still conceptual, not detailed, and the preliminary estimated overall costs are considered to be "order-of-magnitude." The cost engineer must make assumptions about the detailed design in order to prepare the cost estimate. As a project progresses, the design becomes more complete and the cost estimate becomes more "definitive," thus increasing the accuracy of the cost estimate. This process is depicted in the figure below for remedial action projects in the Superfund program; the process for implementation of project alternatives for the Airbase is similar.

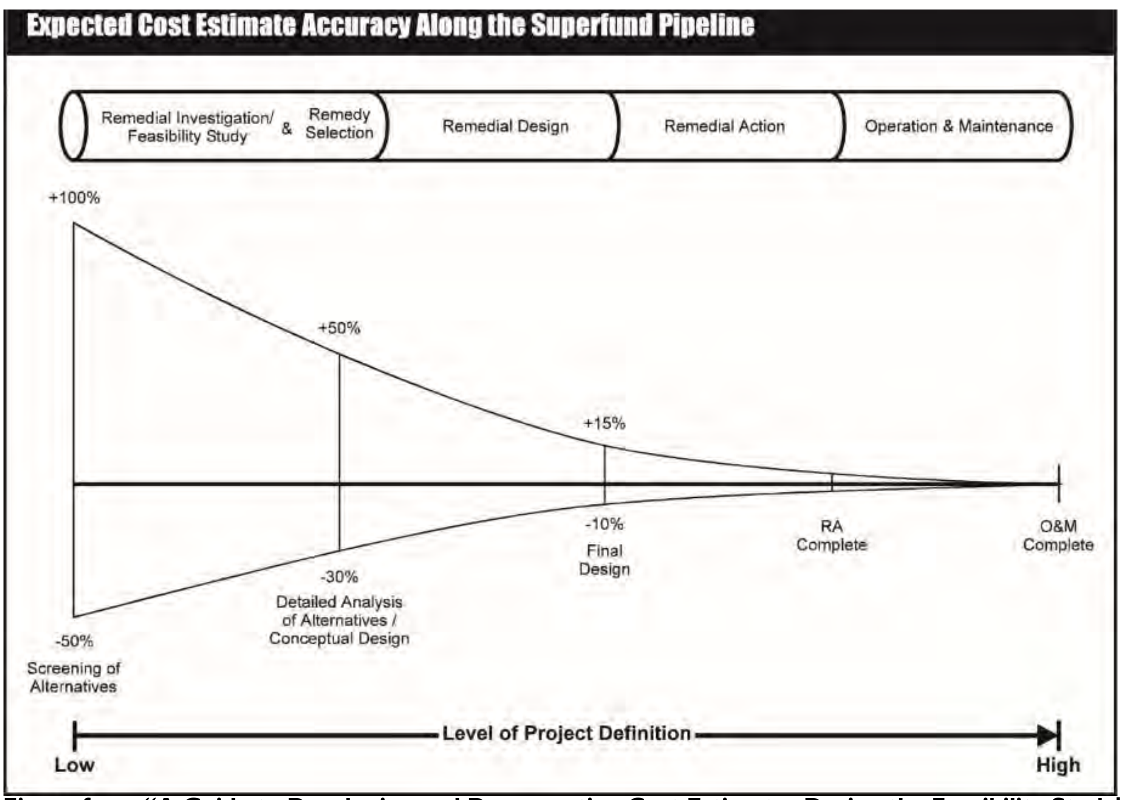

Figure from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (July 2000) EPA 540-R-00-002, OSWER 9355.0-75

Project alternative preliminary estimated overall costs were developed during this phase of the EA primarily for the purpose of comparing project alternatives during the remedy selection process, not for establishing project budgets. As a project alternative moves from the planning stage into the design and implementation stage, the level of project definition increases, thus allowing for a more accurate cost estimate. An "early" estimate of the project alternative's life cycle costs is made during the FS to make a remedy selection decision. The levels of detail employed in making these estimates are conceptual but are considered appropriate for making choices between alternatives. The information provided in the preliminary estimated overall cost is based on the best available information regarding the anticipated scope of the remedial alternatives.

Costs for project alternatives are expected to have a varying accuracies depending the level of project definition. For example, the recommended cost accuracy is from -50% to +100% of actual costs at the “remedial investigation/feasibility study” stage and from -30% to +50% at the “remedy selection” stage. Since the Bien Hoa EA lies between these two stages, cost accuracies of -40% to +75% of actual costs are being used. The accuracy range of –40% to +75% means that, for an estimate of $1,000,000, the actual cost of an alternative is expected to be between $600,000 and $1,750,000.

Flexibility is incorporated into each alternative for the location of project facilities, the selection of cleanup levels, and the period in which project implementation would be completed. Assumptions of the project scope and duration are defined for each alternative to provide cost estimates for the various project alternatives. Important assumptions specific to each project alternative are summarized in the description of the project alternative. Additional assumptions are included in the detailed preliminary estimated overall cost backup.

Types of costs that are assessed for each alternative include the following categories:

Construction Capital Costs

Capital costs are those expenditures that are required to construct a remedial action. They are exclusive of costs required to operate or maintain the action throughout its lifetime. Capital costs consist primarily of expenditures initially incurred to build or install the remedial action (e.g., construction of a water treatment system and related site work). Capital costs include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with activities, such as mobilization/demobilization; monitoring site work; installation of extraction, containment, or treatment systems; utility costs; and disposal of wastes. Capital costs also include expenditures for project management, remedial design, and construction management services that are necessary to support the design and construction of the remedial action.

Annual Operation and Maintenance (O&M) Costs – Monitoring during Construction

Annual O&M costs for monitoring during construction are those costs associated with implementing the sampling and analyses identified in the project Environment Mitigation and Monitoring Plan (EMMP). These costs are estimated mostly on an annual basis. Annual O&M costs for monitoring during construction include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with monitoring. Annual O&M costs for monitoring during construction also include expenditures for project management and technical support necessary to support O&M activities.

Annual O&M Costs – Monitoring and Maintenance after Construction

Annual O&M costs for monitoring and maintenance after construction are those costs associated with implementing the sampling and analyses identified in the EMMP and necessary to ensure or verify the continued effectiveness of a remedial action. These costs are estimated mostly on an annual basis. Annual O&M costs for monitoring and maintenance after construction include all labor, equipment, and material costs (including contractor markups, such as overhead and profit) associated with monitoring and maintenance. Annual O&M costs for monitoring and maintenance after construction also include expenditures for project management and technical support necessary to support O&M activities.

Net Present Value of Capital, Annual O&M, and Periodic Costs

The net present value of each alternative provides the basis for the cost comparison. The net present value cost represents the amount of money that, if invested in the initial year of the remedial action at a given rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life. Future O&M and periodic costs are included and reduced by the appropriate net present value discount rate as outlined in *A Guide to Developing and Documenting Cost Estimates* during the Feasibility Study (EPA 2000a). Per the guidance, the net present value analysis was performed on remedial alternatives using a 7 percent discount (interest) rate over the period of evaluation for each alternative. Inflation and depreciation were not considered in preparing the net present value costs.

For comparison purposes in the EA, net present value costs are not presented for comparison of project alternatives because the project funding mechanism is assumed to be through annual Congressional appropriations without use of an interest-bearing account. Thus the current costs (total project costs excluding net present value discounting) were used for project alternative comparisons.

Preliminary Estimated Overall Cost Presentation

The costs for each project alternative are presented in three components:

1. **Cost Estimate Summary:** The cost summary provides the capital and annual O&M costs and assumptions used to develop the total cost of a project alternative. For each capital and O&M cost, contingency and professional/technical services costs are applied as a percentage of the capital or O&M cost. Contingency covers unknowns or unanticipated conditions associated with construction or O&M activities. Project management, remedial design, and construction management for capital costs are professional/technical services to support construction of the project. Project management and technical support are professional/technical services to support O&M activities. The O&M costs for maintenance and monitoring were developed on an annual basis as a percentage of the capital costs before application of contingency and professional/technical services costs.
2. Net **Present Value Analysis:** The net present value analysis shows how the costs presented in the summary are distributed over the timeframe of the project (assumed to be Years 0 through 50 for purposes of the EA), and indicate the total cost without discounting (current cost) as well as the net present value cost (cost with net present value discounting).
3. **Detailed Spreadsheet Report**: The detailed spreadsheet reports provides the detailed cost backup and information used to provide the assumptions for development of capital costs presented in the cost summaries.

Cost estimates were performed for each alternative at the baseline contamination volume estimate (i.e., without contingency volume) and are summarized in **Table D1**. To assess the sensitivity of each alternative to increases in the volume of contaminated soil and sediment, cost estimates were also performed at the upper value in the estimated contamination volume range (i.e., with contingency volume) and are summarized in **Table D2**. This was accomplished by identifying elements in the baseline cost estimate that were volume dependent and only adjusting the costs for those items at the larger volume.

Cost Backup for Alternatives

Preliminary estimated overall costs have been performed for the following alternatives and are provided at the end of this Appendix:

- Alternative 2: Provide containment of all soil and sediment above MND-approved dioxin limits:
  - Alternative 2A: Contain in a Passive or Active Landfill.
  - Alternative 2B: Contain using Solidification/Stabilization.
- Alternative 3: Treat all soil and sediment above 2,500 ppt using *Ex Situ* Thermal Conductive Heating (TCH); contain the soil and sediment between MND-approved dioxin limits and 2,500 ppt in a Landfill.
- Alternative 4: Treat all soil and sediment above 1,200 ppt using *Ex Situ* TCH; contain the soil and sediment between the MND-approved dioxin limits and 1,200 ppt in a Landfill.
- Alternative 5: Treat all soil and sediment above MND-approved dioxin limits:
  - Alternative 5A: Treat using Incineration.
  - Alternative 5B: Treat using *Ex Situ* TCH.
  - Alternative 5C: Treat using mechano-chemical destruction (MCD).

Table D3 presents a more detailed description of the cost assemblies presented in the detailed spreadsheet reports. This table has two purposes: i) assist the reader with understanding how each of the estimates were constructed; and ii) provide others the information necessary to generate cost estimates of a portion of this work if desired. Given the size, complexity, and costs associated with the remedial alternatives, it is possible that the final remedy may be completed in phases or divided up among different entities for funding purposes.

However, it should be noted that any manipulation or separation of these costs must take into account two considerations:

- All costs pulled from the backup have allocations for general conditions, contractor overhead and profit, and other factors built in to every unit rate presented, but do not include design, construction management, O&M and other factors provided as additional costs on the cost estimate cover sheets. These additional factors should be included unless purposefully excluded.
- Any cost estimate intended to capture a fraction of the work included in an alternative must take care to generate a complete scope of the work that follows the soil from its current location to its final location, and includes all treatment costs as well as any ancillary costs and requirements. Not all of this information may be in the same place in the estimates provided herein, due to the manner in which these alternatives were assembled. In the estimates below, for example, costs for

treatment of certain material may be included under the Pacer Ivy (PI) half of the estimate, but final stockpiling may be covered under the Z1 half of the estimate, given that is where the final stockpile was located. The following table is intended to assist others in verifying all appropriate costs are included.

Table D1 Summary of Alternative Preliminary Estimated Overall Costs for Baseline Contamination Volume

Description	**Alt. 2A** Landfill	**Alt. 2A Mod** Landfill with Active Modification	**Alt. 2B** Solidification/ Stabilization	**Alt. 3** Landfill Materials <2,500 ppt, Ex Situ TCH Materials >2,500 ppt	**Alt. 4** Landfill Materials <1,200 ppt, Ex Situ TCH Materials >1,200 ppt	**Alt. 5A** Incineration	**Alt. 5B** Ex-Situ Thermal Conductive Heating (TCH)	**Alt. 5C** Mechano-Chemical Destruction (MCD)
Time Periods								
Construction Duration (Years)	5	5	6	7	10	8	14	8
Post-Construction O&M Duration (Years) [1]	45	10	44	43	40	0	0	0
Total Construction Capital Costs	$ 114,997,000	$ 127,815,000	$ 188,927,000	$ 212,676,000	$ 360,827,000	$ 652,241,000	$ 515,313,000	$ 586,188,000
O&M - Monitoring during Construction								
Annual O&M - Monitoring during Construction	$ 572,000	$ 631,000	$ 888,000	$ 961,000	$ 1,422,000	$ 1,759,000	$ 1,699,000	$ 1,751,000
Total O&M - Monitoring during Construction	$ 2,860,000	$ 3,155,000	$ 5,328,000	$ 6,727,000	$ 14,220,000	$ 14,072,000	$ 23,786,000	$ 14,008,000
O&M - Monitoring and Maintenance after Construction								
Annual O&M - Monitoring after Construction	$ 115,000	$ 178,000	$ 115,000	$ 93,000	$ -	$ -	$ -	$ -
Annual O&M - Maintenance after Construction	$ 69,000	$ 178,000	$ 69,000	$ 56,000	$ 51,000	$ -	$ -	$ -
Total O&M - Monitoring and Maintenance after Construction	$ 8,280,000	$ 10,000,000	$ 8,096,000	$ 6,407,000	$ 2,040,000	$ -	$ -	$ -
Total Estimated Cost of Remedy	**$ 126,137,000**	**$ 140,970,000**	**$ 202,351,000**	**$ 225,810,000**	**$ 377,087,000**	**$ 666,313,000**	**$ 539,099,000**	**$ 600,196,000**
Low End of Estimate (-40%)	$ 75,682,000	$ 84,582,000	$ 121,411,000	$ 135,486,000	$ 226,252,000	$ 399,788,000	$ 323,459,000	$ 360,118,000
High End of Estimate (+75%)	$ 220,740,000	$ 246,698,000	$ 354,114,000	$ 395,168,000	$ 659,902,000	$ 1,166,048,000	$ 943,423,000	$ 1,050,343,000
Total Estimated Cost of Remedy (Net Present Value)	**$ 98,431,000**	**$ 110,047,000**	**$ 155,982,000**	**$ 170,167,000**	**$ 263,758,000**	**$ 497,335,000**	**$ 336,755,000**	**$ 447,989,000**
Low End of Estimate (-40%)	$ 59,059,000	$ 66,028,000	$ 93,589,000	$ 102,100,000	$ 158,255,000	$ 298,401,000	$ 202,053,000	$ 268,793,000
High End of Estimate (+75%)	$ 172,254,000	$ 192,582,000	$ 272,969,000	$ 297,792,000	$ 461,577,000	$ 870,336,000	$ 589,321,000	$ 783,981,000

Notes:

1 Post-construction monitoring and maintenance required for landfill and solidification/stabilization components of the alternatives.

2 Cost estimates are based on soil/sediment volumes presented in Table 4-3, excluding the contingency volume.

3 The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

4 Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

5 **Costs presented for this alternative are expected to have an accuracy between -40% to +75% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.**

Table D2 Summary of Alternative Preliminary Estimated Overall Costs for Baseline and Contingency Volumes

Description	**Alt. 2A** Landfill	**Alt. 2A Mod** Landfill with Active Modification	**Alt. 2B** Solidification/ Stabilization	**Alt. 3** Landfill Materials <2,500 ppt, Ex Situ TCH Materials >2,500 ppt	**Alt. 4** Landfill Materials <1,200 ppt, Ex Situ TCH Materials >1,200 ppt	**Alt. 5A** Incineration	**Alt. 5B** Ex-Situ Thermal Conductive Heating (TCH)	**Alt. 5C** Mechano-Chemical Destruction (MCD)
Time Periods								
Construction Duration (Years)	6	6	7	7	10	10	16	10
Post-Construction O&M Duration (Years) [1]	44	44	43	43	40	0	0	0
Total Construction Capital Costs	$ 124,793,000	$ 139,873,000	$ 214,509,000	$ 222,714,000	$ 373,624,000	$ 772,781,000	$ 608,343,000	$ 691,681,000
O&M - Monitoring during Construction								
Annual O&M - Monitoring during Construction	$ 623,000	$ 692,000	$ 1,010,000	$ 1,008,000	$ 1,474,000	$ 2,087,000	$ 2,009,000	$ 2,068,000
Total O&M - Monitoring during Construction	$ 3,738,000	$ 4,152,000	$ 7,070,000	$ 7,056,000	$ 14,740,000	$ 20,870,000	$ 32,144,000	$ 20,680,000
O&M - Monitoring and Maintenance after Construction								
Annual O&M - Monitoring after Construction	$ 115,000	$ 178,000	$ 115,000	$ 93,000	$ -	$ -	$ -	$ -
Annual O&M - Maintenance after Construction	$ 69,000	$ 178,000	$ 69,000	$ 56,000	$ 51,000	$ -	$ -	$ -
Total O&M - Monitoring and Maintenance after Construction	$ 8,096,000	$ 9,816,000	$ 7,912,000	$ 6,407,000	$ 2,040,000	$ -	$ -	$ -
Total Estimated Cost of Remedy with Contingency Volume	**$ 136,627,000**	**$ 153,841,000**	**$ 229,491,000**	**$ 236,177,000**	**$ 390,404,000**	**$ 793,651,000**	**$ 640,487,000**	**$ 712,361,000**
Low End of Estimate (-40%)	$ 81,976,000	$ 92,305,000	$ 137,695,000	$ 141,706,000	$ 234,242,000	$ 476,191,000	$ 384,292,000	$ 427,417,000
High End of Estimate (+75%)	$ 239,097,000	$ 269,222,000	$ 401,609,000	$ 413,310,000	$ 683,207,000	$ 1,388,889,000	$ 1,120,852,000	$ 1,246,632,000
Total Estimated Cost of Remedy (Net Present Value)	**$ 103,770,000**	**$ 116,882,000**	**$ 172,137,000**	**$ 178,148,000**	**$ 273,106,000**	**$ 557,412,000**	**$ 378,139,000**	**$ 500,319,000**
Low End of Estimate (-40%)	$ 62,262,000	$ 70,129,000	$ 103,282,000	$ 106,889,000	$ 163,864,000	$ 334,447,000	$ 226,883,000	$ 300,191,000
High End of Estimate (+75%)	$ 181,598,000	$ 204,544,000	$ 301,240,000	$ 311,759,000	$ 477,936,000	$ 975,471,000	$ 661,743,000	$ 875,558,000
Comparison of Baseline and Contingency Costs and Volumes								
Baseline Soil/Sediment Volume (m3)	347,800	347,800	347,800	347,800	408,500	408,500	408,500	408,500
Total Volume Including Contingency (m3)	414,400	414,400	414,400	414,400	495,300	495,300	495,300	495,300
Percentage Increase in Volume from Baseline	19.15%	19.15%	19.15%	19.15%	21.25%	21.25%	21.25%	21.25%
Percentage Increase in Cost from Baseline	8.32%	9.13%	13.41%	4.59%	3.53%	19.11%	18.81%	18.69%
Percentage Increase in Cost from Baseline (Net Present Value)	5.42%	6.21%	10.36%	4.69%	3.54%	12.08%	12.29%	11.68%

Notes:

1 Post-construction monitoring and maintenance required for landfill and solidification/stabilization components of the alternatives.

2 Cost estimates are based on soil/sediment volumes presented in Table 4-3, including the contingency volume.

3 The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

4 Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

5 **Costs presented for this alternative are expected to have an accuracy between -40% to +75% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.**

Table D3 Description of Cost Assemblies in Preliminary Estimated Overall Costs

Assembly Number and Description	**Description**
Costs Applicable to all Alternatives except Alternative 1– No Action	
01000-0301 Safety Equipment	Safety gear, including Tyvek® suits, gloves, boot covers, and respirators required for work with contaminated soil
01000-0301 Demobilization	Demobilization includes costs associated with removing all equipment from the project site and/or treatment equipment removal.
01000-0301 Reconstruct Haul Roads	Improvement and reconstruction of haul roads on the Airbase to allow for trucking of contaminated soils for containment or treatment. Includes road grading, paving, and associated trucking. Includes labor (local) and equipment.
01590-0100 Traffic and Environmental Controls	Includes project signs and fencing to delineate and control work areas, dust control, and sweeping and maintenance of the material haul roads.
01000-0301 In Country Requirements	Clearance of UXO (assumed to be conducted by MND personnel). Includes labor (local) and equipment.
02230-005 Clearing	Clearing of vegetation from excavation areas and from treatment construction and staging areas, including tree removal. Includes labor (local) and equipment.
02310-01-2 Cut to Stockpile (description varies)	Excavate contaminated material within each area listed, and haul to a centralized area for containment or treatment. Includes labor (local), equipment, and decontamination areas.
01000-0301 Water Treatment	Treatment of water from dewatered areas during excavation. Includes equipment for water treatment (pumps, granular activated carbon, etc.)
01000-0301 Additional Dewatering and Fish Removal	Pumping to remove water from lakes with sediment below dioxin limits, and removal of fish and biota from those lakes. Fish and biota would be transported for containment or treatment along with other soils/sediments. Includes labor (local) and equipment.
01562-0224 Dewater Ponds	Includes construction of dewatering system for lakes/ponds prior to sediment excavation. Includes equipment (pumps) and piping.
02240-0200 Dewatering System	Includes installation of well points for dewatering during excavation activities in order to maintain groundwater below the level of excavation.
02310-01-5 Fill Excavated Areas to Original Grade	Cost for backfill of all excavated areas. For containment-only alternatives, backfill will be from imported material. For alternatives with any treatment, fill will be a combination of treated soils and imported materials as indicated in the specific alternatives. Includes labor (local), equipment, and cost of imported fill material.

Assembly Number and Description	Description
Costs Applicable to Landfills (Alternative 2A, 3 and 4)	
01000-0301 Landfill Liner	Cost for installation of all landfill liner and cap systems. Cost includes grading of areas prior to construction, placing imported fill material for subgrade, geosynthetic clay and HDPE liners, leachate collection systems, and revegetating the cover following construction. Cost includes labor (local) and equipment for installation.
02310-01-3 Place Excavated Soil and Sediment in Landfill	Cost for placement of contaminated materials in the constructed landfill. Cost includes placement and compaction of soils in landfill, and decontamination areas. Cost includes labor (local) and equipment.
Costs Applicable to Alternative 2B – Solidification/Stabilization	
01000-0301 Treatment	Treatment costs, including mixing equipment and admixtures for solidification/stabilization. Includes labor (local), equipment, and energy costs.
01000-0301 Cap System	Installation of cap/cover system for final solidified/stabilized soil stockpiles, including liner and cover soil installation and vegetation. Includes labor (local) and equipment.
02310-01-2 Place Treated Material in Pile	Transportation and placement of solidified/stabilized material into final stockpile area, including labor (local) and equipment.
Costs Applicable to Alternative 5A – Incineration	
01000-0301 Treatment (soil and sediment treatment)	First line item (soil and sediment treatment) includes operation of the incinerator, including energy costs, off-gas treatment, and waste/residuals handling. Second line item (incinerator cost) includes construction of the incinerator on site. This cost includes labor (combination of local and expat), equipment, and energy costs, but excludes design.
01000-0301 Temporary Stockpile for Incoming Treated Soils	Costs associated with transfer of material from temporary stockpile area to incinerator, including all labor (local) and equipment.
01000-0301 Temporary Stockpile for Outgoing Treated Soils	Costs associated with transfer of material from incinerator to a temporary stockpile of treated material, including all labor (local) and equipment.
01000-0301 Final Stockpile of Treated Soils	Costs associated with construction of a final soil stockpile for remaining treated soils not used to backfill excavation areas. Costs include labor (local) and equipment costs.
Costs Applicable to Ex Situ Thermal Conductive Heating (Alternative 3, 4, and 5B)	
01000-0301 Treatment (soil and sediment treatment)	First line item (soil and sediment treatment) includes operation of the TCH system, including energy costs, off-gas treatment, and waste/residuals handling. Second line item (TCH) includes construction of the TCH system, including treatment components. This cost includes labor (combination of local and expat), equipment, and energy costs, but excludes design.

Assembly Number and Description	Description
01000-0301 Final Stockpile of Treated Soils	Costs associated with construction of a final soil stockpile for remaining treated soils not used to backfill excavation areas. Costs include labor (local) and equipment costs.
Costs Applicable to Alternative 5C - MCD	
01000-0301 Treatment (soil and sediment treatment)	First line item (soil and sediment treatment) includes operation of the MCD system, including energy costs, dust control, and waste/residuals handling. Second line item (capital costs) includes construction of the MCD system, This cost includes labor (combination of local and expat), equipment, and energy costs, but excludes design.
01000-0301 Temporary Stockpile for Incoming Treated Soils	Costs associated with transfer of material from temporary stockpile area to the MCD system, including all labor (local) and equipment.
01000-0301 Temporary Stockpile for Outgoing Treated Soils	Costs associated with transfer of material from MCD system to a temporary stockpile of treated material, including all labor (local) and equipment.
01000-0301 Final Stockpile of Treated Soils	Costs associated with construction of a final soil stockpile for remaining treated soils not used to backfill excavation areas. Costs include labor (local) and equipment costs.

Alternative 2A

Landfill – Passive

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2A Landfill (Passive)
Description: The landfill alternative will consist of: (1) constructing two landfills, one in the Z1 Area and one in the Pacer Ivy Area; (2) excavating, dewatering, and transporting contaminated soils and sediments to the landfills; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$74,268,754	$74,268,754	From detailed cost estimate
Contingency (Scope and Bid)	30%			$22,280,626	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$96,549,000	Rounded to nearest $1,000
Project Management	5%			$4,827,450	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$5,792,940	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$4,827,450	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$114,996,840	
TOTAL CONSTRUCTION CAPITAL COST				**$114,997,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	5	YR	**$22,999,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$338,249	$338,249	Sampling/analysis required by the EMMP; assume 0.5% of construction cost.
Contingency (Scope and Bid)	30%			$101,475	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$440,000	Rounded to nearest $1,000
Project Management	10%			$44,000	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$66,000	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$22,000	Assumed to apply to 50% of the EMMP implementation
TOTAL				$572,000	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$572,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	5	YR	$572,000	**$2,860,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 6 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction costs.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	45	YR	$115,000	**$5,175,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 6 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	45	YR	$69,000	**$3,105,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 2A Landfill (Passive)	**$126,137,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2A Landfill (Passive)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$22,999,000	$572,000	$0	$0	$23,571,000	0.9346	$22,029,457
2	$22,999,000	$572,000	$0	$0	$23,571,000	0.8734	$20,586,911
3	$22,999,000	$572,000	$0	$0	$23,571,000	0.8163	$19,241,007
4	$22,999,000	$572,000	$0	$0	$23,571,000	0.7629	$17,982,316
5	$22,999,000	$572,000	$0	$0	$23,571,000	0.7130	$16,806,123
6	$0	$0	$115,000	$69,000	$184,000	0.6663	$122,599
7	$0	$0	$115,000	$69,000	$184,000	0.6227	$114,577
8	$0	$0	$115,000	$69,000	$184,000	0.5820	$107,088
9	$0	$0	$115,000	$69,000	$184,000	0.5439	$100,078
10	$0	$0	$115,000	$69,000	$184,000	0.5083	$93,527
11	$0	$0	$115,000	$69,000	$184,000	0.4751	$87,418
12	$0	$0	$115,000	$69,000	$184,000	0.4440	$81,696
13	$0	$0	$115,000	$69,000	$184,000	0.4150	$76,360
14	$0	$0	$115,000	$69,000	$184,000	0.3878	$71,355
15	$0	$0	$115,000	$69,000	$184,000	0.3624	$66,682
16	$0	$0	$115,000	$69,000	$184,000	0.3387	$62,321
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$114,995,000	$2,860,000	$5,175,000	$3,105,000	**$126,135,000**		$98,430,635
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$98,431,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternative 2A
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver:	Database Version 7.0
ENR 20 City CCI:	October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.60				**Z1 Area- Landfill - Alternative 2A**							
	009.--			**Site and Traffic Controls**							
		06.--		**-----**							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	11,159.00 md	-	-	-	41.27 /md	41.27 /md	460,537
				Resperators - One Ea Man	35.00 ea	-	-	-	68.78 /ea	68.78 /ea	2,407
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**462,943.99 /ls**	**462,943.99 /ls**	**462,944**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	318,920.12 /ls	-	318,920.12 /ls	318,920
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**318,920.12 /ls**	**/ls**	**318,920.12 /ls**	**318,920**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.74 /sy	-	-	4.80 /sy	5.54 /sy	104,069
				Fine Grade Subgrade	18,775.00 sy	0.44 /sy	-	-	1.71 /sy	2.15 /sy	40,273
				Pave Roads - (4" Binder 1.5" Top	5,800.00 ton	2.11 /ton	-	-	7.85 /ton	9.96 /ton	57,770
				Haul Bituminous Concrete	5,800.00 ton	1.93 /ton	103.18 /ton	-	12.21 /ton	117.31 /ton	680,405
				Rebuild Interior Haul Roads	**3.30 KM**	**13,824.09 /KM**	**181,339.69 /KM**	**/KM**	**72,265.74 /KM**	**267,429.53 /KM**	**882,517**
			01590-0100	**Traffic and Enviromental Controls -5,367 CH = 600 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.72 /sf	16.51 /sf	-	-	18.23 /sf	3,500
				Plastic Snow Fence	10,000.00 lf	1.18 /lf	4.13 /lf	-	-	5.31 /lf	53,062
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	60.00 wk	-	-	-	1,533.61 /wk	1,533.61 /wk	92,017
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	60.00 wk	-	-	-	3,355.56 /wk	3,355.56 /wk	201,334
				Maintain Haul Rds - Grader- Cat 14/RLV	60.00 wk	1,540.76 /wk	-	-	6,418.93 /wk	7,959.69 /wk	477,581
				Traffic and Enviromental Controls -5,367 CH = 600 CD	**1.00 ls**	**104,567.42 /ls**	**44,440.00 /ls**	**/ls**	**678,485.61 /ls**	**827,493.03 /ls**	**827,493**
				06.-- -----							**2,491,875**
				009.-- Site and Traffic Controls	**1.00 ls**	**150,186.93 /ls**	**642,860.99 /ls**	**318,920.12 /ls**	**1,379,906.56 /ls**	**2,491,874.60 /ls**	**2,491,875**
	009.5			**RVN - In Country Requirements**							
		06.--		**-----**							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,551.36 /ea	-	2,551.36 /ea	25,514
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,513.60 /ls**	**/ls**	**25,513.60 /ls**	**25,514**
				06.-- -----							**25,514**
				009.5 RVN - In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,513.60 /ls**	**/ls**	**25,513.60 /ls**	**25,514**
	010.--			**Z1 Area - Landfill Site**							
		00.9		**Clearing Landfill Areas and Excavated Areas**							
			02230-005	**Clearing ForExcavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	44.14 ac	1,408.70 /ac	-	-	2,059.89 /ac	3,468.59 /ac	153,103
				Clearing ForExcavated Areas	**178,626.90 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.86 /M2**	**153,103**
			02230-005	**Clearing For Containment Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	14.80 ac	1,408.70 /ac	-	-	2,059.89 /ac	3,468.59 /ac	51,335
				Clearing For Containment Areas	**59,893.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.86 /M2**	**51,335**
				00.9 Clearing Landfill Areas and Excavated Areas	**23.85 ha**	**3,481.28 /ha**	**/ha**	**/ha**	**5,090.56 /ha**	**8,571.84 /ha**	**204,438**
		01.--		**Excavate Soil/Sediment to Landfill Area**							
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Soil**							
				Cut to Waste - (2 excavators)	27,598.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	115,314
				Dump Truck	27,598.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	487,626
				Project Health & Safety Technician	288.00 hr	13.76 /hr	-	-	-	13.76 /hr	3,962
				Level 2 Survey Crew	288.00 hr	27.51 /hr	-	-	-	27.51 /hr	7,924
				Decontamination Area	288.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	56,537
				Area Z1 Cut to Stockpile - Containment Soil	**27,598.00 cy**	**4.16 /cy**	**/cy**	**/cy**	**20.17 /cy**	**24.33 /cy**	**671,363**
			02310-01-2	**Area Z1 Taxiway - Landfill Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	59,571
				Dump Truck	14,257.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	251,905
				Project Health & Safety Technician	148.00 hr	13.76 /hr	-	-	-	13.76 /hr	2,036
				Level 2 Survey Crew	148.00 hr	27.51 /hr	-	-	-	27.51 /hr	4,072
				Decontamination Area	148.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	29,054
				Area Z1 Taxiway - Landfill Soil	**14,257.00 cy**	**4.15 /cy**	**/cy**	**/cy**	**20.16 /cy**	**24.31 /cy**	**346,638**
			02310-01-2	**Southwest Area - Containment -Soil**							
				Cut to Waste - (2 excavators)	79,262.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	331,184
				Dump Truck	79,262.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	1,400,472
				Project Health & Safety Technician	825.70 hr	13.76 /hr	-	-	-	13.76 /hr	11,359
				Level 2 Survey Crew	825.70 hr	27.51 /hr	-	-	-	27.51 /hr	22,718
				Decontamination Area	825.70 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	162,093
				Southwest Area - Containment -Soil	**79,262.00 cy**	**4.16 /cy**	**/cy**	**/cy**	**20.17 /cy**	**24.32 /cy**	**1,927,826**
			02310-01-2	**Gate 2 Lake - 1 cd -- Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	7,103
				Dump Truck	1,700.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	30,037
				Project Health & Safety Technician	18.00 hr	13.76 /hr	-	-		13.76 /hr	248
				Level 2 Survey Crew	18.00 hr	27.51 /hr	-	-	-	27.51 /hr	495
				Decontamination Area	18.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	3,534
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.24 /cy	2.75 /cy	4,674
				Gate 2 Lake - 1 cd -- Sediment	**1,700.00 cy**	**4.69 /cy**	**/cy**	**/cy**	**22.42 /cy**	**27.11 /cy**	**46,091**
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	97,280
				Dump Truck	23,282.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	411,367
				Project Health & Safety Technician	243.00 hr	13.76 /hr	-	-		13.76 /hr	3,343
				Level 2 Survey Crew	243.00 hr	27.51 /hr	-	-	-	27.51 /hr	6,686

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Sediment**							
				Decontamination Trailer	243.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	47,703
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 cy	0.51 /cy	-	-	2.24 /cy	2.75 /cy	64,014
				Area Z1 Cut to Stockpile - Containment Sediment	**23,282.00 cy**	**4.67 /cy**	**/cy**	**/cy**	**22.40 /cy**	**27.08 /cy**	**630,394**
				01.-- Excavate Soil/Sediment to Landfill Area	**146,098.00 cy**	**4.24 /cy**	**/cy**	**/cy**	**20.55 /cy**	**24.79 /cy**	**3,622,312**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Water Treatment From Dewatered Areas**							
				Treatment Of Water From Dewatered Areas	1.00 ls	-	-	159,460.06 /ls	-	159,460.06 /ls	159,460
				Water Treatment From Dewatered Areas	**1.00 ls**	**/ls**	**/ls**	**159,460.06 /ls**	**/ls**	**159,460.06 /ls**	**159,460**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	2,000,000.07 /ls	-	2,000,000.07 /ls	2,000,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**2,000,000.07 /ls**	**/ls**	**2,000,000.07 /ls**	**2,000,000**
			01562-0224	**Dewater Ponds - Z1 Area - 2 mo/Pond x 3 ea**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	637.84 /ea	-	637.84 /ea	1,914
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.06 /lf	12.83 /lf	-	-	14.90 /lf	8,938
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	426.74 /ea	3,232.30 /ea	-	-	3,659.03 /ea	10,977
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	247.62 /day	247.62 /day	44,572
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	168.24 /ea	690.04 /ea	-	-	858.28 /ea	2,575
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.65 /lf	8.47 /lf	-	-	10.13 /lf	22,781
				Attend Temporary Diesel Pumps	180.00 day	1,650.82 /day	-	-	-	1,650.82 /day	297,147
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	490
				Dewater Ponds - Z1 Area - 2 mo/Pond x 3 ea	**1.00 ls**	**304,374.44 /ls**	**38,533.36 /ls**	**1,913.53 /ls**	**44,572.06 /ls**	**389,393.39 /ls**	**389,393**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m Space /506sf/ea -**							
				Design Dewatering System	8.50 acre	-	-	6,378.40 /acre	-	6,378.40 /acre	54,216
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,275.68 /ea	-	1,275.68 /ea	3,827
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.44 /lf	218.73 /lf	-	-	222.17 /lf	1,599,641
				Install Discharge Pipe- 6"	12,063.00 lf	1.65 /lf	13.79 /lf	-	-	15.44 /lf	186,211
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,074
				Z1 Area -33,800M2 - 363,800 sf @7.5m Space /506sf/ea -	**7,200.00 lf**	**6.49 /lf**	**241.83 /lf**	**8.06 /lf**	**/lf**	**256.39 /lf**	**1,845,970**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**351,124.82 /ls**	**1,779,709.20 /ls**	**2,219,417.12 /ls**	**44,572.06 /ls**	**4,394,823.20 /ls**	**4,394,823**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1 Landfill - Fill Excavated Areas To Original Grade**							
				FILL from IMPORT	121,116.00 CY	0.96 /CY	-	-	5.30 /CY	6.27 /CY	758,740
				Import Gravel Fill - Material Only	121,116.00 cy	-	13.76 /cy	7.14 /cy	-	20.90 /cy	2,531,399
				Grade and Compact	121,116.00 cy	0.39 /cy	-	-	1.61 /cy	1.99 /cy	241,011
				Dump Truck - Haul	121,116.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	2,139,986
				Load - From Stockpile	121,116.00 cy	0.27 /cy	-	-	1.17 /cy	1.43 /cy	173,444
				Area Z-1 Landfill - Fill Excavated Areas To Original Grade	**121,116.00 cy**	**4.02 /cy**	**13.76 /cy**	**7.14 /cy**	**23.33 /cy**	**48.26 /cy**	**5,844,580**
				02.-- F&I Borrow - Bring Areas to Grade	**92,600.00 M3**	**5.26 /M3**	**17.99 /M3**	**9.34 /M3**	**30.52 /M3**	**63.12 /M3**	**5,844,580**
				010.-- Z1 Area - Landfill Site	**111,700.00 M3**	**13.80 /M3**	**30.85 /M3**	**27.62 /M3**	**53.66 /M3**	**125.93 /M3**	**14,066,153**
	014.--			**Z1 Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-0301	**Z-1 - - Landfill Liner**							
				Import Common Earth	23,543.00 cy	1.20 /cy	-	-	7.47 /cy	8.68 /cy	204,305
				GCL Clay Liner	322,917.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	87,612
				HDPE Liner 60 mils (1.5 mm)	322,917.00 sf	-	-	0.68 /sf	-	0.68 /sf	220,593
				Geocomposite Liner	322,917.00 sf	0.14 /sf	0.14 /sf	-	-	0.28 /sf	88,846
				HDPE Liner 60 mils (1.5 mm)	322,917.00 sf	-	-	0.68 /sf	-	0.68 /sf	220,593
				Geocomposite Liner	322,917.00 sf	0.14 /sf	-	-	-	0.28 /sf	89,273
				24" Sand Layer	23,543.00 cy	1.61 /cy	0.00 /cy	0.00 /cy	9.97 /cy	11.57 /cy	272,407
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	3,281.00 lf	0.65 /lf	3.41 /lf	-	-	4.05 /lf	13,297
				GCL	322,917.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	87,612
				Linear Low Density PE Liner 40 mils (1 mm)	322,917.00 sf	-	0.32 /sf	0.15 /sf	-	0.47 /sf	152,050
				Geocomposite- 250 mils	322,917.00 sf	-	0.15 /sf	0.41 /sf	-	0.56 /sf	180,686
				Import Common Earth	23,543.00 cy	1.20 /cy	0.00 /cy	0.00 /cy	7.47 /cy	8.68 /cy	204,305
				Loam 4"thk	3,950.00 cy	2.45 /cy	27.51 /cy	-	2.33 /cy	32.29 /cy	127,539
				Seeding Mechanical Methods	322,917.00 sf	-	-	0.08 /sf	-	0.08 /sf	24,716
				Import Sand Fill - Materials Only	23,543.00 cy	-	24.76 /cy	7.14 /cy	-	31.91 /cy	751,164
				Import Common Earth - Materials Only	47,086.00 cy	-	9.63 /cy	5.24 /cy	-	14.87 /cy	699,941
				Load - From Stockpile	70,629.00 cy	0.27 /cy	-	-	1.17 /cy	1.43 /cy	101,144
				Dump Truck - Haul	74,579.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	1,317,729
				Z-1 - - Landfill Liner	**7.41 ac**	**65,097.88 /ac**	**194,135.36 /ac**	**143,300.47 /ac**	**245,099.72 /ac**	**653,686.07 /ac**	**4,843,814**
				03.-- F&I Landfill Liner	**30,000.00 M2**	**16.08 /M2**	**47.95 /M2**	**35.40 /M2**	**60.54 /M2**	**161.46 /M2**	**4,843,814**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill -**							
				Place Soil and Sediment In Landfill	146,098.00 cy	0.70 /cy	-	-	4.47 /cy	5.17 /cy	755,518
				Decontamination Area	664.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	130,350
				Place Excavated Soil and Sediment In Landfill -	**146,098.00 cy**	**1.10 /cy**	**/cy**	**/cy**	**4.96 /cy**	**6.06 /cy**	**885,867**
				05.-- Place Excavated Soil/Sediment in Landfill	**111,700.00 M3**	**1.44 /M3**	**/M3**	**/M3**	**6.49 /M3**	**7.93 /M3**	**885,867**
				014.-- Z1 Area - Landfill	**111,700.00 M3**	**5.76 /M3**	**12.88 /M3**	**9.51 /M3**	**22.75 /M3**	**51.30 /M3**	**5,729,681**
				00.60 Z1 Area- Landfill - Alternative 2A	**111,700.00 M3**	**20.90 /M3**	**49.48 /M3**	**40.21 /M3**	**88.77 /M3**	**199.76 /M3**	**22,313,222**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.70				**Pacer Ivy Area Landfill - Alternative 2A**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	30,243.00 md	-	-	-	41.27 /md	41.27 /md	1,248,141
				Resperators - One Ea Man	55.00 ea	-	-	-	68.78 /ea	68.78 /ea	3,783
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,251,924.28 /ls**	**1,251,924.28 /ls**	**1,251,924**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	318,920.11 /ls	-	318,920.11 /ls	318,920
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**318,920.11 /ls**	**/ls**	**318,920.11 /ls**	**318,920**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.74 /sy	-	-	4.80 /sy	5.54 /sy	249,744
				Fine Grade Subgrade	45,056.00 sy	0.44 /sy	-	-	1.71 /sy	2.15 /sy	96,647
				Pave Roads - (4" Binder 1.5" Top	13,900.00 ton	2.11 /ton	-	-	7.85 /ton	9.96 /ton	138,449
				Haul Bituminous Concrete	13,900.00 ton	1.93 /ton	103.18 /ton	-	12.21 /ton	117.31 /ton	1,630,625
				Rebuild Interior Haul Roads	**7.70 KM**	**14,207.97 /KM**	**186,252.84 /KM**	**/KM**	**74,275.00 /KM**	**274,735.81 /KM**	**2,115,466**
			01590-0100	**Traffic and Enviromental Controls**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.72 /sf	16.51 /sf	-	-	18.23 /sf	3,500
				Wood Snow Fence	6,000.00 lf	1.18 /lf	4.13 /lf	-	-	5.31 /lf	31,837
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	85.00 wk	-	-	-	1,533.61 /wk	1,533.61 /wk	130,357
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	85.00 wk	-	-	-	3,355.56 /wk	3,355.56 /wk	285,223
				Maintain Haul Rds - Grader- Cat 14/RLV	85.00 wk	1,540.76 /wk	-	-	6,418.93 /wk	7,959.69 /wk	676,573
				Traffic and Enviromental Controls	**1.00 ls**	**138,369.86 /ls**	**27,931.83 /ls**	**/ls**	**961,187.95 /ls**	**1,127,489.64 /ls**	**1,127,490**
				06.-- -----							4,813,800
				009.-- Site and Traffic Controls	1.00 ls	247,771.25 /ls	1,462,078.71 /ls	318,920.11 /ls	2,785,029.71 /ls	4,813,799.78 /ls	4,813,800
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,551.36 /ea	-	2,551.36 /ea	25,514
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,513.61 /ls**	**/ls**	**25,513.61 /ls**	**25,514**
				06.-- -----							25,514
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,513.61 /ls	/ls	25,513.61 /ls	25,514
	012.--			Pacer Ivy - Landfill Site							
		00.9		Clearing Landfill Areas and Excavated Areas							
			02230-005	**Site Clearing - Excavated Areas**							
				Clear & Grub Light Trees,	37.20 ac	1,408.70 /ac	-	-	2,059.89 /ac	3,468.59 /ac	129,031
				Site Clearing - Excavated Areas	**150,500.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.86 /M2**	**129,031**
			02230-005	**Site Clearing - For Contaminated Areas**							
				Clear & Grub Light Trees, 14.8 ac	17.20 ac	1,408.70 /ac	-	-	2,059.89 /ac	3,468.59 /ac	59,660
				Site Clearing - For Contaminated Areas	**69,606.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.86 /M2**	**59,660**
				00.9 Clearing Landfill Areas and Excavated Areas	22.00 ha	3,483.32 /ha	/ha	/ha	5,093.54 /ha	8,576.87 /ha	188,691
		01.--		Excavate Soil/Sediment to Landfill Area							
			02310-01-2	**Pacer Ivy Cut to Stockpile - Containment -**							
				Cut to Waste - (2 excavators)	167,549.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	700,077
				Dump Truck	167,549.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	2,960,406
				Project Health & Safety Technician	1,746.00 hr	13.76 /hr	-	-	-	13.76 /hr	24,019
				Level 2 Survey Crew	1,746.00 hr	27.51 /hr	-	-	-	27.51 /hr	48,039
				Decontamination Area	1,746.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	342,757
				Pacer Ivy Cut to Stockpile - Containment -	**167,549.00 cy**	**4.16 /cy**	**/cy**	**/cy**	**20.17 /cy**	**24.32 /cy**	**4,075,298**
			02310-01-2	**Northwest Area - Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	36,067
				Dump Truck	8,632.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	152,518
				Project Health & Safety Technician	90.00 hr	13.76 /hr	-	-	-	13.76 /hr	1,238
				Level 2 Survey Crew	90.00 hr	27.51 /hr	-	-	-	27.51 /hr	2,476
				Decontamination Trailer	90.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	17,668
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.24 /cy	2.75 /cy	23,734
				Northwest Area - Cut to Stockpile - Sediment	**8,632.00 cy**	**4.67 /cy**	**/cy**	**/cy**	**22.40 /cy**	**27.07 /cy**	**233,702**
			02310-01-2	**North Area - Cut to Stockpile - Containment**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	187,453
				Dump Truck	44,863.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	792,680
				Project Health & Safety Technician	468.00 hr	13.76 /hr	-	-	-	13.76 /hr	6,438
				Level 2 Survey Crew	468.00 hr	27.51 /hr	-	-	-	27.51 /hr	12,876
				Decontamination Area	468.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	91,873
				North Area - Cut to Stockpile - Containment	**44,863.00 cy**	**4.16 /cy**	**/cy**	**/cy**	**20.17 /cy**	**24.33 /cy**	**1,091,320**
			02310-01-2	**North East Area - Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	136,628
				Dump Truck	32,699.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	577,755
				Project Health & Safety Technician	341.00 hr	13.76 /hr	-	-	-	13.76 /hr	4,691
				Level 2 Survey Crew	341.00 hr	27.51 /hr	-	-	-	27.51 /hr	9,382
				Decontamination Area	341.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	66,942
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,690.00 cy	0.51 /cy	-	-	2.24 /cy	2.75 /cy	89,882
				North East Area - Cut to Stockpile - Sediment	**32,699.00 cy**	**4.67 /cy**	**/cy**	**/cy**	**22.40 /cy**	**27.07 /cy**	**885,280**
			02310-01-2	**Pacer Ivy Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	55,065.00 cy	0.40 /cy	-	-	3.78 /cy	4.18 /cy	230,080
				Dump Truck	55,065.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	972,938
				Project Health & Safety Technician	574.00 hr	13.76 /hr	-	-	-	13.76 /hr	7,896

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Pacer Ivy Cut to Stockpile - Sediment**							
				Level 2 Survey Crew	574.00 hr	27.51 /hr	-	-	-	27.51 /hr	15,793
				Decontamination Area	574.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	112,682
				Articulated Wheel Loader Cat 938 140HP 2.75cy	55,065.00 cy	0.51 /cy	-	-	2.24 /cy	2.75 /cy	151,403
				Pacer Ivy Cut to Stockpile - Sediment	**55,065.00 cy**	**4.67 /cy**	**/cy**	**/cy**	**22.40 /cy**	**27.07 /cy**	**1,490,792**
				01.-- Excavate Soil/Sediment to Landfill Area	**308,807.00 cy**	**4.32 /cy**	**/cy**	**/cy**	**20.87 /cy**	**25.18 /cy**	**7,776,391**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Water Treatment From Dewatered Areas**							
				Treatment Of Water From Dewatered Areas	1.00 ls	-	-	159,460.06 /ls	-	159,460.06 /ls	159,460
				Water Treatment From Dewatered Areas	**1.00 ls**	**/ls**	**/ls**	**159,460.06 /ls**	**/ls**	**159,460.06 /ls**	**159,460**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,500,000.28 /ls	-	4,500,000.28 /ls	4,500,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,500,000.28 /ls**	**/ls**	**4,500,000.28 /ls**	**4,500,000**
			01562-0224	**Dewater Ponds - Pacer Ivy - 2 mo/Pond x 13 Ponds**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	637.84 /ea	-	637.84 /ea	8,292
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.06 /lf	12.83 /lf	-	-	14.90 /lf	38,729
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	426.74 /ea	3,232.30 /ea	-	-	3,659.04 /ea	47,567
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	247.62 /day	247.62 /day	193,146
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	168.25 /ea	690.04 /ea	-	-	858.29 /ea	11,158
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.65 /lf	8.47 /lf	-	-	10.13 /lf	98,719
				Attend Temporary Diesel Pumps	780.00 day	1,650.82 /day	-	-	-	1,650.82 /day	1,287,637
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,124
				Dewater Ponds - Pacer Ivy - 2 mo/Pond x 13 Ponds	**1.00 ls**	**1,318,956.00 /ls**	**166,977.90 /ls**	**8,291.93 /ls**	**193,145.53 /ls**	**1,687,371.36 /ls**	**1,687,371**
			02240-0200	**Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Space / 506sf/ea**							
				Design Dewatering System	41.70 acre	-	-	6,378.40 /acre	-	6,378.40 /acre	265,979
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,275.68 /ea	-	1,275.68 /ea	16,584
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.44 /lf	218.73 /lf	-	-	222.17 /lf	10,397,668
				Install Discharge Pipe- 6"	79,100.00 lf	1.65 /lf	13.79 /lf	-	-	15.44 /lf	1,221,028
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,602
				Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Space / 506sf/ea	**1.00 ls**	**305,136.25 /ls**	**11,327,161.87 /ls**	**282,563.22 /ls**	**/ls**	**11,914,861.34 /ls**	**11,914,861**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,624,092.25 /ls**	**11,494,139.77 /ls**	**4,950,315.49 /ls**	**193,145.53 /ls**	**18,261,693.04 /ls**	**18,261,693**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Pacer Ivy - Landfill - Fill Excavated Areas To Original Grade**							
				FILL from IMPORT	212,411.00 CY	0.96 /CY	-	-	5.30 /CY	6.27 /CY	1,330,664
				Import Gravel Fill - Material Only	212,411.00 cy	-	13.76 /cy	7.14 /cy	-	20.90 /cy	4,439,521
				Grade and Compact	212,411.00 cy	0.39 /cy	-	-	1.61 /cy	1.99 /cy	422,681
				Dump Truck - Haul	212,411.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	3,753,068
				Load - From Stockpile	212,411.00 cy	0.27 /cy	-	-	1.17 /cy	1.43 /cy	304,182
				Pacer Ivy - Landfill - Fill Excavated Areas To Original Grade	**212,411.00 cy**	**4.02 /cy**	**13.76 /cy**	**7.14 /cy**	**23.33 /cy**	**48.26 /cy**	**10,250,116**
				02.-- F&I Borrow - Bring Areas to Grade	**162,400.00 M3**	**5.26 /M3**	**17.99 /M3**	**9.34 /M3**	**30.52 /M3**	**63.12 /M3**	**10,250,116**
				012.-- Pacer Ivy - Landfill Site	**236,100.00 M3**	**16.47 /M3**	**61.06 /M3**	**27.39 /M3**	**49.57 /M3**	**154.50 /M3**	**36,476,891**
	016.--			**Pacer Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-0301	**Pacer Ivy - Landfill Liner**							
				Import Common Earth	71,414.00 cy	1.20 /cy	-	-	7.47 /cy	8.68 /cy	619,728
				GCL Clay Liner	489,758.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	132,879
				HDPE Liner 60 mils (1.5 mm)	489,758.00 sf	-	-	0.68 /sf	-	0.68 /sf	334,567
				Geocomposite Liner	489,758.00 sf	0.14 /sf	-	-	-	0.28 /sf	135,398
				HDPE Liner 60 mils (1.5 mm)	489,758.00 sf	-	-	0.68 /sf	-	0.68 /sf	334,567
				Geocomposite Liner	489,758.00 sf	0.14 /sf	-	-	-	0.28 /sf	135,398
				24" Sand Layer	35,707.00 cy	1.61 /cy	0.00 /cy	0.00 /cy	9.97 /cy	11.57 /cy	413,152
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	4,976.00 lf	0.65 /lf	3.41 /lf	-	-	4.05 /lf	20,167
				GCL	489,758.00 sf	0.14 /sf	0.14 /sf	-	-	0.28 /sf	135,398
				Linear Low Density PE Liner 40 mils (1 mm)	489,758.00 sf	-	0.32 /sf	0.15 /sf	-	0.47 /sf	230,609
				Geocomposite- 250 mils	489,758.00 sf	-	0.15 /sf	0.41 /sf	-	0.56 /sf	274,040
				Import Common Earth - 2 '	35,707.00 cy	1.20 /cy	0.00 /cy	0.00 /cy	7.47 /cy	8.68 /cy	309,864
				Loam 4"thk	6,000.00 cy	2.45 /cy	27.51 /cy	-	2.33 /cy	32.29 /cy	193,730
				Seeding Mechanical Methods	489,758.00 sf	-	-	0.08 /sf	-	0.08 /sf	37,486
				Import Sand Fill - Material Only	35,707.00 cy	-	24.76 /cy	7.14 /cy	-	31.91 /cy	1,139,270
				Import Common Earth - Material Only	107,121.00 cy	-	9.63 /cy	5.24 /cy	-	14.87 /cy	1,592,370
				Dump Truck - Haul	142,828.00 cy	2.41 /cy	-	-	15.26 /cy	17.67 /cy	2,523,613
				Load - From Stockpile	142,828.00 cy	0.27 /cy	-	-	1.17 /cy	1.43 /cy	204,536
				Pacer Ivy - Landfill Liner	**11.24 ac**	**76,129.81 /ac**	**218,953.88 /ac**	**159,913.31 /ac**	**312,861.26 /ac**	**779,961.98 /ac**	**8,766,773**
				03.-- F&I Landfill Liner	**45,500.00 M2**	**18.81 /M2**	**54.09 /M2**	**39.50 /M2**	**77.29 /M2**	**192.68 /M2**	**8,766,773**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill**							
				Place Soil and Sediment In Landfill	308,807.00 cy	0.70 /cy	-	-	4.47 /cy	5.17 /cy	1,596,936
				Decontamination Area	1,404.00 hr	88.04 /hr	-	-	108.27 /hr	196.31 /hr	275,619
				Place Excavated Soil and Sediment In Landfill	**308,807.00 cy**	**1.10 /cy**	**/cy**	**/cy**	**4.96 /cy**	**6.06 /cy**	**1,872,555**
				05.-- Place Excavated Soil/Sediment in Landfill	**236,100.00 M3**	**1.44 /M3**	**/M3**	**/M3**	**6.49 /M3**	**7.93 /M3**	**1,872,555**
				016.-- Pacer Area - Landfill	**236,100.00 M3**	**5.06 /M3**	**10.42 /M3**	**7.61 /M3**	**21.39 /M3**	**45.06 /M3**	**10,639,327**
				00.70 Pacer Ivy Area Landfill - Alternative 2A	**236,100.00 M3**	**22.58 /M3**	**77.68 /M3**	**36.47 /M3**	**82.76 /M3**	**220.06 /M3**	**51,955,532**

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	7,666,579		466,795 hrs	
Material	23,866,639			
Subcontract	13,100,536			
Equipment	29,454,104		597,671 hrs	
Other	180,896			
	74,268,754	**74,268,754**		
-				
Subtotal Direct Cost		**74,268,754**		
Indirect Costs:				
Sales Tax (MEO):				

Subtotal Prior to OH&P		**74,268,754**		

Subtotal for Prime Contractor		**74,268,754**		
Construction Contingency				

Subtotal Cost, Today's Dollars		**74,268,754**		
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016				
		74,268,754		

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 2A

Landfill – Passive

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 2A - Landfill (Passive)

Z1 Area Fixed Costs (not dependent on volume)			**Base Volume**			**Added Contingency Volume**		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 318,920	1	$ 318,920	$ 318,920	1	$ 318,920
01000-0301	Rebuild Interior Haul Roads	km	$ 267,430	3.3	$ 882,517	$ 267,430	3.3	$ 882,517
01000-0301	UXO Clearance	LS	$ 25,513	1	$ 25,513	$ 25,513	1	$ 25,513
02230-005	Clearing - Excavation Areas	m2	$ 0.86	178,627	$ 153,103	$ 1	178,627	$ 153,103
02230-005	Clearing - Containment Areas	m2	$ 0.86	59,893	$ 51,335	$ 1	59,893	$ 51,335
01000-0301	Water Treatment from Dewatered Areas	LS	$ 159,460.00	1	$ 159,460	$ 159,460	1	$ 159,460
01000-0301	Additional Dewatering and Fish Removal	LS	$ 2,000,000.00	1	$ 2,000,000	$ 2,000,000	1	$ 2,000,000
01562-0224	Dewater Ponds	LS	$ 389,393.00	1	$ 389,393	$ 389,393	1	$ 389,393
02240-0200	Dewatering System	lf	$ 1,845,970.00	1	$ 1,845,970	$ 1,845,970	1	$ 1,845,970
01000-0301	Z1 Landfill Liner	m2	$ 161.46	30,000	$ 4,843,814	$ 161	30,000	$ 4,843,814
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 462,944	1	$ 462,944	$ 551,593	1	$ 551,592.85
01590-0100	Traffic and Environmental Controls	LS	$ 827,493	1	$ 827,493	$ 985,949	1	$ 985,949
02310-01-2	Area Z1 - Excavation	cy	$ 24.33	27,598	$ 671,363	$ 24.33	32,883	$ 799,928
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 24.31	14,257	$ 346,638	$ 24.31	16,987	$ 413,013
02310-01-2	Southwest Area - Excavation	cy	$ 24.32	79,262	$ 1,927,826	$ 24.32	94,440	$ 2,296,989
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 27.11	1,700	$ 46,091	$ 27.11	2,026	$ 54,930
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 27.08	23,282	$ 630,394	$ 27.08	27,740	$ 751,100
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 63.12	92,600	$ 5,844,580	$ 63.12	110,332	$ 6,963,760
02310-01-3	Place Excavated Soil in Landfill	m3	$ 7.93	111,700	$ 885,867	$ 7.93	133,089	$ 1,055,498
				Subtotal	**$ 22,313,220**		**Subtotal**	**$ 24,542,786**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 318,920	1	$ 318,920	$ 318,920	1	$ 318,920
01000-0301	Rebuild Interior Haul Roads	km	$ 274,736	7.7	$ 2,115,466	$ 274,736	7.7	$ 2,115,466
01000-0301	UXO Clearance	LS	$ 25,514	1	$ 25,514	$ 25,514	1	$ 25,514
02230-005	Clearing - Excavation Areas	m2	$ 0.86	150,500	$ 129,031	$ 1	150,500	$ 129,031
02230-005	Clearing - Containment Areas	m2	$ 0.86	69,606	$ 59,660	$ 1	69,606	$ 59,660
01000-0301	Water Treatment from Dewatered Areas	LS	$ 159,460.00	1	$ 159,460	$ 159,460	1	$ 159,460
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,500,000.00	1	$ 4,500,000	$ 4,500,000	1	$ 4,500,000
01562-0224	Dewater Ponds	LS	$ 1,687,371.00	1	$ 1,687,371	$ 1,687,371	1	$ 1,687,371
02240-0200	Dewatering System	lf	$11,914,861.00	1	$ 11,914,861	$ 11,914,861	1	$ 11,914,861
01000-0301	Pacer Ivy Landfill Liner	m2	$ 192.68	45,500	$ 8,766,773	$ 193	45,500	$ 8,766,773
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,251,924	1	$ 1,251,924	$ 1,491,654	1	$ 1,491,654.13
01590-0100	Traffic and Environmental Controls	LS	$ 1,127,490	1	$ 1,127,490	$ 1,343,392	1	$ 1,343,392
02310-01-2	Pacer Ivy Area - Excavation	cy	$ 24.32	167,549	$ 4,075,298	$ 24.32	199,633	$ 4,855,677
02310-01-2	Northwest Area - Excavation - Sediment	cy	$ 27.07	8,632	$ 233,702	$ 27.07	10,285	$ 278,455
02310-01-2	North Area - Excavation	cy	$ 24.33	44,863	$ 1,091,320	$ 24.33	53,454	$ 1,300,302
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 27.07	32,699	$ 885,280	$ 27.07	38,961	$ 1,054,815
02310-01-2	Pacer Ivy Area Excavation - Sediment	cy	$ 27.07	55,065	$ 1,490,792	$ 27.07	65,609	$ 1,776,253
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 63.12	162,400	$ 10,250,116	$ 63.12	193,498	$ 12,212,913
02310-01-3	Place Excavated Soil in Landfill	m3	$ 7.93	236,100	$ 1,872,555	$ 7.93	281,311	$ 2,231,132
				Subtotal	**$ 51,955,532**		**Subtotal**	**$ 56,221,648**
				Total	**$ 74,268,752**		**Total**	**$ 80,764,434**

Price Increase due to Contingency Volume $ 6,495,682
Percentage Increase in Price 8.75%
Percentage Increase in Volume 19.15%

1. Construction Capital Costs (Years 1 through 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 80,764,434	$80,764,434	From detailed cost estimate
Contingency (Scope and Bid)	30%			$24,229,330	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$104,994,000	Rounded to nearest $1,000
Project Management	5%			$5,249,700	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$6,299,640	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$5,249,700	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$124,793,040	
TOTAL CONSTRUCTION CAPITAL COST				**$124,793,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	6	YR	**$20,799,000**		Average annual capital cost over the assumed

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$367,833	$367,833	Sampling/analysis required by the EMMP
Contingency (Scope and Bid)	30%			$110,350	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$479,000	Rounded to nearest $1,000
Project Management	10%			$47,900	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$71,850	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$23,950	Assumed to apply to 50% of the EMMP implementation
TOTAL				$622,700	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$623,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	6	YR	$623,000	**$3,738,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	44	YR	$115,000	**$5,060,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	44	YR	$69,000	**$3,036,000**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative				**$136,627,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2A Landfill (Passive)
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$20,799,000	$623,000	$0	$0	$21,422,000	0.9346	$20,021,001
2	$20,799,000	$623,000	$0	$0	$21,422,000	0.8734	$18,709,975
3	$20,799,000	$623,000	$0	$0	$21,422,000	0.8163	$17,486,779
4	$20,799,000	$623,000	$0	$0	$21,422,000	0.7629	$16,342,844
5	$20,799,000	$623,000	$0	$0	$21,422,000	0.7130	$15,273,886
6	$20,799,000	$623,000	$0	$0	$21,422,000	0.6663	$14,273,479
7	$0	$0	$115,000	$69,000	$184,000	0.6227	$114,577
8	$0	$0	$115,000	$69,000	$184,000	0.5820	$107,088
9	$0	$0	$115,000	$69,000	$184,000	0.5439	$100,078
10	$0	$0	$115,000	$69,000	$184,000	0.5083	$93,527
11	$0	$0	$115,000	$69,000	$184,000	0.4751	$87,418
12	$0	$0	$115,000	$69,000	$184,000	0.4440	$81,696
13	$0	$0	$115,000	$69,000	$184,000	0.4150	$76,360
14	$0	$0	$115,000	$69,000	$184,000	0.3878	$71,355
15	$0	$0	$115,000	$69,000	$184,000	0.3624	$66,682
16	$0	$0	$115,000	$69,000	$184,000	0.3387	$62,321
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$124,794,000	$3,738,000	$5,060,000	$3,036,000	**$136,628,000**		$103,770,186
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$103,770,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 2A

Landfill – Active

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2A Landfill (Active)
Description: The landfill alternative will consist of: (1) constructing two landfills, one in the Z1 Area and one in the Pacer Ivy Area; (2) excavating, dewatering, and transporting contaminated soils and sediments to the landfills; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$82,768,754	$82,768,754	From detailed cost estimate
Contingency (Scope and Bid)	30%			$24,830,626	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$107,599,000	Rounded to nearest $1,000
Project Management	5%			$5,379,950	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$6,455,940	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$5,379,950	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$127,814,840	
TOTAL CONSTRUCTION CAPITAL COST				**$127,815,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	5	YR	**$25,563,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 5)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$372,740	$372,740	Sampling/analysis required by the EMMP; assume 0.5% of construction cost.
Contingency (Scope and Bid)	30%			$111,822	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$485,000	Rounded to nearest $1,000
Project Management	10%			$48,500	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$72,750	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$24,250	Assumed to apply to 50% of the EMMP implementation
TOTAL				$630,500	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$631,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	5	YR	$631,000	**$3,155,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 6 to 15)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$105,053	$105,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction.
Contingency (Scope and Bid)	30%			$31,516	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$136,569	
Project Management	10%			$13,657	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$20,485	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$6,828	Assumed to apply to 50% of the EMMP implementation
TOTAL				$177,539	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$178,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	10	YR	$178,000	**$1,780,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 6 to 15)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$105,053	$105,053	Includes annual landfill O&M; assume 0.5% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$31,516	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$136,569	
Project Management	10%			$13,657	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$20,485	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$6,828	Assumed to apply to 50% of the O&M
TOTAL				$177,539	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$178,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	10	YR	$178,000	**$1,780,000**	Total O&M Cost over the assumed duration.

5. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 16 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	35	YR	$115,000	**$4,025,000**	Total O&M Cost over the assumed duration.

6. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 16 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.5% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	35	YR	$69,000	**$2,415,000**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative 2A Landfill (Active)				**$140,970,000**	Assuming no discount factor

Notes:
The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.
Given the lack of performance data it is conservatively assumed that the active landfill will not perform, and after 10 years of monitoring, Monitoring and Maintenance effort will be the same as a passive landfill.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2A Landfill (Active)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$25,563,000	$631,000	$0	$0	$26,194,000	0.9346	$24,480,912
2	$25,563,000	$631,000	$0	$0	$26,194,000	0.8734	$22,877,840
3	$25,563,000	$631,000	$0	$0	$26,194,000	0.8163	$21,382,162
4	$25,563,000	$631,000	$0	$0	$26,194,000	0.7629	$19,983,403
5	$25,563,000	$631,000	$0	$0	$26,194,000	0.7130	$18,676,322
6	$0	$0	$178,000	$178,000	$356,000	0.6663	$237,203
7	$0	$0	$178,000	$178,000	$356,000	0.6227	$221,681
8	$0	$0	$178,000	$178,000	$356,000	0.5820	$207,192
9	$0	$0	$178,000	$178,000	$356,000	0.5439	$193,628
10	$0	$0	$178,000	$178,000	$356,000	0.5083	$180,955
11	$0	$0	$178,000	$178,000	$356,000	0.4751	$169,136
12	$0	$0	$178,000	$178,000	$356,000	0.4440	$158,064
13	$0	$0	$178,000	$178,000	$356,000	0.4150	$147,740
14	$0	$0	$178,000	$178,000	$356,000	0.3878	$138,057
15	$0	$0	$178,000	$178,000	$356,000	0.3624	$129,014
16	$0	$0	$115,000	$69,000	$184,000	0.3387	$62,321
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$127,815,000	$3,155,000	$5,805,000	$4,195,000	**$140,970,000**		$110,046,750
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$110,047,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 2A

Landfill – Active

(Baseline with Contingency Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2A Landfill (Active with Contingency Volume)
Description: The landfill alternative will consist of: (1) constructing two landfills, one in the Z1 Area and one in the Pacer Ivy Area; (2) excavating, dewatering, and transporting contaminated soils and sediments to the landfills; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$90,764,434	$90,764,434	From detailed cost estimate
Contingency (Scope and Bid)	30%			$27,229,330	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$117,994,000	Rounded to nearest $1,000
Project Management	5%			$5,899,700	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$7,079,640	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$5,899,700	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$139,873,040	
TOTAL CONSTRUCTION CAPITAL COST				**$139,873,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	6	YR	**$23,312,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$408,748	$408,748	Sampling/analysis required by the EMMP; assume 0.5% of construction cost.
Contingency (Scope and Bid)	30%			$122,624	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$532,000	Rounded to nearest $1,000
Project Management	10%			$53,200	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$79,800	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$26,600	Assumed to apply to 50% of the EMMP implementation
TOTAL				$691,600	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$692,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	6	YR	$692,000	**$4,152,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 7 to 16)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$105,053	$105,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction.
Contingency (Scope and Bid)	30%			$31,516	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$136,569	
Project Management	10%			$13,657	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$20,485	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$6,828	Assumed to apply to 50% of the EMMP implementation
TOTAL				$177,539	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$178,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	10	YR	$178,000	**$1,780,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 7 to 16)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$105,053	$105,053	Includes annual landfill O&M; assume 0.5% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$31,516	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$136,569	
Project Management	10%			$13,657	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$20,485	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$6,828	Assumed to apply to 50% of the O&M
TOTAL				$177,539	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$178,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	10	YR	$178,000	**$1,780,000**	Total O&M Cost over the assumed duration.

5. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 17 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	34	YR	$115,000	**$3,910,000**	Total O&M Cost over the assumed duration.

6. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 17 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.5% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	34	YR	$69,000	**$2,346,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 2A Landfill (Active with Contingency Volume)	**$153,841,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.
Given the lack of performance data it is conservatively assumed that the active landfill will not perform, and after 10 years of monitoring, Monitoring and Maintenance effort will be the same as a passive landfill.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2A Landfill (Active with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$23,312,000	$692,000	$0	$0	$24,004,000	0.9346	$22,434,138
2	$23,312,000	$692,000	$0	$0	$24,004,000	0.8734	$20,965,094
3	$23,312,000	$692,000	$0	$0	$24,004,000	0.8163	$19,594,465
4	$23,312,000	$692,000	$0	$0	$24,004,000	0.7629	$18,312,652
5	$23,312,000	$692,000	$0	$0	$24,004,000	0.7130	$17,114,852
6	$23,312,000	$692,000	$0	$0	$24,004,000	0.6663	$15,993,865
7	$0	$0	$178,000	$178,000	$356,000	0.6227	$221,681
8	$0	$0	$178,000	$178,000	$356,000	0.5820	$207,192
9	$0	$0	$178,000	$178,000	$356,000	0.5439	$193,628
10	$0	$0	$178,000	$178,000	$356,000	0.5083	$180,955
11	$0	$0	$178,000	$178,000	$356,000	0.4751	$169,136
12	$0	$0	$178,000	$178,000	$356,000	0.4440	$158,064
13	$0	$0	$178,000	$178,000	$356,000	0.4150	$147,740
14	$0	$0	$178,000	$178,000	$356,000	0.3878	$138,057
15	$0	$0	$178,000	$178,000	$356,000	0.3624	$129,014
16	$0	$0	$178,000	$178,000	$356,000	0.3387	$120,577
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$139,872,000	$4,152,000	$5,690,000	$4,126,000	**$153,840,000**		$116,882,230
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$116,882,000**

Notes:

1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.

2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.

3 Total annual expenditure is the total cost per year with no discounting.

4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.

5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 2B

Solidification/Stabilization

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 2B Solidification/Stabilization
Description: The solidification/stabilization alternative will consist of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Mix the soils with admixtures (binders, stabilizers, etc.) to solidify and stabilize the soil and affix the dioxin; (3) stockpile the solidified soils in centralized stockpiles, and (4) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$123,293,670	$123,293,670	From detailed cost estimate
Contingency (Scope and Bid)	30%			$36,988,101	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$160,282,000	Rounded to nearest $1,000
Project Management	5%			$8,014,100	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$9,616,920	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$8,014,100	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$188,927,120	
TOTAL CONSTRUCTION CAPITAL COST				**$188,927,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	6	YR	**$31,488,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 6)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$525,261	$525,261	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$157,578	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$683,000	Rounded to nearest $1,000
Project Management	10%			$68,300	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$102,450	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$34,150	Assumed to apply to 50% of the EMMP implementation
TOTAL				$887,900	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$888,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	6	YR	$888,000	**$5,328,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assumed to be same as landfill monitoring.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	44	YR	$115,000	**$5,060,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 7 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Sampling/analysis required by the EMMP; assumed to be same as landfill monitoring.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, stabilization cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	44	YR	$69,000	**$3,036,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 2B Solidification/Stabilization	**$202,351,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2B Solidification/Stabilization

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$31,488,000	$888,000	$0	$0	$32,376,000	0.9346	$30,258,610
2	$31,488,000	$888,000	$0	$0	$32,376,000	0.8734	$28,277,198
3	$31,488,000	$888,000	$0	$0	$32,376,000	0.8163	$26,428,529
4	$31,488,000	$888,000	$0	$0	$32,376,000	0.7629	$24,699,650
5	$31,488,000	$888,000	$0	$0	$32,376,000	0.7130	$23,084,088
6	$31,488,000	$888,000	$1	$0	$32,376,001	0.6663	$21,572,129
7	$0	$0	$115,000	$69,000	$184,000	0.6227	$114,577
8	$0	$0	$115,000	$69,000	$184,000	0.5820	$107,088
9	$0	$0	$115,000	$69,000	$184,000	0.5439	$100,078
10	$0	$0	$115,000	$69,000	$184,000	0.5083	$93,527
11	$0	$0	$115,000	$69,000	$184,000	0.4751	$87,418
12	$0	$0	$115,000	$69,000	$184,000	0.4440	$81,696
13	$0	$0	$115,000	$69,000	$184,000	0.4150	$76,360
14	$0	$0	$115,000	$69,000	$184,000	0.3878	$71,355
15	$0	$0	$115,000	$69,000	$184,000	0.3624	$66,682
16	$0	$0	$115,000	$69,000	$184,000	0.3387	$62,321
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$188,928,000	$5,328,000	$5,060,001	$3,036,000	**$202,352,001**		$155,982,426
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$155,982,000**

Notes:

1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.

2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.

3 Total annual expenditure is the total cost per year with no discounting.

4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.

5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternate 2B S/S
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver: **ENR 20 City CCI:**	Database Version 7.0 October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.60				**Z1 Area- - Alternative 2B - S/S**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	12,347.00 md	-	-	-	41.05 /md	41.05 /md	506,868
				Resperators - One Ea Man	40.00 ea	-	-	-	68.42 /ea	68.42 /ea	2,737
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**509,604.78 /ls**	**509,604.78 /ls**	**509,605**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	317,099.28 /ls	-	317,099.28 /ls	317,099
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**317,099.28 /ls**	**/ls**	**317,099.28 /ls**	**317,099**
			01000-0301	**Reconstruct Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.74 /sy	-	-	4.78 /sy	5.51 /sy	103,518
				Fine Grade Haul Roads	18,775.00 sy	0.44 /sy	-	-	1.70 /sy	2.13 /sy	40,060
				Pave Haul Roads	5,800.00 ton	2.10 /ton	-	-	7.81 /ton	9.91 /ton	57,464
				Haul Bituminous Concrete	5,800.00 ton	1.92 /ton	102.63 /ton	-	12.15 /ton	116.69 /ton	676,802
				Reconstruct Interior Haul Roads	**3.30 KM**	**13,750.89 /KM**	**180,379.62 /KM**	**/KM**	**71,883.16 /KM**	**266,013.67 /KM**	**877,845**
			01590-0100	**Traffic and Enviromental Controls -5,367 CH = 600 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.71 /sf	16.42 /sf	-	-	18.13 /sf	3,481
				Plastic Snow Fence	10,000.00 lf	1.17 /lf	4.11 /lf	-	-	5.28 /lf	52,781
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	60.00 wk	-	-	-	1,525.49 /wk	1,525.49 /wk	91,529
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	60.00 wk	-	-	-	3,337.79 /wk	3,337.79 /wk	200,268
				Maintain Haul Rds - Grader- Cat 14/RLV	60.00 wk	1,532.61 /wk	-	-	6,384.94 /wk	7,917.55 /wk	475,053
				Traffic and Enviromental Controls -5,367 CH = 600 CD	**1.00 ls**	**104,013.84 /ls**	**44,204.67 /ls**	**/ls**	**674,893.46 /ls**	**823,111.97 /ls**	**823,112**
				06.-- -----							2,527,661
				009.-- Site and Traffic Controls	1.00 ls	149,391.77 /ls	639,457.42 /ls	317,099.28 /ls	1,421,712.66 /ls	2,527,661.13 /ls	2,527,661
	009.5										
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,536.79 /ea	-	2,536.79 /ea	25,368
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,367.94 /ls**	**/ls**	**25,367.94 /ls**	**25,368**
				06.-- -----							25,368
				009.5	1.00 ls	/ls	/ls	25,367.94 /ls	/ls	25,367.94 /ls	25,368
	010.--			Z1 Area -							
		00.9		Clearing Piles and Excavated Areas							
			02230-005	**Clearing For Containment Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	18.80 ac	1,401.24 /ac	-	-	2,048.98 /ac	3,450.22 /ac	64,864
				Clearing For Containment Areas	**76,000.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**64,864**
			02230-005	**Clearing ForExcavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	44.14 ac	1,401.24 /ac	-	-	2,048.98 /ac	3,450.22 /ac	152,293
				Clearing ForExcavated Areas	**178,626.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**152,293**
				00.9 Clearing Piles and Excavated Areas	25.50 ha	3,458.59 /ha	/ha	/ha	5,057.37 /ha	8,515.96 /ha	217,157
		01.--		Excavate Soil/Sediment to Containment Area							
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Soil**							
				Cut to Waste - (2 excavators)	27,598.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	114,703
				Dump Truck	27,598.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	485,045
				Project Health & Safety Technician	288.00 hr	13.68 /hr	-	-	-	13.68 /hr	3,941
				Level 2 Survey Crew	288.00 hr	27.37 /hr	-	-	-	27.37 /hr	7,882
				Decontamination Area	288.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	56,238
				Area Z1 Cut to Stockpile - Containment Soil	**27,598.00 cy**	**4.14 /cy**	**/cy**	**/cy**	**20.06 /cy**	**24.20 /cy**	**667,809**
			02310-01-2	**Area Z1 Taxiway - Containment Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	59,255
				Dump Truck	14,257.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	250,572
				Project Health & Safety Technician	148.00 hr	13.68 /hr	-	-	-	13.68 /hr	2,025
				Level 2 Survey Crew	148.00 hr	27.37 /hr	-	-	-	27.37 /hr	4,050
				Decontamination Area	148.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	28,900
				Area Z1 Taxiway - Containment Soil	**14,257.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.06 /cy**	**24.19 /cy**	**344,803**
			02310-01-2	**Southwest Area - Containment -Soil**							
				Cut to Waste - (2 excavators)	79,262.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	329,430
				Dump Truck	79,262.00 sf	2.40 /sf	-	-	15.18 /sf	17.58 /sf	1,393,057
				Project Health & Safety Technician	825.70 hr	13.68 /hr	-	-	-	13.68 /hr	11,299
				Level 2 Survey Crew	825.70 hr	27.37 /hr	-	-	-	27.37 /hr	22,598
				Decontamination Area	825.70 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	161,235
				Southwest Area - Containment -Soil	**79,262.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.06 /cy**	**24.19 /cy**	**1,917,619**
			02310-01-2	**Gate 2 Lake - 1 cd -- Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	7,066
				Dump Truck	1,700.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	29,878
				Project Health & Safety Technician	18.00 hr	13.68 /hr	-	-		13.68 /hr	246
				Level 2 Survey Crew	18.00 hr	27.37 /hr	-	-	-	27.37 /hr	493
				Decontamination Area	18.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	3,515
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.22 /cy	2.74 /cy	4,649
				Gate 2 Lake - 1 cd -- Sediment	**1,700.00 cy**	**4.67 /cy**	**/cy**	**/cy**	**22.30 /cy**	**26.97 /cy**	**45,847**
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	96,765
				Dump Truck	23,282.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	409,189
				Project Health & Safety Technician	243.00 hr	13.68 /hr	-	-		13.68 /hr	3,325
				Level 2 Survey Crew	243.00 hr	27.37 /hr	-	-	-	27.37 /hr	6,650

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Area Z1 Cut to Stockpile - Containment Sediment**							
				Decontamination Trailer	243.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	47,451
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 cy	0.51 /cy	-	-	2.22 /cy	2.74 /cy	63,676
				Area Z1 Cut to Stockpile - Containment Sediment	**23,282.00 cy**	**4.65 /cy**	**/cy**	**/cy**	**22.29 /cy**	**26.93 /cy**	**627,056**
				01.-- Excavate Soil/Sediment to Containment Area	**146,098.00 cy**	**4.22 /cy**	**/cy**	**/cy**	**20.44 /cy**	**24.66 /cy**	**3,603,134**
		01.055		**Treatment**							
			01000-0301	**Treatment**							
				Treatment Costs	146,098.00 cy	-	-	97.67 /cy	-	97.67 /cy	14,268,892
				Treatment	**146,098.00 cy**	**/cy**	**/cy**	**97.67 /cy**	**/cy**	**97.67 /cy**	**14,268,892**
				01.055 Treatment	**111,700.00 M3**	**/M3**	**/M3**	**127.74 /M3**	**/M3**	**127.74 /M3**	**14,268,892**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	1,999,927.51 /ls	-	1,999,927.51 /ls	1,999,928
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**1,999,927.51 /ls**	**/ls**	**1,999,927.51 /ls**	**1,999,928**
			01000-0301	**Water Treatment From Dewatered Areas**							
				Watered Treatment From Dewatered Areas	1.00 ls	-	-	202,258.61 /ls	-	202,258.61 /ls	202,259
				Water Treatment From Dewatered Areas	**1.00 ls**	**/ls**	**/ls**	**202,258.61 /ls**	**/ls**	**202,258.61 /ls**	**202,259**
			01562-0224	**Dewater Ponds - Z1 Area - 2 mo per pond x 3ea**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	634.20 /ea	-	634.20 /ea	1,903
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.05 /lf	12.76 /lf	-	-	14.82 /lf	8,890
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	424.48 /ea	3,215.19 /ea	-	-	3,639.66 /ea	10,919
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	246.31 /day	246.31 /day	44,336
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	167.35 /ea	686.39 /ea	-	-	853.74 /ea	2,561
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.64 /lf	8.43 /lf	-	-	10.07 /lf	22,661
				Attend Temporary Diesel Pumps	180.00 day	1,642.08 /day	-	-	-	1,642.08 /day	295,574
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	487
				Dewater Ponds - Z1 Area - 2 mo per pond x 3ea	**1.00 ls**	**302,763.00 /ls**	**38,329.35 /ls**	**1,902.59 /ls**	**44,336.06 /ls**	**387,331.00 /ls**	**387,331**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m Space/506sf/ea**							
				Design Dewatering System	8.50 acre	-	-	6,341.99 /acre	-	6,341.99 /acre	53,907
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,268.40 /ea	-	1,268.40 /ea	3,805
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.42 /lf	217.58 /lf	-	-	221.00 /lf	1,591,172
				Install Discharge Pipe- 6"	12,063.00 lf	1.64 /lf	13.71 /lf	-	-	15.36 /lf	185,225
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,063
				Z1 Area -33,800M2 - 363,800 sf @7.5m Space/506sf/ea	**7,200.00 lf**	**6.46 /lf**	**240.55 /lf**	**8.02 /lf**	**/lf**	**255.02 /lf**	**1,836,172**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**349,265.88 /ls**	**1,770,286.77 /ls**	**2,261,800.80 /ls**	**44,336.06 /ls**	**4,425,689.51 /ls**	**4,425,690**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1 Containment- Fill Excavated Areas To Original Grade**							
				FILL from IMPORT	121,116.00 CY	0.96 /CY	-	-	5.27 /CY	6.23 /CY	754,723
				Import Gravel Fill - Material Only	121,116.00 cy	-	13.68 /cy	7.10 /cy	-	20.79 /cy	2,517,638
				Grade and Compact	121,116.00 cy	0.38 /cy	-	-	1.60 /cy	1.98 /cy	239,735
				Dump Truck - Haul	121,116.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	2,128,656
				Load - From Stockpile	121,116.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	172,525
				Area Z-1 Containment- Fill Excavated Areas To Original Grade	**121,116.00 cy**	**4.00 /cy**	**13.68 /cy**	**7.10 /cy**	**23.21 /cy**	**48.00 /cy**	**5,813,278**
				02.-- F&I Borrow - Bring Areas to Grade	**92,600.00 M3**	**5.23 /M3**	**17.90 /M3**	**9.29 /M3**	**30.36 /M3**	**62.78 /M3**	**5,813,278**
				010.-- Z1 Area -	**111,700.00 M3**	**13.78 /M3**	**30.69 /M3**	**155.69 /M3**	**53.45 /M3**	**253.61 /M3**	**28,328,149**
	015.--			**Z1 Area - Pile Construction**							
		03.10		**F&I Pile Cap**							
			01000-0301	**Z-1 - -Cap System**							
				Import Common Earth	23,543.00 cy	1.20 /cy	-	-	7.44 /cy	8.63 /cy	203,224
				GCL Liner	322,917.00 sf	-	-	0.25 /sf	-	0.25 /sf	81,917
				Linear Low Density PE Liner 40 mils (1 mm)	322,917.00 sf	-	-	0.44 /sf	-	0.44 /sf	143,355
				Geocomposite Liner	322,917.00 sf	0.14 /sf	-	-	-	0.28 /sf	88,801
				Import Common Earth	23,543.00 cy	2.07 /cy	0.00 /cy	0.00 /cy	11.39 /cy	13.46 /cy	316,805
				Loam	3,950.00 cy	2.43 /cy	27.37 /cy	-	2.32 /cy	32.12 /cy	126,864
				Seeding Mechanical Methods	322,917.00 sf	-	-	0.08 /sf	-	0.08 /sf	24,575
				Import Common Earth - Material Only	47,086.00 cy	-	9.58 /cy	5.21 /cy	-	14.78 /cy	696,133
				Load - From Stockpile	47,086.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	67,072
				Dump Truck - Haul	47,086.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	827,553
				Z-1 - -Cap System	**7.41 AC**	**34,543.85 /AC**	**75,456.12 /AC**	**66,795.46 /AC**	**164,862.69 /AC**	**347,678.72 /AC**	**2,576,299**
				03.10 F&I Pile Cap	**30,000.00 m2**	**8.53 /m2**	**18.64 /m2**	**16.50 /m2**	**40.72 /m2**	**85.88 /m2**	**2,576,299**
		05.10		**Place Treated Material in Pile**							
			02310-01-2	**Place Treated Material in Pile**							
				Place Treated Soil In Pile	146,098.00 CY	1.28 /CY	-	-	8.15 /CY	9.43 /CY	1,377,783
				Load Trucks	146,098.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	208,111
				Dump Truck - Haul	146,098.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	2,567,724
				Place Treated Material in Pile	**146,098.00 cy**	**3.94 /cy**	**/cy**	**/cy**	**24.49 /cy**	**28.43 /cy**	**4,153,617**
				05.10 Place Treated Material in Pile	**111,700.00 m3**	**5.15 /m3**	**/m3**	**/m3**	**32.04 /m3**	**37.19 /m3**	**4,153,617**
				015.-- Z1 Area - Pile Construction	**30,000.00 m2**	**27.71 /m2**	**18.64 /m2**	**16.50 /m2**	**160.00 /m2**	**224.33 /m2**	**6,729,917**
				00.60 Z1 Area- - Alternative 2B - S/S	**111,700.00 M3**	**22.56 /M3**	**41.42 /M3**	**163.19 /M3**	**109.15 /M3**	**336.72 /M3**	**37,611,095**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.70				**Pacer Ivy Area - Alternative 2B - S/S**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	34,581.00 md	-	-	-	41.05 /md	41.05 /md	1,419,616
				Resperators - One Ea Man	80.00 ea	-	-	-	68.42 /ea	68.42 /ea	5,474
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,425,089.81 /ls**	**1,425,089.81 /ls**	**1,425,090**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	317,099.28 /ls	-	317,099.28 /ls	317,099
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**317,099.28 /ls**	**/ls**	**317,099.28 /ls**	**317,099**
			01000-0301	**Reconstruct Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.74 /sy	-	-	4.78 /sy	5.51 /sy	248,422
				Fine Grade Haul Roads	45,056.00 sy	0.44 /sy	-	-	1.70 /sy	2.13 /sy	96,136
				Pave Haul Roads	13,900.00 ton	2.10 /ton	-	-	7.81 /ton	9.91 /ton	137,716
				Haul Bituminous Concrete	13,900.00 ton	1.92 /ton	102.63 /ton	-	12.15 /ton	116.69 /ton	1,621,992
				Reconstruct Interior Haul Roads	**7.70 KM**	**14,132.75 /KM**	**185,266.75 /KM**	**/KM**	**73,881.76 /KM**	**273,281.26 /KM**	**2,104,266**
			01590-0100	**Traffic and Enviromental Controls**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.71 /sf	16.42 /sf	-	-	18.13 /sf	3,481
				Wood Snow Fence	6,000.00 lf	1.17 /lf	4.11 /lf	-	-	5.28 /lf	31,669
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	85.00 wk	-	-	-	1,525.49 /wk	1,525.49 /wk	129,667
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	85.00 wk	-	-	-	3,337.79 /wk	3,337.79 /wk	283,713
				Maintain Haul Rds - Grader- Cat 14/RLV	85.00 wk	1,532.61 /wk	-	-	6,384.94 /wk	7,917.55 /wk	672,991
				Traffic and Enviromental Controls	**1.00 ls**	**137,637.30 /ls**	**27,783.94 /ls**	**/ls**	**956,099.05 /ls**	**1,121,520.29 /ls**	**1,121,520**
				06.-- -----							4,967,975
				009.-- Site and Traffic Controls	1.00 ls	246,459.44 /ls	1,454,337.94 /ls	317,099.28 /ls	2,950,078.45 /ls	4,967,975.11 /ls	4,967,975
	009.5										
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,536.79 /ea	-	2,536.79 /ea	25,368
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,367.93 /ls**	**/ls**	**25,367.93 /ls**	**25,368**
				06.-- -----							25,368
				009.5	1.00 ls	/ls	/ls	25,367.93 /ls	/ls	25,367.93 /ls	25,368
	012.--			Pacer Ivy -							
		00.9		Clearing Piles and Excavated Areas							
			02230-005	**Site Clearing - Containment Areas**							
				Clear & Grub Light Trees,	15.20 ac	1,401.24 /ac	-	-	2,048.98 /ac	3,450.22 /ac	52,443
				Site Clearing - Containment Areas	**61,690.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**52,443**
			02230-005	**Site Clearing - Excavated Areas**							
				Clear & Grub Light Trees, 14.8 ac	37.20 ac	1,401.24 /ac	-	-	2,048.98 /ac	3,450.22 /ac	128,348
				Site Clearing - Excavated Areas	**150,500.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**128,348**
				00.9 Clearing Piles and Excavated Areas	21.20 ha	3,463.44 /ha	/ha	/ha	5,064.47 /ha	8,527.91 /ha	180,792
		01.--		Excavate Soil/Sediment to Containment Area							
			02310-01-2	**Pacer Ivy Cut to Stockpile - Containment -**							
				Cut to Waste - (2 excavators)	167,549.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	696,371
				Dump Truck	167,549.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	2,944,732
				Project Health & Safety Technician	1,746.00 hr	13.68 /hr	-	-	-	13.68 /hr	23,892
				Level 2 Survey Crew	1,746.00 hr	27.37 /hr	-	-	-	27.37 /hr	47,784
				Decontamination Area	1,746.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	340,942
				Pacer Ivy Cut to Stockpile - Containment -	**167,549.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.06 /cy**	**24.19 /cy**	**4,053,722**
			02310-01-2	**Northwest Area - Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	35,877
				Dump Truck	8,632.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	151,710
				Project Health & Safety Technician	90.00 hr	13.68 /hr	-	-	-	13.68 /hr	1,232
				Level 2 Survey Crew	90.00 hr	27.37 /hr	-	-	-	27.37 /hr	2,463
				Decontamination Trailer	90.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	17,574
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.22 /cy	2.74 /cy	23,608
				Northwest Area - Cut to Stockpile - Sediment	**8,632.00 cy**	**4.65 /cy**	**/cy**	**/cy**	**22.29 /cy**	**26.93 /cy**	**232,464**
			02310-01-2	**North Area - Cut to Stockpile - Containment**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	186,461
				Dump Truck	44,863.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	788,483
				Project Health & Safety Technician	468.00 hr	13.68 /hr	-	-	-	13.68 /hr	6,404
				Level 2 Survey Crew	468.00 hr	27.37 /hr	-	-	-	27.37 /hr	12,808
				Decontamination Area	468.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	91,386
				North Area - Cut to Stockpile - Containment	**44,863.00 cy**	**4.14 /cy**	**/cy**	**/cy**	**20.06 /cy**	**24.20 /cy**	**1,085,542**
			02310-01-2	**North East Area - Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	135,904
				Dump Truck	32,699.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	574,696
				Project Health & Safety Technician	341.00 hr	13.68 /hr	-	-	-	13.68 /hr	4,666
				Level 2 Survey Crew	341.00 hr	27.37 /hr	-	-	-	27.37 /hr	9,332
				Decontamination Area	341.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	66,587
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,699.00 cy	0.51 /cy	-	-	2.22 /cy	2.74 /cy	89,431
				North East Area - Cut to Stockpile - Sediment	**32,699.00 cy**	**4.65 /cy**	**/cy**	**/cy**	**22.29 /cy**	**26.93 /cy**	**880,617**
			02310-01-2	**Pacer Ivy Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	55,065.00 cy	0.40 /cy	-	-	3.76 /cy	4.16 /cy	228,862
				Dump Truck	55,065.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	967,787
				Project Health & Safety Technician	574.00 hr	13.68 /hr	-	-	-	13.68 /hr	7,855

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Pacer Ivy Cut to Stockpile - Sediment**							
				Level 2 Survey Crew	574.00 hr	27.37 /hr	-	-	-	27.37 /hr	15,709
				Decontamination Area	574.00 hr	87.58 /hr	-	-	107.69 /hr	195.27 /hr	112,085
				Articulated Wheel Loader Cat 938 140HP 2.75cy	55,065.00 cy	0.51 /cy	-	-	2.22 /cy	2.74 /cy	150,601
				Pacer Ivy Cut to Stockpile - Sediment	**55,065.00 cy**	**4.65 /cy**	**/cy**	**/cy**	**22.28 /cy**	**26.93 /cy**	**1,482,899**
				01.-- Excavate Soil/Sediment to Containment Area	**308,807.00 cy**	**4.29 /cy**	**/cy**	**/cy**	**20.76 /cy**	**25.05 /cy**	**7,735,244**
		01.055		**Treatment**							
			01000-0301	**Treatment**							
				Treatment Costs	308,807.00 cy	-	-	97.67 /cy	-	97.67 /cy	30,160,123
				Treatment	**308,807.00 cy**	**/cy**	**/cy**	**97.67 /cy**	**/cy**	**97.67 /cy**	**30,160,123**
				01.055 Treatment	**236,100.00 M3**	**/M3**	**/M3**	**127.74 /M3**	**/M3**	**127.74 /M3**	**30,160,123**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,499,836.78 /ls	-	4,499,836.78 /ls	4,499,837
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,499,836.78 /ls**	**/ls**	**4,499,836.78 /ls**	**4,499,837**
			01000-0301	**Water Treatment From Dewatered Areas**							
				Watered Treatment From Dewatered Areas	1.00 ls	-	-	202,258.60 /ls	-	202,258.60 /ls	202,259
				Water Treatment From Dewatered Areas	**1.00 ls**	**/ls**	**/ls**	**202,258.60 /ls**	**/ls**	**202,258.60 /ls**	**202,259**
			01562-0224	**Dewater Ponds - Pacer Ivy 2 mo per pond x 13 ea**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	634.20 /ea	-	634.20 /ea	8,245
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.05 /lf	12.76 /lf	-	-	14.82 /lf	38,524
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	424.48 /ea	3,215.19 /ea	-	-	3,639.67 /ea	47,316
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	246.31 /day	246.31 /day	192,123
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	167.36 /ea	686.39 /ea	-	-	853.74 /ea	11,099
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.64 /lf	8.43 /lf	-	-	10.07 /lf	98,196
				Attend Temporary Diesel Pumps	780.00 day	1,642.08 /day	-	-	-	1,642.08 /day	1,280,820
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,112
				Dewater Ponds - Pacer Ivy 2 mo per pond x 13 ea	**1.00 ls**	**1,311,972.99 /ls**	**166,093.85 /ls**	**8,244.59 /ls**	**192,122.94 /ls**	**1,678,434.37 /ls**	**1,678,434**
			02240-0200	**Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Space / 506sf/ea**							
				Design Dewatering System	41.70 acre	-	-	6,341.99 /acre	-	6,341.99 /acre	264,461
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,268.40 /ea	-	1,268.40 /ea	16,489
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.42 /lf	217.58 /lf	-	-	221.00 /lf	10,342,619
				Install Discharge Pipe- 6"	79,100.00 lf	1.64 /lf	13.71 /lf	-	-	15.36 /lf	1,214,563
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,530
				Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Space / 506sf/ea	**25,300.00 lf**	**12.00 /lf**	**445.34 /lf**	**11.11 /lf**	**/lf**	**468.45 /lf**	**11,851,663**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,615,493.77 /ls**	**11,433,285.63 /ls**	**4,991,289.92 /ls**	**192,122.94 /ls**	**18,232,192.26 /ls**	**18,232,192**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Pacer Ivy - - Fill Excavated Areas To Original Grade**							
				FILL from IMPORT	212,411.00 CY	0.96 /CY	-	-	5.27 /CY	6.23 /CY	1,323,619
				Import Gravel Fill - Material Only	212,411.00 cy	-	13.68 /cy	7.10 /cy	-	20.79 /cy	4,415,386
				Grade and Compact	212,411.00 cy	0.38 /cy	-	-	1.60 /cy	1.98 /cy	420,443
				Dump Truck - Haul	212,411.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	3,733,198
				Load - From Stockpile	212,411.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	302,572
				Pacer Ivy - - Fill Excavated Areas To Original Grade	**212,411.00 cy**	**4.00 /cy**	**13.68 /cy**	**7.10 /cy**	**23.21 /cy**	**48.00 /cy**	**10,195,219**
				02.-- F&I Borrow - Bring Areas to Grade	**162,400.00 M3**	**5.23 /M3**	**17.90 /M3**	**9.29 /M3**	**30.36 /M3**	**62.78 /M3**	**10,195,219**
				012.-- Pacer Ivy -	**236,100.00 M3**	**16.37 /M3**	**60.74 /M3**	**155.27 /M3**	**49.30 /M3**	**281.68 /M3**	**66,503,570**
	017.--			**PI Area - Pile Construction**							
		03.10		**F&I Pile Cap**							
			01000-0301	**PI- -Pile Liner System**							
				Import Common Earth	71,414.00 cy	1.20 /cy	-	-	7.44 /cy	8.63 /cy	616,447
				GCL Liner	489,758.00 sf	-	-	0.25 /sf	-	0.25 /sf	124,242
				Linear Low Density PE Liner 40 mils (1 mm)	489,758.00 sf	-		0.44 /sf	-	0.44 /sf	217,423
				Geocomposite Liner	489,758.00 sf	0.14 /sf	-	-	-	0.28 /sf	134,681
				Import Common Earth	35,707.00 cy	2.00 /cy	0.00 /cy	-	10.99 /cy	12.98 /cy	463,552
				Spread Loam	5,985.00 cy	2.43 /cy	27.37 /cy	-	2.32 /cy	32.12 /cy	192,223
				Seeding Mechanical Methods	489,758.00 sf	-	-	0.08 /sf	-	0.08 /sf	37,272
				Import Common Earth - Materials Only	107,212.00 cy	-	9.58 /cy	5.21 /cy	-	14.78 /cy	1,585,052
				Dump Truck - Haul	107,121.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	1,882,689
				Load - From Stockpile	107,121.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	152,590
				PI- -Pile Liner System	**11.25 AC**	**46,521.44 /AC**	**105,845.09 /AC**	**83,291.46 /AC**	**238,876.06 /AC**	**480,548.52 /AC**	**5,406,171**
				03.10 F&I Pile Cap	**45,500.00 m2**	**11.50 /m2**	**26.17 /m2**	**20.59 /m2**	**59.06 /m2**	**118.82 /m2**	**5,406,171**
		05.10		**Place Treated Material in Pile**							
			02310-01-2	**Place Treated Material in Pile**							
				Place Treated Soil In Pile	308,807.00 CY	1.28 /CY	-	-	8.15 /CY	9.43 /CY	2,912,216
				Load - From Stockpile	308,807.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	439,884
				Dump Truck - Haul	308,807.00 cy	2.40 /cy	-	-	15.18 /cy	17.58 /cy	5,427,391
				Place Treated Material in Pile	**308,807.00 cy**	**3.94 /cy**	**/cy**	**/cy**	**24.49 /cy**	**28.43 /cy**	**8,779,491**
				05.10 Place Treated Material in Pile	**236,100.00 m3**	**5.15 /m3**	**/m3**	**/m3**	**32.04 /m3**	**37.19 /m3**	**8,779,491**
				017.-- PI Area - Pile Construction	**45,500.00 m2**	**38.23 /m2**	**26.17 /m2**	**20.59 /m2**	**225.29 /m2**	**311.77 /m2**	**14,185,662**
				00.70 Pacer Ivy Area - Alternative 2B - S/S	**236,100.00 M3**	**24.78 /M3**	**71.94 /M3**	**160.69 /M3**	**105.21 /M3**	**362.91 /M3**	**85,682,575**

Estimate Totals

Description	Amount	Totals	Hours		Rate
Labor	8,370,518		495,583	hrs	
Material	21,611,229				
Subcontract	56,168,073				
Equipment	37,031,574		705,617	hrs	
Other	112,276				
	123,293,670	**123,293,670**			
-					
Subtotal Direct Cost		**123,293,670**			
Indirect Costs:					
Sales Tax (MEO):					

Subtotal Prior to OH&P		**123,293,670**			

Subtotal for Prime Contractor		**123,293,670**			
Construction Contingency					

Subtotal Cost, Today's Dollars		**123,293,670**			
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016					
		123,293,670			

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 2B

Solidification/Stabilization

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 2B - Solidification/Stabilization

Z1 Area Fixed Costs (not dependent on volume)			Base Volume			Added Contingency Volume		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 317,099	1	$ 317,099	$ 317,099	1	$ 317,099
01000-0301	Rebuild Interior Haul Roads	km	$ 266,014	3.3	$ 877,845	$ 266,014	3.3	$ 877,845
01000-0301	UXO Clearance	LS	$ 25,368	1	$ 25,368	$ 25,368	1	$ 25,368
02230-005	Clearing - Excavation Areas	m2	$ 0.85	178,626	$ 152,293	$ 1	178,626	$ 152,293
02230-005	Clearing - Containment Areas	m2	$ 0.85	76,000	$ 64,864	$ 1	76,000	$ 64,864
01000-0301	Water Treatment from Dewatered Areas	LS	$ 202,259	1	$ 202,259	$ 202,259	1	$ 202,259
01000-0301	Additional Dewatering and Fish Removal	LS	$ 1,999,928	1	$ 1,999,928	$ 1,999,928	1	$ 1,999,928
01562-0224	Dewater Ponds	LS	$ 387,331	1	$ 387,331	$ 387,331	1	$ 387,331
02240-0200	Dewatering System	lf	$ 1,836,172	1	$ 1,836,172	$ 1,836,172	1	$ 1,836,172
01000-0301	Z1 Pile Cap System	m2	$ 85.88	30,000	$ 2,576,299	$ 86	30,000	$ 2,576,299
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 509,605	1	$ 509,605	$ 607,189	1	$ 607,188.94
01590-0100	Traffic and Environmental Controls	LS	$ 823,112	1	$ 823,112	$ 980,729	1	$ 980,729
02310-01-2	Area Z1 - Excavation	cy	$ 24.20	27,598	$ 667,809	$ 24.20	32,883	$ 795,694
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 24.18	14,257	$ 344,803	$ 24.18	16,987	$ 410,827
02310-01-2	Southwest Area - Excavation	cy	$ 24.19	79,262	$ 1,917,619	$ 24.19	94,440	$ 2,284,827
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.97	1,700	$ 45,847	$ 26.97	2,026	$ 54,639
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 26.93	23,282	$ 627,056	$ 26.93	27,740	$ 747,124
01000-0301	Treatment (solidification/stabilization)	m3	$ 127.74	111,700	$ 14,268,892	$ 127.74	133,089	$ 17,001,187
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 62.78	92,600	$ 5,813,278	$ 62.78	110,332	$ 6,926,464
02310-01-2	Place Treated Material In Pile	cy	$ 28.43	146,098	$ 4,153,617	$ 28.43	174,074	$ 4,948,985
				Subtotal	**$ 37,611,096**		**Subtotal**	**$ 43,197,122**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 317,099	1	$ 317,099	$ 317,099	1	$ 317,099
01000-0301	Rebuild Interior Haul Roads	km	$ 273,281	7.7	$ 2,104,266	$ 273,281	7.7	$ 2,104,266
01000-0301	UXO Clearance	LS	$ 25,368	1	$ 25,368	$ 25,368	1	$ 25,368
02230-005	Clearing - Excavation Areas	m2	$ 0.85	150,500	$ 128,348	$ 1	150,500	$ 128,348
02230-005	Clearing - Containment Areas	m2	$ 0.85	61,690	$ 52,443	$ 1	61,690	$ 52,443
01000-0301	Water Treatment from Dewatered Areas	LS	$ 202,259	1	$ 202,259	$ 202,259	1	$ 202,259
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,499,837	1	$ 4,499,837	$ 4,499,837	1	$ 4,499,837
01562-0224	Dewater Ponds	LS	$ 1,678,434	1	$ 1,678,434	$ 1,678,434	1	$ 1,678,434
02240-0200	Dewatering System	lf	$ 11,851,663	1	$ 11,851,663	$ 11,851,663	1	$ 11,851,663
01000-0301	Pacer Ivy Pile Cap System	m2	$ 118.82	45,500	$ 5,406,171	$ 119	45,500	$ 5,406,171
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,425,090	1	$ 1,425,090	$ 1,697,980	1	$ 1,697,979.57
01590-0100	Traffic and Environmental Controls	LS	$ 1,121,520	1	$ 1,121,520	$ 1,336,279	1	$ 1,336,279
02310-01-2	Pacer Ivy Area - Excavation	cy	$ 24.19	167,549	$ 4,053,722	$ 24.19	199,633	$ 4,829,971
02310-01-2	Northwest Area - Excavation - Sediment	cy	$ 26.93	8,632	$ 232,464	$ 26.93	10,285	$ 276,980
02310-01-2	North Area - Excavation	cy	$ 24.20	44,863	$ 1,085,542	$ 24.20	53,454	$ 1,293,417
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 26.93	32,699	$ 880,617	$ 26.93	38,961	$ 1,049,259
02310-01-2	Pacer Ivy Area Excavation - Sediment	cy	$ 26.93	55,065	$ 1,482,899	$ 26.93	65,609	$ 1,766,849
01000-0301	Treatment (solidification/stabilization)	m3	$ 127.74	236,100	$ 30,160,123	$ 127.74	281,311	$ 35,935,512
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 62.78	162,400	$ 10,195,219	$ 62.78	193,498	$ 12,147,503
02310-01-2	Place Treated Material In Pile	cy	$ 28.43	308,807	$ 8,779,491	$ 28.43	367,940	$ 10,460,663
				Subtotal	**$ 85,682,575**		**Subtotal**	**$ 97,060,300**
				Total	**$ 123,293,671**		**Total**	**$ 140,257,423**

Price Increase due to Contingency Volume $ 16,963,751
Percentage Increase in Price 13.76%
Percentage Increase in Volume 19.15%

1. Construction Capital Costs (Years 1 through 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 140,257,423	$140,257,423	From detailed cost estimate
Contingency (Scope and Bid)	30%			$42,077,227	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$182,335,000	Rounded to nearest $1,000
Project Management	5%			$9,116,750	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$3,000,000	Lump Sum
Construction Management	6%			$10,940,100	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$9,116,750	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$214,508,600	
TOTAL CONSTRUCTION CAPITAL COST				**$214,509,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	7	YR	**$30,644,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$597,531	$597,531	Sampling/analysis required by the EMMP
Contingency (Scope and Bid)	30%			$179,259	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$777,000	Rounded to nearest $1,000
Project Management	10%			$77,700	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$116,550	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$38,850	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,010,100	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,010,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	7	YR	$1,010,000	**$7,070,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$68,053	$68,053	Sampling/analysis required by the EMMP; assume 0.5% of construction costs.
Contingency (Scope and Bid)	30%			$20,416	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$88,469	
Project Management	10%			$8,847	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$13,270	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$4,423	Assumed to apply to 50% of the EMMP implementation
TOTAL				$115,009	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$115,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	43	YR	$115,000	**$4,945,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$40,832	$40,832	Includes annual landfill O&M; assume 0.3% of construction capital costs.
Contingency (Scope and Bid)	30%			$12,250	15% Scope (Excavation recommended range 15-55%, landfill disposal cost recommended range 5-15% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$53,082	
Project Management	10%			$5,308	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$7,962	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,654	Assumed to apply to 50% of the O&M
TOTAL				$69,006	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$69,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	43	YR	$69,000	**$2,967,000**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative				**$229,491,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
2B Solidification/Stabilization
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.9346	$29,583,828
2	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.8734	$27,646,604
3	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.8163	$25,839,160
4	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.7629	$24,148,837
5	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.7130	$22,569,302
6	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.6663	$21,091,060
7	$30,644,000	$1,010,000	$0	$0	$31,654,000	0.6227	$19,710,946
8	$0	$0	$115,000	$69,000	$184,000	0.5820	$107,088
9	$0	$0	$115,000	$69,000	$184,000	0.5439	$100,078
10	$0	$0	$115,000	$69,000	$184,000	0.5083	$93,527
11	$0	$0	$115,000	$69,000	$184,000	0.4751	$87,418
12	$0	$0	$115,000	$69,000	$184,000	0.4440	$81,696
13	$0	$0	$115,000	$69,000	$184,000	0.4150	$76,360
14	$0	$0	$115,000	$69,000	$184,000	0.3878	$71,355
15	$0	$0	$115,000	$69,000	$184,000	0.3624	$66,682
16	$0	$0	$115,000	$69,000	$184,000	0.3387	$62,321
17	$0	$0	$115,000	$69,000	$184,000	0.3166	$58,254
18	$0	$0	$115,000	$69,000	$184,000	0.2959	$54,446
19	$0	$0	$115,000	$69,000	$184,000	0.2765	$50,876
20	$0	$0	$115,000	$69,000	$184,000	0.2584	$47,546
21	$0	$0	$115,000	$69,000	$184,000	0.2415	$44,436
22	$0	$0	$115,000	$69,000	$184,000	0.2257	$41,529
23	$0	$0	$115,000	$69,000	$184,000	0.2109	$38,806
24	$0	$0	$115,000	$69,000	$184,000	0.1971	$36,266
25	$0	$0	$115,000	$69,000	$184,000	0.1842	$33,893
26	$0	$0	$115,000	$69,000	$184,000	0.1722	$31,685
27	$0	$0	$115,000	$69,000	$184,000	0.1609	$29,606
28	$0	$0	$115,000	$69,000	$184,000	0.1504	$27,674
29	$0	$0	$115,000	$69,000	$184,000	0.1406	$25,870
30	$0	$0	$115,000	$69,000	$184,000	0.1314	$24,178
31	$0	$0	$115,000	$69,000	$184,000	0.1228	$22,595
32	$0	$0	$115,000	$69,000	$184,000	0.1147	$21,105
33	$0	$0	$115,000	$69,000	$184,000	0.1072	$19,725
34	$0	$0	$115,000	$69,000	$184,000	0.1002	$18,437
35	$0	$0	$115,000	$69,000	$184,000	0.0937	$17,241
36	$0	$0	$115,000	$69,000	$184,000	0.0875	$16,100
37	$0	$0	$115,000	$69,000	$184,000	0.0818	$15,051
38	$0	$0	$115,000	$69,000	$184,000	0.0765	$14,076
39	$0	$0	$115,000	$69,000	$184,000	0.0715	$13,156
40	$0	$0	$115,000	$69,000	$184,000	0.0668	$12,291
41	$0	$0	$115,000	$69,000	$184,000	0.0624	$11,482
42	$0	$0	$115,000	$69,000	$184,000	0.0583	$10,727
43	$0	$0	$115,000	$69,000	$184,000	0.0545	$10,028
44	$0	$0	$115,000	$69,000	$184,000	0.0509	$9,366
45	$0	$0	$115,000	$69,000	$184,000	0.0476	$8,758
46	$0	$0	$115,000	$69,000	$184,000	0.0445	$8,188
47	$0	$0	$115,000	$69,000	$184,000	0.0416	$7,654
48	$0	$0	$115,000	$69,000	$184,000	0.0389	$7,158
49	$0	$0	$115,000	$69,000	$184,000	0.0363	$6,679
50	$0	$0	$115,000	$69,000	$184,000	0.0339	$6,238
TOTALS:	$214,508,000	$7,070,000	$4,945,000	$2,967,000	**$229,490,000**		$172,137,382
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$172,137,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 3

Landfill Material < 2,500 ppt,
Ex Situ TCH treatment for Material > 2,500 ppt

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Landfilling of soils which have dioxin concentrations less than 2,500 ppt TEQ; (3) ex-situ TCH treatment of soils with greater than 2,500 ppt TEQ; and (4) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$135,726,640	$135,726,640	From detailed cost estimate
Contingency (Scope and Bid)	30%			$40,717,992	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$176,445,000	Rounded to nearest $1,000
Project Management	5%			$8,822,250	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$10,586,700	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$8,822,250	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$212,676,200	
TOTAL CONSTRUCTION CAPITAL COST				**$212,676,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	7	YR	**$30,382,000**		Average annual capital cost over the duration, rounded to the nearest $1,000.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$568,103	$568,103	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$170,431	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$739,000	Rounded to nearest $1,000
Project Management	10%			$73,900	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$110,850	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$36,950	Assumed to apply to 50% of the EMMP implementation
TOTAL				$960,700	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$961,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	7	YR	$961,000	**$6,727,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$55,238	$55,238	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction costs.
Contingency (Scope and Bid)	30%			$16,571	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$71,809	
Project Management	10%			$7,181	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$10,771	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$3,590	Assumed to apply to 50% of the EMMP implementation
TOTAL				$93,351	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$93,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	43	YR	$93,000	**$3,999,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$33,143	$33,143	Includes annual landfill O&M; assume 0.3% of landfill construction costs.
Contingency (Scope and Bid)	30%			$9,943	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$43,086	
Project Management	10%			$4,309	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$6,463	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,154	Assumed to apply to 50% of the O&M
TOTAL				$56,012	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$56,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	43	YR	$56,000	**$2,408,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt	**$225,810,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$30,382,000	$961,000	$0	$0	$31,343,000	0.9346	$29,293,168
2	$30,382,000	$961,000	$0	$0	$31,343,000	0.8734	$27,374,976
3	$30,382,000	$961,000	$0	$0	$31,343,000	0.8163	$25,585,291
4	$30,382,000	$961,000	$0	$0	$31,343,000	0.7629	$23,911,575
5	$30,382,000	$961,000	$0	$0	$31,343,000	0.7130	$22,347,559
6	$30,382,000	$961,000	$1	$0	$31,343,001	0.6663	$20,883,842
7	$30,382,000	$961,000	$2	$0	$31,343,002	0.6227	$19,517,287
8	$0	$0	$93,000	$56,000	$149,000	0.5820	$86,718
9	$0	$0	$93,000	$56,000	$149,000	0.5439	$81,041
10	$0	$0	$93,000	$56,000	$149,000	0.5083	$75,737
11	$0	$0	$93,000	$56,000	$149,000	0.4751	$70,790
12	$0	$0	$93,000	$56,000	$149,000	0.4440	$66,156
13	$0	$0	$93,000	$56,000	$149,000	0.4150	$61,835
14	$0	$0	$93,000	$56,000	$149,000	0.3878	$57,782
15	$0	$0	$93,000	$56,000	$149,000	0.3624	$53,998
16	$0	$0	$93,000	$56,000	$149,000	0.3387	$50,466
17	$0	$0	$93,000	$56,000	$149,000	0.3166	$47,173
18	$0	$0	$93,000	$56,000	$149,000	0.2959	$44,089
19	$0	$0	$93,000	$56,000	$149,000	0.2765	$41,199
20	$0	$0	$93,000	$56,000	$149,000	0.2584	$38,502
21	$0	$0	$93,000	$56,000	$149,000	0.2415	$35,984
22	$0	$0	$93,000	$56,000	$149,000	0.2257	$33,629
23	$0	$0	$93,000	$56,000	$149,000	0.2109	$31,424
24	$0	$0	$93,000	$56,000	$149,000	0.1971	$29,368
25	$0	$0	$93,000	$56,000	$149,000	0.1842	$27,446
26	$0	$0	$93,000	$56,000	$149,000	0.1722	$25,658
27	$0	$0	$93,000	$56,000	$149,000	0.1609	$23,974
28	$0	$0	$93,000	$56,000	$149,000	0.1504	$22,410
29	$0	$0	$93,000	$56,000	$149,000	0.1406	$20,949
30	$0	$0	$93,000	$56,000	$149,000	0.1314	$19,579
31	$0	$0	$93,000	$56,000	$149,000	0.1228	$18,297
32	$0	$0	$93,000	$56,000	$149,000	0.1147	$17,090
33	$0	$0	$93,000	$56,000	$149,000	0.1072	$15,973
34	$0	$0	$93,000	$56,000	$149,000	0.1002	$14,930
35	$0	$0	$93,000	$56,000	$149,000	0.0937	$13,961
36	$0	$0	$93,000	$56,000	$149,000	0.0875	$13,038
37	$0	$0	$93,000	$56,000	$149,000	0.0818	$12,188
38	$0	$0	$93,000	$56,000	$149,000	0.0765	$11,399
39	$0	$0	$93,000	$56,000	$149,000	0.0715	$10,654
40	$0	$0	$93,000	$56,000	$149,000	0.0668	$9,953
41	$0	$0	$93,000	$56,000	$149,000	0.0624	$9,298
42	$0	$0	$93,000	$56,000	$149,000	0.0583	$8,687
43	$0	$0	$93,000	$56,000	$149,000	0.0545	$8,121
44	$0	$0	$93,000	$56,000	$149,000	0.0509	$7,584
45	$0	$0	$93,000	$56,000	$149,000	0.0476	$7,092
46	$0	$0	$93,000	$56,000	$149,000	0.0445	$6,631
47	$0	$0	$93,000	$56,000	$149,000	0.0416	$6,198
48	$0	$0	$93,000	$56,000	$149,000	0.0389	$5,796
49	$0	$0	$93,000	$56,000	$149,000	0.0363	$5,409
50	$0	$0	$93,000	$56,000	$149,000	0.0339	$5,051
TOTALS:	$212,674,000	$6,727,000	$3,999,003	$2,408,000	**$225,808,003**		$170,166,955
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$170,167,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternative 3
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver: **ENR 20 City CCI:**	Database Version 7.0 October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.80				**Z1 Area- Landfill - Alternative 3**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-030 1	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	13,836.00 md	-	-	-	40.97 /md	40.97 /md	566,831
				Resperators - One Ea Man	45.00 ea	-	-	-	68.28 /ea	68.28 /ea	3,073
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**569,903.33 /ls**	**569,903.33 /ls**	**569,903**
			01000-030 1	**Demobilization**							
				Demobilization	1.00 ls	-	-	316,398.47 /ls	-	316,398.47 /ls	316,398
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**316,398.47 /ls**	**/ls**	**316,398.47 /ls**	**316,398**
			01000-030 1	**Reconstruct Haul Roads**							
				Reclaim Roads	18,775.00 sy	0.74 /sy	-	-	4.77 /sy	5.50 /sy	103,306
				Fine Grade Roads	18,775.00 sy	0.44 /sy	-	-	1.69 /sy	2.13 /sy	39,978
				Pave Roads	5,800.00 ton	2.09 /ton	-	-	7.79 /ton	9.89 /ton	57,347
				Haul Bituminous Concrete	5,800.00 ton	1.91 /ton	102.42 /ton	-	12.12 /ton	116.45 /ton	675,416
				Reconstruct Haul Roads	**3.30 KM**	**13,722.73 /KM**	**180,010.11 /KM**	**/KM**	**71,735.90 /KM**	**265,468.73 /KM**	**876,047**
			01590-010 0	**Traffic and Enviromental Controls - 686 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.71 /sf	16.39 /sf	-	-	18.09 /sf	3,474
				Plastic Snow Fence	10,000.00 lf	1.17 /lf	4.10 /lf	-	-	5.27 /lf	52,673
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,522.36 /wk	1,522.36 /wk	95,909
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,330.96 /wk	3,330.96 /wk	209,850
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,529.47 /wk	-	-	6,371.86 /wk	7,901.33 /wk	497,784
				Traffic and Enviromental Controls - 686 CD	**1.00 ls**	**108,389.17 /ls**	**44,114.12 /ls**	**/ls**	**707,186.47 /ls**	**859,689.76 /ls**	**859,690**
				06.-- -----							2,622,038
				009.-- Site and Traffic Controls	1.00 ls	153,674.17 /ls	638,147.48 /ls	316,398.47 /ls	1,513,818.26 /ls	2,622,038.38 /ls	2,622,038
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-030 1	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,531.19 /ea	-	2,531.19 /ea	25,312
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,311.87 /ls**	**/ls**	**25,311.87 /ls**	**25,312**
				06.-- -----							25,312
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,311.87 /ls	/ls	25,311.87 /ls	25,312
	010.--			Z1 Area - Landfill Site							
		00.9		Clearing Landfill Areas and Excavated Areas							
			02230-005	**Clearing ForExcavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	54.10 ac	1,398.37 /ac	-	-	2,044.79 /ac	3,443.15 /ac	186,275
				Clearing ForExcavated Areas	**219,100.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**186,275**
			02230-005	**Clearing For Containment/Treatment Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	22.20 ac	1,398.37 /ac	-	-	2,044.79 /ac	3,443.15 /ac	76,438
				Clearing For Containment/Treatment Areas	**90,000.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.50 /M2**	**0.85 /M2**	**76,438**
				00.9 Clearing Landfill Areas and Excavated Areas	30.90 ha	3,452.93 /ha	/ha	/ha	5,049.10 /ha	8,502.03 /ha	262,713
		01.--		Excavate Soil/Sediment to Landfill Area							
			02310-01-2	**Area Z1 Cut to Stockpile - Landfill Site - Containment Soil**							
				Cut to Waste - (2 excavators)	27,598.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	114,468
				Rear Dump Truck 12 cy	27,598.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	484,051
				Project Health & Safety Technician	288.00 hr	13.66 /hr	-	-	-	13.66 /hr	3,933
				Level 2 Survey Crew	288.00 hr	27.31 /hr	-	-	-	27.31 /hr	7,866
				Decontamination - Area	288.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	56,123
				Area Z1 Cut to Stockpile - Landfill Site - Containment Soil	**27,598.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.15 /cy**	**666,441**
			02310-01-2	**Area Z1 Taxiway - Landfill Containment Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	59,134
				Rear Dump Truck 12 cy	14,257.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	250,058
				Project Health & Safety Technician	149.00 hr	13.66 /hr	-	-	-	13.66 /hr	2,035
				Level 2 Survey Crew	149.00 hr	27.31 /hr	-	-	-	27.31 /hr	4,069
				Decontamination Area	149.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	29,036
				Area Z1 Taxiway - Landfill Containment Soil	**14,257.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.15 /cy**	**344,332**
			02310-01-2	**Southwest Area - Containment -Soil**							
				Cut to Waste - (2 excavators)	63,828.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	264,740
				Rear Dump Truck 12 cy	63,828.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	1,119,501
				Project Health & Safety Technician	665.00 hr	13.66 /hr	-	-	-	13.66 /hr	9,081
				Level 2 Survey Crew	665.00 hr	27.31 /hr	-	-	-	27.31 /hr	18,162
				Decontamination Area	665.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	129,589
				Southwest Area - Containment -Soil	**63,828.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.14 /cy**	**1,541,074**
			02310-01-2	**Gate 2 Lake - 1 cd Containment Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	7,051
				Rear Dump Truck 12 cy	1,700.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	29,817
				Project Health & Safety Technician	18.00 hr	13.66 /hr	-	-	-	13.66 /hr	246
				Level 2 Survey Crew	18.00 hr	27.31 /hr	-	-	-	27.31 /hr	492
				Decontamination Area	18.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	3,508
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	4,640

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				Gate 2 Lake - 1 cd Containment Sediment	**1,700.00 cy**	**4.66 /cy**	**/cy**	**/cy**	**22.26 /cy**	**26.91 /cy**	**45,753**
			02310-01-2	**Area Z1 Cut to Stockpile - Landfill Site - Containment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	96,567
				Rear Dump Truck 12 cy	23,282.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	408,351
				Project Health & Safety Technician	242.00 hr	13.66 /hr	-	-	-	13.66 /hr	3,305
				Level 2 Survey Crew	242.00 hr	27.31 /hr	-	-	-	27.31 /hr	6,609
				Decontamination - Area	242.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	47,159
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	63,545
				Area Z1 Cut to Stockpile - Landfill Site - Containment Sediment	**23,282.00 cy**	**4.63 /cy**	**/cy**	**/cy**	**22.24 /cy**	**26.87 /cy**	**625,536**
			02310-01-2	**Southwest Area - Treatment -Soil Contain**							
				Cut to Waste - (2 excavators)	15,434.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	64,016
				Rear Dump Truck 12 cy	15,434.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	270,702
				Level 2 Survey Crew	161.00 hr	27.31 /hr	-	-	-	27.31 /hr	4,397
				Decontamination Area	161.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	31,374
				Project Health & Safety Technician	161.00 hr	13.66 /hr	-	-	-	13.66 /hr	2,199
				Southwest Area - Treatment -Soil Contain	**15,434.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.15 /cy**	**372,688**
				01.-- Excavate Soil/Sediment to Landfill Area	**146,099.00 cy**	**4.21 /cy**	**/cy**	**/cy**	**20.40 /cy**	**24.61 /cy**	**3,595,823**
		01.09		**Treatment**							
			01000-030 1	**Treatment**							
				Treatment TCH	15,545.00 cy	-	-	487.25 /cy	-	487.25 /cy	7,574,358
				Treatment	**1.00 ls**	**/ls**	**/ls**	**7,574,358.13 /ls**	**/ls**	**7,574,358.13 /ls**	**7,574,358**
				01.09 Treatment	**1.00 ls**	**/ls**	**/ls**	**7,574,358.13 /ls**	**/ls**	**7,574,358.13 /ls**	**7,574,358**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-030 1	**Water Treatment - Allowance Per Treatment System - (2 mo/Pond x 3 ea)**							
				Dewatering Treatment System	1.00 ea	-	-	158,199.26 /ea	-	158,199.26 /ea	158,199
				Water Treatment - Allowance Per Treatment System - (2 mo/Pond x 3 ea)	**1.00 ea**	**/ea**	**/ea**	**158,199.26 /ea**	**/ea**	**158,199.26 /ea**	**158,199**
			01000-030 1	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	2,001,271.64 /ls	-	2,001,271.64 /ls	2,001,272
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**2,001,271.64 /ls**	**/ls**	**2,001,271.64 /ls**	**2,001,272**
			01562-022 4	**Dewater Ponds -**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	632.80 /ea	-	632.80 /ea	1,898
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.05 /lf	12.74 /lf	-	-	14.79 /lf	8,872
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	423.60 /ea	3,208.60 /ea	-	-	3,632.20 /ea	10,897
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	245.81 /day	245.81 /day	44,245
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	167.01 /ea	684.98 /ea	-	-	851.99 /ea	2,556
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.64 /lf	8.41 /lf	-	-	10.05 /lf	22,614
				Attend Temporary Diesel Pumps	180.00 day	1,638.71 /day	-	-	-	1,638.71 /day	294,968
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	487
				Dewater Ponds -	**1.00 ls**	**302,142.74 /ls**	**38,250.85 /ls**	**1,898.39 /ls**	**44,245.26 /ls**	**386,537.24 /ls**	**386,537**
			02240-020 0	**Z-1 33,800 M2 - - @7.5m Space / 506sf/ea - (2 mo/Pond x 3 ea)**							
				Design Dewatering System	8.50 acre	-	-	6,327.97 /acre	-	6,327.97 /acre	53,788
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,265.60 /ea	-	1,265.60 /ea	3,797
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.41 /lf	217.13 /lf	-	-	220.54 /lf	1,587,913
				Install Discharge Pipe- 6"	12,063.00 lf	1.64 /lf	13.69 /lf	-	-	15.32 /lf	184,845
				Remove Discharge Pipe	12,083.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,063
				Z-1 33,800 M2 - - @7.5m Space / 506sf/ea - (2 mo/Pond x 3 ea)	**1.00 ls**	**46,411.05 /ls**	**1,728,409.43 /ls**	**57,584.53 /ls**	**/ls**	**1,832,405.01 /ls**	**1,832,405**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**348,553.79 /ls**	**1,766,660.28 /ls**	**2,218,953.82 /ls**	**44,245.26 /ls**	**4,378,413.15 /ls**	**4,378,413**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1 Landfill - Fill Excavated Areas To Original Grade -**							
				Fill To Grade	121,254.00 CY	0.96 /CY	-	-	5.26 /CY	6.22 /CY	754,035
				Import Gravel Fill - Material Only	105,884.00 cy	-	13.66 /cy	7.09 /cy	-	20.74 /cy	2,196,380
				Grade and Compact	121,254.00 cy	0.38 /cy	-	-	1.59 /cy	1.98 /cy	239,517
				Load Treated Soil	15,371.00 cy	0.27 /cy	0.00 /cy	-	1.16 /cy	1.42 /cy	21,851
				Load - From Stockpile	105,884.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	150,519
				Dump Truck - Haul	121,254.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	2,126,716
				Area Z-1 Landfill - Fill Excavated Areas To Original Grade -	**121,254.00 cy**	**3.99 /cy**	**11.93 /cy**	**6.19 /cy**	**23.16 /cy**	**45.27 /cy**	**5,489,017**
				02.-- F&I Borrow - Bring Areas to Grade	**92,706.00 M3**	**5.22 /M3**	**15.60 /M3**	**8.10 /M3**	**30.29 /M3**	**59.21 /M3**	**5,489,017**
		07.--		**Treated Soil**							
			01000-030 1	**Stockpile Treated Soil**							
				Stockpile Treated Soil From PI Area	65,882.00 cy	0.70 /cy	-	-	4.44 /cy	5.13 /cy	338,198
				Stockpile Treated Soil	**50,370.00 M3**	**0.91 /M3**	**/M3**	**/M3**	**5.81 /M3**	**6.71 /M3**	**338,198**
				07.-- Treated Soil	**50,370.00 M3**	**0.91 /M3**	**/M3**	**/M3**	**5.81 /M3**	**6.71 /M3**	**338,198**
				010.-- Z1 Area - Landfill Site	**111,700.00 M3**	**14.33 /M3**	**28.76 /M3**	**94.39 /M3**	**56.23 /M3**	**193.72 /M3**	**21,638,523**
	014.--			**Z1 Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-030 1	**Z-1 - - Landfill Liner**							
				Import Common Earth	20,600.00 cy	1.20 /cy	-	-	7.42 /cy	8.61 /cy	177,455

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			01000-030 1	**Z-1 - - Landfill Liner**							
				GCL Clay Liner	282,553.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	76,099
				HDPE Liner 60 mils (1.5 mm)	282,553.00 sf	-	-	0.68 /sf	-	0.68 /sf	191,493
				Geocomposite Liner	282,553.00 sf	0.14 /sf	-	-	-	0.27 /sf	77,542
				HDPE Liner 60 mils (1.5 mm)	282,553.00 sf	-	-	0.68 /sf	-	0.68 /sf	191,493
				Geocomposite Liner	282,553.00 sf	0.14 /sf	-	-	-	0.27 /sf	77,542
				24" Sand Layer	20,600.00 cy	1.59 /cy	0.00 /cy	0.00 /cy	9.89 /cy	11.49 /cy	236,607
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	2,870.00 lf	0.64 /lf	3.38 /lf	-	-	4.02 /lf	11,546
				GCL	282,553.00 sf	0.14 /sf	0.15 /sf	-	-	0.28 /sf	79,850
				Linear Low Density PE Liner 40 mils (1 mm)	282,553.00 sf	-	0.00 /sf	0.44 /sf	-	0.44 /sf	125,159
				Geocomposite- 250 mils	282,553.00 sf	-	0.00 /sf	0.54 /sf	-	0.54 /sf	153,767
				Import Common Earth	20,600.00 cy	1.20 /cy	0.00 /cy	0.00 /cy	7.42 /cy	8.61 /cy	177,455
				Loam	3,455.00 cy	2.43 /cy	27.31 /cy	-	2.31 /cy	32.05 /cy	110,738
				Seeding Mechanical Methods	282,553.00 sf	-	-	0.08 /sf	-	0.08 /sf	21,456
				Import Sand Fill - Materials Only	20,600.00 cy	-	24.58 /cy	7.09 /cy	-	31.67 /cy	652,361
				Import Common Earth - Materials Only	41,200.00 cy	-	9.56 /cy	7.09 /cy	-	16.65 /cy	685,835
				Dump Truck - Haul	65,255.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	1,144,530
				Load - From Stockpile	65,255.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	92,763
				Z-1 - - Landfill Liner	**6.50 ac**	**64,598.97 /ac**	**166,622.22 /ac**	**172,517.73 /ac**	**243,304.07 /ac**	**659,029.54 /ac**	**4,283,692**
				03.-- F&I Landfill Liner	**26,250.00 M2**	**16.00 /M2**	**41.26 /M2**	**42.72 /M2**	**60.25 /M2**	**163.19 /M2**	**4,283,692**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill -**							
				Place Soil and Sediment In Landfill	130,665.00 cy	0.70 /cy	-	-	4.44 /cy	5.13 /cy	670,755
				Decontamination Area	594.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	115,753
				Place Excavated Soil and Sediment In Landfill -	**130,664.00 cy**	**1.09 /cy**	**/cy**	**/cy**	**4.93 /cy**	**6.02 /cy**	**786,508**
				05.-- Place Excavated Soil/Sediment in Landfill	**99,900.00 M3**	**1.43 /M3**	**/M3**	**/M3**	**6.44 /M3**	**7.87 /M3**	**786,508**
				014.-- Z1 Area - Landfill	**99,900.00 M3**	**5.63 /M3**	**10.84 /M3**	**11.23 /M3**	**22.28 /M3**	**50.75 /M3**	**5,070,200**
				00.80 Z1 Area- Landfill - Alternative 3	**111,700.00 M3**	**20.75 /M3**	**44.17 /M3**	**107.49 /M3**	**89.71 /M3**	**262.81 /M3**	**29,356,073**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.90				**Pacer Ivy Area Landfill - Alternative 3**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	31,914.00 md	-	-	-	40.97 /md	40.97 /md	1,307,447
				Resperators - One Ea Man	120.00 ea	-	-	-	68.28 /ea	68.28 /ea	8,194
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,315,640.50 /ls**	**1,315,640.50 /ls**	**1,315,640**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	316,398.48 /ls	-	316,398.48 /ls	316,398
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	632,796.97 /ls	-	632,796.97 /ls	632,797
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**949,195.45 /ls**	**/ls**	**949,195.45 /ls**	**949,195**
			01000-0301	**Reconstruct Haul Roads**							
				Reclaim Roads	45,056.00 sy	0.74 /sy	-	-	4.77 /sy	5.50 /sy	247,913
				Fine Grade Roads	45,056.00 sy	0.44 /sy	-	-	1.69 /sy	2.13 /sy	95,939
				Pave Roads	13,900.00 ton	2.09 /ton	-	-	7.79 /ton	9.89 /ton	137,434
				Haul Bituminous Concrete	13,900.00 ton	1.91 /ton	102.42 /ton	-	12.12 /ton	116.45 /ton	1,618,669
				Reconstruct Haul Roads	**7.70 KM**	**14,103.80 /KM**	**184,887.23 /KM**	**/KM**	**73,730.41 /KM**	**272,721.44 /KM**	**2,099,955**
			01590-0100	**Traffic and Enviromental Controls**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.71 /sf	16.39 /sf	-	-	18.09 /sf	3,474
				Wood Snow Fence	6,000.00 lf	1.17 /lf	4.10 /lf	-	-	5.27 /lf	31,604
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	83.00 wk	-	-	-	1,522.36 /wk	1,522.36 /wk	126,356
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	83.00 wk	-	-	-	3,330.96 /wk	3,330.96 /wk	276,469
				Maintain Haul Rds - Grader- Cat 14/RLV	83.00 wk	1,529.47 /wk	-	-	6,371.86 /wk	7,901.33 /wk	655,810
				Traffic and Enviromental Controls	**1.00 ls**	**134,296.40 /ls**	**27,727.03 /ls**	**/ls**	**931,690.11 /ls**	**1,093,713.54 /ls**	**1,093,714**
				06.-- -----							5,458,505
				009.-- Site and Traffic Controls	1.00 ls	242,895.68 /ls	1,451,358.69 /ls	949,195.45 /ls	2,815,054.75 /ls	5,458,504.57 /ls	5,458,505
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,531.19 /ea	-	2,531.19 /ea	25,312
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,311.89 /ls**	**/ls**	**25,311.89 /ls**	**25,312**
				06.-- -----							25,312
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,311.89 /ls	/ls	25,311.89 /ls	25,312
	012.--			Pacer Ivy - Landfill Site							
		00.9		Clearing Landfill Areas and Excavated Areas							
			02230-005	**Site Clearing - Excavated Areas**							
				Clear & Grub Light Trees, 14.8 ac	37.20 ac	1,398.37 /ac	-	-	2,044.79 /ac	3,443.15 /ac	128,085
				Site Clearing - Excavated Areas	**150,500.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**128,085**
			02230-005	**Site Clearing - Containment/Treatment Areas**							
				Clear & Grub Light Trees, 14.8 ac	17.10 ac	1,398.37 /ac	-	-	2,044.79 /ac	3,443.15 /ac	58,878
				Site Clearing - Containment/Treatment Areas	**69,200.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.51 /M2**	**0.85 /M2**	**58,878**
				00.9 Clearing Landfill Areas and Excavated Areas	22.00 ha	3,451.43 /ha	/ha	/ha	5,046.90 /ha	8,498.33 /ha	186,963
		01.--		Excavate Soil/Sediment to Landfill Area							
			02310-01-2	**Pacer Ivy Cut to Stockpile - Containment - Soil**							
				Cut to Waste - (2 excavators)	93,780.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	388,972
				Rear Dump Truck 12 cy	93,780.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	1,644,840
				Project Health & Safety Technician	977.00 hr	13.66 /hr	-	-	-	13.66 /hr	13,342
				Level 2 Survey Crew	977.00 hr	27.31 /hr	-	-	-	27.31 /hr	26,684
				Decontamination Area	977.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	190,388
				Pacer Ivy Cut to Stockpile - Containment - Soil	**93,780.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.14 /cy**	**2,264,226**
			02310-01-2	**Pacer Ivy Cut to Stockpile - Treatment Soil**							
				Cut to Waste - (2 excavators)	73,768.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	305,968
				Rear Dump Truck 12 cy	73,768.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	1,293,843
				Project Health & Safety Technician	769.00 hr	13.66 /hr	-	-	-	13.66 /hr	10,501
				Level 2 Survey Crew	769.00 hr	27.31 /hr	-	-	-	27.31 /hr	21,003
				Decontamination Area	769.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	149,855
				Pacer Ivy Cut to Stockpile - Treatment Soil	**73,768.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.15 /cy**	**1,781,170**
			02310-01-2	**Northwest Area - Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	35,803
				Rear Dump Truck 12 cy	8,632.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	151,400
				Project Health & Safety Technician	90.00 hr	13.66 /hr	-	-	-	13.66 /hr	1,229
				Level 2 Survey Crew	90.00 hr	27.31 /hr	-	-	-	27.31 /hr	2,458
				Decontamination Area	90.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	17,538
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	23,560
				Northwest Area - Cut to Stockpile - Containment Sediment	**8,632.00 cy**	**4.64 /cy**	**/cy**	**/cy**	**22.24 /cy**	**26.88 /cy**	**231,988**
			02310-01-2	**North Area - Cut to Stockpile - Containment Soil**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	186,079
				Rear Dump Truck 12 cy	44,863.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	786,868
				Project Health & Safety Technician	468.00 hr	13.66 /hr	-	-	-	13.66 /hr	6,391
				Level 2 Survey Crew	468.00 hr	27.31 /hr	-	-	-	27.31 /hr	12,782

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**North Area - Cut to Stockpile - Containment Soil**							
				Decontamination - Area	468.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	91,199
				North Area - Cut to Stockpile - Containment Soil	**44,863.00 cy**	**4.13 /cy**	**/cy**	**/cy**	**20.02 /cy**	**24.15 /cy**	**1,083,319**
			02310-01-2	**North East Area - Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	135,626
				Rear Dump Truck 12 cy	32,699.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	573,519
				Project Health & Safety Technician	341.00 hr	13.66 /hr	-	-	-	13.66 /hr	4,657
				Level 2 Survey Crew	341.00 hr	27.31 /hr	-	-	-	27.31 /hr	9,313
				Decontamination - Area	341.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	66,451
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,699.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	89,248
				North East Area - Cut to Stockpile - Containment Sediment	**32,699.00 cy**	**4.64 /cy**	**/cy**	**/cy**	**22.24 /cy**	**26.88 /cy**	**878,813**
			02310-01-2	**Pacer Ivy Cut to Stockpile - Containment - Sediment**							
				Cut to Waste - (2 excavators)	34,922.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	144,846
				Rear Dump Truck 12 cy	34,922.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	612,509
				Project Health & Safety Technician	364.00 hr	13.66 /hr	-	-	-	13.66 /hr	4,971
				Level 2 Survey Crew	364.00 hr	27.31 /hr	-	-	-	27.31 /hr	9,942
				Decontamination Area	364.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	70,933
				Articulated Wheel Loader Cat 938 140HP 2.75cy	34,922.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	95,315
				Pacer Ivy Cut to Stockpile - Containment - Sediment	**34,922.00 cy**	**4.64 /cy**	**/cy**	**/cy**	**22.24 /cy**	**26.88 /cy**	**938,515**
			02310-01-2	**Pacer Ivy Cut to Stockpile - Treatment - Sediment**							
				Cut to Waste - (2 excavators)	20,142.00 cy	0.40 /cy	-	-	3.75 /cy	4.15 /cy	83,543
				Rear Dump Truck 12 cy	20,142.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	353,278
				Project Health & Safety Technician	210.00 hr	13.66 /hr	-	-	-	13.66 /hr	2,868
				Level 2 Survey Crew	210.00 ls	27.31 /ls	-	-	-	27.31 /ls	5,735
				Decontamination Area	210.00 hr	87.40 /hr	-	-	107.47 /hr	194.87 /hr	40,923
				Articulated Wheel Loader Cat 938 140HP 2.75cy	20,142.00 cy	0.51 /cy	-	-	2.22 /cy	2.73 /cy	54,975
				Pacer Ivy Cut to Stockpile - Treatment - Sediment	**20,142.00 cy**	**4.64 /cy**	**/cy**	**/cy**	**22.24 /cy**	**26.88 /cy**	**541,322**
				01.-- Excavate Soil/Sediment to Landfill Area	**308,806.00 cy**	**4.29 /cy**	**/cy**	**/cy**	**20.71 /cy**	**25.00 /cy**	**7,719,353**
		01.09		**Treatment**							
			01000-030 1	**Treatment**							
				Treatment TCH	93,911.00 cy	-	-	485.99 /cy	-	487.25 /cy	45,758,479
				Capital Costs	1.00 ls	-	-	10,124,751.37 /ls	-	10,124,751.37 /ls	10,124,751
				Treatment	**71,800.00 M3**	**/M3**	**/M3**	**776.66 /M3**	**/M3**	**778.32 /M3**	**55,883,230**
				01.09 Treatment	**1.00 ls**	**/ls**	**/ls**	**55,764,376.69 /ls**	**/ls**	**55,883,229.87 /ls**	**55,883,230**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-030 1	**Water Treatment - Allowance Per Treatment System**							
				Dewatering Treatment System	1.00 ea	-	-	158,199.25 /ea	-	158,199.25 /ea	158,199
				Water Treatment - Allowance Per Treatment System	**1.00 ea**	**/ea**	**/ea**	**158,199.25 /ea**	**/ea**	**158,199.25 /ea**	**158,199**
			01000-030 1	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,502,861.37 /ls	-	4,502,861.37 /ls	4,502,861
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,502,861.37 /ls**	**/ls**	**4,502,861.37 /ls**	**4,502,861**
			01562-022 4	**Dewater Ponds - Pacer Ivy - (2 mo/Pond X 13 ea)**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	632.80 /ea	-	632.80 /ea	8,226
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.05 /lf	12.74 /lf	-	-	14.79 /lf	38,445
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	423.61 /ea	3,208.60 /ea	-	-	3,632.21 /ea	47,219
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	245.81 /day	245.81 /day	191,729
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	167.01 /ea	684.98 /ea	-	-	851.99 /ea	11,076
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.64 /lf	8.41 /lf	-	-	10.05 /lf	97,995
				Attend Temporary Diesel Pumps	780.00 day	1,638.71 /day	-	-	-	1,638.71 /day	1,278,196
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,108
				Dewater Ponds - Pacer Ivy - (2 mo/Pond X 13 ea)	**1.00 ls**	**1,309,285.39 /ls**	**165,753.57 /ls**	**8,226.36 /ls**	**191,729.39 /ls**	**1,674,994.71 /ls**	**1,674,995**
			02240-020 0	**Pacer- 119,000M2 - - @7.5m / 506sf/ea - (2 mo/Pond x 13 ea)**							
				Design Dewatering System	47.10 acre	-	-	6,327.97 /acre	-	6,327.97 /acre	298,047
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,265.60 /ea	-	1,265.60 /ea	16,453
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.41 /lf	217.13 /lf	-	-	220.54 /lf	10,321,432
				Install Discharge Pipe- 6"	79,100.00 lf	1.64 /lf	13.69 /lf	-	-	15.32 /lf	1,212,075
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,502
				Pacer- 119,000M2 - - @7.5m / 506sf/ea - (2 mo/Pond x 13 ea)	**1.00 ls**	**302,898.95 /ls**	**11,244,110.69 /ls**	**314,500.09 /ls**	**/ls**	**11,861,509.73 /ls**	**11,861,510**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,612,184.34 /ls**	**11,409,864.26 /ls**	**4,983,787.07 /ls**	**191,729.39 /ls**	**18,197,565.06 /ls**	**18,197,565**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Pacer Ivy - Landfill - Fill Excavated Areas To Original Grade**							
				Fill From Borrow and Treated Material	212,322.00 CY	0.96 /CY	-	-	5.26 /CY	6.22 /CY	1,320,354
				Import Gravel Fill - Materials Only	184,303.00 cy	-	13.66 /cy	7.09 /cy	-	20.74 /cy	3,823,046
				Grade and Compact	212,322.00 cy	0.38 /cy	-	-	1.59 /cy	1.98 /cy	419,406
				Load Import - From Stockpile	184,303.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	261,995
				Load Treated Soil	28,019.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	39,830
				Dump Truck - Haul	212,322.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	3,723,989
				Pacer Ivy - Landfill - Fill Excavated Areas To Original Grade	**212,322.00 cy**	**3.99 /cy**	**11.85 /cy**	**6.15 /cy**	**23.16 /cy**	**45.16 /cy**	**9,588,621**
				02.-- F&I Borrow - Bring Areas to Grade	**162,332.00 M3**	**5.22 /M3**	**15.50 /M3**	**8.05 /M3**	**30.29 /M3**	**59.07 /M3**	**9,588,621**
		07.--		**Treated Soil**							

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			01000-030 1	**Load and Haul To Z-1 Area**							
				Load Treated Soil	65,882.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	93,654
				Haul Treated Soil To Z-1 Area	65,882.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	1,155,527
				Load and Haul To Z-1 Area	**50,370.00 M3**	**3.47 /M3**	**/M3**	**/M3**	**21.33 /M3**	**24.80 /M3**	**1,249,182**
				07.-- Treated Soil	**50,370.00 M3**	**3.47 /M3**	**/M3**	**/M3**	**21.33 /M3**	**24.80 /M3**	**1,249,182**
				012.-- Pacer Ivy - Landfill Site	**236,100.00 M3**	**17.09 /M3**	**58.99 /M3**	**262.83 /M3**	**53.75 /M3**	**393.16 /M3**	**92,824,914**
	016.--			**Pacer Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-030 1	**Pacer Ivy - - Landfill Liner**							
				Import Common Earth	54,934.00 cy	1.20 /cy	-	-	7.42 /cy	8.61 /cy	473,220
				GCL Clay Liner	376,737.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	101,465
				HDPE Liner 60 mils (1.5 mm)	376,737.00 sf	-	-	0.68 /sf	-	0.68 /sf	255,324
				Geocomposite Liner	376,737.00 sf	0.14 /sf	-	-	-	0.27 /sf	103,389
				HDPE Liner 60 mils (1.5 mm)	376,737.00 sf	-	-	0.68 /sf	-	0.68 /sf	255,324
				Geocomposite Liner	376,737.00 sf	0.14 /sf	-	-	-	0.27 /sf	103,389
				24" Sand Layer	27,467.00 cy	1.59 /cy	0.00 /cy	0.00 /cy	9.89 /cy	11.49 /cy	315,480
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	3,828.00 lf	0.64 /lf	3.38 /lf	-	-	4.02 /lf	15,400
				GCL	376,737.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	101,465
				Linear Low Density PE Liner 40 mils (1 mm)	376,737.00 sf	-	-	0.44 /sf	-	0.44 /sf	166,879
				Geocomposite- 250 mils	376,737.00 sf	-	0.15 /sf	0.41 /sf	-	0.56 /sf	209,166
				Import Common Earth	27,467.00 cy	1.20 /cy	0.00 /cy	0.00 /cy	7.42 /cy	8.61 /cy	236,610
				Loam	4,600.00 cy	2.43 /cy	27.31 /cy	-	2.31 /cy	32.05 /cy	147,437
				Seeding Mechanical Methods	376,737.00 sf	-	-	0.08 /sf	-	0.08 /sf	28,608
				Sand Fill - Materials Only	27,467.00 cy	-	24.58 /cy	7.09 /cy	-	31.67 /cy	869,825
				Earth Soil Layer - Materials Only	82,384.00 cy	-	9.56 /cy	5.19 /cy	-	14.75 /cy	1,215,424
				Dump Truck - Haul	114,451.00 cy	2.39 /cy	-	-	15.15 /cy	17.54 /cy	2,007,396
				Load - From Stockpil	114,451.00 cy	0.27 /cy	-	-	1.16 /cy	1.42 /cy	162,697
				Pacer Ivy - - Landfill Liner	**8.60 ac**	**77,388.06 /ac**	**204,405.22 /ac**	**172,241.80 /ac**	**320,920.17 /ac**	**787,034.71 /ac**	**6,768,498**
				03.-- F&I Landfill Liner	**35,000.00 M2**	**19.02 /M2**	**50.23 /M2**	**42.32 /M2**	**78.86 /M2**	**193.39 /M2**	**6,768,498**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill**							
				Place Soil and Sediment In Landfill	214,896.00 cy	0.70 /cy	-	-	4.44 /cy	5.13 /cy	1,103,145
				Decontamination Area	976.00 ch	87.40 /ch	-	-	107.47 /ch	194.87 /ch	190,193
				Place Excavated Soil and Sediment In Landfill	**214,896.00 cy**	**1.09 /cy**	**/cy**	**/cy**	**4.93 /cy**	**6.02 /cy**	**1,293,339**
				05.-- Place Excavated Soil/Sediment in Landfill	**164,300.00 M3**	**1.43 /M3**	**/M3**	**/M3**	**6.44 /M3**	**7.87 /M3**	**1,293,339**
				016.-- Pacer Area - Landfill	**236,100.00 M3**	**3.81 /M3**	**7.45 /M3**	**6.27 /M3**	**16.17 /M3**	**34.15 /M3**	**8,061,837**
				00.90 Pacer Ivy Area Landfill - Alternative 3	**236,100.00 M3**	**21.93 /M3**	**72.58 /M3**	**273.23 /M3**	**81.85 /M3**	**450.53 /M3**	**106,370,567**

Estimate Totals

Description	Amount	Totals	Hours		Rate
Labor	7,494,635		476,734	hrs	
Material	22,069,736				
Subcontract	76,516,988				
Equipment	29,344,632		654,107	hrs	
Other	300,649				
	135,726,640	**135,726,640**			
-					
Subtotal Direct Cost		**135,726,640**			
Indirect Costs: Sales Tax (MEO): ---------------					
Subtotal Prior to OH&P		**135,726,640**			

Subtotal for Prime Contractor		**135,726,640**			
Construction Contingency ---------------					
Subtotal Cost, Today's Dollars		**135,726,640**			
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016					
		135,726,640			

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 3

Landfill Material < 2,500 ppt,
Ex Situ TCH treatment for Material > 2,500 ppt

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 3 - Landfill Materials <2,500 ppt, Ex Situ TCH Materials >2,500 ppt

Z1 Area Fixed Costs (not dependent on volume)			Base Volume			Added Contingency Volume		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 316,398	1	$ 316,398	$ 316,398	1	$ 316,398
01000-0301	Rebuild Interior Haul Roads	km	$ 265,469	3.3	$ 876,047	$ 265,469	3.3	$ 876,047
01000-0301	UXO Clearance	LS	$ 25,312	1	$ 25,312	$ 25,312	1	$ 25,312
02230-005	Clearing - Excavation Areas	m2	$ 0.85	219,100	$ 186,275	$ 1	219,100	$ 186,275
02230-005	Clearing - Containment/Treatment Areas	m2	$ 0.85	90,000	$ 76,438	$ 1	90,000	$ 76,438
01000-0301	Water Treatment from Dewatered Areas	LS	$ 158,199	1	$ 158,199	$ 158,199	1	$ 158,199
01000-0301	Additional Dewatering and Fish Removal	LS	$ 2,001,272	1	$ 2,001,272	$ 2,001,272	1	$ 2,001,272
01562-0224	Dewater Ponds	LS	$ 386,537	1	$ 386,537	$ 386,537	1	$ 386,537
02240-0200	Dewatering System	lf	$ 1,832,405	1	$ 1,832,405	$ 1,832,405	1	$ 1,832,405
01000-0301	Z1 Landfill Liner	m2	$ 163.19	26,250	$ 4,283,692	$ 163	26,250	$ 4,283,692
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 569,903	1	$ 569,903	$ 679,033	1	$ 679,033.36
01590-0100	Traffic and Environmental Controls	LS	$ 859,690	1	$ 859,690	$ 1,024,311	1	$ 1,024,311
02310-01-2	Area Z1 - Excavation	cy	$ 24.15	27,598	$ 666,441	$ 24.15	32,883	$ 794,064
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 24.15	14,257	$ 344,332	$ 24.15	16,987	$ 410,266
02310-01-2	Southwest Area - Containment - Excavatior	cy	$ 24.14	63,828	$ 1,541,074	$ 24.14	76,050	$ 1,836,164
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.91	1,700	$ 45,753	$ 26.91	2,026	$ 54,527
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 26.87	23,282	$ 625,536	$ 26.87	27,740	$ 745,313
02310-01-2	Southwest Area - Treatment - Excavation	cy	$ 24.15	15,434	$ 372,688	$ 24.15	18,389	$ 444,043
01000-0301	Treatment (TCH)	cy	$ 487.25	15,545	$ 7,574,358	$ 487.25	15,545	$ 7,574,358
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 59.21	92,706	$ 5,489,017	$ 59.21	110,458	$ 6,540,093
01000-0301	Stockpile treated soil from PI area	m3	$ 6.71	50,370	$ 338,198	$ 6.71	60,015	$ 402,957
02310-01-3	Place Excavated Soil/Sediment in Landfill	m3	$ 7.87	99,900	$ 786,508	$ 7.87	121,985	$ 960,382
				Subtotal	**$ 29,356,073**		**Subtotal**	**$ 31,608,086**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	Description	Unit	Unit Cost	Quantity	Total Cost	Unit Cost	Quantity	Total Cost
01000-0301	Demobilization	LS	$ 949,195	1	$ 949,195	$ 949,195	1	$ 949,195
01000-0301	Rebuild Interior Haul Roads	km	$ 272,721	7.7	$ 2,099,955	$ 272,721	7.7	$ 2,099,955
01000-0301	UXO Clearance	LS	$ 25,312	1	$ 25,312	$ 25,312	1	$ 25,312
02230-005	Clearing - Excavation Areas	m2	$ 0.85	150,500	$ 128,085	$ 1	150,500	$ 128,085
02230-005	Clearing - Containment/Treatment Areas	m2	$ 0.85	69,200	$ 58,878	$ 1	69,200	$ 58,878
01000-0301	Treatment (Capital Costs)	LS	$10,124,751.00	1	$ 10,124,751	$ 10,124,751	1	$ 10,124,751
01000-0301	Water Treatment from Dewatered Areas	LS	$ 158,199	1	$ 158,199	$ 158,199	1	$ 158,199
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,502,861	1	$ 4,502,861	$ 4,502,861	1	$ 4,502,861
01562-0224	Dewater Ponds	LS	$ 1,674,994	1	$ 1,674,994	$ 1,674,994	1	$ 1,674,994
02240-0200	Dewatering System	lf	$ 11,861,510	1	$ 11,861,510	$ 11,861,510	1	$ 11,861,510
01000-0301	Pacer Ivy Landfill Liner	m2	$ 193.39	35,000	$ 6,768,498	$ 193	35,000	$ 6,768,498
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,315,640	1	$ 1,315,640	$ 1,567,571	1	$ 1,567,571.06
01590-0100	Traffic and Environmental Controls	LS	$ 1,093,714	1	$ 1,093,714	$ 1,303,149	1	$ 1,303,149
02310-01-2	Pacer Ivy Area - Containment - Excavation	cy	$ 24.14	93,780	$ 2,264,226	$ 24.14	111,738	$ 2,697,804
02310-01-2	Pacer Ivy Area - Treatment - Excavation	cy	$ 24.15	73,768	$ 1,781,170	$ 24.15	87,894	$ 2,122,250
02310-01-2	Northwest Area - Containment - Excavation - Sediment	cy	$ 26.88	8,632	$ 231,988	$ 26.88	10,285	$ 276,413
02310-01-2	North Area - Excavation	cy	$ 24.15	44,863	$ 1,083,319	$ 24.15	53,454	$ 1,290,768
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 26.88	32,699	$ 878,813	$ 26.88	38,961	$ 1,047,109
02310-01-2	Pacer Ivy Area Excavation - Containment - Sediment	cy	$ 26.87	34,922	$ 938,515	$ 26.87	41,609	$ 1,118,225
02310-01-2	Pacer Ivy Area Excavation - Treatment - Sediment	cy	$ 26.88	20,142	$ 541,322	$ 26.88	23,999	$ 644,980
01000-0301	Treatment (TCH)	cy	$ 487.25	93,911	$ 45,758,479	$ 487.25	93,911	$ 45,758,479
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 59.07	162,332	$ 9,588,621	$ 59.07	193,417	$ 11,424,749
01000-0301	Load and Haul to Z1 Area	m3	$ 24.80	50,370	$ 1,249,182	$ 24.80	60,015	$ 1,488,379
02310-01-3	Place Excavated Soil/Sediment in Landfill	m3	$ 7.87	164,300	$ 1,293,339	$ 7.87	213,745	$ 1,682,561
				Subtotal	**$ 106,370,566**		**Subtotal**	**$ 110,774,676**
				Total	**$ 135,726,639**		**Total**	**$ 142,382,762**

Price Increase due to Contingency Volume $ 6,656,124

Percentage Increase in Price 4.90%

Percentage Increase in Volume 19.15%

1. Construction Capital Costs (Years 1 through 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 142,382,762	$142,382,762	From detailed cost estimate
Contingency (Scope and Bid)	30%			$42,714,829	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$185,098,000	Rounded to nearest $1,000
Project Management	5%			$9,254,900	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$11,105,880	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$9,254,900	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$222,713,680	
TOTAL CONSTRUCTION CAPITAL COST				**$222,714,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	7	YR	**$31,816,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 7)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$595,964	$595,964	Sampling/analysis required by the EMMP
Contingency (Scope and Bid)	30%			$178,789	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$775,000	Rounded to nearest $1,000
Project Management	10%			$77,500	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$116,250	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$38,750	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,007,500	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,008,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	7	YR	$1,008,000	**$7,056,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$55,238	$55,238	Sampling/analysis required by the EMMP; assume 0.5% of landfill construction costs.
Contingency (Scope and Bid)	30%			$16,571	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$71,809	
Project Management	10%			$7,181	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$10,771	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$3,590	Assumed to apply to 50% of the EMMP implementation
TOTAL				$93,351	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$93,000**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	43	YR	$93,000	**$3,999,000**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 8 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$33,143	$33,143	Includes annual landfill O&M; assume 0.3% of landfill construction costs.
Contingency (Scope and Bid)	30%			$9,943	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$43,086	
Project Management	10%			$4,309	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$6,463	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$2,154	Assumed to apply to 50% of the O&M
TOTAL				$56,012	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$56,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	43	YR	$56,000	**$2,408,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative	**$236,177,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
3 - Landfill below 2,500 ppt, ex-situ TCH greater than 2,500 ppt
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$31,816,000	$1,008,000	$0	$0	$32,824,000	0.9346	$30,677,310
2	$31,816,000	$1,008,000	$0	$0	$32,824,000	0.8734	$28,668,482
3	$31,816,000	$1,008,000	$0	$0	$32,824,000	0.8163	$26,794,231
4	$31,816,000	$1,008,000	$0	$0	$32,824,000	0.7629	$25,041,430
5	$31,816,000	$1,008,000	$0	$0	$32,824,000	0.7130	$23,403,512
6	$31,816,000	$1,008,000	$1	$0	$32,824,001	0.6663	$21,870,632
7	$31,816,000	$1,008,000	$2	$0	$32,824,002	0.6227	$20,439,506
8	$0	$0	$93,000	$56,000	$149,000	0.5820	$86,718
9	$0	$0	$93,000	$56,000	$149,000	0.5439	$81,041
10	$0	$0	$93,000	$56,000	$149,000	0.5083	$75,737
11	$0	$0	$93,000	$56,000	$149,000	0.4751	$70,790
12	$0	$0	$93,000	$56,000	$149,000	0.4440	$66,156
13	$0	$0	$93,000	$56,000	$149,000	0.4150	$61,835
14	$0	$0	$93,000	$56,000	$149,000	0.3878	$57,782
15	$0	$0	$93,000	$56,000	$149,000	0.3624	$53,998
16	$0	$0	$93,000	$56,000	$149,000	0.3387	$50,466
17	$0	$0	$93,000	$56,000	$149,000	0.3166	$47,173
18	$0	$0	$93,000	$56,000	$149,000	0.2959	$44,089
19	$0	$0	$93,000	$56,000	$149,000	0.2765	$41,199
20	$0	$0	$93,000	$56,000	$149,000	0.2584	$38,502
21	$0	$0	$93,000	$56,000	$149,000	0.2415	$35,984
22	$0	$0	$93,000	$56,000	$149,000	0.2257	$33,629
23	$0	$0	$93,000	$56,000	$149,000	0.2109	$31,424
24	$0	$0	$93,000	$56,000	$149,000	0.1971	$29,368
25	$0	$0	$93,000	$56,000	$149,000	0.1842	$27,446
26	$0	$0	$93,000	$56,000	$149,000	0.1722	$25,658
27	$0	$0	$93,000	$56,000	$149,000	0.1609	$23,974
28	$0	$0	$93,000	$56,000	$149,000	0.1504	$22,410
29	$0	$0	$93,000	$56,000	$149,000	0.1406	$20,949
30	$0	$0	$93,000	$56,000	$149,000	0.1314	$19,579
31	$0	$0	$93,000	$56,000	$149,000	0.1228	$18,297
32	$0	$0	$93,000	$56,000	$149,000	0.1147	$17,090
33	$0	$0	$93,000	$56,000	$149,000	0.1072	$15,973
34	$0	$0	$93,000	$56,000	$149,000	0.1002	$14,930
35	$0	$0	$93,000	$56,000	$149,000	0.0937	$13,961
36	$0	$0	$93,000	$56,000	$149,000	0.0875	$13,038
37	$0	$0	$93,000	$56,000	$149,000	0.0818	$12,188
38	$0	$0	$93,000	$56,000	$149,000	0.0765	$11,399
39	$0	$0	$93,000	$56,000	$149,000	0.0715	$10,654
40	$0	$0	$93,000	$56,000	$149,000	0.0668	$9,953
41	$0	$0	$93,000	$56,000	$149,000	0.0624	$9,298
42	$0	$0	$93,000	$56,000	$149,000	0.0583	$8,687
43	$0	$0	$93,000	$56,000	$149,000	0.0545	$8,121
44	$0	$0	$93,000	$56,000	$149,000	0.0509	$7,584
45	$0	$0	$93,000	$56,000	$149,000	0.0476	$7,092
46	$0	$0	$93,000	$56,000	$149,000	0.0445	$6,631
47	$0	$0	$93,000	$56,000	$149,000	0.0416	$6,198
48	$0	$0	$93,000	$56,000	$149,000	0.0389	$5,796
49	$0	$0	$93,000	$56,000	$149,000	0.0363	$5,409
50	$0	$0	$93,000	$56,000	$149,000	0.0339	$5,051
TOTALS:	$222,712,000	$7,056,000	$3,999,003	$2,408,000	**$236,175,003**		$178,148,360
TOTAL PRESENT VALUE OF ALTERNATIVE[5]							**$178,148,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 4

Landfill Material < 1,200 ppt,
Ex Situ TCH treatment for Material > 1,200 ppt

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt

Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) Landfilling of soils which have dioxin concentrations less than 1,200 ppt TEQ; (3) ex-situ TCH treatment of soils with greater than 1,200 ppt TEQ; and (4) backfilling excavations. Note that the 1,020 ppt corresponds to the industrial action level of 1,200 ppt less the 15% CSF.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$233,969,848	$233,969,848	From detailed cost estimate
Contingency (Scope and Bid)	30%			$70,190,954	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$304,161,000	Rounded to nearest $1,000
Project Management	5%			$15,208,050	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$18,249,660	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$15,208,050	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$360,826,760	
TOTAL CONSTRUCTION CAPITAL COST				**$360,827,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	10	YR	**$36,083,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$841,398	$841,398	Sampling/analysis required by the EMMP; assume 0.4% of construction cost.
Contingency (Scope and Bid)	30%			$252,419	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,094,000	Rounded to nearest $1,000
Project Management	10%			$109,400	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$164,100	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$54,700	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,422,200	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,422,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	10	YR	$1,422,000	**$14,220,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	Not required since landfilled material <1200 ppt and located in industrial area.
Contingency (Scope and Bid)	30%			$0	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$30,462	$30,462	Includes annual landfill O&M; assume 0.3% of landfill construction costs.
Contingency (Scope and Bid)	30%			$9,139	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$39,601	
Project Management	10%			$3,960	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$5,940	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$1,980	Assumed to apply to 50% of the O&M
TOTAL				$51,481	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$51,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	40	YR	$51,000	**$2,040,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt	**$377,087,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity	CSF	Concentration Safety Factor
LS	Lump Sum	O&M	Operations and Maintenance		
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan		

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$36,083,000	$1,422,000	$0	$0	$37,505,000	0.9346	$35,052,173
2	$36,083,000	$1,422,000	$0	$0	$37,505,000	0.8734	$32,756,867
3	$36,083,000	$1,422,000	$0	$0	$37,505,000	0.8163	$30,615,332
4	$36,083,000	$1,422,000	$0	$0	$37,505,000	0.7629	$28,612,565
5	$36,083,000	$1,422,000	$0	$0	$37,505,000	0.7130	$26,741,065
6	$36,083,000	$1,422,000	$1	$0	$37,505,001	0.6663	$24,989,582
7	$36,083,000	$1,422,000	$2	$0	$37,505,002	0.6227	$23,354,365
8	$36,083,000	$1,422,000	$3	$0	$37,505,003	0.5820	$21,827,912
9	$36,083,000	$1,422,000	$4	$0	$37,505,004	0.5439	$20,398,972
10	$36,083,000	$1,422,000	$5	$0	$37,505,005	0.5083	$19,063,794
11	$0	$0	$0	$51,000	$51,000	0.4751	$24,230
12	$0	$0	$0	$51,000	$51,000	0.4440	$22,644
13	$0	$0	$0	$51,000	$51,000	0.4150	$21,165
14	$0	$0	$0	$51,000	$51,000	0.3878	$19,778
15	$0	$0	$0	$51,000	$51,000	0.3624	$18,482
16	$0	$0	$0	$51,000	$51,000	0.3387	$17,274
17	$0	$0	$0	$51,000	$51,000	0.3166	$16,147
18	$0	$0	$0	$51,000	$51,000	0.2959	$15,091
19	$0	$0	$0	$51,000	$51,000	0.2765	$14,102
20	$0	$0	$0	$51,000	$51,000	0.2584	$13,178
21	$0	$0	$0	$51,000	$51,000	0.2415	$12,317
22	$0	$0	$0	$51,000	$51,000	0.2257	$11,511
23	$0	$0	$0	$51,000	$51,000	0.2109	$10,756
24	$0	$0	$0	$51,000	$51,000	0.1971	$10,052
25	$0	$0	$0	$51,000	$51,000	0.1842	$9,394
26	$0	$0	$0	$51,000	$51,000	0.1722	$8,782
27	$0	$0	$0	$51,000	$51,000	0.1609	$8,206
28	$0	$0	$0	$51,000	$51,000	0.1504	$7,670
29	$0	$0	$0	$51,000	$51,000	0.1406	$7,171
30	$0	$0	$0	$51,000	$51,000	0.1314	$6,701
31	$0	$0	$0	$51,000	$51,000	0.1228	$6,263
32	$0	$0	$0	$51,000	$51,000	0.1147	$5,850
33	$0	$0	$0	$51,000	$51,000	0.1072	$5,467
34	$0	$0	$0	$51,000	$51,000	0.1002	$5,110
35	$0	$0	$0	$51,000	$51,000	0.0937	$4,779
36	$0	$0	$0	$51,000	$51,000	0.0875	$4,463
37	$0	$0	$0	$51,000	$51,000	0.0818	$4,172
38	$0	$0	$0	$51,000	$51,000	0.0765	$3,902
39	$0	$0	$0	$51,000	$51,000	0.0715	$3,647
40	$0	$0	$0	$51,000	$51,000	0.0668	$3,407
41	$0	$0	$0	$51,000	$51,000	0.0624	$3,182
42	$0	$0	$0	$51,000	$51,000	0.0583	$2,973
43	$0	$0	$0	$51,000	$51,000	0.0545	$2,780
44	$0	$0	$0	$51,000	$51,000	0.0509	$2,596
45	$0	$0	$0	$51,000	$51,000	0.0476	$2,428
46	$0	$0	$0	$51,000	$51,000	0.0445	$2,270
47	$0	$0	$0	$51,000	$51,000	0.0416	$2,122
48	$0	$0	$0	$51,000	$51,000	0.0389	$1,984
49	$0	$0	$0	$51,000	$51,000	0.0363	$1,851
50	$0	$0	$0	$51,000	$51,000	0.0339	$1,729
TOTALS:	$360,830,000	$14,220,000	$15	$2,040,000	**$377,090,015**		$263,758,253
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$263,758,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternative 4
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver:	Database Version 7.0
ENR 20 City CCI:	October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
01				**Z1 Area- Landfill - Alternative 4**							
	009.--			**Site and Traffic Controls**							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	19,293.00 md	-	-	-	40.85 /md	40.85 /md	788,016
				Resperators - One Ea Man	40.00 ea	-	-	-	68.07 /ea	68.07 /ea	2,723
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**790,739.43 /ls**	**790,739.43 /ls**	**790,739**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	315,372.34 /ls	-	315,372.34 /ls	315,372
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	630,744.72 /ls	-	630,744.72 /ls	630,745
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**946,117.06 /ls**	**/ls**	**946,117.06 /ls**	**946,117**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.74 /sy	-	-	4.75 /sy	5.49 /sy	102,996
				Fine Grade Subbase	18,775.00 sy	0.44 /sy	-	-	1.69 /sy	2.12 /sy	39,858
				Pave Roads - (4" Binder/1.5" Top)	5,800.00 ton	2.09 /ton	-	-	7.77 /ton	11.22 /ton	65,071
				On-Highway Rear Dump Truck 18CY	5,800.00 ton	1.91 /ton	102.11 /ton	-	12.08 /ton	116.10 /ton	673,386
				Rebuild Interior Haul Roads	**3.30 KM**	**13,681.48 /KM**	**179,469.06 /KM**	**/KM**	**71,520.28 /KM**	**267,063.74 /KM**	**881,310**
			01590-0100	**Traffic and Enviromental Controls -**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.34 /sf	-	-	18.04 /sf	3,464
				Plastic Snow Fence	10,000.00 lf	1.17 /lf	4.08 /lf	-	-	5.25 /lf	52,515
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	60.00 wk	-	-	-	1,517.79 /wk	1,517.79 /wk	91,067
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	60.00 wk	-	-	-	3,320.95 /wk	3,320.95 /wk	199,257
				Maintain Haul Rds - Grader- Cat 14/RLV	60.00 wk	1,524.87 /wk	-	-	6,352.71 /wk	7,877.58 /wk	472,655
				Traffic and Enviromental Controls -	**1.00 ls**	**103,488.74 /ls**	**43,981.55 /ls**	**/ls**	**671,486.58 /ls**	**818,956.87 /ls**	**818,957**
				06.-- -----							3,437,124
				009.-- Site and Traffic Controls	**1.00 ls**	**148,637.63 /ls**	**636,229.44 /ls**	**946,117.06 /ls**	**1,698,242.92 /ls**	**3,437,123.70 /ls**	**3,437,124**
	009.5			**RVN - In Country Requirements**							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,522.98 /ea	-	2,522.98 /ea	25,230
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,229.79 /ls**	**/ls**	**25,229.79 /ls**	**25,230**
				06.-- -----							25,230
				009.5 RVN - In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,229.79 /ls**	**/ls**	**25,229.79 /ls**	**25,230**
	010.--			**Z1 Area - Landfill Site**							
		00.9		**Clearing Containment/Treatment Areas**							
			02230-005	**Clearing For Containment/Treatment Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	39.50 ac	1,394.17 /ac	-	-	2,038.64 /ac	3,432.81 /ac	135,596
				Clearing For Containment/Treatment Areas	**159,850.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.50 /M2**	**0.85 /M2**	**135,596**
			02230-005	**Clearing ForExcavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	54.14 ac	1,394.17 /ac	-	-	2,038.64 /ac	3,432.81 /ac	185,852
				Clearing ForExcavated Areas	**219,096.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.50 /M2**	**0.85 /M2**	**185,852**
				00.9 Clearing Containment/Treatment Areas	**37.90 ha**	**3,444.58 /ha**	**/ha**	**/ha**	**5,036.89 /ha**	**8,481.47 /ha**	**321,448**
		01.--		**Excavate Soil/Sediment to Landfill Area**							
			02310-01-2	**Area Z1 Cut to Stockpile -Containment Soil**							
				Cut to Waste - (2 excavators)	27,598.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	114,124
				Rear Dump Truck 12 cy	27,598.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	482,596
				Project Health & Safety Technician	287.50 hr	13.62 /hr	-	-		13.62 /hr	3,914
				Survey Crew - 2 Men	287.50 hr	27.23 /hr	-	-	-	27.23 /hr	7,829
				Decontamination Area	287.50 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	55,857
				Area Z1 Cut to Stockpile -Containment Soil	**27,598.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.07 /cy**	**664,320**
			02310-01-2	**Area Z1 Cut to Stockpile -Treatment Soil**							
				Cut to Waste - (2 excavators)	79,393.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	328,309
				Rear Dump Truck 12 cy	79,393.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	1,388,316
				Health & Safety Technician	827.00 hr	13.62 /hr	-	-	-	13.62 /hr	11,260
				Level 2 Survey Crew	827.00 hr	27.23 /hr	-	-	-	27.23 /hr	22,519
				Decontamination Area	827.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	160,673
				Area Z1 Cut to Stockpile -Treatment Soil	**79,393.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.07 /cy**	**1,911,077**
			02310-01-2	**Area Z1 Taxiway -Treatment - Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	58,956
				Rear Dump Truck 12 cy	14,257.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	249,307
				Project Health & Safety Technician	148.50 hr	13.62 /hr	-	-	-	13.62 /hr	2,022
				Level 2 Survey Crew	148.50 hr	27.23 /hr	-	-	-	27.23 /hr	4,044
				Decontamination Trailer	148.50 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	28,851
				Area Z1 Taxiway -Treatment - Soil	**14,257.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.07 /cy**	**343,180**
			02310-01-2	**Southwest Area - Containment - Soil**							
				Cut to Waste - (2 excavators)	54,280.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	224,461
				Rear Dump Truck 12 cy	54,280.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	949,174
				Project Health & Safety Technician	568.40 hr	13.62 /hr	-	-	-	13.62 /hr	7,739
				Level 2 Survey Crew	565.40 hr	27.23 /hr	-	-	-	27.23 /hr	15,396
				Decontamination Area	565.40 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	109,848
				Southwest Area - Containment - Soil	**54,280.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.07 /cy**	**1,306,618**
			02310-01-2	**Southwest Area - Treatment - Soil**							
				Cut to Waste - (2 excavators)	24,982.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	103,307
				Rear Dump Truck 12 cy	24,982.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	436,851
				Project Health & Safety Technician	261.00 hr	13.62 /hr	-	-		13.62 /hr	3,553
				Level 2 Survey Crew	261.00 hr	27.23 /hr	-	-	-	27.23 /hr	7,107

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Southwest Area - Treatment - Soil**							
				Decontamination Area	261.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	50,708
				Southwest Area - Treatment - Soil	**24,982.00 cy**	**4.12 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.08 /cy**	**601,526**
			02310-01-2	**Gate 2 Lake - 1 cd - Containment Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	7,030
				Rear Dump Truck 12 cy	1,700.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	29,727
				Project Health & Safety Technician	18.00 hr	13.62 /hr	-	-		13.62 /hr	245
				Level 2 Survey Crew	18.00 hr	27.23 /hr	-	-	-	27.23 /hr	490
				Decontamination Area	18.00 hr	87.14 /hr	-	-	107.15 /hr	194.28 /hr	3,497
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	4,626
				Gate 2 Lake - 1 cd - Containment Sediment	**1,700.00 cy**	**4.64 /cy**	**/cy**	**/cy**	**22.19 /cy**	**26.83 /cy**	**45,616**
			02310-01-2	**Area Z1 Cut to Stockpile -Containment Sediment**							
				Cut to Waste - (2 excavators)	21,058.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	87,080
				Rear Dump Truck 12 cy	21,058.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	368,233
				Project Health & Safety Technician	220.00 hr	13.62 /hr	-	-		13.62 /hr	2,995
				Level 2 Survey Crew	220.00 hr	27.23 /hr	-	-	-	27.23 /hr	5,991
				Decontamination Area	220.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	42,743
				Articulated Wheel Loader Cat 938 140HP 2.75cy	21,058.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	57,302
				Area Z1 Cut to Stockpile -Containment Sediment	**21,058.00 cy**	**4.63 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.80 /cy**	**564,344**
			02310-01-2	**Area Z1 Cut to Stockpile -Treatment Sediment**							
				Cut to Waste - (2 excavators)	2,224.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	9,197
				Rear Dump Truck 12 cy	2,224.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	38,890
				Project Health & Safety Technician	23.20 cy	13.61 /cy	-	-	-	13.61 /cy	316
				Level 2 Survey Crew	23.20 hr	27.23 /hr	-	-	-	27.23 /hr	632
				Decontamination Area	23.20 hr	87.13 /hr	-	-	107.15 /hr	194.28 /hr	4,507
				Articulated Wheel Loader Cat 938 140HP 2.75cy	2,224.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	6,052
				Area Z1 Cut to Stockpile -Treatment Sediment	**2,224.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.80 /cy**	**59,594**
				01.-- Excavate Soil/Sediment to Landfill Area	**225,491.00 cy**	**4.17 /cy**	**/cy**	**/cy**	**20.20 /cy**	**24.38 /cy**	**5,496,274**
		01.05		**Treatment**							
			01000-0301	**Treatment**							
				Treatment Costs TCH	120,724.00 cy	-	-	485.67 /cy	-	485.67 /cy	58,632,438
				Capital Cost per Pile	1.00 ea	-	-	10,091,915.21 /ea	-	10,091,915.21 /ea	10,091,915
				Treatment	**120,724.00 cy**	**/cy**	**/cy**	**569.27 /cy**	**/cy**	**569.27 /cy**	**68,724,353**
				01.05 Treatment	**1.00 ls**	**/ls**	**/ls**	**68,724,353.12 /ls**	**/ls**	**68,724,353.12 /ls**	**68,724,353**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Dewatering Treatment Cost**							
				Dewatering Treatment	1.00 ls	-	-	157,686.19 /ls	-	157,686.19 /ls	157,686
				Dewatering Treatment Cost	**1.00 ls**	**/ls**	**/ls**	**157,686.19 /ls**	**/ls**	**157,686.19 /ls**	**157,686**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	1,999,863.73 /ls	-	1,999,863.73 /ls	1,999,864
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**1,999,863.73 /ls**	**/ls**	**1,999,863.73 /ls**	**1,999,864**
			01562-0224	**Dewater Ponds - Z1 Area - (2 mo/pond x 3 ea)**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	630.75 /ea	-	630.75 /ea	1,892
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.04 /lf	12.70 /lf	-	-	14.74 /lf	8,845
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	422.34 /ea	3,198.95 /ea	-	-	3,621.29 /ea	10,864
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	245.07 /day	245.07 /day	44,112
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	166.51 /ea	682.92 /ea	-	-	849.43 /ea	2,548
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.63 /lf	8.39 /lf	-	-	10.02 /lf	22,546
				Attend Temporary Diesel Pumps	180.00 day	1,633.79 /day	-	-	-	1,633.79 /day	294,082
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	485
				Dewater Ponds - Z1 Area - (2 mo/pond x 3 ea)	**1.00 ls**	**301,234.64 /ls**	**38,135.82 /ls**	**1,892.25 /ls**	**44,112.27 /ls**	**385,374.98 /ls**	**385,375**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m = @506sf/ea -(2 mo/pond x 3 ea)**							
				Design Dewatering System	8.50 acre	-	-	6,307.45 /acre	-	6,307.45 /acre	53,613
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,261.49 /ea	-	1,261.49 /ea	3,784
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.40 /lf	216.48 /lf	-	-	219.88 /lf	1,583,140
				Install Discharge Pipe- 6"	12,063.00 lf	1.63 /lf	13.64 /lf	-	-	15.28 /lf	184,290
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,053
				Z1 Area -33,800M2 - 363,800 sf @7.5m = @506sf/ea -(2 mo/pond x 3 ea)	**1.00 ls**	**46,268.16 /ls**	**1,723,214.41 /ls**	**57,397.79 /ls**	**/ls**	**1,826,880.36 /ls**	**1,826,880**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**347,502.80 /ls**	**1,761,350.23 /ls**	**2,216,839.96 /ls**	**44,112.27 /ls**	**4,369,805.26 /ls**	**4,369,805**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1 Landfill - Fill Excavated Areas To Original Grade -**							
				Fill to Grade	200,628.00 CY	0.95 /CY	-	-	5.25 /CY	6.20 /CY	1,243,884
				Load From Stockpile	145,671.00 cy	0.27 /cy	0.00 /cy	0.00 /cy	1.15 /cy	1.42 /cy	206,456
				Grade and Compact	200,628.00 cy	0.38 /cy	-	-	1.59 /cy	1.97 /cy	395,116
				Import Gravel Fill - Materials Only	145,671.00 cy	-	13.62 /cy	7.06 /cy	-	20.68 /cy	3,012,365
				Dump Truck - Haul	200,628.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	3,508,308
				Load Treated Soil`	54,957.00 cy	0.12 /cy	-	-	1.15 /cy	1.27 /cy	69,703
				Area Z-1 Landfill - Fill Excavated Areas To Original Grade -	**200,628.00 cy**	**3.94 /cy**	**9.89 /cy**	**5.13 /cy**	**23.09 /cy**	**42.05 /cy**	**8,435,830**
				02.-- F&I Borrow - Bring Areas to Grade	**153,391.00 M3**	**5.15 /M3**	**12.93 /M3**	**6.71 /M3**	**30.20 /M3**	**55.00 /M3**	**8,435,830**
		05.50		**Stockpile Treated Soils**							
			01000-0301	**Stockpile Treated Soils**							
				Stockpile Treated Soils - (From Z1 & PI)	131,841.00 cy	1.91 /cy	-	-	12.17 /cy	14.07 /cy	1,855,583
				Stockpile Treated Soils	**131,841.00 cy**	**1.91 /cy**	**/cy**	**/cy**	**12.17 /cy**	**14.07 /cy**	**1,855,583**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
				05.50 Stockpile Treated Soils	**100,800.00 M3**	**2.49 /M3**	**/M3**	**/M3**	**15.92 /M3**	**18.41 /M3**	**1,855,583**
				010.-- Z1 Area - Landfill Site	**172,400.00 M3**	**14.27 /M3**	**21.72 /M3**	**417.46 /M3**	**63.97 /M3**	**517.42 /M3**	**89,203,294**
	014.--			**Z1 Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-0301	**Z1 Area - Landfill Liner**							
				Import Common Earth	20,600.00 cy	1.19 /cy	-	-	7.40 /cy	8.59 /cy	176,922
				GCL Clay Liner	282,553.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	75,870
				HDPE Liner 60 mils (1.5 mm)	282,553.00 sf	-	-	0.68 /sf	-	0.68 /sf	190,872
				Geocomposite Liner	282,553.00 sf	0.14 /sf	-	-	-	0.27 /sf	77,309
				HDPE Liner 60 mils (1.5 mm)	282,553.00 sf	-	-	0.68 /sf	-	0.68 /sf	190,872
				Geocomposite Liner	282,553.00 sf	0.14 /sf	-	-	-	0.27 /sf	77,308
				24" Sand Layer	20,600.00 cy	1.59 /cy	0.00 /cy	0.00 /cy	9.86 /cy	11.45 /cy	235,896
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	2,870.00 lf	0.64 /lf	3.37 /lf	-	-	4.01 /lf	11,511
				GCL	282,553.00 sf	0.14 /sf	-	-	-	0.27 /sf	77,309
				Linear Low Density PE Liner 40 mils (1 mm)	282,553.00 sf	-	-	0.44 /sf	-	0.44 /sf	124,753
				Geocomposite- 250 mils	282,553.00 sf	-	0.15 /sf	0.40 /sf	-	0.55 /sf	156,376
				Import Common Earth	41,200.00 cy	1.19 /cy	0.00 /cy	0.00 /cy	7.40 /cy	8.59 /cy	353,844
				Seeding Mechanical Methods	282,553.00 sf	-	-	0.08 /sf	-	0.08 /sf	21,386
				Loam 4"	3,455.00 cy	2.42 /cy	27.23 /cy	-	2.31 /cy	31.96 /cy	110,406
				Sand Fill - Materials Only	20,600.00 cy	-	24.51 /cy	7.06 /cy	-	31.57 /cy	650,366
				Common Earth - Materials Only	41,200.00 cy	-	9.53 /cy	5.18 /cy	-	14.71 /cy	605,952
				Dump Truck - Haul	65,255.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	1,141,090
				Load - From Stockpile	65,255.00 cy	0.27 /cy	-	-	1.15 /cy	1.42 /cy	92,484
				Z1 Area - Landfill Liner	**6.50 ac**	**68,180.32 /ac**	**166,302.24 /ac**	**153,964.35 /ac**	**266,016.04 /ac**	**672,388.72 /ac**	**4,370,527**
				03.-- F&I Landfill Liner	**26,250.00 M2**	**16.88 /M2**	**41.18 /M2**	**38.13 /M2**	**65.87 /M2**	**166.50 /M2**	**4,370,527**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill -**							
				Place Soil and Sediment In Landfill	104,767.00 cy	0.69 /cy	-	-	4.43 /cy	5.12 /cy	536,194
				Decontamination Area	476.00 ch	87.14 /ch	-	-	107.15 /ch	194.29 /ch	92,479
				Place Excavated Soil and Sediment In Landfill -	**104,767.00 cy**	**1.09 /cy**	**/cy**	**/cy**	**4.91 /cy**	**6.00 /cy**	**628,673**
				05.-- Place Excavated Soil/Sediment in Landfill	**80,100.00 M3**	**1.42 /M3**	**/M3**	**/M3**	**6.42 /M3**	**7.85 /M3**	**628,673**
				014.-- Z1 Area - Landfill	**172,400.00 M3**	**3.23 /M3**	**6.27 /M3**	**5.81 /M3**	**13.01 /M3**	**29.00 /M3**	**4,999,200**
				01 Z1 Area- Landfill - Alternative 4	**172,400.00 M3**	**18.37 /M3**	**31.68 /M3**	**428.90 /M3**	**86.83 /M3**	**566.50 /M3**	**97,664,847**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
02				**Pacer Ivy Area Landfill - Alternative 4**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	30,018.00 md	-	-	-	40.85 /md	40.85 /md	1,226,076
				Resperators - One Ea Man	60.00 ea	-	-	-	68.08 /ea	68.08 /ea	4,084
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,230,160.14 /ls**	**1,230,160.14 /ls**	**1,230,160**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	315,372.36 /ls	-	315,372.36 /ls	315,372
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	630,744.70 /ls	-	630,744.70 /ls	630,745
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**946,117.06 /ls**	**/ls**	**946,117.06 /ls**	**946,117**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.74 /sy	-	-	4.75 /sy	5.49 /sy	247,168
				Fine Grade Subbase	45,056.00 sy	0.44 /sy	-	-	1.69 /sy	2.12 /sy	95,651
				Pave Roads - (4" Binder/1.5" Top)	13,900.00 ton	2.09 /ton	-	-	7.77 /ton	11.22 /ton	155,946
				On-Highway Rear Dump Truck 18CY	13,900.00 ton	1.91 /ton	102.11 /ton	-	12.08 /ton	116.10 /ton	1,613,804
				Rebuild Interior Haul Roads	**7.70 KM**	**14,061.41 /KM**	**184,331.52 /KM**	**/KM**	**73,508.80 /KM**	**274,359.48 /KM**	**2,112,568**
			01590-0100	**Traffic and Enviromental Controls - 686 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.34 /sf	-	-	18.04 /sf	3,464
				Plastic Snow Fence	10,000.00 lf	1.17 /lf	4.08 /lf	-	-	5.25 /lf	52,515
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,517.79 /wk	1,517.79 /wk	95,621
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,320.95 /wk	3,320.95 /wk	209,220
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,524.87 /wk	-	-	6,352.71 /wk	7,877.58 /wk	496,287
				Traffic and Enviromental Controls - 686 CD	**1.00 ls**	**108,063.34 /ls**	**43,981.58 /ls**	**/ls**	**705,060.91 /ls**	**857,105.83 /ls**	**857,106**
				06.-- -----							5,145,951
				009.-- Site and Traffic Controls	1.00 ls	216,336.19 /ls	1,463,334.27 /ls	946,117.06 /ls	2,501,238.83 /ls	5,145,951.04 /ls	5,145,951
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,522.98 /ea	-	2,522.98 /ea	25,230
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,229.77 /ls**	**/ls**	**25,229.77 /ls**	**25,230**
				06.-- -----							25,230
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,229.77 /ls	/ls	25,229.77 /ls	25,230
	012.--			Pacer Ivy - Landfill Site							
		00.9		Clearing Containment/Treatment Areas							
			02230-005	**Site Clearing - Containment/Treatment Areas**							
				Clear & Grub Light Trees, 14.8 ac	17.10 ac	1,394.17 /ac	-	-	2,038.64 /ac	3,432.81 /ac	58,701
				Site Clearing - Containment/Treatment Areas	**69,290.00 M2**	**0.34 /M2**	**/M2**	**/M2**	**0.50 /M2**	**0.85 /M2**	**58,701**
			02230-005	**Site Clearing - Excavated Areas**							
				Clear & Grub Light Trees, 14.8 ac	38.00 ac	1,394.17 /ac	-	-	2,038.64 /ac	3,432.81 /ac	130,447
				Site Clearing - Excavated Areas	**150,500.00 M2**	**0.35 /M2**	**/M2**	**/M2**	**0.52 /M2**	**0.87 /M2**	**130,447**
				00.9 Clearing Containment/Treatment Areas	22.00 ha	3,491.75 /ha	/ha	/ha	5,105.87 /ha	8,597.62 /ha	189,148
		01.--		Excavate Soil/Sediment to Landfill Area							
			02310-01-2	**Pacer Ivy Cut to Stockpile - Containment - Soil**							
				Cut to Waste - (2 excavators)	36,099.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	149,278
				Rear Dump Truck 12 cy	36,099.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	631,250
				Project Health & Safety Technician	377.00 hr	13.62 /hr	-	-		13.62 /hr	5,133
				Level 2 Survey Crew	377.00 hr	27.23 /hr	-	-	-	27.23 /hr	10,266
				Decontamination Area	377.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	73,245
				Pacer Ivy Cut to Stockpile - Containment - Soil	**36,099.00 cy**	**4.12 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.08 /cy**	**869,172**
			02310-01-2	**Pacer Ivy Cut to Stockpile -- Contain Sediment**							
				Cut to Waste - (2 excavators)	26,159.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	108,174
				Rear Dump Truck 12 cy	26,159.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	457,433
				Project Health & Safety Technician	273.00 hr	13.62 /hr	-	-	-	13.62 /hr	3,717
				Level 2 Survey Crew	273.00 hr	27.23 /hr	-	-	-	27.23 /hr	7,434
				Decontamination Area	273.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	53,040
				Articulated Wheel Loader Cat 938 140HP 2.75cy	26,159.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	71,183
				Pacer Ivy Cut to Stockpile -- Contain Sediment	**26,159.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.80 /cy**	**700,980**
			02310-01-2	**Northwest Area - Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	35,695
				Rear Dump Truck 12 cy	8,632.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	150,945
				Project Health & Safety Technician	90.00 hr	13.62 /hr	-	-	-	13.62 /hr	1,225
				Level 2 Survey Crew	90.00 hr	27.23 /hr	-	-	-	27.23 /hr	2,451
				Decontamination Area	90.00 hr	87.14 /hr	-	-	107.15 /hr	194.28 /hr	17,486
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	23,489
				Northwest Area - Cut to Stockpile - Containment Sediment	**8,632.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.80 /cy**	**231,291**
			02310-01-2	**North Area - Cut to Stockpile - Sediment**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	185,519
				Rear Dump Truck 12 cy	44,863.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	784,503
				Project Health & Safety Technician	467.30 hr	13.62 /hr	-	-	-	13.62 /hr	6,362
				Level 2 Survey Crew	467.30 hr	27.23 /hr	-	-	-	27.23 /hr	12,724
				Decontamination Area	467.30 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	90,789
				Articulated Wheel Loader Cat 938 140HP 2.75cy	44,863.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	122,080
				North Area - Cut to Stockpile - Sediment	**44,863.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.79 /cy**	**1,201,977**
			02310-01-2	**North East Area - Cut to Stockpile - Containment Sediment**							
				Cut to Waste - (2 excavators)	31,260.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	129,268

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**North East Area - Cut to Stockpile - Containment Sediment**							
				Rear Dump Truck 12 cy	31,260.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	546,632
				Project Health & Safety Technician	326.00 hr	13.62 /hr	-	-	-	13.62 /hr	4,438
				Level 2 Survey Crew	326.00 hr	27.23 /hr	-	-	-	27.23 /hr	8,877
				Decontamination Area	326.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	63,337
				Articulated Wheel Loader Cat 938 140HP 2.75cy	31,260.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	85,064
				North East Area - Cut to Stockpile - Containment Sediment	**31,260.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.80 /cy**	**837,615**
			02310-01-2	**North East Area - Cut to Stockpile - Treatment Sediment**							
				Cut to Waste - (2 excavators)	1,439.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	5,951
				Rear Dump Truck 12 cy	1,439.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	25,163
				Project Health & Safety Technician	15.00 hr	13.61 /hr	-	-	-	13.61 /hr	204
				Level 2 Survey Crew	15.00 hr	27.23 /hr	-	-	-	27.23 /hr	408
				Decontamination Area	15.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	2,914
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,439.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	3,916
				North East Area - Cut to Stockpile - Treatment Sediment	**1,439.00 cy**	**4.62 /cy**	**/cy**	**/cy**	**22.17 /cy**	**26.79 /cy**	**38,557**
			02310-01-2	**Pacer Ivy Cut to Stockpile -- Treatment Soil**							
				Cut to Waste - (2 excavators)	131,449.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	543,573
				Rear Dump Truck 12 cy	131,499.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	2,299,474
				Project Health & Safety Technician	1,369.00 ch	13.62 /ch	-	-	-	13.62 /ch	18,639
				Level 2 Survey Crew	1,369.00 ch	27.23 /ch	-	-	-	27.23 /ch	37,278
				Decontamination Area	1,369.00 ch	87.14 /ch	-	-	107.15 /ch	194.29 /ch	265,976
				Pacer Ivy Cut to Stockpile -- Treatment Soil	**131,449.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.08 /cy**	**3,164,939**
			02310-01-2	**Pacer Ivy Cut to Stockpile -- Treatment Sediment**							
				Cut to Waste - (2 excavators)	28,906.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	119,533
				Rear Dump Truck 12 cy	28,906.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	505,468
				Project Health & Safety Technician	1.00 ch	13.62 /ch	-	-	-	13.62 /ch	14
				Level 2 Survey Crew	1.00 ch	27.24 /ch	-	-	-	27.24 /ch	27
				Decontamination Area	1.00 ch	87.13 /ch	-	-	107.14 /ch	194.27 /ch	194
				Articulated Wheel Loader Cat 938 140HP 2.75cy	28,906.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	78,658
				Pacer Ivy Cut to Stockpile -- Treatment Sediment	**28,906.00 cy**	**3.29 /cy**	**/cy**	**/cy**	**21.06 /cy**	**24.35 /cy**	**703,895**
				01.-- Excavate Soil/Sediment to Landfill Area	**308,807.00 cy**	**4.22 /cy**	**/cy**	**/cy**	**20.87 /cy**	**25.09 /cy**	**7,748,426**
		01.05		**Treatment**							
			01000-0301	**Treatment**							
				Treatment Costs TCH	161,794.00 cy	-	-	485.67 /cy	-	485.67 /cy	78,579,045
				Capital Cost per Pile	1.00 ea	-	-	10,091,915.20 /ea	-	10,091,915.20 /ea	10,091,915
				Treatment	**161,794.00 cy**	**/cy**	**/cy**	**548.05 /cy**	**/cy**	**548.05 /cy**	**88,670,960**
				01.05 Treatment	**1.00 ls**	**/ls**	**/ls**	**88,670,960.46 /ls**	**/ls**	**88,670,960.46 /ls**	**88,670,960**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Dewatering Treatment Cost**							
				Dewatering Treatment	1.00 ls	-	-	157,686.18 /ls	-	157,686.18 /ls	157,686
				Dewatering Treatment Cost	**1.00 ls**	**/ls**	**/ls**	**157,686.18 /ls**	**/ls**	**157,686.18 /ls**	**157,686**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,499,692.44 /ls	-	4,499,692.44 /ls	4,499,692
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,499,692.44 /ls**	**/ls**	**4,499,692.44 /ls**	**4,499,692**
			01562-0224	**Dewater Ponds - Pacer Ivy - (2 mo/Pond x 13 ea)**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	630.75 /ea	-	630.75 /ea	8,200
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.04 /lf	12.70 /lf	-	-	14.74 /lf	38,330
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	422.34 /ea	3,198.96 /ea	-	-	3,621.29 /ea	47,077
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	245.07 /day	245.07 /day	191,153
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	166.51 /ea	682.92 /ea	-	-	849.43 /ea	11,043
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.63 /lf	8.39 /lf	-	-	10.02 /lf	97,700
				Attend Temporary Diesel Pumps	780.00 day	1,633.79 /day	-	-	-	1,633.79 /day	1,274,354
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,102
				Dewater Ponds - Pacer Ivy - (2 mo/Pond x 13 ea)	**1.00 ls**	**1,305,350.07 /ls**	**165,255.42 /ls**	**8,199.70 /ls**	**191,153.11 /ls**	**1,669,958.30 /ls**	**1,669,958**
			02240-0200	**Pacer - 119,000M2 - - @7.5m / 506sf/ea - (2 mo/Pond x 21 ea)**							
				Design Dewatering System	41.70 acre	-	-	6,307.45 /acre	-	6,307.45 /acre	263,021
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,261.49 /ea	-	1,261.49 /ea	16,399
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.40 /lf	216.48 /lf	-	-	219.88 /lf	10,290,409
				Install Discharge Pipe- 6"	79,100.00 lf	1.63 /lf	13.64 /lf	-	-	15.28 /lf	1,208,432
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,462
				Pacer - 119,000M2 - - @7.5m / 506sf/ea - (2 mo/Pond x 21 ea)	**1.00 ls**	**301,988.54 /ls**	**11,210,314.65 /ls**	**279,419.90 /ls**	**/ls**	**11,791,723.09 /ls**	**11,791,723**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,607,338.61 /ls**	**11,375,570.07 /ls**	**4,944,998.22 /ls**	**191,153.11 /ls**	**18,119,060.01 /ls**	**18,119,060**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area P I - Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	212,272.00 CY	0.95 /CY	-	-	5.25 /CY	6.20 /CY	1,316,076
				Dump Truck - Haul	212,272.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	3,711,922
				Import Gravel Fill - Materials Only	116,365.00 cy	-	13.62 /cy	7.06 /cy	-	20.68 /cy	2,406,339
				Load - From Stockpile	212,272.00 cy	0.27 /cy	-	-	1.15 /cy	1.42 /cy	300,847
				Grade and Compact	212,272.00 cy	0.38 /cy	-	-	1.59 /cy	1.97 /cy	418,047
				Area P I - Fill Excavated Areas To Original Grade	**212,272.00 cy**	**3.98 /cy**	**7.46 /cy**	**3.87 /cy**	**23.09 /cy**	**38.41 /cy**	**8,153,231**
				02.-- F&I Borrow - Bring Areas to Grade	**162,293.00 M3**	**5.21 /M3**	**9.76 /M3**	**5.07 /M3**	**30.20 /M3**	**50.24 /M3**	**8,153,231**
		02.50		**Load and Haul Soil From PI to Z1**							
			02310-01-2	**Load & Haul Treated Soil From PI to Z1**							
				Cut to Waste - (2 excavators)	65,976.00 cy	0.40 /cy	-	-	3.74 /cy	4.14 /cy	272,827
				Rear Dump Truck 12 cy	65,976.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	1,153,698
				Project Health & Safety Technician	687.00 ch	13.62 /ch	-	-		13.62 /ch	9,353
				Level 2 Survey Crew	687.00 ch	27.23 /ch	-	-	-	27.23 /ch	18,707

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Load & Haul Treated Soil From PI to Z1**							
				Decontamination Area	687.00 ch	87.14 /ch	-	-	107.15 /ch	194.29 /ch	133,473
				Load & Haul Treated Soil From PI to Z1	**65,976.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.96 /cy**	**24.07 /cy**	**1,588,058**
				02.50 Load and Haul Soil From PI to Z1	**50,442.00 M3**	**5.38 /M3**	**/M3**	**/M3**	**26.10 /M3**	**31.48 /M3**	**1,588,058**
				012.-- Pacer Ivy - Landfill Site	**236,100.00 M3**	**17.38 /M3**	**54.89 /M3**	**399.99 /M3**	**54.92 /M3**	**527.19 /M3**	**124,468,883**
	016.--			**Pacer Area - Landfill**							
		03.--		**F&I Landfill Liner**							
			01000-0301	**Pacer Ivy - Landfill Liner**							
				Import Common Earth	47,086.00 cy	1.19 /cy	-	-	7.40 /cy	8.59 /cy	404,396
				GCL Clay Liner	322,917.00 sf	0.14 /sf	0.13 /sf	-	-	0.27 /sf	86,708
				HDPE Liner 60 mils (1.5 mm)	322,917.00 sf	-	-	0.68 /sf	-	0.68 /sf	218,139
				Geocomposite Liner	322,917.00 sf	0.14 /sf	-	-	-	0.27 /sf	88,352
				HDPE Liner 60 mils (1.5 mm)	322,917.00 sf	-	-	0.68 /sf	-	0.68 /sf	218,139
				Geocomposite Liner	322,917.00 sf	0.14 /sf	-	-	-	0.27 /sf	88,352
				24" Sand Layer	23,543.00 cy	1.59 /cy	0.00 /cy	0.00 /cy	9.86 /cy	11.45 /cy	269,597
				PVC Pipe, Slip Joint Coupling, Perforated, Sch 40, 6"dia	3,280.00 lf	0.64 /lf	3.37 /lf	-	-	4.01 /lf	13,156
				GCL	322,917.00 sf	0.14 /sf	-	-	-	0.27 /sf	88,352
				Geocomposite 250 mil	322,917.00 sf		-	0.54 /sf	-	0.54 /sf	175,163
				Import Soil Cover	23,543.00 cy	1.19 /cy	0.00 /cy	0.00 /cy	7.40 /cy	8.59 /cy	202,198
				Seeding Mechanical Methods	322,917.00 sf	-	-	0.08 /sf	-	0.08 /sf	24,441
				Linear Low Density PE Liner 40 mils (1 mm)	322,917.00 sf	-	-	0.44 /sf	-	0.44 /sf	142,575
				Loam 4"	3,950.00 cy	2.42 /cy	27.23 /cy	-	2.31 /cy	31.96 /cy	126,223
				Earth Fill - Materials Only	70,629.00 cy	-	9.53 /cy	5.18 /cy	-	14.71 /cy	1,038,782
				Sand Fill - Materials Only	23,543.00 cy	-	24.51 /cy	7.06 /cy	-	31.57 /cy	743,280
				Dump Truck - Haul	98,122.00 cy	2.38 /cy	-	-	15.10 /cy	17.49 /cy	1,715,823
				Load - From Stockpile	98,122.00 cy	0.27 /cy	-	-	1.15 /cy	1.42 /cy	139,066
				Pacer Ivy - Landfill Liner	**7.50 ac**	**75,842.32 /ac**	**188,192.87 /ac**	**174,724.12 /ac**	**314,518.06 /ac**	**771,032.39 /ac**	**5,782,743**
				03.-- F&I Landfill Liner	**30,000.00 M2**	**18.96 /M2**	**47.05 /M2**	**43.68 /M2**	**78.63 /M2**	**192.76 /M2**	**5,782,743**
		05.--		**Place Excavated Soil/Sediment in Landfill**							
			02310-01-3	**Place Excavated Soil and Sediment In Landfill**							
				Place Soil and Sediment In Landfill	147,014.00 cy	0.69 /cy	-	-	4.43 /cy	5.12 /cy	752,412
				Decontamination Area	668.00 hr	87.14 /hr	-	-	107.15 /hr	194.29 /hr	129,782
				Place Excavated Soil and Sediment In Landfill	**147,014.00 cy**	**1.09 /cy**	**/cy**	**/cy**	**4.91 /cy**	**6.00 /cy**	**882,194**
				05.-- Place Excavated Soil/Sediment in Landfill	**112,400.00 M3**	**1.42 /M3**	**/M3**	**/M3**	**6.42 /M3**	**7.85 /M3**	**882,194**
				016.-- Pacer Area - Landfill	**236,100.00 M3**	**3.09 /M3**	**5.98 /M3**	**5.55 /M3**	**13.05 /M3**	**28.23 /M3**	**6,664,937**
				02 Pacer Ivy Area Landfill - Alternative 4	**236,100.00 M3**	**21.39 /M3**	**67.07 /M3**	**409.66 /M3**	**78.56 /M3**	**577.32 /M3**	**136,305,001**

Estimate Totals

Description	Amount	Totals	Hours		Rate
Labor	8,215,971		486,613	hrs	
Material	21,296,487				
Subcontract	170,662,156				
Equipment	33,518,732		693,984	hrs	
Other	276,502				
	233,969,848	**233,969,848**			
-					
Subtotal Direct Cost		**233,969,848**			
Indirect Costs:					
Sales Tax (MEO):					

Subtotal Prior to OH&P		**233,969,848**			

Subtotal for Prime Contractor		**233,969,848**			
Construction Contingency					

Subtotal Cost, Today's Dollars		**233,969,848**			
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016					
		233,969,848			

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 4

Landfill Material < 1,200 ppt,
Ex Situ TCH treatment for Material > 1,200 ppt

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 4 - Landfill Materials <1,200 ppt, Ex Situ TCH Materials >1,200 ppt

Z1 Area Fixed Costs (not dependent on volume)			**Base Volume**			**Added Contingency Volume**		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 946,117	1	$ 946,117	$ 946,117	1	$ 946,117
01000-0301	Rebuild Interior Haul Roads	km	$ 267,064	3.3	$ 881,310	$ 267,064	3.3	$ 881,310
01000-0301	UXO Clearance	LS	$ 25,230	1	$ 25,230	$ 25,230	1	$ 25,230
02230-005	Clearing - Excavation Areas	m2	$ 0.85	219,096	$ 185,852	$ 1	219,096	$ 185,852
02230-005	Clearing - Containment/Treatment Areas	m2	$ 0.85	159,850	$ 135,596	$ 1	159,850	$ 135,596
01000-0301	Treatment (Capital costs)	ea	$10,091,915.00	1	$ 10,091,915	$ 10,091,915	1	$ 10,091,915
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,686	1	$ 157,686	$ 157,686	1	$ 157,686
01000-0301	Additional Dewatering and Fish Removal	LS	$ 1,999,864	1	$ 1,999,864	$ 1,999,864	1	$ 1,999,864
01562-0224	Dewater Ponds	LS	$ 385,375	1	$ 385,375	$ 385,375	1	$ 385,375
02240-0200	Dewatering System	lf	$ 1,826,880	1	$ 1,826,880	$ 1,826,880	1	$ 1,826,880
01000-0301	Z1 Landfill Liner	m2	$ 166.50	26,250	$ 4,370,527	$ 166	26,250	$ 4,370,527
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 790,739	1	$ 790,739	$ 958,759	1	$ 958,759.46
01590-0100	Traffic and Environmental Controls	LS	$ 818,957	1	$ 818,957	$ 992,973	1	$ 992,973
02310-01-2	Area Z1 - Containment - Excavation	cy	$ 24.07	27,598	$ 664,320	$ 24.07	33,462	$ 805,474
02310-01-2	Area Z1 - Treatment - Excavation	cy	$ 24.07	79,393	$ 1,911,077	$ 24.07	96,263	$ 2,317,156
02310-01-2	Area Z1 Taxiway - Treatment - Excavation	cy	$ 24.07	14,257	$ 343,180	$ 24.07	17,286	$ 416,091
02310-01-2	Southwest Area - Containment - Excavatior	cy	$ 24.07	54,280	$ 1,306,618	$ 24.07	65,814	$ 1,584,262
02310-01-2	Southwest Area - Treatment - Excavation	cy	$ 24.08	24,982	$ 601,526	$ 24.08	30,290	$ 729,334
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.83	1,700	$ 45,616	$ 26.83	2,061	$ 55,303
02310-01-2	Area Z1 - Containment - Excavation - Sediment	cy	$ 26.80	21,058	$ 564,344	$ 26.80	25,533	$ 684,272
02310-01-2	Area Z1 - Treatment - Excavation - Sediment	cy	$ 26.80	2,224	$ 59,594	$ 26.80	2,697	$ 72,268
01000-0301	Treatment (TCH)	cy	$ 485.67	120,724	$ 58,632,438	$ 485.67	120,724	$ 58,632,438
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 55.00	153,391	$ 8,435,830	$ 55.00	185,984	$ 10,228,302
01000-0301	Stockpile treated soil from Z1 and PI area	m3	$ 14.07	131,841	$ 1,855,583	$ 14.07	159,855	$ 2,249,863
02310-01-3	Place Excavated Soil/Sediment in Landfill	m3	$ 7.85	80,100	$ 628,673	$ 7.85	102,428	$ 803,917
				Subtotal	**$ 97,664,847**		**Subtotal**	**$ 101,536,765**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 946,117	1	$ 946,117	$ 946,117	1	$ 946,117
01000-0301	Rebuild Interior Haul Roads	km	$ 274,359	7.7	$ 2,112,568	$ 274,359	7.7	$ 2,112,568
01000-0301	UXO Clearance	LS	$ 25,230	1	$ 25,230	$ 25,230	1	$ 25,230
02230-005	Clearing - Excavation Areas	m2	$ 0.87	150,500	$ 130,447	$ 1	150,500	$ 130,447
02230-005	Clearing - Containment/Treatment Areas	m2	$ 0.85	69,290	$ 58,701	$ 1	69,290	$ 58,701
01000-0301	Treatment (Capital Costs)	LS	$10,091,915.00	1	$ 10,091,915	$ 10,091,915	1	$ 10,091,915
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,686	1	$ 157,686	$ 157,686	1	$ 157,686
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,499,692	1	$ 4,499,692	$ 4,499,692	1	$ 4,499,692
01562-0224	Dewater Ponds	LS	$ 1,669,958	1	$ 1,669,958	$ 1,669,958	1	$ 1,669,958
02240-0200	Dewatering System	lf	$ 11,791,723	1	$ 11,791,723	$ 11,791,723	1	$ 11,791,723
01000-0301	Pacer Ivy Landfill Liner	m2	$ 192.76	30,000	$ 5,782,743	$ 193	30,000	$ 5,782,743
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,230,160	1	$ 1,230,160	$ 1,491,550	1	$ 1,491,550.18
01590-0100	Traffic and Environmental Controls	LS	$ 857,106	1	$ 857,106	$ 1,039,228	1	$ 1,039,228
02310-01-2	Pacer Ivy Area - Containment - Excavation	cy	$ 24.08	36,099	$ 869,172	$ 24.08	43,769	$ 1,053,846
02310-01-2	Pacer Ivy Area Excavation - Containment - Sediment	cy	$ 26.80	26,159	$ 700,980	$ 26.80	31,717	$ 849,917
02310-01-2	Northwest Area - Containment - Excavation - Sediment	cy	$ 26.79	8,632	$ 231,291	$ 26.79	10,466	$ 280,432
02310-01-2	North Area - Excavation	cy	$ 26.79	44,863	$ 1,201,977	$ 26.79	54,396	$ 1,457,387
02310-01-2	Northeast Area Excavation - Containment - Sediment	cy	$ 26.80	31,260	$ 837,615	$ 26.80	37,902	$ 1,015,588
02310-01-2	Northeast Area Excavation - Treatment - Sediment	cy	$ 26.79	1,439	$ 38,557	$ 26.79	1,745	$ 46,756
02310-01-2	Pacer Ivy Area - Treatment - Excavation	cy	$ 24.08	131,449	$ 3,164,939	$ 24.08	159,380	$ 3,837,442
02310-01-2	Pacer Ivy Area Excavation - Treatment - Sediment	cy	$ 24.35	28,906	$ 703,895	$ 24.35	35,048	$ 853,460
01000-0301	Treatment (TCH)	cy	$ 485.67	161,794	$ 78,579,045	$ 485.67	161,794	$ 78,579,045
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 50.24	162,293	$ 8,153,231	$ 50.24	196,778	$ 9,885,679
01000-0301	Load and Haul to Z1 Area	m3	$ 31.48	50,442	$ 1,588,058	$ 31.48	61,160	$ 1,925,491
02310-01-3	Place Excavated Soil/Sediment in Landfill	m3	$ 7.85	112,400	$ 882,194	$ 7.85	170,356	$ 1,337,073
				Subtotal	**$ 136,305,001**		**Subtotal**	**$ 140,919,676**
				Total	**$ 233,969,848**		**Total**	**$ 242,456,441**

Price Increase due to Contingency Volume $ 8,486,592
Percentage Increase in Price 3.63%
Percentage Increase in Volume 21.25%

1. Construction Capital Costs (Years 1 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 242,456,441	$242,456,441	From detailed cost estimate
Contingency (Scope and Bid)	30%			$72,736,932	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$315,193,000	Rounded to nearest $1,000
Project Management	5%			$15,759,650	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$8,000,000	Lump Sum
Construction Management	6%			$18,911,580	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$15,759,650	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$373,623,880	
TOTAL CONSTRUCTION CAPITAL COST				**$373,624,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	10	YR	**$37,362,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$871,918	$871,918	Sampling/analysis required by the EMMP; assume 0.000% of construction cost.
Contingency (Scope and Bid)	30%			$261,575	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,134,000	Rounded to nearest $1,000
Project Management	10%			$113,400	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$170,100	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$56,700	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,474,200	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,474,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	10	YR	$1,474,000	**$14,740,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	Not required since landfilled material <1200 ppt and located in industrial area.
Contingency (Scope and Bid)	30%			$0	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$30,462	$30,462	Includes annual landfill O&M; assume 0.3% of landfill construction capital costs.
Contingency (Scope and Bid)	30%			$9,139	15% Scope (Excavation recommended range 15-55%, thermal treatment cost recommended range 15-35%, landfill disposal cost recommended range 10-20% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$39,601	
Project Management	10%			$3,960	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$5,940	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$1,980	Assumed to apply to 50% of the O&M
TOTAL				$51,481	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$51,000**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	40	YR	$51,000	**$2,040,000**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative	**$390,404,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
4 - Landfill below 1,200 ppt, ex-situ TCH greater than 1,200 ppt (with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$37,362,000	$1,474,000	$0	$0	$38,836,000	0.9346	$36,296,126
2	$37,362,000	$1,474,000	$0	$0	$38,836,000	0.8734	$33,919,362
3	$37,362,000	$1,474,000	$0	$0	$38,836,000	0.8163	$31,701,827
4	$37,362,000	$1,474,000	$0	$0	$38,836,000	0.7629	$29,627,984
5	$37,362,000	$1,474,000	$0	$0	$38,836,000	0.7130	$27,690,068
6	$37,362,000	$1,474,000	$1	$0	$38,836,001	0.6663	$25,876,427
7	$37,362,000	$1,474,000	$2	$0	$38,836,002	0.6227	$24,183,178
8	$37,362,000	$1,474,000	$3	$0	$38,836,003	0.5820	$22,602,554
9	$37,362,000	$1,474,000	$4	$0	$38,836,004	0.5439	$21,122,903
10	$37,362,000	$1,474,000	$5	$0	$38,836,005	0.5083	$19,740,341
11	$0	$0	$0	$51,000	$51,000	0.4751	$24,230
12	$0	$0	$0	$51,000	$51,000	0.4440	$22,644
13	$0	$0	$0	$51,000	$51,000	0.4150	$21,165
14	$0	$0	$0	$51,000	$51,000	0.3878	$19,778
15	$0	$0	$0	$51,000	$51,000	0.3624	$18,482
16	$0	$0	$0	$51,000	$51,000	0.3387	$17,274
17	$0	$0	$0	$51,000	$51,000	0.3166	$16,147
18	$0	$0	$0	$51,000	$51,000	0.2959	$15,091
19	$0	$0	$0	$51,000	$51,000	0.2765	$14,102
20	$0	$0	$0	$51,000	$51,000	0.2584	$13,178
21	$0	$0	$0	$51,000	$51,000	0.2415	$12,317
22	$0	$0	$0	$51,000	$51,000	0.2257	$11,511
23	$0	$0	$0	$51,000	$51,000	0.2109	$10,756
24	$0	$0	$0	$51,000	$51,000	0.1971	$10,052
25	$0	$0	$0	$51,000	$51,000	0.1842	$9,394
26	$0	$0	$0	$51,000	$51,000	0.1722	$8,782
27	$0	$0	$0	$51,000	$51,000	0.1609	$8,206
28	$0	$0	$0	$51,000	$51,000	0.1504	$7,670
29	$0	$0	$0	$51,000	$51,000	0.1406	$7,171
30	$0	$0	$0	$51,000	$51,000	0.1314	$6,701
31	$0	$0	$0	$51,000	$51,000	0.1228	$6,263
32	$0	$0	$0	$51,000	$51,000	0.1147	$5,850
33	$0	$0	$0	$51,000	$51,000	0.1072	$5,467
34	$0	$0	$0	$51,000	$51,000	0.1002	$5,110
35	$0	$0	$0	$51,000	$51,000	0.0937	$4,779
36	$0	$0	$0	$51,000	$51,000	0.0875	$4,463
37	$0	$0	$0	$51,000	$51,000	0.0818	$4,172
38	$0	$0	$0	$51,000	$51,000	0.0765	$3,902
39	$0	$0	$0	$51,000	$51,000	0.0715	$3,647
40	$0	$0	$0	$51,000	$51,000	0.0668	$3,407
41	$0	$0	$0	$51,000	$51,000	0.0624	$3,182
42	$0	$0	$0	$51,000	$51,000	0.0583	$2,973
43	$0	$0	$0	$51,000	$51,000	0.0545	$2,780
44	$0	$0	$0	$51,000	$51,000	0.0509	$2,596
45	$0	$0	$0	$51,000	$51,000	0.0476	$2,428
46	$0	$0	$0	$51,000	$51,000	0.0445	$2,270
47	$0	$0	$0	$51,000	$51,000	0.0416	$2,122
48	$0	$0	$0	$51,000	$51,000	0.0389	$1,984
49	$0	$0	$0	$51,000	$51,000	0.0363	$1,851
50	$0	$0	$0	$51,000	$51,000	0.0339	$1,729
TOTALS:	$373,620,000	$14,740,000	$15	$2,040,000	**$390,400,015**		$273,106,396
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$273,106,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 5A

Incineration

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5A Incineration
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using a rotary kiln incinerator; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$429,204,694	$429,204,694	From detailed cost estimate
Contingency (Scope and Bid)	30%			$128,761,408	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$557,966,000	Rounded to nearest $1,000
Project Management	5%			$27,898,300	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$33,477,960	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$27,898,300	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$652,240,560	
TOTAL CONSTRUCTION CAPITAL COST				**$652,241,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	8	YR	**$81,530,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,040,724	$1,040,724	Sampling/analysis required by the EMMP; assume 0.2% of construction cost.
Contingency (Scope and Bid)	30%			$312,217	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,353,000	Rounded to nearest $1,000
Project Management	10%			$135,300	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$202,950	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$67,650	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,758,900	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,759,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	8	YR	$1,759,000	**$14,072,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5A Incineration	**$666,313,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5A Incineration

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.9346	$77,841,899
2	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.8734	$72,744,613
3	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.8163	$67,988,811
4	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.7629	$63,541,178
5	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.7130	$59,385,057
6	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.6663	$55,495,461
7	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.6227	$51,864,060
8	$81,530,000	$1,759,000	$0	$0	$83,289,000	0.5820	$48,474,198
9	$0	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$0	$0	$0	0.5083	$0
11	$0	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$652,240,000	$14,072,000	$0	$0	**$666,312,000**		$497,335,277
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$497,335,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternate 5A Incineration
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver: **ENR 20 City CCI:**	Database Version 7.0 October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.92				**Z1 Area - Treatment Alternative 5A - Incinerate At Z1**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	16,831.00 md	-	-	-	40.74 /md	40.74 /md	685,654
				Resperators - One Ea Man	80.00 ea	-	-	-	67.90 /ea	67.90 /ea	5,432
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**691,086.00 /ls**	**691,086.00 /ls**	**691,086**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,479.90 /ls	-	314,479.90 /ls	314,480
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	628,959.79 /ls	-	628,959.79 /ls	628,960
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,439.69 /ls**	**/ls**	**943,439.69 /ls**	**943,440**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	102,726
				Fine Grade Subbase	18,775.00 sy	0.44 /sy	-	-	1.68 /sy	2.12 /sy	39,753
				Pave Roads - (4" Binder/1.5" Top)	5,800.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	64,900
				On-Highway Rear Dump Truck 18CY	5,800.00 ton	1.90 /ton	101.84 /ton	-	12.05 /ton	115.80 /ton	671,620
				Rebuild Interior Haul Roads	**3.30 KM**	**13,645.61 /KM**	**178,998.50 /KM**	**/KM**	**71,332.76 /KM**	**266,363.51 /KM**	**879,000**
			01590-0100	**Traffic and Enviromental Controls -**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	17.99 /sf	3,455
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.07 /lf	-	-	5.24 /lf	52,377
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,513.81 /wk	1,513.81 /wk	95,370
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,312.24 /wk	3,312.24 /wk	208,671
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,520.87 /wk	-	-	6,336.05 /wk	7,856.92 /wk	494,986
				Traffic and Enviromental Controls -	**1.00 ls**	**107,780.00 /ls**	**43,866.25 /ls**	**/ls**	**703,212.23 /ls**	**854,858.48 /ls**	**854,858**
				06.-- -----							3,368,384
				009.-- Site and Traffic Controls	1.00 ls	152,810.51 /ls	634,561.29 /ls	943,439.69 /ls	1,629,696.35 /ls	3,368,383.76 /ls	3,368,384
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,515.84 /ea	-	2,515.84 /ea	25,158
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,158.39 /ls**	**/ls**	**25,158.39 /ls**	**25,158**
				06.-- -----							25,158
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,158.39 /ls	/ls	25,158.39 /ls	25,158
	010.--			Z1 Area -							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	54.10 ac	1,390.51 /ac	-	-	2,033.29 /ac	3,423.80 /ac	185,228
				Clearing For Excavated Areas	**219,100.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**185,228**
			02230-005	**Clearing For Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	36.60 ac	1,390.51 /ac	-	-	2,033.30 /ac	3,423.80 /ac	125,311
				Clearing For Treatment Area	**148,000.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**125,311**
				00.9 Clearing For Piles and Excavated Areas	36.72 ha	3,434.62 /ha	/ha	/ha	5,022.33 /ha	8,456.95 /ha	310,539
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Soil**							
				Cut to Waste - (2 excavators)	106,990.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	441,269
				Rear Dump Truck 12 cy	106,990.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	1,865,989
				Project Health & Safety Technician	1,115.00 hr	13.58 /hr	-	-	-	13.58 /hr	15,141
				Level 2 Survey Crew	1,115.00 hr	27.16 /hr	-	-	-	27.16 /hr	30,282
				Decontamination Area	1,115.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	216,059
				Area Z1 Cut to Stockpile - Z1 Treatment Soil	**106,990.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.01 /cy**	**2,568,740**
			02310-01-2	**Area Z1 Taxiway - Treatment Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	58,802
				Rear Dump Truck 12 cy	14,257.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	248,653
				Project Health & Safety Technician	149.00 hr	13.58 /hr	-	-	-	13.58 /hr	2,023
				Level 2 Survey Crew	149.00 hr	27.16 /hr	-	-	-	27.16 /hr	4,047
				Area Z1 Taxiway - Treatment Soil	**14,257.00 cy**	**3.20 /cy**	**/cy**	**/cy**	**18.79 /cy**	**21.99 /cy**	**313,525**
			02310-01-2	**Southwest Area - Containment - Soil**							
				Cut to Waste - (2 excavators)	79,262.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	326,908
				Rear Dump Truck 12 cy	79,262.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	1,382,391
				Project Health & Safety Technician	826.00 ch	13.58 /ch	-	-	-	13.58 /ch	11,216
				Level 2 Survey Crew	826.00 hr	27.16 /hr	-	-	-	27.16 /hr	22,433
				Decontamination Area	826.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	160,058
				Southwest Area - Containment - Soil	**79,262.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.01 /cy**	**1,903,007**
			02310-01-2	**Gate 2 Lake - 1 cd Treatment Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	7,011
				Rear Dump Truck 12 cy	1,700.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	29,649
				Project Health & Safety Technician	18.00 hr	13.58 /hr	-	-	-	13.58 /hr	244
				Level 2 Survey Crew	18.00 hr	27.16 /hr	-	-	-	27.16 /hr	489
				Decontamination Area	18.00 hr	86.91 /hr	-	-	106.87 /hr	193.77 /hr	3,488
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.21 /cy	2.71 /cy	4,614
				Gate 2 Lake - 1 cd Treatment Sediment	**1,700.00 cy**	**4.63 /cy**	**/cy**	**/cy**	**22.13 /cy**	**26.76 /cy**	**45,496**
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	96,024
				Rear Dump Truck 12 cy	23,282.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	406,056
				Project Health & Safety Technician	243.00 hr	13.58 /hr	-	-	-	13.58 /hr	3,300
				Level 2 Survey Crew	243.00 hr	27.16 /hr	-	-	-	27.16 /hr	6,599

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Decontamination Area	243.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	47,087
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 CY	0.51 /CY	-	-	2.21 /CY	2.71 /CY	63,188
				Area Z1 Cut to Stockpile - Z1 Treatment Sediment	**23,282.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.73 /cy**	**622,255**
				01.-- Excavate Soil/Sediment to Treatment Area	**225,491.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**20.08 /cy**	**24.18 /cy**	**5,453,022**
		01.055		**Treatment**							
			01000-0301	**Treatment - (Soil and Sediment)**							
				Soil and Sediment Treatment	225,491.00 cy	-	-	639.02 /cy	-	639.02 /cy	144,093,969
				Incinerator Cost	1.00 ls		-	25,158,391.76 /ls		25,158,391.76 /ls	25,158,392
				Treatment - (Soil and Sediment)	**225,491.00 cy**	**/cy**	**/cy**	**750.60 /cy**	**/cy**	**750.60 /cy**	**169,252,361**
				01.055 Treatment	**172,400.00 M3**	**/M3**	**/M3**	**981.74 /M3**	**/M3**	**981.74 /M3**	**169,252,361**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment System	1.00 ls	-	-	157,239.96 /ls	-	157,239.96 /ls	157,240
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,239.96 /ls**	**/ls**	**157,239.96 /ls**	**157,240**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	2,000,000.06 /ls	-	2,000,000.06 /ls	2,000,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**2,000,000.06 /ls**	**/ls**	**2,000,000.06 /ls**	**2,000,000**
			01562-0224	**Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	628.96 /ea	-	628.96 /ea	1,887
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.04 /lf	12.67 /lf	-	-	14.70 /lf	8,822
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	421.23 /ea	3,190.57 /ea	-	-	3,611.80 /ea	10,835
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	244.43 /day	244.43 /day	43,997
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	166.07 /ea	681.13 /ea	-	-	847.21 /ea	2,542
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.63 /lf	8.37 /lf	-	-	9.99 /lf	22,487
				Attend Temporary Diesel Pumps	180.00 day	1,629.50 /day	-	-	-	1,629.50 /day	293,311
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	484
				Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea	**1.00 ls**	**300,444.82 /ls**	**38,035.84 /ls**	**1,886.89 /ls**	**43,996.60 /ls**	**384,364.15 /ls**	**384,364**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	8.50 acre	-	-	6,289.60 /acre	-	6,289.60 /acre	53,462
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,257.92 /ea	-	1,257.92 /ea	3,774
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.40 /lf	215.91 /lf	-	-	219.30 /lf	1,578,989
				Install Discharge Pipe- 6"	12,063.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	183,807
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,048
				Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea	**1.00 ls**	**46,146.87 /ls**	**1,718,696.13 /ls**	**57,235.34 /ls**	**/ls**	**1,822,078.34 /ls**	**1,822,078**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**346,591.69 /ls**	**1,756,731.97 /ls**	**2,216,362.25 /ls**	**43,996.60 /ls**	**4,363,682.51 /ls**	**4,363,683**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1- Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	200,625.00 CY	0.95 /CY	-	-	5.23 /CY	6.18 /CY	1,240,604
				Load Trucks From Treated Pile	159,686.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	225,725
				Dump Truck - Haul	200,625.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	3,499,056
				Import Gravel Fill - Material Only	40,939.00 cy	-	13.58 /cy	7.04 /cy	-	20.62 /cy	844,307
				Load Import	40,939.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	57,870
				Grade and Compact	200,625.00 cy	0.38 /cy	-	-	1.58 /cy	1.96 /cy	394,074
				Area Z-1- Fill Excavated Areas To Original Grade	**200,625.00 cy**	**3.97 /cy**	**2.77 /cy**	**1.44 /cy**	**23.03 /cy**	**31.21 /cy**	**6,261,636**
				02.-- F&I Borrow - Bring Areas to Grade	**153,389.00 M3**	**5.19 /M3**	**3.62 /M3**	**1.88 /M3**	**30.12 /M3**	**40.82 /M3**	**6,261,636**
				010.-- Z1 Area -	**172,400.00 M3**	**12.73 /M3**	**13.41 /M3**	**996.27 /M3**	**54.39 /M3**	**1,076.81 /M3**	**185,641,241**
	014.--			**Z1 Area**							
		07		**Stockpile Material**							
			01000-0301	**Temporary Stockpile For Incoming Untreated Soils**							
				Stockpile For Treatment	225,491.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	683,787
				Temporary Stockpile For Incoming Untreated Soils	**225,491.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**683,787**
			01000-0301	**Temporary Stockpile For Outgoing Treated Soils**							
				Treated Soil Stockpile	225,491.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	683,787
				Temporary Stockpile For Outgoing Treated Soils	**225,491.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**683,787**
			01000-0301	**Final Stockpile Of Treated Soils -**							
				Treated Soil Stockpile	173,278.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	525,454
				Final Stockpile Of Treated Soils -	**173,278.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**525,454**
				07 Stockpile Material	**398,769.00 cy**	**0.55 /cy**	**/cy**	**/cy**	**4.20 /cy**	**4.75 /cy**	**1,893,028**
				014.-- Z1 Area	**172,400.00 M3**	**1.28 /M3**	**/M3**	**/M3**	**9.71 /M3**	**10.98 /M3**	**1,893,028**
				00.92 Z1 Area - Treatment Alternative 5A - Incinerate At Z1	**172,400.00 M3**	**14.89 /M3**	**17.10 /M3**	**1,001.89 /M3**	**73.55 /M3**	**1,107.47 /M3**	**190,927,811**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.93				**PI Treatment Alternate 5A Incinerate At PI**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	29,777.00 md	-	-	-	40.74 /md	40.74 /md	1,213,043
				Resperators - One Ea Man	86.00 ea	-	-	-	67.90 /ea	67.90 /ea	5,839
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,218,882.18 /ls**	**1,218,882.18 /ls**	**1,218,882**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,479.92 /ls	-	314,479.92 /ls	314,480
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	628,959.78 /ls	-	628,959.78 /ls	628,960
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,439.70 /ls**	**/ls**	**943,439.70 /ls**	**943,440**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	246,520
				Fine Grade Subbase	45,056.00 sy	0.44 /sy	-	-	1.68 /sy	2.12 /sy	95,400
				Pave Roads - (4" Binder/1.5" Top)	13,900.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	155,537
				On-Highway Rear Dump Truck 18CY	13,900.00 ton	1.90 /ton	101.84 /ton	-	12.05 /ton	115.80 /ton	1,609,573
				Rebuild Interior Haul Roads	**7.70 KM**	**14,024.55 /KM**	**183,848.20 /KM**	**/KM**	**73,316.06 /KM**	**273,640.12 /KM**	**2,107,029**
			01590-0100	**Traffic and Enviromental Controls - 686 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	17.99 /sf	3,455
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.07 /lf	-	-	5.24 /lf	52,377
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,513.81 /wk	1,513.81 /wk	95,370
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,312.24 /wk	3,312.24 /wk	208,671
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,520.87 /wk	-	-	6,336.05 /wk	7,856.92 /wk	494,986
				Traffic and Enviromental Controls - 686 CD	**1.00 ls**	**107,780.00 /ls**	**43,866.24 /ls**	**/ls**	**703,212.24 /ls**	**854,858.48 /ls**	**854,858**
				06.-- -----							5,124,209
				009.-- Site and Traffic Controls	1.00 ls	215,769.00 /ls	1,459,497.40 /ls	943,439.70 /ls	2,486,628.09 /ls	5,124,209.26 /ls	5,124,209
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,515.84 /ea	-	2,515.84 /ea	25,158
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,158.40 /ls**	**/ls**	**25,158.40 /ls**	**25,158**
				06.-- -----							25,158
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,158.40 /ls	/ls	25,158.40 /ls	25,158
	012.--			Pacer Ivy							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas (150,500 M2)**							
				Clear & Grub Light Trees, -2.47 ac/cd	37.20 ac	1,390.51 /ac	-	-	2,033.30 /ac	3,423.80 /ac	127,366
				Clearing For Excavated Areas (150,500 M2)	**150,500.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**127,366**
			02230-005	**Clearing For Project Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	15.20 ac	1,390.51 /ac	-	-	2,033.29 /ac	3,423.80 /ac	52,042
				Clearing For Project Treatment Area	**61,690.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.84 /m2**	**52,042**
				00.9 Clearing For Piles and Excavated Areas	21.20 ha	3,436.92 /ha	/ha	/ha	5,025.69 /ha	8,462.61 /ha	179,407
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area PI - Treatment Sediment**							
				Cut to Waste - (2 excavators)	55,065.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	227,110
				Rear Dump Truck 12 cy	55,065.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	960,377
				Project Health & Safety Technician	574.00 hr	13.58 /hr	-	-		13.58 /hr	7,794
				Level 2 Survey Crew	574.00 hr	27.16 /hr	-	-	-	27.16 /hr	15,589
				Decontamination Area	574.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	111,227
				Articulated Wheel Loader Cat 938 140HP 2.75cy	55,065.00 cy	0.51 /cy	-	-	2.21 /cy	2.71 /cy	149,448
				Area PI - Treatment Sediment	**55,065.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.11 /cy**	**26.72 /cy**	**1,471,545**
			02310-01-2	**Area Pacer Ivy - Treatment Soil**							
				Cut to Waste - (2 excavators)	167,549.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	691,039
				Rear Dump Truck 12 cy	167,549.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	2,922,185
				Project Health & Safety Technician	1,746.00 hr	13.58 /hr	-	-		13.58 /hr	23,709
				Level 2 Survey Crew	1,746.00 hr	27.16 /hr	-	-	-	27.16 /hr	47,419
				Decontamination Area	1,746.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	338,331
				Area Pacer Ivy - Treatment Soil	**167,549.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.01 /cy**	**4,022,683**
			02310-01-2	**Northwest Area - Treatment Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	35,602
				Rear Dump Truck 12 cy	8,632.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	150,549
				Project Health & Safety Technician	90.00 hr	13.58 /hr	-	-		13.58 /hr	1,222
				Level 2 Survey Crew	90.00 hr	27.16 /hr	-	-	-	27.16 /hr	2,444
				Decontamination Trailer	90.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	17,440
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.21 /cy	2.71 /cy	23,428
				Northwest Area - Treatment Sediment	**8,632.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.11 /cy**	**26.72 /cy**	**230,684**
			02310-01-2	**North Area - Treatment Soil**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	185,033
				Rear Dump Truck 12 cy	44,863.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	782,446
				Project Health & Safety Technician	468.00 ch	13.58 /ch	-	-		13.58 /ch	6,355
				Level 2 Survey Crew	468.00 hr	27.16 /hr	-	-	-	27.16 /hr	12,710
				Decontamination Area	468.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	90,687
				North Area - Treatment Soil	**44,863.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.01 /cy**	**1,077,230**
			02310-01-2	**Northeast Area Treatment Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.73 /cy	4.12 /cy	134,864
				Rear Dump Truck 12 cy	32,699.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	570,296

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Northeast Area Treatment Sediment**							
				Project Health & Safety Technician	341.00 hr	13.58 /hr	-	-		13.58 /hr	4,631
				Level 2 Survey Crew	341.00 hr	27.16 /hr	-	-	-	27.16 /hr	9,261
				Decontamination Area	341.00 hr	86.91 /hr	-	-	106.87 /hr	193.78 /hr	66,077
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,699.00 cy	0.51 /cy	-	-	2.21 /cy	2.71 /cy	88,746
				Northeast Area Treatment Sediment	**32,699.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.11 /cy**	**26.73 /cy**	**873,875**
				01.-- Excavate Soil/Sediment to Treatment Area	**308,807.00 cy**	**4.26 /cy**	**/cy**	**/cy**	**20.60 /cy**	**24.86 /cy**	**7,676,017**
		01.055		**Treatment**							
			01000-0301	**Treatment**							
				Soil and Sediment Treatment	308,808.00 cy	-	-	639.02 /cy	-	639.02 /cy	197,335,461
				Treatment	**308,808.00 cy**	**/cy**	**/cy**	**639.02 /cy**	**/cy**	**639.02 /cy**	**197,335,461**
				01.055 Treatment	**236,100.00 M3**	**/M3**	**/M3**	**835.81 /M3**	**/M3**	**835.81 /M3**	**197,335,461**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment	1.00 ls	-	-	157,239.94 /ls	-	157,239.94 /ls	157,240
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,239.94 /ls**	**/ls**	**157,239.94 /ls**	**157,240**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,500,000.15 /ls	-	4,500,000.15 /ls	4,500,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,500,000.15 /ls**	**/ls**	**4,500,000.15 /ls**	**4,500,000**
			01562-0224	**Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	628.96 /ea	-	628.96 /ea	8,176
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.04 /lf	12.67 /lf	-	-	14.70 /lf	38,229
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	421.23 /ea	3,190.57 /ea	-	-	3,611.79 /ea	46,953
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	244.43 /day	244.43 /day	190,652
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	166.07 /ea	681.13 /ea	-	-	847.21 /ea	11,014
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.63 /lf	8.37 /lf	-	-	9.99 /lf	97,444
				Attend Temporary Diesel Pumps	780.00 day	1,629.50 /day	-	-	-	1,629.50 /day	1,271,013
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,096
				Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea	**1.00 ls**	**1,301,927.49 /ls**	**164,822.09 /ls**	**8,176.47 /ls**	**190,651.92 /ls**	**1,665,577.97 /ls**	**1,665,578**
			02240-0200	**Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	41.70 acre	-	-	6,289.60 /acre	-	6,289.60 /acre	262,276
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,257.92 /ea	-	1,257.92 /ea	16,353
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.40 /lf	215.91 /lf	-	-	219.30 /lf	10,263,428
				Install Discharge Pipe- 6"	79,100.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	1,205,264
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,426
				Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea	**1.00 ls**	**301,196.75 /ls**	**11,180,921.28 /ls**	**278,629.20 /ls**	**/ls**	**11,760,747.23 /ls**	**11,760,747**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,603,124.24 /ls**	**11,345,743.37 /ls**	**4,944,045.76 /ls**	**190,651.92 /ls**	**18,083,565.29 /ls**	**18,083,565**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area P I - Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	212,322.00 CY	0.95 /CY	-	-	5.23 /CY	6.18 /CY	1,312,934
				Load Trucks From Treated Pile	201,466.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	284,784
				Dump Truck - Haul	212,322.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	3,703,061
				Import Gravel Fill - Material Only	10,856.00 cy	-	13.58 /cy	7.04 /cy	-	20.62 /cy	223,889
				Load Import - From Stockpile	10,856.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	15,346
				Grade and Compact	212,322.00 cy	0.38 /cy	-	-	1.58 /cy	1.96 /cy	417,049
				Area P I - Fill Excavated Areas To Original Grade	**212,322.00 cy**	**3.97 /cy**	**0.69 /cy**	**0.36 /cy**	**23.03 /cy**	**28.06 /cy**	**5,957,063**
				02.-- F&I Borrow - Bring Areas to Grade	**162,332.00 M3**	**5.19 /M3**	**0.91 /M3**	**0.47 /M3**	**30.12 /M3**	**36.70 /M3**	**5,957,063**
				012.-- Pacer Ivy	**236,100.00 M3**	**16.24 /M3**	**48.68 /M3**	**857.08 /M3**	**48.91 /M3**	**970.91 /M3**	**229,231,514**
	016.--			**Pacer Area**							
		07		**Stockpile Material**							
			01000-0301	**Temporary Stockpile For Incoming Untreated Soils**							
				Stockpile For Treatment	308,807.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	936,437
				Temporary Stockpile For Incoming Untreated Soils	**308,807.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**936,437**
			01000-0301	**Temporary Stockpile For Outgoing Treated Soils**							
				Treated Soil Stockpile	308,807.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	936,437
				Temporary Stockpile For Outgoing Treated Soils	**308,807.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**936,437**
			02310-01-5	**Load and Haul Treated Material From PI to Z1**							
				Load Trucks From Treated Pile	107,303.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	151,679
				Rear Dump Truck 12 cy	107,303.00 cy	2.38 /cy	-	-	15.06 /cy	17.44 /cy	1,871,448
				Load and Haul Treated Material From PI to Z1	**107,303.00 cy**	**2.64 /cy**	**/cy**	**/cy**	**16.21 /cy**	**18.85 /cy**	**2,023,127**
				07 Stockpile Material	**398,516.00 cy**	**1.26 /cy**	**/cy**	**/cy**	**8.52 /cy**	**9.78 /cy**	**3,896,002**
				016.-- Pacer Area	**236,100.00 M3**	**2.12 /M3**	**/M3**	**/M3**	**14.38 /M3**	**16.50 /M3**	**3,896,002**
				00.93 PI Treatment Alternate 5A Incinerate At PI	**236,100.00 M3**	**19.28 /M3**	**54.86 /M3**	**861.18 /M3**	**73.82 /M3**	**1,009.22 /M3**	**238,276,884**

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	7,118,549		432,887 hrs	
Material	15,899,868			
Subcontract	376,050,289			
Equipment	30,109,237		639,905 hrs	
Other	26,751			
	429,204,694	**429,204,694**		
-				
Subtotal Direct Cost		**429,204,694**		
Indirect Costs:				
Sales Tax (MEO):				

Subtotal Prior to OH&P		**429,204,694**		

Subtotal for Prime Contractor		**429,204,694**		
Construction Contingency				

Subtotal Cost, Today's Dollars		**429,204,694**		
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016				
		429,204,694		

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 5A

Incineration

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 5A - Incineration

Z1 Area Fixed Costs (not dependent on volume)			Base Volume			Added Contingency Volume		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,440	1	$ 943,440	$ 943,440	1	$ 943,440
01000-0301	Rebuild Interior Haul Roads	km	$ 266,364	3.3	$ 879,000	$ 266,364	3.3	$ 879,000
01000-0301	UXO Clearance	LS	$ 25,158	1	$ 25,158	$ 25,158	1	$ 25,158
02230-005	Clearing - Excavation Areas	m2	$ 0.85	219,100	$ 185,228	$ 1	219,100	$ 185,228
02230-005	Clearing - Containment Areas	m2	$ 0.85	148,000	$ 125,311	$ 1	148,000	$ 125,311
01000-0301	Treatment (incinerator cost)	LS	$25,158,392.00	1	$ 25,158,392	$ 25,158,392	1	$ 25,158,392
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,240	1	$ 157,240	$ 157,240	1	$ 157,240
01000-0301	Additional Dewatering and Fish Removal	LS	$ 2,000,000	1	$ 2,000,000	$ 2,000,000	1	$ 2,000,000
01562-0224	Dewater Ponds	LS	$ 384,364	1	$ 384,364	$ 384,364	1	$ 384,364
02240-0200	Dewatering System	lf	$ 1,822,078	1	$ 1,822,078	$ 1,822,078	1	$ 1,822,078
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 691,086	1	$ 691,086	$ 837,931	1	$ 837,931.20
01590-0100	Traffic and Environmental Controls	LS	$ 854,858	1	$ 854,858	$ 1,036,502	1	$ 1,036,502
02310-01-2	Area Z1 - Treatment - Excavation	cy	$ 24.01	106,990	$ 2,568,740	$ 24.01	129,724	$ 3,114,564
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 21.99	14,257	$ 313,525	$ 21.99	17,286	$ 380,136
02310-01-2	Southwest Area - Excavation	cy	$ 24.01	79,262	$ 1,903,007	$ 24.01	96,104	$ 2,307,368
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.76	1,700	$ 45,496	$ 26.76	2,061	$ 55,158
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 26.73	23,282	$ 622,255	$ 26.73	28,229	$ 754,472
01000-0301	Treatment (incineration)	cy	$ 639.02	225,491	$ 144,093,969	$ 639.02	273,404	$ 174,711,485
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 40.82	153,389	$ 6,261,636	$ 40.82	185,982	$ 7,592,145
01000-0301	Temporary Stockpile Untreated Soils	cy	$ 3.03	225,491	$ 683,787	$ 3.03	273,404	$ 829,080
01000-0301	Temporary Stockpile Treated Soils	cy	$ 3.03	225,491	$ 683,787	$ 3.03	273,404	$ 829,080
01000-0301	Final Stockpile of Treated Soils	cy	$ 3.03	173,278	$ 525,454	$ 3.03	210,097	$ 637,105
				Subtotal	**$ 190,927,810**		**Subtotal**	**$ 224,765,237**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,440	1	$ 943,440	$ 943,440	1	$ 943,440
01000-0301	Rebuild Interior Haul Roads	km	$ 273,640	7.7	$ 2,107,029	$ 273,640	7.7	$ 2,107,029
01000-0301	UXO Clearance	LS	$ 25,158	1	$ 25,158	$ 25,158	1	$ 25,158
02230-005	Clearing - Excavation Areas	m2	$ 0.85	150,500	$ 127,366	$ 1	150,500	$ 127,366
02230-005	Clearing - Containment Areas	m2	$ 0.84	61,690	$ 52,042	$ 1	61,690	$ 52,042
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,240	1	$ 157,240	$ 157,240	1	$ 157,240
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,500,000	1	$ 4,500,000	$ 4,500,000	1	$ 4,500,000
01562-0224	Dewater Ponds	LS	$ 1,665,578	1	$ 1,665,578	$ 1,665,578	1	$ 1,665,578
02240-0200	Dewatering System	lf	$ 11,760,747	1	$ 11,760,747	$ 11,760,747	1	$ 11,760,747
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,218,882	1	$ 1,218,882	$ 1,477,876	1	$ 1,477,875.78
01590-0100	Traffic and Environmental Controls	LS	$ 854,858	1	$ 854,858	$ 1,036,502	1	$ 1,036,502
02310-01-2	Pacer Ivy Area Excavation - Sediment	cy	$ 26.72	55,065	$ 1,471,545	$ 26.72	66,765	$ 1,784,213
02310-01-2	Pacer Ivy Area Excavation - Soil	cy	$ 24.01	167,549	$ 4,022,683	$ 24.01	203,151	$ 4,877,451
02310-01-2	Northwest Area - Excavation - Sediment	cy	$ 26.72	8,632	$ 230,684	$ 26.72	10,466	$ 279,697
02310-01-2	North Area - Excavation	cy	$ 24.01	44,863	$ 1,077,230	$ 24.01	54,396	$ 1,306,132
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 26.72	32,699	$ 873,875	$ 26.72	39,647	$ 1,059,559
01000-0301	Treatment (incineration)	cy	$ 639.02	308,808	$ 197,335,461	$ 639.02	374,425	$ 239,266,243
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 36.70	162,332	$ 5,957,063	$ 36.70	196,825	$ 7,222,846
01000-0301	Temporary Stockpile Untreated Soils	cy	$ 3.03	308,807	$ 936,437	$ 3.03	374,424	$ 1,135,416
01000-0301	Temporary Stockpile Treated Soils	cy	$ 3.03	308,807	$ 936,437	$ 3.03	374,424	$ 1,135,416
01000-0301	Load and Haul Treated Material to Z1	cy	$ 18.85	107,303	$ 2,023,127	$ 18.85	130,103	$ 2,453,006
				Subtotal	**$ 238,276,882**		**Subtotal**	**$ 284,372,957**
				Total	**$ 429,204,692**		**Total**	**$ 509,138,193**

Price Increase due to Contingency Volume $ 79,933,502
Percentage Increase in Price 18.62%
Percentage Increase in Volume 21.25%

1. Construction Capital Costs (Years 1 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 509,138,193	$509,138,193	From detailed cost estimate
Contingency (Scope and Bid)	30%			$152,741,458	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$661,880,000	Rounded to nearest $1,000
Project Management	5%			$33,094,000	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$39,712,800	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$33,094,000	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$772,780,800	
TOTAL CONSTRUCTION CAPITAL COST				**$772,781,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	10	YR	**$77,278,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,234,544	$1,234,544	Sampling/analysis required by the EMMP
Contingency (Scope and Bid)	30%			$370,363	15% Scope (Excavation recommended range 15-55%, on-site incineration cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,605,000	Rounded to nearest $1,000
Project Management	10%			$160,500	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$240,750	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$80,250	Assumed to apply to 50% of the EMMP implementation
TOTAL				$2,086,500	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$2,087,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	10	YR	$2,087,000	**$20,870,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTIO	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative				**$793,651,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5A Incineration
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.9346	$74,174,529
2	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.8734	$69,317,391
3	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.8163	$64,785,650
4	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.7629	$60,547,559
5	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.7130	$56,587,245
6	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.6663	$52,880,900
7	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.6227	$49,420,586
8	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.5820	$46,190,430
9	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.5439	$43,166,624
10	$77,278,000	$2,087,000	$0	$0	$79,365,000	0.5083	$40,341,230
11	$0	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$772,780,000	$20,870,000	$0	$0	**$793,650,000**		$557,412,144
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$557,412,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 5B

Ex Situ TCH

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5B Ex-Situ Thermal Conductive Heating (TCH)
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using ex-situ thermal conductive heating; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 14)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$338,403,580	$338,403,580	From detailed cost estimate
Contingency (Scope and Bid)	30%			$101,521,074	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$439,925,000	Rounded to nearest $1,000
Project Management	5%			$21,996,250	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$26,395,500	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$21,996,250	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$515,313,000	
TOTAL CONSTRUCTION CAPITAL COST				**$515,313,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	14	YR	**$36,808,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 14)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,004,917	$1,004,917	Sampling/analysis required by the EMMP; assume 0.3% of construction cost.
Contingency (Scope and Bid)	30%			$301,475	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,307,000	Rounded to nearest $1,000
Project Management	10%			$130,700	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$196,050	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$65,350	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,699,100	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,699,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	14	YR	$1,699,000	**$23,786,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 15 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	36	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 15 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	36	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5B Ex-Situ Thermal Conductive Heating (TCH)	**$539,099,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5B Ex-Situ Thermal Conductive Heating (TCH)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.9346	$35,988,642
2	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.8734	$33,632,014
3	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.8163	$31,433,264
4	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.7629	$29,376,990
5	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.7130	$27,455,491
6	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.6663	$25,657,214
7	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.6227	$23,978,309
8	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.5820	$22,411,074
9	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.5439	$20,943,957
10	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.5083	$19,573,108
11	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.4751	$18,294,676
12	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.4440	$17,097,108
13	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.4150	$15,980,405
14	$36,808,000	$1,699,000	$0	$0	$38,507,000	0.3878	$14,933,015
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$515,312,000	$23,786,000	$0	$0	**$539,098,000**		$336,755,267
						TOTAL PRESENT VALUE OF ALTERNATIVE[5]	**$336,755,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternate 5B   TCH
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver:	Database Version 7.0
ENR 20 City CCI:	October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.92				**Z1 Area - Treatment Alternative 5B TCH**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	15,903.00 md	-	-	-	40.76 /md	40.76 /md	648,122
				Resperators - One Ea Man	80.00 ea	-	-	-	67.93 /ea	67.93 /ea	5,434
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**653,556.25 /ls**	**653,556.25 /ls**	**653,556**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,622.65 /ls	-	314,622.65 /ls	314,623
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	629,245.28 /ls	-	629,245.28 /ls	629,245
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,867.93 /ls**	**/ls**	**943,867.93 /ls**	**943,868**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	102,769
				Fine Grade Subbase	18,775.00 sy	0.44 /sy	-	-	2.72 /sy	3.16 /sy	59,251
				Pave Roads - (4" Binder/1.5" Top)	5,800.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	64,928
				On-Highway Rear Dump Truck 18CY	5,800.00 ton	1.90 /ton	101.89 /ton	-	12.06 /ton	115.85 /ton	671,903
				Rebuild Interior Haul Roads	**3.30 KM**	**13,651.35 /KM**	**179,073.76 /KM**	**/KM**	**77,266.15 /KM**	**272,378.90 /KM**	**898,850**
			01590-0100	**Traffic and Enviromental Controls -**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	18.00 /sf	3,456
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.08 /lf	-	-	5.24 /lf	52,399
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,514.45 /wk	1,514.45 /wk	95,410
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,313.63 /wk	3,313.63 /wk	208,759
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,521.51 /wk	-	-	6,338.72 /wk	7,860.23 /wk	495,194
				Traffic and Enviromental Controls -	**1.00 ls**	**107,825.33 /ls**	**43,884.68 /ls**	**/ls**	**703,507.95 /ls**	**855,217.96 /ls**	**855,218**
				06.-- -----							3,351,493
				009.-- Site and Traffic Controls	1.00 ls	152,874.78 /ls	634,828.08 /ls	943,867.93 /ls	1,612,042.48 /ls	3,351,492.52 /ls	3,351,493
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,516.98 /ea	-	2,516.98 /ea	25,170
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,169.82 /ls**	**/ls**	**25,169.82 /ls**	**25,170**
				06.-- -----							25,170
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,169.82 /ls	/ls	25,169.82 /ls	25,170
	010.--			Z1 Area -							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	54.10 ac	1,391.09 /ac	-	-	2,034.15 /ac	3,425.24 /ac	185,306
				Clearing For Excavated Areas	**219,100.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**185,306**
			02230-005	**Clearing For Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	36.60 ac	1,391.09 /ac	-	-	2,034.15 /ac	3,425.24 /ac	125,364
				Clearing For Treatment Area	**148,000.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**125,364**
				00.9 Clearing For Piles and Excavated Areas	36.72 ha	3,436.06 /ha	/ha	/ha	5,024.44 /ha	8,460.50 /ha	310,670
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Soil**							
				Cut to Waste - (2 excavators)	106,990.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	441,455
				Rear Dump Truck 12 cy	106,990.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,866,774
				Project Health & Safety Technician	1,115.00 hr	13.59 /hr	-	-	-	13.59 /hr	15,147
				Level 2 Survey Crew	1,115.00 hr	27.17 /hr	-	-	-	27.17 /hr	30,294
				Decontamination Area	1,115.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	216,150
				Area Z1 Cut to Stockpile - Z1 Treatment Soil	**106,990.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.92 /cy**	**24.02 /cy**	**2,569,820**
			02310-01-2	**Area Z1 Taxiway - Treatment Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	58,826
				Rear Dump Truck 12 cy	14,257.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	248,758
				Project Health & Safety Technician	149.00 hr	13.59 /hr	-	-	-	13.59 /hr	2,024
				Level 2 Survey Crew	149.00 hr	27.17 /hr	-	-	-	27.17 /hr	4,048
				Area Z1 Taxiway - Treatment Soil	**14,257.00 cy**	**3.20 /cy**	**/cy**	**/cy**	**18.80 /cy**	**22.00 /cy**	**313,656**
			02310-01-2	**Southwest Area - Containment - Soil**							
				Cut to Waste - (2 excavators)	79,262.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	327,045
				Rear Dump Truck 12 cy	79,262.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,382,972
				Project Health & Safety Technician	826.00 ch	13.59 /ch	-	-	-	13.59 /ch	11,221
				Level 2 Survey Crew	826.00 hr	27.17 /hr	-	-	-	27.17 /hr	22,442
				Decontamination Area	826.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	160,126
				Southwest Area - Containment - Soil	**79,262.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.92 /cy**	**24.02 /cy**	**1,903,807**
			02310-01-2	**Gate 2 Lake - 1 cd Treatment Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	7,014
				Rear Dump Truck 12 cy	1,700.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	29,662
				Project Health & Safety Technician	18.00 hr	13.58 /hr	-	-	-	13.58 /hr	245
				Level 2 Survey Crew	18.00 hr	27.17 /hr	-	-	-	27.17 /hr	489
				Decontamination Area	18.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	3,489
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	4,616
				Gate 2 Lake - 1 cd Treatment Sediment	**1,700.00 cy**	**4.63 /cy**	**/cy**	**/cy**	**22.14 /cy**	**26.77 /cy**	**45,515**
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	96,065
				Rear Dump Truck 12 cy	23,282.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	406,227
				Project Health & Safety Technician	243.00 hr	13.59 /hr	-	-	-	13.59 /hr	3,301
				Level 2 Survey Crew	243.00 hr	27.17 /hr	-	-	-	27.17 /hr	6,602

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Decontamination Area	243.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	47,107
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	63,215
				Area Z1 Cut to Stockpile - Z1 Treatment Sediment	**23,282.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.13 /cy**	**26.74 /cy**	**622,517**
				01.-- Excavate Soil/Sediment to Treatment Area	**225,491.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**20.09 /cy**	**24.19 /cy**	**5,455,315**
		01.055		**Treatment**							
			01000-0301	**Treatment - (Soil and Sediment)**							
				Soil and Sediment Treatment	225,491.00 cy	-	-	484.52 /cy	-	484.52 /cy	109,254,645
				TCH	1.00 ls		-	10,067,924.61 /ls		10,067,924.61 /ls	10,067,925
				Treatment - (Soil and Sediment)	**225,491.00 cy**	**/cy**	**/cy**	**529.17 /cy**	**/cy**	**529.17 /cy**	**119,322,570**
				01.055 Treatment	**172,400.00 M3**	**/M3**	**/M3**	**692.13 /M3**	**/M3**	**692.13 /M3**	**119,322,570**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment System	1.00 ls	-	-	157,311.33 /ls	-	157,311.33 /ls	157,311
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,311.33 /ls**	**/ls**	**157,311.33 /ls**	**157,311**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	2,000,000.26 /ls	-	2,000,000.26 /ls	2,000,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**2,000,000.26 /ls**	**/ls**	**2,000,000.26 /ls**	**2,000,000**
			01562-0224	**Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	629.25 /ea	-	629.25 /ea	1,888
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.04 /lf	12.67 /lf	-	-	14.71 /lf	8,826
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	421.40 /ea	3,191.91 /ea	-	-	3,613.31 /ea	10,840
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	244.53 /day	244.53 /day	44,015
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	166.14 /ea	681.42 /ea	-	-	847.56 /ea	2,543
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.63 /lf	8.37 /lf	-	-	10.00 /lf	22,497
				Attend Temporary Diesel Pumps	180.00 day	1,630.19 /day	-	-	-	1,630.19 /day	293,434
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	484
				Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea	**1.00 ls**	**300,571.13 /ls**	**38,051.86 /ls**	**1,887.75 /ls**	**44,015.10 /ls**	**384,525.84 /ls**	**384,526**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	8.50 acre	-	-	6,292.45 /acre	-	6,292.45 /acre	53,486
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,258.49 /ea	-	1,258.49 /ea	3,775
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.40 /lf	216.00 /lf	-	-	219.40 /lf	1,579,653
				Install Discharge Pipe- 6"	12,063.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	183,884
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,048
				Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea	**1.00 ls**	**46,166.25 /ls**	**1,719,418.84 /ls**	**57,261.32 /ls**	**/ls**	**1,822,846.41 /ls**	**1,822,846**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**346,737.38 /ls**	**1,757,470.70 /ls**	**2,216,460.66 /ls**	**44,015.10 /ls**	**4,364,683.84 /ls**	**4,364,684**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1- Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	200,625.00 CY	0.95 /CY	-	-	5.24 /CY	6.19 /CY	1,241,125
				Load Trucks From Treated Pile	159,686.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	225,820
				Dump Truck - Haul	200,625.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	3,500,528
				Import Gravel Fill - Materials Only	40,939.00 cy	-	13.59 /cy	7.05 /cy	-	20.63 /cy	844,672
				Load Gravel - From Stockpile	40,939.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	57,894
				Grade and Compact	200,625.00 cy	0.38 /cy	-	-	1.59 /cy	1.97 /cy	394,239
				Area Z-1- Fill Excavated Areas To Original Grade	**200,625.00 cy**	**3.97 /cy**	**2.77 /cy**	**1.44 /cy**	**23.04 /cy**	**31.22 /cy**	**6,264,279**
				02.-- F&I Borrow - Bring Areas to Grade	**153,389.00 M3**	**5.20 /M3**	**3.63 /M3**	**1.88 /M3**	**30.14 /M3**	**40.84 /M3**	**6,264,279**
				010.-- Z1 Area -	**172,400.00 M3**	**12.73 /M3**	**13.42 /M3**	**706.66 /M3**	**54.41 /M3**	**787.23 /M3**	**135,717,517**
	014.--			**Z1 Area**							
		07		**Stockpile Material**							
			01000-0301	**Final Stockpile Of Treated Soils -**							
				Treated Soil Stockpile	173,278.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	525,675
				Final Stockpile Of Treated Soils -	**173,278.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**525,675**
				07 Stockpile Material	**173,278.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**525,675**
				014.-- Z1 Area	**132,480.00 M3**	**0.46 /M3**	**/M3**	**/M3**	**3.51 /M3**	**3.97 /M3**	**525,675**
				00.92 Z1 Area - Treatment Alternative 5B TCH	**172,400.00 M3**	**13.98 /M3**	**17.10 /M3**	**712.28 /M3**	**66.46 /M3**	**809.86 /M3**	**139,619,854**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.93				**PI Treatment Alternate 5B TCH**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	28,864.00 md	-	-	-	40.76 /md	40.76 /md	1,176,344
				Resperators - One Ea Man	86.00 ea	-	-	-	67.93 /ea	67.93 /ea	5,842
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,182,185.66 /ls**	**1,182,185.66 /ls**	**1,182,186**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,622.65 /ls	-	314,622.65 /ls	314,623
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	629,245.29 /ls	-	629,245.29 /ls	629,245
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,867.94 /ls**	**/ls**	**943,867.94 /ls**	**943,868**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	246,623
				Fine Grade Subbase	45,056.00 sy	0.44 /sy	-	-	2.72 /sy	3.16 /sy	142,191
				Pave Roads - (4" Binder/1.5" Top)	13,900.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	155,602
				On-Highway Rear Dump Truck 18CY	13,900.00 ton	1.90 /ton	101.89 /ton	-	12.06 /ton	115.85 /ton	1,610,249
				Rebuild Interior Haul Roads	**7.70 KM**	**14,030.44 /KM**	**183,925.51 /KM**	**/KM**	**79,418.42 /KM**	**279,826.70 /KM**	**2,154,666**
			01590-0100	**Traffic and Enviromental Controls - 686 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	18.00 /sf	3,456
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.08 /lf	-	-	5.24 /lf	52,399
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,514.45 /wk	1,514.45 /wk	95,410
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,313.63 /wk	3,313.63 /wk	208,759
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,521.51 /wk	-	-	6,338.72 /wk	7,860.23 /wk	495,194
				Traffic and Enviromental Controls - 686 CD	**1.00 ls**	**107,825.39 /ls**	**43,884.67 /ls**	**/ls**	**703,507.90 /ls**	**855,217.96 /ls**	**855,218**
				06.-- -----							5,135,937
				009.-- Site and Traffic Controls	1.00 ls	215,859.74 /ls	1,460,111.07 /ls	943,867.94 /ls	2,497,215.41 /ls	5,135,937.18 /ls	5,135,937
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,516.98 /ea	-	2,516.98 /ea	25,170
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,169.81 /ls**	**/ls**	**25,169.81 /ls**	**25,170**
				06.-- -----							25,170
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,169.81 /ls	/ls	25,169.81 /ls	25,170
	012.--			Pacer Ivy							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas (150,500 M2)**							
				Clear & Grub Light Trees, -2.47 ac/cd	37.20 ac	1,391.10 /ac	-	-	2,034.15 /ac	3,425.24 /ac	127,419
				Clearing For Excavated Areas (150,500 M2)	**150,500.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**127,419**
			02230-005	**Clearing For Project Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	15.20 ac	1,391.09 /ac	-	-	2,034.15 /ac	3,425.24 /ac	52,064
				Clearing For Project Treatment Area	**61,690.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.84 /m2**	**52,064**
				00.9 Clearing For Piles and Excavated Areas	21.20 ha	3,438.37 /ha	/ha	/ha	5,027.80 /ha	8,466.17 /ha	179,483
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area PI - Treatment Sediment**							
				Cut to Waste - (2 excavators)	55,065.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	227,205
				Rear Dump Truck 12 cy	55,065.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	960,780
				Project Health & Safety Technician	574.00 hr	13.59 /hr	-	-		13.59 /hr	7,798
				Level 2 Survey Crew	574.00 hr	27.17 /hr	-	-	-	27.17 /hr	15,595
				Decontamination Area	574.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	111,274
				Articulated Wheel Loader Cat 938 140HP 2.75cy	55,065.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	149,511
				Area PI - Treatment Sediment	**55,065.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.74 /cy**	**1,472,164**
			02310-01-2	**Area Pacer Ivy - Treatment Soil**							
				Cut to Waste - (2 excavators)	167,549.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	691,329
				Rear Dump Truck 12 cy	167,549.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	2,923,414
				Project Health & Safety Technician	1,746.00 hr	13.59 /hr	-	-		13.59 /hr	23,719
				Level 2 Survey Crew	1,746.00 hr	27.17 /hr	-	-	-	27.17 /hr	47,438
				Decontamination Area	1,746.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	338,474
				Area Pacer Ivy - Treatment Soil	**167,549.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.92 /cy**	**24.02 /cy**	**4,024,375**
			02310-01-2	**Northwest Area - Treatment Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	35,617
				Rear Dump Truck 12 cy	8,632.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	150,612
				Project Health & Safety Technician	90.00 hr	13.59 /hr	-	-		13.59 /hr	1,223
				Level 2 Survey Crew	90.00 hr	27.17 /hr	-	-	-	27.17 /hr	2,445
				Decontamination Trailer	90.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	17,447
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	23,437
				Northwest Area - Treatment Sediment	**8,632.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.74 /cy**	**230,781**
			02310-01-2	**North Area - Treatment Soil**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	185,111
				Rear Dump Truck 12 cy	44,863.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	782,775
				Project Health & Safety Technician	468.00 ch	13.59 /ch	-	-		13.59 /ch	6,358
				Level 2 Survey Crew	468.00 hr	27.17 /hr	-	-	-	27.17 /hr	12,715
				Decontamination Area	468.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	90,725
				North Area - Treatment Soil	**44,863.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.92 /cy**	**24.02 /cy**	**1,077,683**
			02310-01-2	**Northeast Area Treatment Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	134,920
				Rear Dump Truck 12 cy	32,699.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	570,536

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Northeast Area Treatment Sediment**							
				Project Health & Safety Technician	341.00 hr	13.59 /hr	-	-		13.59 /hr	4,632
				Level 2 Survey Crew	341.00 hr	27.17 /hr	-	-	-	27.17 /hr	9,265
				Decontamination Area	341.00 hr	86.94 /hr	-	-	106.91 /hr	193.86 /hr	66,105
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,699.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	88,783
				Northeast Area Treatment Sediment	**32,699.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.74 /cy**	**874,242**
				01.-- Excavate Soil/Sediment to Treatment Area	**308,807.00 cy**	**4.26 /cy**	**/cy**	**/cy**	**20.60 /cy**	**24.87 /cy**	**7,679,245**
		01.055		**Treatment**							
			01000-0301	**Treatment**							
				Soil and Sediment Treatment	308,808.00 cy	-	-	484.52 /cy	-	484.52 /cy	149,623,304
				TCH	1.00 ea	-	-	10,067,924.60 /ea	-	10,067,924.60 /ea	10,067,925
				Treatment	**308,808.00 cy**	**/cy**	**/cy**	**517.12 /cy**	**/cy**	**517.12 /cy**	**159,691,228**
				01.055 Treatment	**236,100.00 M3**	**/M3**	**/M3**	**676.37 /M3**	**/M3**	**676.37 /M3**	**159,691,228**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment	1.00 ls	-	-	157,311.32 /ls	-	157,311.32 /ls	157,311
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,311.32 /ls**	**/ls**	**157,311.32 /ls**	**157,311**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,500,000.07 /ls	-	4,500,000.07 /ls	4,500,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,500,000.07 /ls**	**/ls**	**4,500,000.07 /ls**	**4,500,000**
			01562-0224	**Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	629.24 /ea	-	629.24 /ea	8,180
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.04 /lf	12.67 /lf	-	-	14.71 /lf	38,245
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	421.40 /ea	3,191.91 /ea	-	-	3,613.31 /ea	46,973
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	244.53 /day	244.53 /day	190,732
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	166.14 /ea	681.42 /ea	-	-	847.56 /ea	11,018
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.63 /lf	8.37 /lf	-	-	10.00 /lf	97,485
				Attend Temporary Diesel Pumps	780.00 day	1,630.19 /day	-	-	-	1,630.19 /day	1,271,547
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,097
				Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea	**1.00 ls**	**1,302,474.91 /ls**	**164,891.42 /ls**	**8,180.17 /ls**	**190,732.07 /ls**	**1,666,278.57 /ls**	**1,666,279**
			02240-0200	**Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	41.70 acre	-	-	6,292.45 /acre	-	6,292.45 /acre	262,395
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,258.49 /ea	-	1,258.49 /ea	16,360
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.40 /lf	216.00 /lf	-	-	219.40 /lf	10,267,743
				Install Discharge Pipe- 6"	79,100.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	1,205,771
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,432
				Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea	**1.00 ls**	**301,323.35 /ls**	**11,185,622.74 /ls**	**278,755.67 /ls**	**/ls**	**11,765,701.76 /ls**	**11,765,702**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,603,798.26 /ls**	**11,350,514.16 /ls**	**4,944,247.23 /ls**	**190,732.07 /ls**	**18,089,291.72 /ls**	**18,089,292**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area P I - Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	212,322.00 CY	0.95 /CY	-	-	5.24 /CY	6.19 /CY	1,313,486
				Load Trucks From Treated Pile	201,466.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	284,903
				Dump Truck - Haul	212,322.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	3,704,618
				Import Gravel Fill - Material Only	10,856.00 cy	-	13.59 /cy	7.05 /cy	-	20.63 /cy	223,986
				Load Gravel Import	10,856.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	15,352
				Grade and Compact	212,232.00 cy	0.38 /cy	-	-	1.59 /cy	1.97 /cy	417,048
				Area P I - Fill Excavated Areas To Original Grade	**212,322.00 cy**	**3.97 /cy**	**0.70 /cy**	**0.36 /cy**	**23.04 /cy**	**28.07 /cy**	**5,959,394**
				02.-- F&I Borrow - Bring Areas to Grade	**162,332.00 M3**	**5.20 /M3**	**0.91 /M3**	**0.47 /M3**	**30.14 /M3**	**36.71 /M3**	**5,959,394**
				012.-- Pacer Ivy	**236,100.00 M3**	**16.25 /M3**	**48.70 /M3**	**697.64 /M3**	**48.93 /M3**	**811.52 /M3**	**191,598,642**
	016.--			**Pacer Area**							
		07		**Stockpile Material**							
			02310-01-5	**Load and Haul Treated Material From PI to Z1**							
				Load Trucks From Treated Pile	107,303.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	151,743
				Dump Truck 12 cy - Haul	107,303.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,872,235
				Load and Haul Treated Material From PI to Z1	**107,303.00 cy**	**2.64 /cy**	**/cy**	**/cy**	**16.22 /cy**	**18.86 /cy**	**2,023,978**
				07 Stockpile Material	**107,303.00 cy**	**2.64 /cy**	**/cy**	**/cy**	**16.22 /cy**	**18.86 /cy**	**2,023,978**
				016.-- Pacer Area	**82,039.00 M3**	**3.46 /M3**	**/M3**	**/M3**	**21.22 /M3**	**24.67 /M3**	**2,023,978**
				00.93 PI Treatment Alternate 5B TCH	**236,100.00 M3**	**18.37 /M3**	**54.88 /M3**	**701.74 /M3**	**66.88 /M3**	**841.95 /M3**	**198,783,726**

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	6,745,147		413,102 hrs	
Material	15,906,554			
Subcontract	288,477,609			
Equipment	27,247,508		605,814 hrs	
Other	26,762			
	338,403,580	**338,403,580**		
-				
Subtotal Direct Cost		**338,403,580**		
Indirect Costs:				
Sales Tax (MEO):				

Subtotal Prior to OH&P		**338,403,580**		

Subtotal for Prime Contractor		**338,403,580**		
Construction Contingency				

Subtotal Cost, Today's Dollars		**338,403,580**		
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016				
		338,403,580		

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 5B

Ex Situ TCH

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 5B - Ex-Situ Thermal Conductive Heating

Z1 Area Fixed Costs (not dependent on volume)			Base Volume			Added Contingency Volume		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,868	1	$ 943,868	$ 943,868	1	$ 943,868
01000-0301	Rebuild Interior Haul Roads	km	$ 272,379	3.3	$ 898,850	$ 272,379	3.3	$ 898,850
01000-0301	UXO Clearance	LS	$ 25,170	1	$ 25,170	$ 25,170	1	$ 25,170
02230-005	Clearing - Excavation Areas	m2	$ 0.85	219,100	$ 185,306	$ 1	219,100	$ 185,306
02230-005	Clearing - Containment Areas	m2	$ 0.85	148,000	$ 125,364	$ 1	148,000	$ 125,364
01000-0301	Treatment (TCH Capital Cost)	LS	$ 10,067,925.00	1	$ 10,067,925	$ 10,067,925	1	$ 10,067,925
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,311	1	$ 157,311	$ 157,311	1	$ 157,311
01000-0301	Additional Dewatering and Fish Removal	LS	$ 2,000,000	1	$ 2,000,000	$ 2,000,000	1	$ 2,000,000
01562-0224	Dewater Ponds	LS	$ 384,526	1	$ 384,526	$ 384,526	1	$ 384,526
02240-0200	Dewatering System	lf	$ 1,822,846	1	$ 1,822,846	$ 1,822,846	1	$ 1,822,846
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 653,556	1	$ 653,556	$ 792,427	1	$ 792,426.95
01590-0100	Traffic and Environmental Controls	LS	$ 855,218	1	$ 855,218	$ 1,036,939	1	$ 1,036,939
02310-01-2	Area Z1 - Treatment - Excavation	cy	$ 24.02	106,990	$ 2,569,820	$ 24.02	129,724	$ 3,115,873
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 22.00	14,257	$ 313,656	$ 22.00	17,286	$ 380,294
02310-01-2	Southwest Area - Excavation	cy	$ 24.02	79,262	$ 1,903,807	$ 24.02	96,104	$ 2,308,337
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.77	1,700	$ 45,515	$ 26.77	2,061	$ 55,180
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 26.74	23,282	$ 622,517	$ 26.74	28,229	$ 754,790
01000-0301	Treatment (TCH)	cy	$ 484.52	225,491	$ 109,254,645	$ 484.52	273,404	$ 132,469,397
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 40.84	153,389	$ 6,264,279	$ 40.84	185,982	$ 7,595,351
01000-0301	Final Stockpile of Treated Soils	cy	$ 3.03	173,278	$ 525,675	$ 3.03	210,097	$ 637,373
				Subtotal	**$ 139,619,854**		**Subtotal**	**$ 165,757,128**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,868	1	$ 943,868	$ 943,868	1	$ 943,868
01000-0301	Rebuild Interior Haul Roads	km	$ 279,827	7.7	$ 2,154,666	$ 279,827	7.7	$ 2,154,666
01000-0301	UXO Clearance	LS	$ 25,170	1	$ 25,170	$ 25,170	1	$ 25,170
02230-005	Clearing - Excavation Areas	m2	$ 0.85	150,500	$ 127,419	$ 1	150,500	$ 127,419
02230-005	Clearing - Containment Areas	m2	$ 0.84	61,690	$ 52,064	$ 1	61,690	$ 52,064
01000-0301	Treatment (TCH Capital Cost)	LS	$ 10,067,925.00	1	$ 10,067,925	$ 10,067,925	1	$ 10,067,925
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,311	1	$ 157,311	$ 157,311	1	$ 157,311
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,500,000	1	$ 4,500,000	$ 4,500,000	1	$ 4,500,000
01562-0224	Dewater Ponds	LS	$ 1,666,279	1	$ 1,666,279	$ 1,666,279	1	$ 1,666,279
02240-0200	Dewatering System	lf	$ 11,765,702	1	$ 11,765,702	$ 11,765,702	1	$ 11,765,702
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,182,186	1	$ 1,182,186	$ 1,433,382	1	$ 1,433,382.44
01590-0100	Traffic and Environmental Controls	LS	$ 855,218	1	$ 855,218	$ 1,036,939	1	$ 1,036,939
02310-01-2	Pacer Ivy Area Excavation - Sediment	cy	$ 26.74	55,065	$ 1,472,164	$ 26.74	66,765	$ 1,784,964
02310-01-2	Pacer Ivy Area Excavation - Soil	cy	$ 24.02	167,549	$ 4,024,375	$ 24.02	203,151	$ 4,879,502
02310-01-2	Northwest Area - Excavation - Sediment	cy	$ 26.74	8,632	$ 230,781	$ 26.74	10,466	$ 279,814
02310-01-2	North Area - Excavation	cy	$ 24.02	44,863	$ 1,077,683	$ 24.02	54,396	$ 1,306,681
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 26.74	32,699	$ 874,242	$ 26.74	39,647	$ 1,060,004
01000-0301	Treatment (TCH)	cy	$ 484.52	308,808	$ 149,623,304	$ 484.52	374,425	$ 181,415,978
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 36.71	162,332	$ 5,959,394	$ 36.71	196,825	$ 7,225,672
01000-0301	Load and Haul Treated Material to Z1	cy	$ 18.86	107,303	$ 2,023,978	$ 18.86	130,103	$ 2,454,038
				Subtotal	**$ 198,783,728**		**Subtotal**	**$ 234,337,378**
				Total	**$ 338,403,582**		**Total**	**$ 400,094,506**

Price Increase due to Contingency Volume	**$ 61,690,925**
Percentage Increase in Price	**18.23%**
Percentage Increase in Volume	**21.25%**

1. Construction Capital Costs (Years 1 through 16)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 400,094,506	$400,094,506	From detailed cost estimate
Contingency (Scope and Bid)	30%			$120,028,352	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$520,123,000	Rounded to nearest $1,000
Project Management	5%			$26,006,150	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$31,207,380	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$26,006,150	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$608,342,680	
TOTAL CONSTRUCTION CAPITAL COST				**$608,343,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	16	YR	**$38,021,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 16)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,188,113	$1,188,113	Sampling/analysis required by the EMMP.
Contingency (Scope and Bid)	30%			$356,434	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to TCH) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,545,000	Rounded to nearest $1,000
Project Management	10%			$154,500	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$231,750	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$77,250	Assumed to apply to 50% of the EMMP implementation
TOTAL				$2,008,500	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$2,009,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	16	YR	$2,009,000	**$32,144,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 17 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	34	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 17 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	34	YR	$0	**$0**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative				**$640,487,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5B Ex-Situ Thermal Conductive Heating (TCH)
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.9346	$37,412,038
2	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.8734	$34,962,202
3	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.8163	$32,676,489
4	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.7629	$30,538,887
5	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.7130	$28,541,390
6	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.6663	$26,671,989
7	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.6227	$24,926,681
8	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.5820	$23,297,460
9	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.5439	$21,772,317
10	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.5083	$20,347,249
11	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.4751	$19,018,253
12	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.4440	$17,773,320
13	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.4150	$16,612,450
14	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.3878	$15,523,634
15	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.3624	$14,506,872
16	$38,021,000	$2,009,000	$0	$0	$40,030,000	0.3387	$13,558,161
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$608,336,000	$32,144,000	$0	$0	**$640,480,000**		$378,139,392
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$378,139,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Alternative 5C

MCD

(Baseline Volume)

Cost Estimate Summary, Environmental Assessment of Project Alternatives

Project Alternative: 5C Mechano-Chemical Destruction (MCD)
Description: This alternative consists of: (1) excavating, dewatering, and transporting contaminated soils and sediments to centralized areas for treatment; (2) treatment of soils using mechano-chemical destrucion (ball milling) reactors; and (3) backfilling excavations.

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

1. Construction Capital Costs (Years 1 through 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$385,403,409	$385,403,409	From detailed cost estimate
Contingency (Scope and Bid)	30%			$115,621,023	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$501,024,000	Rounded to nearest $1,000
Project Management	5%			$25,051,200	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$30,061,440	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$25,051,200	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$586,187,840	
TOTAL CONSTRUCTION CAPITAL COST				**$586,188,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	8	YR	**$73,274,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 8)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,035,803	$1,035,803	Sampling/analysis required by the EMMP; assume 0.3% of construction cost.
Contingency (Scope and Bid)	30%			$310,741	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,347,000	Rounded to nearest $1,000
Project Management	10%			$134,700	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$202,050	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$67,350	Assumed to apply to 50% of the EMMP implementation
TOTAL				$1,751,100	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$1,751,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	8	YR	$1,751,000	**$14,008,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 9 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTION	42	YR	$0	**$0**	Total O&M Cost over the assumed duration.

Total Cost of Project Alternative 5C Mechano-Chemical Destruction (MCD)	**$600,196,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).
Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5C Mechano-Chemical Destruction (MCD)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.9346	$70,118,365
2	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.8734	$65,526,835
3	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.8163	$61,242,908
4	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.7629	$57,236,573
5	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.7130	$53,492,825
6	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.6663	$49,989,158
7	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.6227	$46,718,068
8	$73,274,000	$1,751,000	$0	$0	$75,025,000	0.5820	$43,664,550
9	$0	$0	$0	$0	$0	0.5439	$0
10	$0	$0	$0	$0	$0	0.5083	$0
11	$0	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$586,192,000	$14,008,000	$0	$0	**$600,200,000**		$447,989,282
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$447,989,000**

Notes:
1 Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
2 Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
3 Total annual expenditure is the total cost per year with no discounting.
4 Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
5 Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance
Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Bien Hoa, Vietnam
USAID Environmental Assessment - Alternate 5C MDC
Opinion of Probable Construction Cost, 10% Design, November 2015

Project name	Environmental Assessment Bien Hoa Vietnam
Estimator	Dodge
Labor rate table	XVietnam15 R1
Equipment rate table	00 15 Equip Rate BOF
CDM Smith DB ver:	Database Version 7.0
ENR 20 City CCI:	October 2015: 10,128
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding, market or negotiating conditions. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. The total cost shown is valid to only two significant figures Assumptions: No rock excavation is required Dewatering as noted. There is consideration for contaminated soils or hazardous materials (i.e. asbestos, lead) Based on standard locallly accepted work week with no overtime. MOPO (Maintenance of Plant Operation) is not included This job is sales tax exempt.
Report format	Sorted by 'Package/Area/Element/Assembly' 'Detail' summary Allocate addons Paginate

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.92				**Z1 Area - Treatment Alternative 5C MCD At Z1**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	16,831.00 md	-	-	-	40.75 /md	40.75 /md	685,826
				Resperators - One Ea Man	80.00 ea	-	-	-	67.91 /ea	67.91 /ea	5,433
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**691,258.97 /ls**	**691,258.97 /ls**	**691,259**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,564.84 /ls	-	314,564.84 /ls	314,565
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	629,129.73 /ls	-	629,129.73 /ls	629,130
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,694.57 /ls**	**/ls**	**943,694.57 /ls**	**943,695**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	18,775.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	102,751
				Fine Grade Subbase	18,775.00 sy	0.44 /sy	-	-	1.68 /sy	2.12 /sy	39,763
				Pave Roads - (4" Binder/1.5" Top)	5,800.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	64,917
				On-Highway Rear Dump Truck 18CY	5,800.00 ton	1.90 /ton	101.87 /ton	-	12.06 /ton	115.83 /ton	671,788
				Rebuild Interior Haul Roads	**3.30 KM**	**13,649.03 /KM**	**179,043.29 /KM**	**/KM**	**71,350.60 /KM**	**266,430.16 /KM**	**879,220**
			01590-0100	**Traffic and Enviromental Controls -**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	18.00 /sf	3,455
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.08 /lf	-	-	5.24 /lf	52,390
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,514.19 /wk	1,514.19 /wk	95,394
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,313.07 /wk	3,313.07 /wk	208,723
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,521.25 /wk	-	-	6,337.64 /wk	7,858.89 /wk	495,110
				Traffic and Enviromental Controls -	**1.00 ls**	**107,806.98 /ls**	**43,877.21 /ls**	**/ls**	**703,388.23 /ls**	**855,072.42 /ls**	**855,072**
				06.-- -----							3,369,245
				009.-- Site and Traffic Controls	1.00 ls	152,848.78 /ls	634,720.06 /ls	943,694.57 /ls	1,630,104.18 /ls	3,369,245.49 /ls	3,369,245
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,516.52 /ea	-	2,516.52 /ea	25,165
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,165.18 /ls**	**/ls**	**25,165.18 /ls**	**25,165**
				06.-- -----							25,165
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,165.18 /ls	/ls	25,165.18 /ls	25,165
	010.--			Z1 Area -							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas**							
				Clear & Grub Light Trees, -2.47 ac/cd	54.10 ac	1,390.86 /ac	-	-	2,033.80 /ac	3,424.66 /ac	185,274
				Clearing For Excavated Areas	**219,100.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**185,274**
			02230-005	**Clearing For Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	36.60 ac	1,390.86 /ac	-	-	2,033.80 /ac	3,424.66 /ac	125,343
				Clearing For Treatment Area	**148,000.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**125,343**
				00.9 Clearing For Piles and Excavated Areas	36.72 ha	3,435.48 /ha	/ha	/ha	5,023.58 /ha	8,459.06 /ha	310,617
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Soil**							
				Cut to Waste - (2 excavators)	106,990.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	441,380
				Rear Dump Truck 12 cy	106,990.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,866,456
				Project Health & Safety Technician	1,115.00 hr	13.58 /hr	-	-	-	13.58 /hr	15,145
				Level 2 Survey Crew	1,115.00 hr	27.17 /hr	-	-	-	27.17 /hr	30,289
				Decontamination Area	1,115.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	216,113
				Area Z1 Cut to Stockpile - Z1 Treatment Soil	**106,990.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.02 /cy**	**2,569,383**
			02310-01-2	**Area Z1 Taxiway - Treatment Soil**							
				Cut to Waste - (2 excavators)	14,257.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	58,816
				Rear Dump Truck 12 cy	14,257.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	248,715
				Project Health & Safety Technician	149.00 hr	13.58 /hr	-	-	-	13.58 /hr	2,024
				Level 2 Survey Crew	149.00 hr	27.17 /hr	-	-	-	27.17 /hr	4,048
				Area Z1 Taxiway - Treatment Soil	**14,257.00 cy**	**3.20 /cy**	**/cy**	**/cy**	**18.80 /cy**	**22.00 /cy**	**313,603**
			02310-01-2	**Southwest Area - Containment - Soil**							
				Cut to Waste - (2 excavators)	79,262.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	326,990
				Rear Dump Truck 12 cy	79,262.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,382,737
				Project Health & Safety Technician	826.00 ch	13.58 /ch	-	-	-	13.58 /ch	11,219
				Level 2 Survey Crew	826.00 hr	27.17 /hr	-	-	-	27.17 /hr	22,438
				Decontamination Area	826.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	160,098
				Southwest Area - Containment - Soil	**79,262.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.02 /cy**	**1,903,483**
			02310-01-2	**Gate 2 Lake - 1 cd Treatment Sediment**							
				Cut to Waste - (2 excavators)	1,700.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	7,013
				Rear Dump Truck 12 cy	1,700.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	29,657
				Project Health & Safety Technician	18.00 hr	13.58 /hr	-	-	-	13.58 /hr	245
				Level 2 Survey Crew	18.00 hr	27.16 /hr	-	-	-	27.16 /hr	489
				Decontamination Area	18.00 hr	86.93 /hr	-	-	106.89 /hr	193.82 /hr	3,489
				Articulated Wheel Loader Cat 938 140HP 2.75cy	1,700.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	4,615
				Gate 2 Lake - 1 cd Treatment Sediment	**1,700.00 cy**	**4.63 /cy**	**/cy**	**/cy**	**22.14 /cy**	**26.77 /cy**	**45,507**
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Cut to Waste - (2 excavators)	23,282.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	96,048
				Rear Dump Truck 12 cy	23,282.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	406,158
				Project Health & Safety Technician	243.00 hr	13.58 /hr	-	-	-	13.58 /hr	3,301
				Level 2 Survey Crew	243.00 hr	27.17 /hr	-	-	-	27.17 /hr	6,601

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Area Z1 Cut to Stockpile - Z1 Treatment Sediment**							
				Decontamination Area	243.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	47,099
				Articulated Wheel Loader Cat 938 140HP 2.75cy	23,282.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	63,204
				Area Z1 Cut to Stockpile - Z1 Treatment Sediment	**23,282.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.73 /cy**	**622,411**
				01.-- Excavate Soil/Sediment to Treatment Area	**225,491.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**20.09 /cy**	**24.19 /cy**	**5,454,387**
		01.055		**Treatment**							
			01000-0301	**Treatment - (Soil and Sediment)**							
				Soil and Sediment Treatment	225,491.00 cy	-	-	551.12 /cy	-	551.12 /cy	124,272,064
				Capital Costs	1.00 ls		-	28,310,836.90 /ls		28,310,836.90 /ls	28,310,837
				Treatment - (Soil and Sediment)	**225,491.00 cy**	**/cy**	**/cy**	**676.67 /cy**	**/cy**	**676.67 /cy**	**152,582,901**
				01.055 Treatment	**172,400.00 M3**	**/M3**	**/M3**	**885.05 /M3**	**/M3**	**885.05 /M3**	**152,582,901**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment System	1.00 ls	-	-	157,282.43 /ls	-	157,282.43 /ls	157,282
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,282.43 /ls**	**/ls**	**157,282.43 /ls**	**157,282**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	2,000,000.18 /ls	-	2,000,000.18 /ls	2,000,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**2,000,000.18 /ls**	**/ls**	**2,000,000.18 /ls**	**2,000,000**
			01562-0224	**Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea**							
				Mobilize & Demobilize Temp Pumps	3.00 ea	-	-	629.13 /ea	-	629.13 /ea	1,887
				Install Temp & By-Pass Pipe & Fittings 8"	600.00 lf	2.04 /lf	12.67 /lf	-	-	14.71 /lf	8,824
				Temp. & By-Pass Manifold/Header - 14"	3.00 ea	421.33 /ea	3,191.37 /ea	-	-	3,612.70 /ea	10,838
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	180.00 day	-	-	-	244.49 /day	244.49 /day	44,008
				Temp. & By-Pass Manifold/Header - 6"	3.00 ea	166.11 /ea	681.31 /ea	-	-	847.42 /ea	2,542
				Install Temp & By-Pass Pipe & Fittings 6"	2,250.00 lf	1.63 /lf	8.37 /lf	-	-	10.00 /lf	22,493
				Attend Temporary Diesel Pumps	180.00 day	1,629.91 /day	-	-	-	1,629.91 /day	293,384
				Remove Temporary & By-Pass Pipe	2,850.00 lf	0.17 /lf	-	-	-	0.17 /lf	484
				Dewater Ponds - Z1 Area - 2 mo/pond x 3 ea	**1.00 ls**	**300,519.98 /ls**	**38,045.39 /ls**	**1,887.40 /ls**	**44,007.61 /ls**	**384,460.38 /ls**	**384,460**
			02240-0200	**Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	8.50 acre	-	-	6,291.30 /acre	-	6,291.30 /acre	53,476
				Mobilize Dewatering Equipment	3.00 ea	-	-	1,258.27 /ea	-	1,258.27 /ea	3,775
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	7,200.00 lf	3.40 /lf	215.96 /lf	-	-	219.36 /lf	1,579,384
				Install Discharge Pipe- 6"	12,063.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	183,853
				Remove Discharge Pipe	12,063.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,048
				Z1 Area -33,800M2 - 363,800 sf @7.5m Spacing / 506sf/ea	**1.00 ls**	**46,158.39 /ls**	**1,719,126.28 /ls**	**57,250.81 /ls**	**/ls**	**1,822,535.48 /ls**	**1,822,535**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**346,678.37 /ls**	**1,757,171.67 /ls**	**2,216,420.82 /ls**	**44,007.61 /ls**	**4,364,278.47 /ls**	**4,364,278**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area Z-1- Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	200,625.00 CY	0.95 /CY	-	-	5.23 /CY	6.19 /CY	1,240,914
				Load - From Treated Pile	159,686.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	225,782
				Dump Truck - Haul	200,625.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	3,499,932
				Import Gravel - Material Only	40,939.00 cy	-	13.58 /cy	7.05 /cy	-	20.63 /cy	844,524
				Load Gravel - From Stockpile	40,939.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	57,884
				Grade and Compact	200,625.00 cy	0.38 /cy	-	-	1.58 /cy	1.97 /cy	394,172
				Area Z-1- Fill Excavated Areas To Original Grade	**200,625.00 cy**	**3.97 /cy**	**2.77 /cy**	**1.44 /cy**	**23.04 /cy**	**31.22 /cy**	**6,263,209**
				02.-- F&I Borrow - Bring Areas to Grade	**153,389.00 M3**	**5.20 /M3**	**3.63 /M3**	**1.88 /M3**	**30.13 /M3**	**40.83 /M3**	**6,263,209**
				010.-- Z1 Area -	**172,400.00 M3**	**12.73 /M3**	**13.42 /M3**	**899.58 /M3**	**54.41 /M3**	**980.14 /M3**	**168,975,392**
	014.--			**Z1 Area**							
		07		**Stockpile Material**							
			01000-0301	**Temporary Stockpile For Incoming Untreated Soils**							
				Stockpile For Treatment	225,491.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	683,958
				Temporary Stockpile For Incoming Untreated Soils	**225,491.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**683,958**
			01000-0301	**Temporary Stockpile For Outgoing Treated Soils**							
				Treated Soil Stockpile	225,491.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	683,958
				Temporary Stockpile For Outgoing Treated Soils	**225,491.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**683,958**
			01000-0301	**Final Stockpile Of Treated Soils -**							
				Treated Soil Stockpile	173,278.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	525,586
				Final Stockpile Of Treated Soils -	**173,278.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**525,586**
				07 Stockpile Material	**398,769.00 cy**	**0.55 /cy**	**/cy**	**/cy**	**4.20 /cy**	**4.75 /cy**	**1,893,502**
				014.-- Z1 Area	**172,400.00 M3**	**1.28 /M3**	**/M3**	**/M3**	**9.71 /M3**	**10.98 /M3**	**1,893,502**
				00.92 Z1 Area - Treatment Alternative 5C MCD At Z1	**172,400.00 M3**	**14.89 /M3**	**17.10 /M3**	**905.20 /M3**	**73.57 /M3**	**1,010.81 /M3**	**174,263,305**

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
00.93				**PI Treatment Alternate 5C MCD At PI**							
	009.--			Site and Traffic Controls							
		06.--		-----							
			01000-0301	**Safety Equipment**							
				Tyvek Suits - Gloves - Boot Covers - 2 Sets Per Day @ $15.00	29,777.00 md	-	-	-	40.75 /md	40.75 /md	1,213,347
				Resperators - One Ea Man	86.00 ea	-	-	-	67.91 /ea	67.91 /ea	5,841
				Safety Equipment	**1.00 ls**	**/ls**	**/ls**	**/ls**	**1,219,187.24 /ls**	**1,219,187.24 /ls**	**1,219,187**
			01000-0301	**Demobilization**							
				Demobilization	1.00 ls	-	-	314,564.86 /ls	-	314,564.86 /ls	314,565
				Treatment Structure/Facilities Dismantling	1.00 ls	-	-	629,129.70 /ls	-	629,129.70 /ls	629,130
				Demobilization	**1.00 ls**	**/ls**	**/ls**	**943,694.56 /ls**	**/ls**	**943,694.56 /ls**	**943,695**
			01000-0301	**Rebuild Interior Haul Roads**							
				Reclaim Haul Roads	45,056.00 sy	0.73 /sy	-	-	4.74 /sy	5.47 /sy	246,581
				Fine Grade Subbase	45,056.00 sy	0.44 /sy	-	-	1.68 /sy	2.12 /sy	95,424
				Pave Roads - (4" Binder/1.5" Top)	13,900.00 ton	2.08 /ton	-	-	7.75 /ton	11.19 /ton	155,576
				On-Highway Rear Dump Truck 18CY	13,900.00 ton	1.90 /ton	101.87 /ton	-	12.06 /ton	115.83 /ton	1,609,975
				Rebuild Interior Haul Roads	**7.70 KM**	**14,028.05 /KM**	**183,894.21 /KM**	**/KM**	**73,334.41 /KM**	**273,708.60 /KM**	**2,107,556**
			01590-0100	**Traffic and Enviromental Controls - 686 CD**							
				Project Signs, 4' x 4' - (4ea @ 3 Entrances)	192.00 sf	1.70 /sf	16.30 /sf	-	-	18.00 /sf	3,455
				Plastic Snow Fence	10,000.00 lf	1.16 /lf	4.08 /lf	-	-	5.24 /lf	52,390
				Self Propelled Pavement Broom 96" 85HP - (W/Oper @ 50% Time)	63.00 wk	-	-	-	1,514.19 /wk	1,514.19 /wk	95,394
				On-Highway Water Truck 4000 Gallons 9W/Oper @ 50% Time	63.00 wk	-	-	-	3,313.07 /wk	3,313.07 /wk	208,723
				Maintain Haul Rds - Grader- Cat 14/RLV	63.00 wk	1,521.25 /wk	-	-	6,337.64 /wk	7,858.89 /wk	495,110
				Traffic and Enviromental Controls - 686 CD	**1.00 ls**	**107,806.99 /ls**	**43,877.21 /ls**	**/ls**	**703,388.22 /ls**	**855,072.42 /ls**	**855,072**
				06.-- -----							5,125,510
				009.-- Site and Traffic Controls	1.00 ls	215,822.96 /ls	1,459,862.65 /ls	943,694.56 /ls	2,487,250.43 /ls	5,125,510.41 /ls	5,125,510
	009.5			RVN - In Country Requirements							
		06.--		-----							
			01000-0301	**In Country Requirements**							
				UXO - By RVN Military	10.00 ea	-	-	2,516.52 /ea	-	2,516.52 /ea	25,165
				In Country Requirements	**1.00 ls**	**/ls**	**/ls**	**25,165.19 /ls**	**/ls**	**25,165.19 /ls**	**25,165**
				06.-- -----							25,165
				009.5 RVN - In Country Requirements	1.00 ls	/ls	/ls	25,165.19 /ls	/ls	25,165.19 /ls	25,165
	012.--			Pacer Ivy							
		00.9		Clearing For Piles and Excavated Areas							
			02230-005	**Clearing For Excavated Areas (150,500 M2)**							
				Clear & Grub Light Trees, -2.47 ac/cd	37.20 ac	1,390.86 /ac	-	-	2,033.80 /ac	3,424.66 /ac	127,397
				Clearing For Excavated Areas (150,500 M2)	**150,500.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.85 /m2**	**127,397**
			02230-005	**Clearing For Project Treatment Area**							
				Clear & Grub Light Trees, -2.47 ac/cd	15.20 ac	1,390.86 /ac	-	-	2,033.81 /ac	3,424.66 /ac	52,055
				Clearing For Project Treatment Area	**61,690.00 m2**	**0.34 /m2**	**/m2**	**/m2**	**0.50 /m2**	**0.84 /m2**	**52,055**
				00.9 Clearing For Piles and Excavated Areas	21.20 ha	3,437.78 /ha	/ha	/ha	5,026.95 /ha	8,464.73 /ha	179,452
		01.--		Excavate Soil/Sediment to Treatment Area							
			02310-01-2	**Area PI - Treatment Sediment**							
				Cut to Waste - (2 excavators)	55,065.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	227,167
				Rear Dump Truck 12 cy	55,065.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	960,617
				Project Health & Safety Technician	574.00 hr	13.58 /hr	-	-		13.58 /hr	7,796
				Level 2 Survey Crew	574.00 hr	27.17 /hr	-	-	-	27.17 /hr	15,593
				Decontamination Area	574.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	111,255
				Articulated Wheel Loader Cat 938 140HP 2.75cy	55,065.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	149,485
				Area PI - Treatment Sediment	**55,065.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.73 /cy**	**1,471,913**
			02310-01-2	**Area Pacer Ivy - Treatment Soil**							
				Cut to Waste - (2 excavators)	167,549.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	691,212
				Rear Dump Truck 12 cy	167,549.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	2,922,916
				Project Health & Safety Technician	1,746.00 hr	13.58 /hr	-	-		13.58 /hr	23,715
				Level 2 Survey Crew	1,746.00 hr	27.17 /hr	-	-	-	27.17 /hr	47,430
				Decontamination Area	1,746.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	338,416
				Area Pacer Ivy - Treatment Soil	**167,549.00 cy**	**4.10 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.02 /cy**	**4,023,690**
			02310-01-2	**Northwest Area - Treatment Sediment**							
				Cut to Waste - (2 excavators)	8,632.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	35,611
				Rear Dump Truck 12 cy	8,632.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	150,586
				Project Health & Safety Technician	90.00 hr	13.58 /hr	-	-		13.58 /hr	1,222
				Level 2 Survey Crew	90.00 hr	27.17 /hr	-	-	-	27.17 /hr	2,445
				Decontamination Trailer	90.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	17,444
				Articulated Wheel Loader Cat 938 140HP 2.75cy	8,632.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	23,433
				Northwest Area - Treatment Sediment	**8,632.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.73 /cy**	**230,742**
			02310-01-2	**North Area - Treatment Soil**							
				Cut to Waste - (2 excavators)	44,863.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	185,079
				Rear Dump Truck 12 cy	44,863.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	782,642
				Project Health & Safety Technician	468.00 ch	13.58 /ch	-	-		13.58 /ch	6,357
				Level 2 Survey Crew	468.00 hr	27.17 /hr	-	-	-	27.17 /hr	12,713
				Decontamination Area	468.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	90,709
				North Area - Treatment Soil	**44,863.00 cy**	**4.11 /cy**	**/cy**	**/cy**	**19.91 /cy**	**24.02 /cy**	**1,077,500**
			02310-01-2	**Northeast Area Treatment Sediment**							
				Cut to Waste - (2 excavators)	32,699.00 cy	0.40 /cy	-	-	3.73 /cy	4.13 /cy	134,897
				Rear Dump Truck 12 cy	32,699.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	570,439

Package	Area	Element	Assembly	Description	Takeoff Quantity	Labor Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Equip Cost/Unit	Total Cost/Unit	Total Amount
			02310-01-2	**Northeast Area Treatment Sediment**							
				Project Health & Safety Technician	341.00 hr	13.58 /hr	-	-		13.58 /hr	4,632
				Level 2 Survey Crew	341.00 hr	27.17 /hr	-	-	-	27.17 /hr	9,263
				Decontamination Area	341.00 hr	86.93 /hr	-	-	106.90 /hr	193.82 /hr	66,094
				Articulated Wheel Loader Cat 938 140HP 2.75cy	32,699.00 cy	0.51 /cy	-	-	2.21 /cy	2.72 /cy	88,768
				Northeast Area Treatment Sediment	**32,699.00 cy**	**4.61 /cy**	**/cy**	**/cy**	**22.12 /cy**	**26.73 /cy**	**874,093**
				01.-- Excavate Soil/Sediment to Treatment Area	**308,807.00 cy**	**4.26 /cy**	**/cy**	**/cy**	**20.60 /cy**	**24.86 /cy**	**7,677,938**
		01.055		**Treatment**							
			01000-0301	**Treatment**							
				Soil and Sediment Treatment	308,808.00 cy	-	-	551.12 /cy	-	551.12 /cy	170,189,531
				Treatment	**308,808.00 cy**	**/cy**	**/cy**	**551.12 /cy**	**/cy**	**551.12 /cy**	**170,189,531**
				01.055 Treatment	**236,100.00 M3**	**/M3**	**/M3**	**720.84 /M3**	**/M3**	**720.84 /M3**	**170,189,531**
		01.1-		**Dewater Lakes and Wet Areas**							
			01000-0301	**Treatment For Dewatering Work**							
				Dewatering Treatment	1.00 ls	-	-	157,282.43 /ls	-	157,282.43 /ls	157,282
				Treatment For Dewatering Work	**1.00 ls**	**/ls**	**/ls**	**157,282.43 /ls**	**/ls**	**157,282.43 /ls**	**157,282**
			01000-0301	**Additional Dewatering and Fish Removal**							
				Additional Dewatering and Fish Removal	1.00 ls	-	-	4,500,000.04 /ls	-	4,500,000.04 /ls	4,500,000
				Additional Dewatering and Fish Removal	**1.00 ls**	**/ls**	**/ls**	**4,500,000.04 /ls**	**/ls**	**4,500,000.04 /ls**	**4,500,000**
			01562-0224	**Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea**							
				Mobilize & Demobilize Temp Pumps	13.00 ea	-	-	629.13 /ea	-	629.13 /ea	8,179
				Install Temp & By-Pass Pipe & Fittings 8"	2,600.00 lf	2.04 /lf	12.67 /lf	-	-	14.71 /lf	38,239
				Temp. & By-Pass Manifold/Header - 14"	13.00 ea	421.33 /ea	3,191.37 /ea	-	-	3,612.70 /ea	46,965
				Temp Pumping 40,000 gph (660 gpm/0.960 MGD)	780.00 day	-	-	-	244.49 /day	244.49 /day	190,700
				Temp. & By-Pass Manifold/Header - 6"	13.00 ea	166.12 /ea	681.31 /ea	-	-	847.42 /ea	11,016
				Install Temp & By-Pass Pipe & Fittings 6"	9,750.00 lf	1.63 /lf	8.37 /lf	-	-	10.00 /lf	97,469
				Attend Temporary Diesel Pumps	780.00 day	1,629.91 /day	-	-	-	1,629.91 /day	1,271,331
				Remove Temporary & By-Pass Pipe	12,350.00 lf	0.17 /lf	-	-	-	0.17 /lf	2,097
				Dewater Ponds - Pacer Ivy - 2 mo/pond x 13 ea	**1.00 ls**	**1,302,253.27 /ls**	**164,863.36 /ls**	**8,178.68 /ls**	**190,699.62 /ls**	**1,665,994.93 /ls**	**1,665,995**
			02240-0200	**Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea**							
				Design Dewatering System	41.70 acre	-	-	6,291.30 /acre	-	6,291.30 /acre	262,347
				Mobilize Dewatering Equipment	13.00 ea	-	-	1,258.26 /ea	-	1,258.26 /ea	16,357
				Install/Operate/Remove Sys 2" @ 5'o/c,100' header,6"d first mo	46,800.00 lf	3.40 /lf	215.96 /lf	-	-	219.36 /lf	10,265,996
				Install Discharge Pipe- 6"	79,100.00 lf	1.63 /lf	13.61 /lf	-	-	15.24 /lf	1,205,565
				Remove Discharge Pipe	79,100.00 lf	0.17 /lf	-	-	-	0.17 /lf	13,430
				Pacer Area - 119,000M2 - 1,280,905 sf - @7.5m Spacing / 506sf/ea	**1.00 ls**	**301,272.13 /ls**	**11,183,719.36 /ls**	**278,704.47 /ls**	**/ls**	**11,763,695.96 /ls**	**11,763,696**
				01.1- Dewater Lakes and Wet Areas	**1.00 ls**	**1,603,525.40 /ls**	**11,348,582.72 /ls**	**4,944,165.62 /ls**	**190,699.62 /ls**	**18,086,973.36 /ls**	**18,086,973**
		02.--		**F&I Borrow - Bring Areas to Grade**							
			02310-01-5	**Area P I - Fill Excavated Areas To Original Grade**							
				Fill To Grade With Treated Soil & Gravel Import	212,322.00 CY	0.95 /CY	-	-	5.23 /CY	6.19 /CY	1,313,263
				Load - From Treated Pile	201,466.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	284,855
				Dump Truck - Haul	212,322.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	3,703,988
				Import Gravel - Material Only	10,856.00 cy	-	13.58 /cy	7.05 /cy	-	20.63 /cy	223,947
				Load Gravel - From Stockpile	10,856.00 cy	0.26 /cy	-	-	1.15 /cy	1.41 /cy	15,349
				Grade and Compact	212,322.00 cy	0.38 /cy	-	-	1.58 /cy	1.97 /cy	417,154
				Area P I - Fill Excavated Areas To Original Grade	**212,322.00 cy**	**3.97 /cy**	**0.69 /cy**	**0.36 /cy**	**23.04 /cy**	**28.06 /cy**	**5,958,556**
				02.-- F&I Borrow - Bring Areas to Grade	**162,332.00 M3**	**5.20 /M3**	**0.91 /M3**	**0.47 /M3**	**30.13 /M3**	**36.71 /M3**	**5,958,556**
				012.-- Pacer Ivy	**236,100.00 M3**	**16.25 /M3**	**48.69 /M3**	**742.10 /M3**	**48.92 /M3**	**855.96 /M3**	**202,092,451**
	016.--			**Pacer Area**							
		07		**Stockpile Material**							
			01000-0301	**Temporary Stockpile For Incoming Untreated Soils**							
				Stockpile For Treatment	308,807.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	936,672
				Temporary Stockpile For Incoming Untreated Soils	**308,807.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**936,672**
			01000-0301	**Temporary Stockpile For Outgoing Treated Soils**							
				Treated Soil Stockpile	308,807.00 cy	0.35 /cy	-	-	2.68 /cy	3.03 /cy	936,672
				Temporary Stockpile For Outgoing Treated Soils	**308,807.00 cy**	**0.35 /cy**	**/cy**	**/cy**	**2.68 /cy**	**3.03 /cy**	**936,672**
			02310-01-5	**Load and Haul Treated Material From PI to Z1**							
				Load - From Treated Pile	107,303.00 cy	0.26 /cy			1.15 /cy	1.41 /cy	151,717
				Dump Truck - Haul	107,303.00 cy	2.38 /cy	-	-	15.07 /cy	17.45 /cy	1,871,916
				Load and Haul Treated Material From PI to Z1	**107,303.00 cy**	**2.64 /cy**	**/cy**	**/cy**	**16.22 /cy**	**18.86 /cy**	**2,023,633**
				07 Stockpile Material	**398,516.00 cy**	**1.26 /cy**	**/cy**	**/cy**	**8.52 /cy**	**9.78 /cy**	**3,896,977**
				016.-- Pacer Area	**236,100.00 M3**	**2.12 /M3**	**/M3**	**/M3**	**14.38 /M3**	**16.51 /M3**	**3,896,977**
				00.93 PI Treatment Alternate 5C MCD At PI	**236,100.00 M3**	**19.28 /M3**	**54.88 /M3**	**746.21 /M3**	**73.84 /M3**	**894.28 /M3**	**211,140,103**

Estimate Totals

Description	Amount	Totals	Hours		Rate
Labor	7,120,331		432,887	hrs	
Material	15,903,848				
Subcontract	332,235,699				
Equipment	30,116,773		639,905	hrs	
Other	26,758				
	385,403,409	**385,403,409**			
-					
Subtotal Direct Cost		**385,403,409**			
Indirect Costs:					
Sales Tax (MEO):					

Subtotal Prior to OH&P		**385,403,409**			

Subtotal for Prime Contractor		**385,403,409**			
Construction Contingency					

Subtotal Cost, Today's Dollars		**385,403,409**			
Escalation to Mid Point of Construction. Based on 3%/year October 2015 to October 2016					
		385,403,409			

This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated on the front sheet of this estimate.
There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, land acquisition or temporary/permanent easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope.
The total cost shown is valid to only two significant figures.

Alternative 5C

MCD

(Baseline with Contingency Volume)

Evaluation of Cost Sensitivity with Contingency Volume
Alternative 5C - Mechano-Chemical Destruction

Z1 Area Fixed Costs (not dependent on volume)			Base Volume			Added Contingency Volume		
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,695	1	$ 943,695	$ 943,695	1	$ 943,695
01000-0301	Rebuild Interior Haul Roads	km	$ 266,430	3.3	$ 879,220	$ 266,430	3.3	$ 879,220
01000-0301	UXO Clearance	LS	$ 25,165	1	$ 25,165	$ 25,165	1	$ 25,165
02230-005	Clearing - Excavation Areas	m2	$ 0.85	219,100	$ 185,274	$ 1	219,100	$ 185,274
02230-005	Clearing - Containment Areas	m2	$ 0.85	148,000	$ 125,343	$ 1	148,000	$ 125,343
01000-0301	Treatment (Capital cost)	LS	$28,310,837.00	1	$ 28,310,837	$ 28,310,837	1	$ 28,310,837
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,282	1	$ 157,282	$ 157,282	1	$ 157,282
01000-0301	Additional Dewatering and Fish Removal	LS	$ 2,000,000	1	$ 2,000,000	$ 2,000,000	1	$ 2,000,000
01562-0224	Dewater Ponds	LS	$ 384,460	1	$ 384,460	$ 384,460	1	$ 384,460
02240-0200	Dewatering System	lf	$ 1,822,535	1	$ 1,822,535	$ 1,822,535	1	$ 1,822,535
Z1 Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 691,259	1	$ 691,259	$ 838,141	1	$ 838,140.96
01590-0100	Traffic and Environmental Controls	LS	$ 855,072	1	$ 855,072	$ 1,036,762	1	$ 1,036,762
02310-01-2	Area Z1 - Treatment - Excavation	cy	$ 24.02	106,990	$ 2,569,383	$ 24.02	129,724	$ 3,115,344
02310-01-2	Area Z1 Taxiway - Excavation	cy	$ 22.00	14,257	$ 313,603	$ 22.00	17,286	$ 380,230
02310-01-2	Southwest Area - Excavation	cy	$ 24.02	79,262	$ 1,903,483	$ 24.02	96,104	$ 2,307,945
02310-01-2	Gate 2 Lake - Excavation - Sediment	cy	$ 26.77	1,700	$ 45,507	$ 26.77	2,061	$ 55,171
02310-01-2	Area Z1 - Excavation - Sediment	cy	$ 26.73	23,282	$ 622,411	$ 26.73	28,229	$ 754,661
01000-0301	Treatment (incineration)	cy	$ 551.12	225,491	$ 124,272,064	$ 551.12	273,404	$ 150,677,762
02310-01-5	Area Z1 - Fill Excavated Areas to Grade	m3	$ 40.83	153,389	$ 6,263,209	$ 40.83	185,982	$ 7,594,052
01000-0301	Temporary Stockpile Untreated Soils	cy	$ 3.03	225,491	$ 683,958	$ 3.03	273,404	$ 829,288
01000-0301	Temporary Stockpile Treated Soils	cy	$ 3.03	225,491	$ 683,958	$ 3.03	273,404	$ 829,288
01000-0301	Final Stockpile of Treated Soils	cy	$ 3.03	173,278	$ 525,586	$ 3.03	210,097	$ 637,265
				Subtotal	**$ 174,263,303**		**Subtotal**	**$ 203,889,720**

Pacer Ivy Area Fixed Costs (not dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Demobilization	LS	$ 943,695	1	$ 943,695	$ 943,695	1	$ 943,695
01000-0301	Rebuild Interior Haul Roads	km	$ 273,709	7.7	$ 2,107,556	$ 273,709	7.7	$ 2,107,556
01000-0301	UXO Clearance	LS	$ 25,165	1	$ 25,165	$ 25,165	1	$ 25,165
02230-005	Clearing - Excavation Areas	m2	$ 0.85	150,500	$ 127,397	$ 1	150,500	$ 127,397
02230-005	Clearing - Containment Areas	m2	$ 0.84	61,690	$ 52,055	$ 1	61,690	$ 52,055
01000-0301	Water Treatment from Dewatered Areas	LS	$ 157,282	1	$ 157,282	$ 157,282	1	$ 157,282
01000-0301	Additional Dewatering and Fish Removal	LS	$ 4,500,000	1	$ 4,500,000	$ 4,500,000	1	$ 4,500,000
01562-0224	Dewater Ponds	LS	$ 1,665,995	1	$ 1,665,995	$ 1,665,995	1	$ 1,665,995
02240-0200	Dewatering System	lf	$ 11,763,695	1	$ 11,763,695	$ 11,763,695	1	$ 11,763,695
Pacer Ivy Area Variable Costs (dependent on volume)								
Assembly Number	**Description**	**Unit**	**Unit Cost**	**Quantity**	**Total Cost**	**Unit Cost**	**Quantity**	**Total Cost**
01000-0301	Safety Equipment	LS	$ 1,219,187	1	$ 1,219,187	$ 1,478,246	1	$ 1,478,245.58
01590-0100	Traffic and Environmental Controls	LS	$ 855,072	1	$ 855,072	$ 1,036,762	1	$ 1,036,762
02310-01-2	Pacer Ivy Area Excavation - Sediment	cy	$ 26.73	55,065	$ 1,471,913	$ 26.73	66,765	$ 1,784,660
02310-01-2	Pacer Ivy Area Excavation - Soil	cy	$ 24.02	167,549	$ 4,023,690	$ 24.02	203,151	$ 4,878,672
02310-01-2	Northwest Area - Excavation - Sediment	cy	$ 26.73	8,632	$ 230,742	$ 26.73	10,466	$ 279,767
02310-01-2	North Area - Excavation	cy	$ 24.02	44,863	$ 1,077,500	$ 24.02	54,396	$ 1,306,459
02310-01-2	Northeast Area Excavation - Sediment	cy	$ 26.73	32,699	$ 874,093	$ 26.73	39,647	$ 1,059,824
01000-0301	Treatment (MCD)	cy	$ 551.12	308,808	$ 170,189,531	$ 551.12	374,425	$ 206,352,216
02310-01-5	Pacer Ivy - Fill Excavated Areas to Grade	m3	$ 36.71	162,332	$ 5,958,556	$ 36.71	196,825	$ 7,224,655
01000-0301	Temporary Stockpile Untreated Soils	cy	$ 3.03	308,807	$ 936,672	$ 3.03	374,424	$ 1,135,701
01000-0301	Temporary Stockpile Treated Soils	cy	$ 3.03	308,807	$ 936,672	$ 3.03	374,424	$ 1,135,701
01000-0301	Load and Haul Treated Material to Z1	cy	$ 18.86	107,303	$ 2,023,633	$ 18.86	130,103	$ 2,453,619
				Subtotal	**$ 211,140,100**		**Subtotal**	**$ 251,469,121**
				Total	**$ 385,403,403**		**Total**	**$ 455,358,840**

Price Increase due to Contingency Volume $ 69,955,437
Percentage Increase in Price 18.15%
Percentage Increase in Volume 21.25%

1. Construction Capital Costs (Years 1 through 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Estimated Construction Cost	1	LS	$ 455,358,840	$455,358,840	From detailed cost estimate
Contingency (Scope and Bid)	30%			$136,607,652	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$591,966,000	Rounded to nearest $1,000
Project Management	5%			$29,598,300	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
Remedial Design	1	LS		$5,000,000	Lump Sum
Construction Management	6%			$35,517,960	Percentage from Exhibit 5-8 in EPA 540-R-00-002 was used.
VAT	10%			$29,598,300	Assumed to apply to 50% of the Estimated Construction Cost
TOTAL				$691,680,560	
TOTAL CONSTRUCTION CAPITAL COST				**$691,681,000**	Total capital cost is rounded to the nearest $1,000.
CONSTRUCTION CAPITAL COSTS PER YEAR	10	YR	**$69,168,000**		Average annual capital cost over the assumed duration.

2. Annual Operations and Maintenance (O&M) Costs - Monitoring During Construction (Years 1 to 10)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$1,223,814	$1,223,814	Sampling/analysis required by the EMMP.
Contingency (Scope and Bid)	30%			$367,144	15% Scope (Excavation recommended range 15-55%, incineration (assumed similar to MCD) cost recommended range 15-35% in EPA 540-R-00-002), 15% Bid (Middle of recommended range in EPA 540-R-00-002).
SUBTOTAL				$1,591,000	Rounded to nearest $1,000
Project Management	10%			$159,100	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$238,650	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$79,550	Assumed to apply to 50% of the EMMP implementation
TOTAL				$2,068,300	
ANNUAL O&M COST - MONITORING DURING CONSTRUCTION				**$2,068,000**	Annual O&M cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING DURING CONSTRUCTION	10	YR	$2,068,000	**$20,680,000**	Total O&M Cost over the assumed duration.

3. Annual Operations and Maintenance (O&M) Costs - Monitoring After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
EMMP Implementation	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the EMMP implementation
TOTAL				$0	
ANNUAL O&M COST - MONITORING AFTER CONSTRUCTION				**$0**	Annual O&M Monitoring cost is rounded to the nearest $1,000.
TOTAL O&M COST - MONITORING AFTER CONSTRUCTION	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.

4. Annual Operations and Maintenance (O&M) Costs - Maintenance After Construction (Years 11 to 50)

SPREADSHEET REPORT DESCRIPTION	QTY	UNIT(S)	UNIT COST	TOTAL	NOTES
Maintenance	1	LS	$0	$0	No long-term O&M required
Contingency (Scope and Bid)	30%			$0	No long-term O&M required
SUBTOTAL				$0	
Project Management	10%			$0	High end of suggested range for O&M Activities in EPA 540-R-00-002
Technical Support	15%			$0	Middle value of the recommended range in EPA 540-R-00-002 was used.
VAT	10%			$0	Assumed to apply to 50% of the O&M
TOTAL				$0	
TOTAL ANNUAL O&M COST - MAINTENANCE AFTER CONSTRUCTION				**$0**	Annual O&M Maintenance cost is rounded to the nearest $1,000.
TOTAL O&M COST - MAINTENANCE AFTER CONSTRUCTIO	40	YR	$0	**$0**	Total O&M Cost over the assumed duration.
Total Cost of Project Alternative				**$712,361,000**	Assuming no discount factor

Notes:

The cost summary and present value analyses provided are based on guidance presented in "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000).

Percentages used for professional/technical services costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 540-R-00-002 (July 2000

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Abbreviations:

EA	Each	QTY	Quantity
LS	Lump Sum	O&M	Operations and Maintenance
YR	Year	EMMP	Environmental Mitigation and Monitoring Plan

Present Value Analysis, Environmental Assessment of Project Alternatives

Project Alternative:
5C Mechano-Chemical Destruction (MCD)
(with Contingency Volume)

Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Year[1]	Capital Costs[2]	Annual O&M - Monitoring during Construction[2]	Annual O&M - Monitoring after Construction[2]	Annual O&M - Maintenance after Construction[2]	Total Annual Expenditure[3]	Discount Factor (7.0%)	Present Value[4]
0	$0	$0	$0	$0	$0	1.0000	$0
1	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.9346	$66,577,166
2	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.8734	$62,217,522
3	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.8163	$58,149,947
4	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.7629	$54,345,944
5	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.7130	$50,791,268
6	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.6663	$47,464,547
7	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.6227	$44,358,657
8	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.5820	$41,459,352
9	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.5439	$38,745,260
10	$69,168,000	$2,068,000	$0	$0	$71,236,000	0.5083	$36,209,259
11	$0	$0	$0	$0	$0	0.4751	$0
12	$0	$0	$0	$0	$0	0.4440	$0
13	$0	$0	$0	$0	$0	0.4150	$0
14	$0	$0	$0	$0	$0	0.3878	$0
15	$0	$0	$0	$0	$0	0.3624	$0
16	$0	$0	$0	$0	$0	0.3387	$0
17	$0	$0	$0	$0	$0	0.3166	$0
18	$0	$0	$0	$0	$0	0.2959	$0
19	$0	$0	$0	$0	$0	0.2765	$0
20	$0	$0	$0	$0	$0	0.2584	$0
21	$0	$0	$0	$0	$0	0.2415	$0
22	$0	$0	$0	$0	$0	0.2257	$0
23	$0	$0	$0	$0	$0	0.2109	$0
24	$0	$0	$0	$0	$0	0.1971	$0
25	$0	$0	$0	$0	$0	0.1842	$0
26	$0	$0	$0	$0	$0	0.1722	$0
27	$0	$0	$0	$0	$0	0.1609	$0
28	$0	$0	$0	$0	$0	0.1504	$0
29	$0	$0	$0	$0	$0	0.1406	$0
30	$0	$0	$0	$0	$0	0.1314	$0
31	$0	$0	$0	$0	$0	0.1228	$0
32	$0	$0	$0	$0	$0	0.1147	$0
33	$0	$0	$0	$0	$0	0.1072	$0
34	$0	$0	$0	$0	$0	0.1002	$0
35	$0	$0	$0	$0	$0	0.0937	$0
36	$0	$0	$0	$0	$0	0.0875	$0
37	$0	$0	$0	$0	$0	0.0818	$0
38	$0	$0	$0	$0	$0	0.0765	$0
39	$0	$0	$0	$0	$0	0.0715	$0
40	$0	$0	$0	$0	$0	0.0668	$0
41	$0	$0	$0	$0	$0	0.0624	$0
42	$0	$0	$0	$0	$0	0.0583	$0
43	$0	$0	$0	$0	$0	0.0545	$0
44	$0	$0	$0	$0	$0	0.0509	$0
45	$0	$0	$0	$0	$0	0.0476	$0
46	$0	$0	$0	$0	$0	0.0445	$0
47	$0	$0	$0	$0	$0	0.0416	$0
48	$0	$0	$0	$0	$0	0.0389	$0
49	$0	$0	$0	$0	$0	0.0363	$0
50	$0	$0	$0	$0	$0	0.0339	$0
TOTALS:	$691,680,000	$20,680,000	$0	$0	**$712,360,000**		$500,318,922
					TOTAL PRESENT VALUE OF ALTERNATIVE[5]		**$500,319,000**

Notes:
[1] Duration is assumed to be 51 years (Years 0 through 50) for present value analysis and do not represent actual annual appropriations required.
[2] Capital costs, for purposes of this analysis, are assumed to be distributed as indicated on the Cost Estimate Summary table for the alternative.
[3] Total annual expenditure is the total cost per year with no discounting.
[4] Present value is the total cost per year including a 7.0% discount factor for that year. See Table PV-ADRFT for details.
[5] Total present value is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost, per guidance

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes. Costs are prepared solely to facilitate relative comparisons between alternatives for evaluation purposes and do not represent annual appropriations or total budgetary expenditures required.

Annual Discount Rate Factors Table

Annual Discount Rate Factors Table
Environmental Assessment of Project Alternatives

Project Alternative: ALL
Client: USAID Vietnam
Site: Bien Hoa Airbase
Phase: Environmental Assessment of Remedial Alternatives
Level of Project: 10% (Conceptual)
Base Year (Year 0): 2nd Quarter, Fiscal Year 2016 (FY16)

Discount Rate (Percent):		7.0	
Year	**Discount Factor[1,2]**	**Year**	**Discount Factor[1,2]**
0	1.0000	26	0.1722
1	0.9346	27	0.1609
2	0.8734	28	0.1504
3	0.8163	29	0.1406
4	0.7629	30	0.1314
5	0.7130	31	0.1228
6	0.6663	32	0.1147
7	0.6227	33	0.1072
8	0.5820	34	0.1002
9	0.5439	35	0.0937
10	0.5083	36	0.0875
11	0.4751	37	0.0818
12	0.4440	38	0.0765
13	0.4150	39	0.0715
14	0.3878	40	0.0668
15	0.3624	41	0.0624
16	0.3387	42	0.0583
17	0.3166	43	0.0545
18	0.2959	44	0.0509
19	0.2765	45	0.0476
20	0.2584	46	0.0445
21	0.2415	47	0.0416
22	0.2257	48	0.0389
23	0.2109	49	0.0363
24	0.1971	50	0.0339
25	0.1842		

Notes:

[1] Annual discount factors were calculated using the formulas and guidance presented in Section 4.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

[2] The real discount rate of 7.0% was obtained from "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000, Page 4-5 for non-Federal facilities.

APPENDIX E

ENVIRONMENTAL BASELINE INFORMATION

Environmental Baseline Tables

Table E1: Particle size distribution, moisture content, and TOC results in collected samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Sample type	Depth (cm)	Collection date	Sand (%)	Silt (%)	Clay (%)	Gravel (%)	Moisture content (%)	pH (SU)	Total organic carbon (mg/kg)
Northeast area	Soil	NE-01	MIS	0-30	4/10/2015	48.4	38.7	1.0	11.9	7.4	6.11	2,100
Northeast area	Sediment	NE-15	Sub	15-30	3/21/2015	47.2	36.6	16.1	0.1	4.1	4.79	6,500
Pacer Ivy area	Soil	PI-01	Sub	0-30	4/13/2015	80.2	12.6	0.2	7.0	5.1	5.40	9,100
Southwest area	Soil	SW-02	Sub	0-30	11/15/2014	67.3	18.3	11.7	2.7	21.0	6.95	8,800
Z1 area	Soil	Z1-01-landfill	Sub	0-100	4/14/2015	43.4	35.5	21.1	0.0	4.4	5.21	2,700
Z1 area	Soil	Z1-03	MIS	120-150	12/2/2014	45.2	23.6	30.7	0.5	5.4	5.03	1,900

* ***Notes*** :

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- mg/kg: milligram per kilogram
- MIS: multi-increment sampling sample
- SU: standard unit
- Sub: subsample

Table E2: Metal results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Antimony (mg/kg)	Arsenic (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Thallium (mg/kg)	Zinc (mg/kg)
				QCVN[1]	-	12	-	10	-	100	300	-	-	-	-	-	300
		EPA Risk-Based Screening Table[2]			470	3	2300	980	100000	47000	800	46	11000	5800	5800	-	100000
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	0.7	11.0	0.4	0.5	37.0	43.0	41.0	0.4	11.0	0.6	0.4	0.1	290.0
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	0.2	5.7	0.2	0.4	27.0	23.0	23.0	0.2	6.5	0.4	0.1	0.1	160.0
Northeast area	Soil	NE-03	0-30	4/11/2015	0.7	3.1	0.1	0.1	15.0	15.0	16.0	0.1	1.8	0.3	0.0	0.0	18.0
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	0.4	11.0	0.2	0.2	20.0	6.7	12.0	0.0	6.4	0.1	0.0	0.0	28.0
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	0.4	31.0	0.2	0.2	24.0	11.0	14.0	0.0	3.4	0.4	0.0	0.1	20.0
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	0.1	3.7	0.2	0.0	24.0	14.0	6.6	0.0	7.2	0.2	0.0	0.1	13.0
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	0.5	15.0	0.2	0.6	31.0	13.0	59.0	0.0	2.9	0.5	0.1	0.0	32.0
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	0.2	15.0	0.1	0.1	25.0	10.0	12.0	0.0	3.2	0.4	0.0	0.0	14.0
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	0.4	63.0	0.9	0.2	51.0	26.0	18.0	0.2	23.0	0.4	0.1	0.1	72.0
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	1.5	6.7	0.3	2.0	26.0	35.0	95.0	0.2	8.9	0.3	0.2	0.0	250.0
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	1.4	20.0	0.4	4.4	70.0	30.0	57.0	0.2	7.6	0.4	0.8	0.1	200.0
Southwest area	Soil	SW-01	0-30	11/13/2014	0.7	25.0	0.1	0.5	15.0	31.0	37.0	0.1	2.9	0.3	0.2	0.0	93.0
Southwest area	Soil	SW-03	0-30	11/15/2014	0.9	15.0	0.2	1.0	21.0	31.0	35.0	0.1	4.6	0.3	0.5	0.0	140.0
Southwest area	Soil	SW-08	0-30	11/18/2014	0.5	6.2	0.2	1.4	19.0	37.0	46.0	0.1	4.9	0.4	0.4	0.1	56.0
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	0.3	29.0	0.0	0.0	27.0	7.1	11.0	0.0	1.9	0.4	0.0	0.1	5.6
Z1 area	Soil	Z1-02	0-30	3/25/2015	0.4	9.9	0.2	0.1	29.0	20.0	9.7	0.0	5.0	0.3	0.0	0.0	23.0
Z1 area	Soil	Z1-03	60-90	12/2/2014	0.1	3.8	0.0	0.1	14.0	6.1	9.5	0.0	1.2	0.3	0.0	0.0	7.1
Z1 area	Soil	Z1-04	120-150	12/1/2014	0.2	7.8	0.0	0.1	28.0	9.5	10.0	0.0	1.1	0.5	0.0	0.1	4.4
Z1 area	Soil	Z1-07	0-30	4/10/2015	0.6	12.0	0.1	0.3	15.0	24.0	30.0	0.1	8.3	0.3	0.4	0.1	73.0
Z1 area	Sediment	Z1-09	0-15	4/8/2015	0.3	15.0	0.1	0.4	17.0	17.0	17.0	0.1	4.0	0.4	0.1	0.1	97.0
Z1 area	Soil	Z1-16	30-60	4/10/2015	0.1	3.6	0.0	0.0	15.0	8.7	11.0	0.0	1.4	0.3	0.0	0.1	7.6
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	0.1	3.7	0.0	0.0	17.0	3.3	5.2	0.0	1.1	0.3	0.0	0.0	3.2

* ***Notes*** :

- %: percent
- µg/kg: microgram per kilogram
- cm: centimeter
- DU: decision unit
- ID: identification

1 QCVN 03:2008/BTNMT - National Technical Regulations on the Allowable Limits of Heavy Metals in Soils - Industrial Soil

2 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

(grey) Exceeds EPA risk-based screening level, but below the QCVN criterion

(yellow) Exceeds both EPA risk-based screening level and QCVN criterion

Table E3: Herbicide results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	2,4,5-T (µg/kg)	2,4-D (µg/kg)	Silvex (2,4,5,-TP) (µg/kg)	2,4-DB (µg/kg)	Dicamba (µg/kg)	Dichlorprop (µg/kg)	MCPA (µg/kg)	Mecoprop (µg/kg)	Picloram (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					**8.2E+06**	**9.6E+06**	**6.6E+06**	**6.6E+06**	**2.5E+07**	**-**	**4.1E+05**	**8.2E+05**	**5.7E+07**
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 25	160.0	< 17	< 33	< 21	< 12	< 2,100	< 1,900	630.0
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	23.0	< 5.0	41.0	< 3.0	< 1.9	< 1.1	< 190	< 170	< 1.8
Northeast area	Soil	NE-03	0-30	4/11/2015	12.0	< 5.1	1.6	< 3.1	< 1.9	< 1.1	< 190	< 170	< 1.8
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2.4	< 5.2	< 1.7	< 3.1	< 2.0	< 1.1	< 200	< 180	< 1.9
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	12,000.0	6,000.0	3.3	< 3.20	< 2.00	< 1.20	< 200	< 180	26.0
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 2.2	< 4.8	< 1.5	< 2.9	< 1.8	< 1.1	< 180	< 160	< 1.7
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	14.0	18.0	< 1.70	< 3.20	< 2.00	< 1.20	< 200	< 180	40.0
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	14.0	9.5	< 1.70	< 3.30	< 2.10	< 1.20	< 210	< 190	< 1.90
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	76.0	20.0	< 1.7	< 3.1	< 2.0	< 1.1	< 200	< 180	< 1.9
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	4.7	6.8	< 1.70	< 3.20	< 2.00	< 1.20	< 200	< 180	< 1.90
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	4,100.0	3,700.0	95.0	< 30	< 19	< 11	48,000.0	< 1,700	49.0
Southwest area	Soil	SW-01	0-30	11/13/2014	2,700.0	2,000.0	< 17.0	< 32.0	< 20.0	< 12.0	< 2,000	< 1,800	2,900.0
Southwest area	Soil	SW-03	0-30	11/15/2014	62.0	28.0	< 1.60	< 3.00	< 1.90	< 1.10	< 190	< 170	< 1.80
Southwest area	Soil	SW-08	0-30	11/18/2014	< 2.40	< 5.20	< 1.70	< 3.10	< 2.00	< 1.10	< 200	< 180	< 1.90
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	20,000.0	12,000.0	< 83	< 160	< 99	< 57	< 9,900	< 8,800	500.0
Z1 area	Soil	Z1-02	0-30	3/25/2015	130.0	110.0	< 16	< 30	< 19	< 11	< 1,900	< 1,700	< 18
Z1 area	Soil	Z1-03	60-90	12/2/2014	170.0	100.0	< 1.70	< 3.10	< 2.00	< 1.10	< 200	< 180	< 1.90
Z1 area	Soil	Z1-04	120-150	12/1/2014	35.0	10.0	< 1.70	< 3.20	< 2.00	< 1.20	< 200	< 180	< 1.90
Z1 area	Soil	Z1-07	0-30	4/10/2015	100.0	38.0	4.5	17.0	< 1.9	< 1.1	< 190	< 170	5.3
Z1 area	Sediment	Z1-09	0-15	4/8/2015	85.0	97.0	40.0	< 3.1	< 2.0	< 1.1	< 200	< 180	< 1.9
Z1 area	Soil	Z1-16	30-60	4/10/2015	12.0	< 5.1	< 1.6	< 3.1	< 2	< 1.1	< 200	< 170	< 1.8
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 1.9	< 4.1	< 1.3	< 2.5	< 1.6	< 0.9	< 160	< 140	< 1.5

* ***Notes*** :

- %: percent
- µg/kg: microgram per kilogram
- 2,4,5-T: 2,4,5-trichlorophenoxyacetic acid
- 2,4,5-TP: 2,4,5-trichlorophenoxyacetic acid
- 2,4-D: 2,4-dichlorophenoxyacetic acid
- 2,4-DB: 2,4-dichlorophenoxybutyric acid
- cm: centimeter
- DU: decision unit
- ID: identification
- MCPA: 2-methyl-4-chlorophenoxyacetic acid

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E4: PCB results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	PCB-1016 (µg/kg)	PCB-1221 (µg/kg)	PCB-1232 (µg/kg)	PCB-1242 (µg/kg)	PCB-1248 (µg/kg)	PCB-1254 (µg/kg)	PCB-1260 (µg/kg)	PCB-1262 (µg/kg)	PCB-1268 (µg/kg)	Total polychlorinated biphenyls (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					2.7E+04	8.3E+02	7.2E+02	9.5E+02	9.5E+02	9.7E+02	9.9E+02	-	-	9.4E+02
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 1.9	< 2.3	< 3.2	< 2.3	< 2.3	< 2.2	< 2.0	< 3.4	< 1.8	< 3.4
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	< 0.86	< 1.10	< 1.50	< 1.10	< 1.10	66.0	< 0.92	< 1.60	< 0.85	66.0
Northeast area	Soil	NE-03	0-30	4/11/2015	< 0.88	< 1.10	< 1.50	< 1.10	< 1.10	< 1.0	< 0.95	< 1.60	< 0.87	< 1.60
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 0.18	< 0.22	< 0.3	< 0.22	< 0.22	< 0.21	< 0.19	< 0.32	< 0.18	< 0.32
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 0.18	< 0.22	< 0.31	< 0.22	< 0.22	< 0.21	< 0.19	< 0.33	< 0.18	< 0.33
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 0.86	< 1.0	< 1.40	< 1.10	< 1.0	< 1.0	< 0.92	< 1.50	< 0.84	< 1.50
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 0.18	< 0.22	< 0.3	< 0.22	< 0.22	< 0.21	69.0	< 0.32	< 0.18	69.0
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 0.19	< 0.23	< 0.31	< 0.23	< 0.23	< 0.22	0.5	< 0.34	< 0.18	0.5
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 0.92	< 1.10	< 1.60	< 1.10	< 1.10	< 1.10	2.0	< 1.0	< 0.91	2.0
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 1.80	< 2.20	< 3.10	< 2.20	< 2.20	< 2.10	1100.0	< 3.30	< 1.80	1100.0
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 0.88	< 1.10	< 1.50	< 1.10	92	< 1.0	46	< 1.6	< 0.86	140
Southwest area	Soil	SW-01	0-30	11/13/2014	< 0.18	< 0.22	< 0.30	< 0.22	< 0.22	< 0.21	< 0.19	< 0.32	< 0.18	< 0.32
Southwest area	Soil	SW-03	0-30	11/15/2014	< 0.17	< 0.21	< 0.29	< 0.22	< 0.21	< 0.20	11.0	< 0.31	< 0.17	11.0
Southwest area	Soil	SW-08	0-30	11/18/2014	< 0.18	< 0.22	< 0.30	< 0.22	< 0.22	7.3	10.0	< 0.32	< 0.18	17.0
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 1.8	< 2.2	< 3.0	< 2.2	< 2.2	< 2.1	< 1.9	< 3.2	< 1.8	< 3.2
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 0.87	< 1.1	< 1.5	< 1.1	< 1.1	< 1	1.3	< 1.6	< 0.86	< 1.6
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 0.17	< 0.21	< 0.30	< 0.22	< 0.21	< 0.20	1.2	< 0.32	< 0.17	1.2
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 0.18	< 0.23	< 0.31	< 0.23	< 0.22	< 0.21	1.7	< 0.33	< 0.18	1.7
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 0.87	< 1.1	< 1.5	< 1.1	< 1.1	< 1	4.1	< 1.6	< 0.86	4.1
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 0.88	< 1.1	< 1.5	< 1.1	< 1.1	< 1.0	1.9	< 1.6	< 0.87	1.9
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 0.88	< 1.1	< 1.5	< 1.1	< 1.1	< 1.0	< 0.94	< 1.6	< 0.87	< 1.6
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 0.91	< 1.1	< 1.5	< 1.1	< 1.1	< 1.1	< 0.98	< 1.6	< 0.90	< 1.6

* ***Notes***:

- %: percent
- µg/kg: microgram per kilogram
- cm: centimeter
- DU: decision unit
- ID: identification
- PCB: polychlorinated biphenyl

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Exceeds EPA risk-based screening level

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	1,1'-Biphenyl (µg/kg)	1,2,4,5-Tetrachlorobenzene (µg/kg)	1,2,4-Trichlorobenzene (µg/kg)	1,2-Dichlorobenzene (µg/kg)	1,2-Diphenylhydrazine (as Azobenzene) (µg/kg)	1,3-Dichlorobenzene (µg/kg)	1,4-Dichlorobenzene (µg/kg)	1-Methylnaphthalene (µg/kg)	2,2'-oxybis[1-chloropropane] (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					2.0E+05	3.5E+05	1.1E+05	9.3E+06	2.9E+03	-	1.1E+04	7.3E+04	4.7E+07
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 33	< 28	< 20	< 38	< 47	< 28	< 26	< 7.8	< 7.9
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	< 15	< 13	< 9.3	< 18	< 22	< 13	< 12	< 3.6	< 3.6
Northeast area	Soil	NE-03	0-30	4/11/2015	< 3.1	< 2.6	< 1.9	< 3.6	< 4.4	< 2.7	< 2.5	0.8	< 0.74
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 3.1	< 2.6	< 1.9	< 3.7	< 4.5	< 2.7	< 2.5	1.2	< 0.75
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 3.2	< 2.7	< 2	< 3.7	< 4.5	< 2.8	< 2.5	0.79	< 0.76
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 3	< 2.6	< 1.9	< 3.5	< 4.3	< 2.6	< 2.4	< 0.72	< 0.73
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 3.2	< 2.7	< 2	< 3.7	< 4.5	< 2.8	< 2.5	< 0.76	< 0.76
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 16	< 14	< 10	< 19	< 23	< 14	< 13	< 3.9	< 3.9
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 3.2	< 2.7	< 2	< 3.8	< 4.6	< 2.8	< 2.6	1.1	< 0.78
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 16	< 13	< 9.8	< 19	< 23	< 14	< 13	< 3.8	< 3.8
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	< 170	< 170	< 170	< 170	< 170	< 170	< 34	< 34
Southwest area	Soil	SW-01	0-30	11/13/2014	< 3.1	< 2.7	< 1.9	< 3.7	< 4.5	< 2.7	< 2.5	< 0.75	< 0.76
Southwest area	Soil	SW-03	0-30	11/15/2014	< 15	< 13	< 9.4	< 18	< 22	< 13	< 12	< 3.6	< 3.6
Southwest area	Soil	SW-08	0-30	11/18/2014	< 16	< 13	< 9.6	< 18	< 22	< 14	< 12	< 3.7	< 3.8
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 340	< 340	< 340	< 340	< 340	< 340	< 70	< 70
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 330	< 330	< 330	< 330	< 330	< 330	< 68	< 68
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 3.1	< 2.6	< 1.9	< 3.6	< 4.4	< 2.7	< 2.5	< 0.74	< 0.74
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 3.2	< 2.7	< 2	< 3.8	< 4.6	< 2.8	< 2.6	< 0.77	< 0.78
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 15	< 13	< 9.6	< 18	< 22	< 13	< 12	< 3.7	< 3.7
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 16	< 13	< 9.6	< 18	< 22	< 14	< 12	< 3.7	< 3.8
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 3	< 2.6	< 1.9	< 3.6	< 4.4	< 2.7	< 2.4	< 0.73	< 0.74
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 3.2	< 2.7	< 2	< 3.7	< 4.6	< 2.8	< 2.6	< 0.76	< 0.77

* ***Notes***:

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/kg: microgram per kilogram
- SVOC: semivolatile organic compound

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	2,3,4,6-Tetrachlorophenol (µg/kg)	2,4,5-Trichlorophenol (µg/kg)	2,4,6-Trichlorophenol (µg/kg)	2,4-Dichlorophenol (µg/kg)	2,4-Dimethylphenol (µg/kg)	2,4-Dinitrophenol (µg/kg)	2,4-Dinitrotoluene (µg/kg)	2,6-Dichlorophenol (µg/kg)	2,6-Dinitrotoluene (µg/kg)	2-Chloronaphthalene (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					**2.5E+07**	**8.2E+07**	**2.1E+05**	**2.5E+06**	**1.6E+07**	**1.6E+06**	**7.4E+03**	**-**	**1.5E+03**	**6.4E+07**
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 23	< 39	< 55	< 7.3	< 57	< 430	< 29	< 36	< 38	< 7.6
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	< 11	< 18	< 25	< 3.4	< 26	< 200	< 14	< 16	< 17	< 3.5
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2.2	< 3.7	< 5.2	< 0.69	< 5.4	< 41	< 2.8	< 3.4	< 3.6	< 0.72
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2.2	< 3.7	< 5.2	< 0.7	< 5.5	< 42	< 2.8	< 3.4	< 3.6	< 0.73
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	3	850	12	290	< 5.5	< 42	< 2.9	8.2	< 3.7	< 0.74
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 2.2	< 3.6	< 5	< 0.68	< 5.3	< 40	< 2.7	< 3.3	< 3.5	< 0.7
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 2.3	< 3.8	< 5.3	< 0.71	< 5.5	< 42	< 2.9	< 3.4	< 3.7	< 0.74
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 12	< 19	< 27	< 3.7	< 29	< 220	< 15	< 18	< 19	< 3.8
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 2.3	< 3.8	< 5.4	< 0.72	< 5.6	< 43	< 2.9	< 3.5	< 3.7	< 0.75
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 11	< 19	< 27	< 3.6	< 28	< 210	< 14	< 17	< 18	< 3.7
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	< 170	< 170	< 34	< 170	< 870	< 170	< 170	< 170	< 34
Southwest area	Soil	SW-01	0-30	11/13/2014	< 2.3	43	< 5.3	29	< 5.5	< 42	< 2.8	< 3.4	< 3.6	< 0.73
Southwest area	Soil	SW-03	0-30	11/15/2014	< 11	< 18	< 25	< 3.4	< 26	< 200	< 14	< 16	< 17	< 3.5
Southwest area	Soil	SW-08	0-30	11/18/2014	< 11	< 19	< 26	< 3.5	< 27	< 210	< 14	< 17	< 18	< 3.6
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	280	< 340	72	< 340	< 1800	< 340	< 340	< 340	< 70
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 330	< 330	< 68	< 330	< 1700	< 330	< 330	< 330	< 68
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 2.2	< 3.7	< 5.2	< 0.69	< 5.4	< 41	< 2.8	< 3.4	< 3.6	< 0.72
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 2.3	< 3.8	< 5.4	< 0.72	< 5.6	< 43	< 2.9	< 3.5	< 3.7	< 0.75
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 11	< 18	< 26	< 3.5	< 27	< 210	< 14	< 17	< 18	< 3.6
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 11	< 19	< 26	< 3.5	< 27	< 210	< 14	< 17	< 18	< 3.6
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 2.2	< 3.6	< 5.1	< 0.68	< 5.3	< 41	< 2.8	< 3.3	< 3.5	< 0.71
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 2.3	< 3.8	< 5.3	< 0.72	< 5.6	< 42	< 2.9	< 3.5	< 3.7	< 0.74

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1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	2-Chlorophenol (µg/kg)	2-Methylnaphthalene (µg/kg)	2-Methylphenol (µg/kg)	2-Nitroaniline (µg/kg)	2-Nitrophenol (µg/kg)	3,3'-Dichlorobenzidine (µg/kg)	3-Nitroaniline (µg/kg)	4,6-Dinitro-2-methylphenol (µg/kg)	4-Bromophenyl phenyl ether (µg/kg)	4-Chloro-3-methylphenol (µg/kg)
				EPA Risk-Based Screening Table - Industrial Soil[1]	**5.8E+06**	**3.0E+06**	**4.1E+07**	**8.0E+06**	**-**	**5.1E+03**	**-**	**6.6E+04**	**-**	**8.2E+07**
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 30	< 6.6	< 25	< 160	< 40	< 39	< 150	< 150	< 32	< 34
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	< 14	6.9	< 12	< 75	< 19	< 18	< 69	< 68	< 15	< 16
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2.8	1.2	< 2.4	< 15	< 3.8	< 3.6	< 14	< 14	< 3	< 3.2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2.9	1.8	< 2.4	< 16	< 3.8	< 3.7	< 14	< 14	< 3	< 3.2
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 2.9	1.2	< 2.5	< 16	< 3.9	< 3.7	< 15	< 14	< 3.1	< 3.3
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 2.8	< 0.61	< 2.4	< 15	< 3.7	< 3.6	< 14	< 14	< 2.9	< 3.1
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 2.9	0.85	< 2.5	< 16	< 3.9	< 3.7	< 15	< 14	< 3.1	< 3.3
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 15	< 3.3	< 13	< 82	< 20	< 19	< 75	< 73	< 16	< 17
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 2.9	1.2	< 2.5	< 16	< 4	< 3.8	< 15	< 14	< 3.1	< 3.3
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 14	< 3.2	< 12	< 79	< 20	< 19	< 73	< 71	< 15	< 16
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	5.1	< 170	< 870	< 170	< 170	< 870	< 870	< 170	< 170
Southwest area	Soil	SW-01	0-30	11/13/2014	< 2.9	0.71	< 2.5	< 16	< 3.9	< 3.7	< 14	< 14	< 3.1	< 3.2
Southwest area	Soil	SW-03	0-30	11/15/2014	< 14	< 3	< 12	< 76	< 19	< 18	< 70	< 68	< 15	< 16
Southwest area	Soil	SW-08	0-30	11/18/2014	< 14	< 3.1	< 12	< 78	< 19	< 18	< 72	< 70	< 15	< 16
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 70	< 340	< 1800	< 340	< 340	< 1800	< 1800	< 340	< 340
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 68	< 330	< 1700	< 330	< 330	< 1700	< 1700	< 330	< 330
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 2.8	< 0.62	< 2.4	< 15	< 3.8	< 3.6	< 14	< 14	< 3	< 3.2
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 2.9	< 0.65	< 2.5	< 16	< 4	< 3.8	< 15	< 14	< 3.1	< 3.3
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 14	< 3.1	< 12	< 77	< 19	< 18	< 71	< 69	< 15	< 16
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 14	< 3.1	< 12	< 78	< 19	< 18	< 72	< 70	< 15	< 16
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 2.8	< 0.61	< 2.4	< 15	< 3.8	< 3.6	< 14	< 14	< 3	< 3.1
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 2.9	< 0.64	< 2.5	< 16	< 3.9	< 3.8	< 15	< 14	< 3.1	< 3.3

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1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	4-Chloroaniline (µg/kg)	4-Chlorophenyl phenyl ether (µg/kg)	4-Nitroaniline (µg/kg)	4-Nitrophenol (µg/kg)	Acenaphthene (µg/kg)	Acenaphthylene (µg/kg)	Acetophenone (µg/kg)	Aniline (µg/kg)	Anthracene (µg/kg)	Atrazine (µg/kg)
		EPA Risk-Based Screening Table - Industrial Soil[1]			1.1E+04	-	1.1E+05	-	4.5E+07	-	1.2E+08	4.0E+05	2.3E+08	1.0E+04
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 29	< 41	< 150	< 130	< 7	< 8.4	< 30	< 28	12	< 36
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	51	< 19	< 68	< 61	5.9	< 3.9	18	< 13	< 3.3	< 16
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2.8	< 3.8	< 14	< 13	< 0.66	< 0.79	5.8	< 2.7	< 0.67	< 3.4
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2.8	< 3.9	< 14	< 13	< 0.67	< 0.8	< 2.9	< 2.7	< 0.68	< 3.4
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 2.8	< 3.9	< 14	< 13	< 0.68	< 0.81	< 2.9	< 2.9	< 0.69	< 3.4
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 2.7	< 3.7	< 14	< 12	< 0.65	< 0.77	4.2	< 2.6	< 0.66	< 3.3
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 2.8	< 3.9	< 14	< 13	< 0.68	5.1	3.5	< 2.8	5.7	< 3.4
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 15	< 20	< 74	< 67	< 3.5	< 4.2	< 15	< 14	< 3.6	< 18
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 2.9	< 4	< 15	< 13	< 0.69	< 0.82	5.4	< 2.8	< 0.7	< 3.5
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 14	< 20	< 72	< 65	< 3.4	< 4.1	< 15	< 14	4.3	< 17
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	58	< 170	< 870	< 870	< 34	< 34	< 170	< 170	< 34	< 170
Southwest area	Soil	SW-01	0-30	11/13/2014	< 2.8	< 3.9	< 14	< 13	< 0.67	2.1	4.1	< 2.7	2	< 3.4
Southwest area	Soil	SW-03	0-30	11/15/2014	< 14	< 19	< 68	< 62	< 3.2	< 3.9	< 14	< 13	< 3.3	< 16
Southwest area	Soil	SW-08	0-30	11/18/2014	< 14	< 19	< 70	< 63	< 3.3	< 4	< 14	< 14	< 3.4	< 17
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 340	< 1800	< 1800	< 70	< 70	< 340	< 340	< 70	< 340
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 330	< 1700	< 1700	< 68	< 68	< 330	< 330	< 68	< 330
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 2.8	< 3.8	< 14	< 13	< 0.66	< 0.79	3.7	< 2.7	< 0.67	< 3.4
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 2.9	< 4	< 15	< 13	< 0.69	< 0.82	< 3	< 2.8	< 0.7	< 3.5
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 14	< 19	< 70	< 63	< 3.3	< 4	< 14	< 13	< 3.4	< 17
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 14	< 19	< 71	< 64	< 3.3	< 4	< 14	< 14	< 3.4	< 17
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 2.7	< 3.8	< 14	< 12	< 0.66	0.98	3.6	< 2.7	1.2	< 3.3
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 2.9	< 4	< 14	< 13	< 0.69	< 0.82	3.3	< 2.8	< 0.7	< 3.5

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1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Benzaldehyde (µg/kg)	Benzo[a]anthracene (µg/kg)	Benzo[a]pyrene (µg/kg)	Benzo[b]fluoranthene (µg/kg)	Benzo[g,h,i]perylene (µg/kg)	Benzo[k]fluoranthene (µg/kg)	Benzyl alcohol (µg/kg)	Bis(2-chloroethoxy)methane (µg/kg)	Bis(2-chloroethyl)ether (µg/kg)	Bis(2-ethylexyl) phthalate (µg/kg)
		EPA Risk-Based Screening Table - Industrial Soil[1]			1.2E+08	2.9E+03	2.9E+02	2.9E+03	-	2.9E+04	8.2E+07	2.5E+06	1.0E+03	1.6E+05
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	170	34	40	80	64	< 15	< 44	< 24	< 9.8	2600
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	39	11	17	32	34	8.2	< 20	< 11	< 4.5	11000
Northeast area	Soil	NE-03	0-30	4/11/2015	9.9	1.5	1.7	3.5	2.4	< 1.4	< 4.2	< 2.3	< 0.92	300
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 5.2	1.3	< 0.7	2.7	< 0.69	< 1.4	< 4.2	< 2.3	< 0.94	38
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 5.3	3.1	3.1	4.1	5	2.8	< 4.3	< 2.3	< 0.95	44
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 5.1	< 0.85	< 0.67	< 1.1	< 0.67	< 1.4	< 4.1	< 2.2	< 0.91	32
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 5.3	6.2	20	30	100	15	< 4.3	< 2.3	< 0.95	43
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 27	< 4.6	< 3.7	< 5.7	< 3.6	< 7.4	< 22	< 12	< 4.9	32
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	7.6	1.4	< 0.72	4.4	< 0.71	2.1	< 4.3	< 2.4	< 0.96	76
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 27	20	23	30	30	18	< 21	< 12	< 4.8	260
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	11	13	28	30	< 34	< 170	< 170	< 34	740
Southwest area	Soil	SW-01	0-30	11/13/2014	< 5.3	47	54	63	57	32	< 4.2	< 2.3	< 0.94	84
Southwest area	Soil	SW-03	0-30	11/15/2014	< 25	58	55	65	56	38	< 20	< 11	< 4.5	230
Southwest area	Soil	SW-08	0-30	11/18/2014	< 26	23	43	60	52	33	< 21	< 11	< 4.7	37
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 70	< 70	< 70	< 70	< 70	< 340	< 340	< 70	< 700
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 68	< 68	< 68	< 68	< 68	< 330	< 330	< 68	1300
Z1 area	Soil	Z1-03	60-90	12/2/2014	5.6	< 0.86	< 0.69	< 1.1	1.8	< 1.4	< 4.2	< 2.3	< 0.92	20
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 5.4	< 0.9	< 0.72	< 1.1	< 0.72	< 1.5	< 4.4	< 2.4	< 0.97	60
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 26	6.3	4.9	7.6	7.9	< 7	< 21	< 11	< 4.6	2300
Z1 area	Sediment	Z1-09	0-15	4/8/2015	27	9.2	9.4	14	15	10	< 21	< 11	< 4.7	880
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 5.1	6.2	5.8	8.7	6.2	2.9	< 4.1	< 2.2	< 0.92	63
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 5.3	< 0.89	< 0.71	< 1.1	< 0.71	< 1.4	< 4.3	< 2.3	< 0.96	63

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1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Butyl benzyl phthalate (µg/kg)	Caprolactam (µg/kg)	Carbazole (µg/kg)	Chrysene (µg/kg)	Dibenz(a,h)anthracene (µg/kg)	Dibenzofuran (µg/kg)	Diethyl phthalate (µg/kg)	Dimethyl phthalate (µg/kg)	Di-n-butyl phthalate (µg/kg)	Di-n-octyl phthalate (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					**1.2E+06**	**4.0E+08**	**-**	**2.9E+05**	**2.9E+02**	**1.0E+06**	**6.6E+08**	**-**	**8.2E+07**	**8.2E+06**
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 50	< 280	< 6.7	31	< 8.1	< 36	< 40	< 40	83	< 38
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	170	< 130	< 3.1	25	< 3.7	< 17	< 18	< 18	200	< 18
Northeast area	Soil	NE-03	0-30	4/11/2015	36	< 26	< 0.63	2.9	< 0.77	< 3.4	4.8	< 3.8	42	< 3.6
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	14	< 26	< 0.64	1.7	< 0.78	< 3.4	4.7	< 3.8	4.8	< 3.7
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 4.8	< 27	< 0.65	4.5	< 0.79	< 3.5	< 3.9	< 3.9	7.7	< 3.7
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	19	< 25	< 0.62	< 0.8	< 0.75	< 3.3	4.9	< 3.7	15	< 3.6
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 4.8	< 27	< 0.65	11	11	< 3.5	< 3.9	< 3.9	6.2	< 3.7
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 25	< 140	< 3.4	< 4.3	< 4.1	< 18	< 20	< 20	< 23	< 19
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	14	< 27	1.4	4.2	< 0.8	< 3.5	22	< 3.9	10	< 3.8
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 24	< 130	< 3.3	31	11	< 17	< 19	< 19	< 22	< 19
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	< 870	< 34	31	< 34	< 170	24	< 170	< 170	< 170
Southwest area	Soil	SW-01	0-30	11/13/2014	< 4.8	< 27	1.5	53	13	< 3.5	< 3.8	< 3.8	160	< 3.7
Southwest area	Soil	SW-03	0-30	11/15/2014	31	< 130	< 3.1	63	11	< 17	< 18	< 18	< 21	< 18
Southwest area	Soil	SW-08	0-30	11/18/2014	< 24	< 130	< 3.2	31	9.7	< 17	< 19	< 19	< 22	< 18
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 1800	< 70	< 70	< 70	< 340	< 340	< 340	< 340	< 340
Z1 area	Soil	Z1-02	0-30	3/25/2015	130	< 1700	< 68	< 68	< 68	< 330	37	< 330	< 330	< 330
Z1 area	Soil	Z1-03	60-90	12/2/2014	5.4	< 26	< 0.64	< 0.82	< 0.77	< 3.4	< 3.8	< 3.8	5.2	< 3.6
Z1 area	Soil	Z1-04	120-150	12/1/2014	9.1	< 27	< 0.66	< 0.86	< 0.8	< 3.5	< 3.9	< 3.9	6	< 3.8
Z1 area	Soil	Z1-07	0-30	4/10/2015	120	< 130	< 3.2	5.6	< 3.8	< 17	39	< 19	< 22	< 18
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 24	< 130	< 3.2	11	< 3.9	< 17	81	< 19	40	< 18
Z1 area	Soil	Z1-16	30-60	4/10/2015	12	< 26	0.84	7.3	< 0.76	< 3.4	5	< 3.7	20	< 3.6
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	21	< 27	< 0.66	< 0.85	< 0.79	< 3.5	20	< 3.9	9.1	< 3.8

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Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Dinoseb (µg/kg)	Fluoranthene (µg/kg)	Fluorene (µg/kg)	Hexachlorobenzene (µg/kg)	Hexachlorobutadiene (µg/kg)	Hexachlorocyclopentadiene (µg/kg)	Hexachloroethane (µg/kg)	Indeno[1,2,3-cd]pyrene (µg/kg)	Isophorone (µg/kg)	Methyphenol, 3 & 4 (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					8.2E+05	3.0E+07	3.0E+07	9.6E+02	5.3E+03	7.5E+03	8.0E+03	2.9E+03	2.4E+06	8.2E+07
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	< 47	63	< 9.6	< 7.8	< 8.2	< 39	< 26	47	< 27	< 36
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	< 22	36	6.1	< 3.6	< 3.8	< 18	< 12	17	< 13	22
Northeast area	Soil	NE-03	0-30	4/11/2015	< 4.4	4.5	1	< 0.73	< 0.77	< 3.7	< 2.5	1.5	< 2.6	4.1
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 4.5	1.8	< 0.92	< 0.74	< 0.78	< 3.8	< 2.5	< 0.72	< 2.6	< 3.4
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	< 4.6	5	< 0.93	< 0.75	< 0.79	< 3.8	< 2.5	4	< 2.7	< 3.5
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 4.3	1.6	< 0.89	< 0.72	< 0.75	< 3.6	< 2.4	< 0.7	< 2.5	< 3.3
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	< 4.6	4.4	< 0.93	< 0.75	< 0.79	< 3.8	< 2.5	60	< 2.7	< 3.5
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 23	< 3.9	< 4.8	< 3.9	< 4.1	< 20	< 13	< 3.8	< 14	< 18
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	< 4.6	5.3	< 0.95	< 0.77	< 0.8	< 3.9	< 2.6	< 0.74	< 2.7	< 3.5
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 23	39	< 4.7	< 3.8	< 4	< 19	< 13	23	< 13	< 17
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 170	45	< 34	< 34	< 34	< 170	< 170	17	< 170	< 170
Southwest area	Soil	SW-01	0-30	11/13/2014	< 4.5	43	< 0.93	< 0.75	< 0.79	< 3.8	< 2.5	45	< 2.6	< 3.4
Southwest area	Soil	SW-03	0-30	11/15/2014	< 22	73	< 4.5	< 3.6	< 3.8	< 18	< 12	44	< 13	< 17
Southwest area	Soil	SW-08	0-30	11/18/2014	< 22	14	< 4.6	< 3.7	< 3.9	< 19	< 12	48	< 13	< 17
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 340	< 70	< 70	< 70	< 70	< 340	< 340	< 70	< 340	< 340
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 330	< 68	< 68	< 68	< 68	< 330	< 330	< 68	< 330	< 330
Z1 area	Soil	Z1-03	60-90	12/2/2014	< 4.4	1.4	< 0.91	< 0.73	< 0.77	< 3.7	< 2.5	1.2	< 2.6	< 3.4
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 4.6	1.1	< 0.95	< 0.77	< 0.81	< 3.9	< 2.6	< 0.74	< 2.7	< 3.5
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 22	11	< 4.6	< 3.7	< 3.9	< 19	< 12	< 3.6	< 13	< 17
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 22	20	5.4	< 3.7	< 3.9	< 19	< 13	9.2	< 13	< 17
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 4.4	12	< 0.9	< 0.73	< 0.76	< 3.7	< 2.5	4.2	< 2.6	< 3.3
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 4.6	1.2	< 0.94	< 0.76	< 0.8	< 3.8	< 2.6	< 0.74	< 2.7	< 3.5

* ***Notes***:
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- µg/kg: microgram per kilogram
- SVOC: semivolatile organic compound

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Naphthalene (µg/kg)	Nitrobenzene (µg/kg)	N-Nitrosodiethylamine (µg/kg)	N-Nitrosodimethylamine (µg/kg)	N-Nitrosodi-n-propylamine (µg/kg)	N-Nitrosodiphenylamine (µg/kg)	Pentachlorobenzene (µg/kg)	Pentachlorophenol (µg/kg)	Phenanthrene (µg/kg)	Phenol (µg/kg)
EPA Risk-Based Screening Table - Industrial Soil[1]					**1.7E+04**	**2.2E+04**	**1.5E+01**	**3.4E+01**	**3.3E+02**	**4.7E+05**	**9.3E+05**	**4.0E+03**	**-**	**2.5E+08**
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	21	< 30	< 24	< 31	20	< 34	< 19	< 33	38	< 8.6
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	10	< 14	< 11	< 14	< 4	< 16	< 8.7	< 15	26	21
Northeast area	Soil	NE-03	0-30	4/11/2015	4.2	< 2.9	< 2.3	< 3	< 0.81	< 3.2	< 1.8	< 3.1	4.2	9.4
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	8.4	< 2.9	< 2.3	< 3	< 0.82	< 3.2	< 1.8	< 3.1	1.4	< 0.83
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	1.5	< 2.9	< 2.3	< 3	< 0.83	< 3.3	< 1.8	< 3.2	3	4.5
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	< 0.58	< 2.8	< 2.2	< 2.9	< 0.79	< 3.1	< 1.8	< 3	2	< 0.8
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	2	< 2.9	< 2.3	< 3	< 0.83	< 3.3	< 1.8	< 3.2	2.7	5
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 3.1	< 15	< 12	< 16	< 4.3	< 17	< 9.5	< 16	< 5.8	< 4.3
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	1.4	< 3	< 2.4	< 3.1	< 0.84	< 3.3	< 1.9	< 3.2	4.1	< 0.85
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	< 3.1	< 15	< 12	< 15	< 4.2	< 16	< 9.2	< 16	13	< 4.2
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	< 34	< 340	< 170	< 170	< 34	< 170	< 170	< 170	< 34	< 34
Southwest area	Soil	SW-01	0-30	11/13/2014	< 0.61	< 2.9	< 2.3	< 3	< 0.82	21	< 1.8	< 3.1	3.3	4.3
Southwest area	Soil	SW-03	0-30	11/15/2014	< 2.9	< 14	< 11	< 14	< 4	< 16	< 8.8	< 15	9.1	< 4
Southwest area	Soil	SW-08	0-30	11/18/2014	< 3	< 14	< 11	< 15	< 4.1	< 16	< 9	< 16	< 5.5	< 4.1
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 70	< 700	< 340	< 340	< 70	< 340	< 340	< 340	< 70	< 70
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 68	< 670	< 330	< 330	< 68	< 330	< 330	< 330	< 68	< 68
Z1 area	Soil	Z1-03	60-90	12/2/2014	1.1	< 2.9	< 2.3	< 3	< 0.81	< 3.2	< 1.8	< 3.1	1.5	10
Z1 area	Soil	Z1-04	120-150	12/1/2014	< 0.62	< 3	< 2.4	< 3.1	< 0.84	< 3.3	< 1.9	< 3.2	1.2	6.9
Z1 area	Soil	Z1-07	0-30	4/10/2015	< 3	< 14	< 11	< 15	< 4.1	< 16	< 9	< 15	8.5	< 4.1
Z1 area	Sediment	Z1-09	0-15	4/8/2015	< 3	< 15	< 11	< 15	< 4.1	< 16	< 9	< 16	18	< 4.1
Z1 area	Soil	Z1-16	30-60	4/10/2015	< 0.59	< 2.8	< 2.2	< 2.9	< 0.8	< 3.2	< 1.8	< 3.1	5.1	< 0.81
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 0.62	< 3	< 2.3	< 3.1	< 0.84	< 3.3	< 1.9	< 3.2	1.4	< 0.84

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- µg/kg: microgram per kilogram
- SVOC: semivolatile organic compound

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E5: SVOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Pyrene (µg/kg)	Pyridine (µg/kg)
				EPA Risk-Based Screening Table - Industrial Soil[1]	2.3E+07	1.2E+06
Bien Hung lake	Sediment	BHL-01	0-15	4/14/2015	67	< 18
Gate 2 lake	Sediment	G2L-01	0-15	4/11/2015	34	< 8.4
Northeast area	Soil	NE-03	0-30	4/11/2015	2.8	< 1.7
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	1.6	< 1.7
Pacer Ivy area	Soil	PI-02	60-90	11/24/2014	4	< 1.8
Pacer Ivy area	Soil	PI-04	60-90	4/8/2015	0.9	< 1.7
Pacer Ivy area	Soil	PI-06	0-30	11/18/2014	3.6	< 1.8
Pacer Ivy area	Soil	PI-07	0-30	11/25/2014	< 3.7	< 9.1
Pacer Ivy area	Soil	PI-08	0-30	3/26/2015	2.9	< 1.8
Pacer Ivy area	Soil	PI-14	0-30	11/20/2014	28	< 8.8
Pacer Ivy area	Sediment	PI-20	0-15	3/23/2015	26	< 170
Southwest area	Soil	SW-01	0-30	11/13/2014	40	< 1.8
Southwest area	Soil	SW-03	0-30	11/15/2014	57	< 8.4
Southwest area	Soil	SW-08	0-30	11/18/2014	12	< 8.7
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 70	< 340
Z1 area	Soil	Z1-02	0-30	3/25/2015	< 68	< 330
Z1 area	Soil	Z1-03	60-90	12/2/2014	1.2	< 1.7
Z1 area	Soil	Z1-04	120-150	12/1/2014	0.81	< 1.8
Z1 area	Soil	Z1-07	0-30	4/10/2015	6.7	< 8.6
Z1 area	Sediment	Z1-09	0-15	4/8/2015	13	< 8.7
Z1 area	Soil	Z1-16	30-60	4/10/2015	9.9	< 1.7
Z1 taxiway area	Soil	ZT-01	30-60	4/11/2015	< 0.72	< 1.8

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- ID: identification
- µg/kg: microgram per kilogram
- SVOC: semivolatile organic compound

1 United States Enviromental Protection Agency Regional Screening Levels - Industrial Soil

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	1-Methyl-2-pyrrolidone (NMP) (µg/L)	1,1,1,2-Tetrachloroethane (µg/L)	1,1,1-Trichloroethane (TCA) (µg/L)	1,1,2,2-Tetrachloroethane (µg/L)	1,1,2-Trichloroethane (µg/L)	1,1-Dichloroethane (µg/L)	1,1-Dichloropropene (µg/L)	1,2,3-Trichlorobenzene (µg/L)	1,2,3-Trichloropropane (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	9.5	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* ***Notes*** :

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	1,2,4-Trichlorobenzene (µg/L)	1,2,4-Trimethylbenzene (µg/L)	1,2-Dibromo-3-chloropropane (µg/L)	1,2-Dibromoethane (EDB) (µg/L)	1,2-Dichlorobenzene (µg/L)	1,2-Dichloroethane (EDC) (µg/L)	1,2-Dichloropropane (µg/L)	1,3,5-Trimethylbenzene (µg/L)	1,3-Dichlorobenzene (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

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- %: percent
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- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	1,3-Dichloropropane (µg/L)	1,4-Dichlorobenzene (µg/L)	2,2-Dichloropropane (µg/L)	2,4-Dinitrotoluene (µg/L)	2-Butanone (MEK) (µg/L)	2-Chlorotoluene (µg/L)	2-Ehoxyethyl acetate (µg/L)	2-phenyl-2-propanol (µg/L)	4-Chlorotoluene (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

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- %: percent
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- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Acetophenone (µg/L)	Benzene (µg/L)	Bis-(2-methoxyethyl)ether (µg/L)	Bromobenzene (µg/L)	Bromochloromethane (µg/L)	Bromodichloromethane (µg/L)	Bromoform (µg/L)	Bromomethane (µg/L)	Carbon Disulfide (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* ***Notes*** :

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

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Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Carbon Tetrachloride (µg/L)	Chlorobenzene (µg/L)	Chloroethane (µg/L)	Chloroform (µg/L)	Chloromethane (µg/L)	cis-1,2-Dichloroethene (µg/L)	cis-1,3-Dichloropropene (µg/L)	Cyclohexane (µg/L)	Cyclohexanone (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* ***Notes***:

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Dibromochloromethane (µg/L)	Dibromomethane (µg/L)	Dichlorodifluoromethane (µg/L)	Dichloromethane (µg/L)	Ethylbenzene (µg/L)	Formamide (µg/L)	Hexachlorobutadiene (µg/L)	Isopropylbenzene (µg/L)	m-Cresol (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	6.6
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* ***Notes*** :

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	m,p-Xylenes (µg/L)	n-Butylbenzene (µg/L)	n-n-dimethylacetamide (DMAC) (µg/L)	n-n-Dimethylformamide (DMFa) (µg/L)	n-Hexane (µg/L)	Naphthalene (µg/L)	o-Cresol (µg/L)	o-Xylene (µg/L)	p-Cresol (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	6.4	< 2	< 2	< 2	< 2	6.6
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	56.3	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	71.6	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

* ***Notes*** :

- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	p-Isopropyltoluene (µg/L)	Pentachloroethane (µg/L)	Pentane (µg/L)	Phenol (µg/L)	Propylbenzene (µg/L)	sec-Butylbenzene (µg/L)	Styrene (µg/L)	tert-Butylbenzene (µg/L)	Tetrachloroethene (PCE) (µg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2

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- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- µg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E6: VOC results in collected soil and sediment samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Sub-DU	Depth (cm)	Collection date	Tetrahydrofuran (THF) (μg/L)	Toluene (μg/L)	trans-1,2-Dichloroethene (μg/L)	trans-1,3-Dichloropropene (μg/L)	Trichloroethene (TCE) (μg/L)	Trichlorofluoromethane (μg/L)	Vinyl Chloride (μg/L)
Bien Hung Lake	Sediment	BHL-01	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Gate 2 Lake	Sediment	G2L-01	0-15	3/19/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Northeast area	Soil	NE-03	0-30	4/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-03	0-30	11/7/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-01	0-30	11/11/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Southwest area	Soil	SW-08	0-30	11/14/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-01	0-30	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-02	60-90	11/18/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-04	30-60	3/16/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-06	0-30	11/17/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-07	0-30	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-08	0-30	3/13/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Soil	PI-14	0-30	11/19/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Pacer Ivy area	Sediment	PI-20	0-15	3/11/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-01-landfill	0-100	4/14/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-02	0-30	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-03	60-90	11/20/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-04	120-150	11/21/2014	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-07	30-60	3/20/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Sediment	Z1-09	0-15	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 area	Soil	Z1-16	30-60	3/25/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Z1 taxiway area	Soil	ZT-01	30-60	3/27/2015	< 2	< 2	< 2	< 2	< 2	< 2	< 2

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- %: percent
- cm: centimeter
- DU: decision unit
- ID: identification
- μg/L: microgram per liter of methanol
- VOC: volatile organic compound

Note: Soil samples for VOCs were placed directly into a 1-liter jar containing approximately 0.5 L of methanol for preservation immediately upon sampling. Each MIS sample consisted of approximately 150 grams of soil in 0.5 L of methanol to extract VOCs, and the methanol was analyzed by the laboratory. Results were not converted to weight/weight basis (ug/kg), as the only compounds detected were at very low levels, and would be significantly below applicable risk-based standards.

Table E7: Metal results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Filtration?	Media	Collection date	Antimony (µg/L)	Arsenic (µg/L)	Beryllium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Mercury (µg/L)	Nickel (µg/L)	Selenium (µg/L)	Silver (µg/L)	Thallium (µg/L)	Zinc (µg/L)
USEPA Drinking Water Standard[1]				**6**	**10**	**4**	**5**	**100**	**1300**	**15**	**2**	**100**	**50**	**-**	**2**	**5000**
Discharge criteria from QCVN[2]				**-**	**50**	**-**	**50**	**200**	**2000**	**100**	**5**	**200**	**-**	**-**	**-**	**3000**
MW-01	Unfiltered	Groundwater	4/14/2015	< 0.1	0.36	< 0.5	< 0.05	< 0.5	< 0.1	< 0.05	< 0.1	< 0.5	< 0.05	< 0.05	< 1	3
MW-02	Unfiltered	Groundwater	4/14/2015	< 0.1	2.5	< 0.5	< 0.05	< 0.5	0.7	1.62	< 0.1	1.7	< 0.05	< 0.05	< 1	12
MW-03	Unfiltered	Groundwater	4/15/2015	< 0.1	6.5	< 0.5	< 0.05	2.9	13.5	6.43	< 0.1	16.6	1.4	< 0.05	< 1	39
MW-04	Unfiltered	Groundwater	4/15/2015	< 0.1	0.6	< 0.5	< 0.05	< 0.5	0.36	0.16	< 0.1	< 0.5	< 0.05	0.22	< 1	3
MW-05	Unfiltered	Groundwater	4/14/2015	0.4	5	< 0.5	1.44	< 0.5	1.4	64.8	< 0.1	1.9	< 0.05	< 0.05	< 1	13
MW-06	Unfiltered	Groundwater	4/14/2015	< 0.1	4.8	< 0.5	0.15	5.2	20.6	21.31	< 0.1	9.2	9.1	< 0.05	< 1	48

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- DU: decision unit
- ID: identification

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

2 QCVN 40:2011/BTMNT - National Technical Regulation on Industrial Wastewater

[orange shading] Exceeds the MCL, but does not exceed the QCVN discharge criterion

Table E8: Herbicide results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Filtration?	Media	Collection date	MCPA (µg/L)	Mecoprop (µg/L)	Picloram (µg/L)	2,4,5-T (µg/L)	2,4-D (µg/L)	2,4-DB (µg/L)	Dicamba (µg/L)	Dichlorprop (µg/L)	Silvex (2,4,5-TP) (µg/L)
			USEPA Drinking Water Standard[1]	**-**	**-**	**500**	**-**	**70**	**-**	**-**	**-**	**50**
MW-01	Unfiltered	Groundwater	4/14/2015	< 17	< 19	0.42	< 0.063	< 0.037	< 0.15	< 0.086	< 0.15	< 0.063
MW-02	Unfiltered	Groundwater	4/14/2015	< 17	< 19	0.46	< 0.062	< 0.037	< 0.15	< 0.085	< 0.15	< 0.062
MW-03	Unfiltered	Groundwater	4/15/2015	< 17	< 19	0.24	< 0.063	< 0.037	< 0.15	< 0.086	< 0.15	< 0.063
MW-04	Unfiltered	Groundwater	4/15/2015	< 17	< 19	1.2	< 0.063	< 0.037	< 0.15	< 0.086	< 0.15	0.19
MW-05	Unfiltered	Groundwater	4/14/2015	< 17	< 19	420	< 0.063	< 0.037	< 0.15	< 0.086	< 0.15	< 0.063
MW-06	Unfiltered	Groundwater	4/14/2015	< 17	< 19	0.66	< 0.064	< 0.038	< 0.15	< 0.087	< 0.15	< 0.064
Offsite well #1	Unfiltered	Groundwater	4/14/2015	< 18	< 20	< 0.079	< 0.064	< 0.042	< 0.17	< 0.096	< 0.17	< 0.064
Offsite well #2	Unfiltered	Groundwater	4/14/2015	< 19	< 21	< 0.087	< 0.07	< 0.042	< 0.17	< 0.096	< 0.17	< 0.07
Offsite well #3	Unfiltered	Groundwater	4/14/2015	< 18	< 20	< 0.08	< 0.064	< 0.038	< 0.15	< 0.088	< 0.15	< 0.064
Offsite well #4	Unfiltered	Groundwater	4/14/2015	< 18	< 20	0.3	< 0.064	< 0.038	< 0.16	< 0.088	< 0.16	< 0.064
Offsite well #5	Unfiltered	Groundwater	4/14/2015	< 18	< 20	< 0.082	< 0.066	< 0.039	< 0.16	< 0.09	< 0.16	< 0.066
Offsite well #6	Unfiltered	Groundwater	4/14/2015	< 17	< 19	16	< 0.063	< 0.038	< 0.15	< 0.086	< 0.15	< 0.063
Water tower	Pre-filter	Groundwater	4/14/2015	< 17	< 19	0.11	< 0.062	< 0.037	< 0.15	< 0.085	< 0.15	< 0.062
Water tower	Post-filter	Groundwater	4/14/2015	< 18	< 20	0.2	< 0.064	< 0.038	< 0.15	< 0.088	< 0.15	< 0.064

* ***Notes***:

- %: percent
- µg/L: microgram per liter
- 2,4,5-T: 2,4,5-trichlorophenoxyacetic acid
- 2,4,5-TP: 2,4,5-trichlorophenoxyacetic acid
- 2,4-D: 2,4-dichlorophenoxyacetic acid
- 2,4-DB: 2,4-dichlorophenoxybutyric acid
- DU: decision unit
- ID: identification
- MCPA: 2-methyl-4-chlorophenoxyacetic acid
- MW: monitoring well

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

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Table E9: PCB results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	PCB-1016 (µg/L)	PCB-1221 (µg/L)	PCB-1232 (µg/L)	PCB-1242 (µg/L)	PCB-1248 (µg/L)	PCB-1254 (µg/L)	PCB-1260 (µg/L)	PCB-1262 (µg/L)	PCB-1268 (µg/L)	Total polychlorinated biphenyls (µg/L)
USEPA Drinking Water Standard[1]			-	-	-	-	-	-	-	-	-	**0.5**
Discharge criteria from QCVN[2]			-	-	-	-	-	-	-	-	-	**3**
MW-01	Groundwater	4/14/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-02	Groundwater	4/14/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-03	Groundwater	4/15/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-04	Groundwater	4/15/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-05	Groundwater	4/14/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MW-06	Groundwater	4/14/2015	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

* ***Notes*** :

- %: percent
- µg/kg: microgram per kilogram
- cm: centimeter
- DU: decision unit
- ID: identification
- PCB: polychlorinated biphenyl

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

2 QCVN 40:2011/BTMNT - National Technical Regulation on Industrial Wastewater

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	1,1,1,2-tetrachloroethane (µg/L)	1,1,1-trichloroethane (µg/L)	1,1,2,2-tetrachloroethane (µg/L)	1,1,2-trichloroethane (µg/L)	1,1-dichloroethane (µg/L)	1,1-dichloroethene (µg/L)	1,1-dichloropropene (µg/L)	1,2,3-trichlorobenzene (µg/L)	1,2,3-trichloropropane (µg/L)	1,2,4-trichlorobenzene (µg/L)
USEPA Drinking Water Standard[1]			**-**	**200**	**-**	**5**	**-**	**7**	**-**	**-**	**-**	**70**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	1,2,4-trimethylbenzene (µg/L)	1,2-dibromo-3-chloropropane (µg/L)	1,2-dibromoethane (µg/L)	1,2-dichlorobenzene (µg/L)	1,2-dichloroethane (µg/L)	1,2-dichloropropane (µg/L)	1,3,5-trichlorobenzene (µg/L)	1,3,5-trimethylbenzene (µg/L)	1,3-dichlorobenzene (µg/L)	1,3-dichloropropane (µg/L)
USEPA Drinking Water Standard[1]			**-**	**0.2**	**0.05**	**600**	**5**	**5**	**-**	**-**	**-**	**-**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	1,4-dichlorobenzene (µg/L)	1,4-dioxane (µg/L)	1-chlorohexane (µg/L)	2,2-dichloropropane (µg/L)	2-butanone (µg/L)	2-chloroethyl vinyl ether (µg/L)	2-chlorotoluene (µg/L)	2-hexanone (µg/L)	2-nitropropane (µg/L)	3-chloro-1-propene (µg/L)
USEPA Drinking Water Standard[1]			**75**	-	-	-	-	-	-	-	-	-
MW-01	Groundwater	4/14/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	4-chlorotoluene (µg/L)	4-isopropyltoluene (µg/L)	4-methyl-2-pentanone (µg/L)	Acetone (µg/L)	Acetonitrile (µg/L)	Acrolein (µg/L)	Acrylonitrile (µg/L)	Benzene (µg/L)	Bromobenzene (µg/L)	Bromochloromethane (µg/L)
USEPA Drinking Water Standard[1]			-	-	-	-	-	-	-	5	-	-
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Bromodichloromethane (µg/L)	Bromoform (µg/L)	Bromomethane (µg/L)	Carbon disulfide (µg/L)	Carbon tetrachloride (µg/L)	Chlorobenzene (µg/L)	Chloroethane (µg/L)	Chloroform (µg/L)	Chloromethane (µg/L)	Chloroprene (µg/L)
USEPA Drinking Water Standard[1]			**80**	**80**	**-**	**-**	**5**	**100**	**-**	**80**	**-**	**-**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	cis-1,2-dichloroethene (µg/L)	cis-1,3-dichloropropene (µg/L)	cis-1,4-dichloro-2-butene (µg/L)	Dibromochloromethane (µg/L)	Dibromomethane (µg/L)	Dichlorodifluoromethane (µg/L)	Dichlorofluoromethane (µg/L)	Diisopropyl ether (µg/L)	Ethyl acetate (µg/L)	Ethyl ether (µg/L)
USEPA Drinking Water Standard[1]			**70**	**-**	**-**	**80**	**-**	**-**	**-**	**-**	**-**	**-**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	4.5	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	3.3	< 1	< 1	< 1	< 1	< 1	< 5	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Ethyl methacrylate (µg/L)	Ethylbenzene (µg/L)	Hexachlorobutadiene (µg/L)	Iodomethane (µg/L)	Iobutanol (µg/L)	Isopropylbenzene (µg/L)	m,p-xylenes (µg/L)	Methacrylonitrile (µg/L)	Methyl methacrylate (µg/L)	Methyl tert-butyl ether (µg/L)
USEPA Drinking Water Standard[1]			-	700	-	-	-	-	-	-	-	-
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 5	< 5	< 5	< 1	< 5	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Methylene chloride (μg/L)	n-butylbenzene (μg/L)	n-hexane (μg/L)	n-octane (μg/L)	n-propylbenzene (μg/L)	o-xylene (μg/L)	Propionitrile (μg/L)	sec-butylbenzene (μg/L)	Styrene (μg/L)	tert-amyl methyl ether (μg/L)
USEPA Drinking Water Standard[1]			**5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**100**	**-**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- μg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	tert-butyl alcohol (µg/L)	tert-butyl ethyl ether (µg/L)	tert-butylbenzene (µg/L)	Tetrachloroethene (µg/L)	Tetrahydrofuran (µg/L)	Toluene (µg/L)	trans-1,2-dichloroethene (µg/L)	trans-1,3-dichloropropene (µg/L)	trans-1,4-dichloro-2-butene (µg/L)	Trichloroethene (µg/L)
	USEPA Drinking Water Standard[1]		**-**	**-**	**-**	**5**	**-**	**1000**	**100**	**-**	**-**	**5**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E10: VOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Trichlorofluoromethane (µg/L)	Trichlorotrifluoroethane (µg/L)	Vinyl acetate (µg/L)	Vinyl chloride (µg/L)
USEPA Drinking Water Standard[1]			**-**	**-**	**-**	**2**
MW-01	Groundwater	4/14/2015	< 1	< 1	< 1	< 1
MW-02	Groundwater	4/14/2015	< 1	< 1	< 1	< 1
MW-03	Groundwater	4/15/2015	< 1	< 1	< 1	< 1
MW-04	Groundwater	4/15/2015	< 1	< 1	< 1	< 1
MW-05	Groundwater	4/14/2015	< 1	< 1	< 1	< 1
MW-06	Groundwater	4/14/2015	< 1	< 1	< 1	< 1

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- VOC: volatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	1,2-Dichlorobenzene (µg/L)	1,2,4-Trichlorobenzene (µg/L)	1,3-Dichlorobenzene (µg/L)	1,4-Dichlorobenzene (µg/L)	2-Chloronaphthalene (µg/L)	2-Chlorophenol (µg/L)	2-Methylnaphthalene (µg/L)	2-Methylphenol (µg/L)	2-Nitroaniline (µg/L)	2-Nitrophenol (µg/L)
USEPA Drinking Water Standard[1]			**600**	**70**	**-**	**75**	**-**	**-**	**-**	**-**	**-**	**-**
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	2,2'-oxybis (1-Chloropropane) (µg/L)	2,4-Dichlorophenol (µg/L)	2,4-Dimethylphenol (µg/L)	2,4-Dinitrophenol (µg/L)	2,4-Dinitrotoluene (µg/L)	2,4,5-Trichlorophenol (µg/L)	2,4,6-Trichlorophenol (µg/L)	2,6-Dinitrotoluene (µg/L)	3-Nitroaniline (µg/L)	3,3'-Dichlorobenzidine (µg/L)
	USEPA Drinking Water Standard[1]		-	-	-	-	-	-	-	-	-	-
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	4-Bromophenyl-phenylether (µg/L)	4-Chloro-3-methylphenol (µg/L)	4-Chloroaniline (µg/L)	4-Chlorophenyl-phenyl ether (µg/L)	4-Methylphenol (µg/L)	4-Nitroaniline (µg/L)	4-Nitrophenol (µg/L)	4,6-Dinitro-2-methylphenol (µg/L)	Acenaphthene (µg/L)	Acenaphthylene (µg/L)
	USEPA Drinking Water Standard[1]		-	-	-	-	-	-	-	-	-	-
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Anthracene (µg/L)	Benzo(a)anthracene (µg/L)	Benzo(a)pyrene (µg/L)	Benzo(b)fluoranthene (µg/L)	Benzo(g,h,i)perylene (µg/L)	Benzo(k)fluoranthene (µg/L)	bis(2-Chloroethoxy)-methane (µg/L)	bis(2-Chloroethyl) ether (µg/L)	bis(2-Ethylhexyl)phthalate (µg/L)	Butylbenzylphthalate (µg/L)
USEPA Drinking Water Standard[1]			**-**	**-**	**0.2**	**-**	**-**	**-**	**-**	**-**	**6**	**-**
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Carbazole (µg/L)	Chrysene (µg/L)	Di-n-butylphthalate (µg/L)	Di-n-octylphthalate (µg/L)	Dibenz(a,h)anthracene (µg/L)	Dibenzofuran (µg/L)	Diethylphthalate (µg/L)	Dimethylphthalate (µg/L)	Fluoranthene (µg/L)	Fluorene (µg/L)
USEPA Drinking Water Standard[1]			-	-	-	-	-	-	-	-	-	-
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes***:

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Hexachlorobenzene (µg/L)	Hexachlorobutadiene (µg/L)	Hexachlorocyclopentadiene (µg/L)	Hexachloroethane (µg/L)	Indeno(1,2,3-cd)pyrene (µg/L)	Isophorone (µg/L)	N-Nitroso-di-n-propylamine (µg/L)	N-nitrosodiphenylamine (µg/L)	Naphthalene (µg/L)	Nitrobenzene (µg/L)
USEPA Drinking Water Standard[1]			**1**	**-**	**50**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency
Maximum Contaminant Levels (MCLs)

Table E11: SVOC results in collected groundwater samples, Bien Hoa Airbase, Vietnam, 2014-2015.

Site ID	Media	Collection date	Pentachlorophenol (µg/L)	Phenanthrene (µg/L)	Phenol (µg/L)	Pyrene (µg/L)
	USEPA Drinking Water Standard[1]		1	-	-	-
MW-01	Groundwater	4/14/2015	< 10	< 10	< 10	< 10
MW-02	Groundwater	4/14/2015	< 10	< 10	< 10	< 10
MW-03	Groundwater	4/15/2015	< 10	< 10	< 10	< 10
MW-04	Groundwater	4/15/2015	< 10	< 10	< 10	< 10
MW-05	Groundwater	4/14/2015	< 10	< 10	< 10	< 10
MW-06	Groundwater	4/14/2015	< 10	< 10	< 10	< 10

* ***Notes*** :

- %: percent
- µg/L: microgram per liter
- cm: centimeter
- DU: decision unit
- ID: identification
- SVOC: semivolatile organic compound

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

Table E12: Dong Nai River water quality, 2011.

			pH	Oxygen (mg/l)	Total Matter Solids (TSS) (mg/l)	COD (mg/l)	BOD_5 (mg/l)	Ammonium (NH^+_4) µg/l	Salt (%)	Nitrite (NO^-_2) µg/l	Phosphate (PO_4^{3-}) µg/l	Arsenic (As) µg/l	Lead (Pb) µg/l	Iron (Fe) (mg/l)	Total Oil/ Grease µg/l	Phenol µg/l	E.Coli (MPN/100ml)	Coliform (MPN/100ml)
		Standard	-	5	30	15	6	200	-	20	200	20	5	1	20	0.5	50	5,000
		LB[1]	7.0	6.6	64	13	6	80	0.03	2	27	1	1.00	1.44	0.5	2	1500	93,000
	2011, April	MS[1]	6.9	6.5	20	20	6	60	0.03	2	24	1	1.00	0.79	0.5	2	230	2,300
		RB[1]	6.8	6.6	19	12	6	60	0.03	2	22	1	1.00	1.15	0.5	2	230	4,300
Hoa An Bridge		LB[1]	6.7	6.4	15	9	5	100	0.03	7	18	1	1.00	0.92	10.0	2	380	3,800
	2011, May	MS[1]	6.6	6.0	32	11	5	130	0.03	8	38	1	1.00	1.70	10.0	2	1500	20,000
		RB[1]	6.9	6.2	37	10	6	130	0.03	7	38	1	1.00	1.63	10.0	2	2400	28,000
		LB[1]	6.7	6.5	21	12	6	70	0.03	2	29	1	1.00	1.02	10.0	2	230	4,300
	2011, April	MS[1]	6.8	6.4	36	19	6	50	0.03	3	29	1	1.00	1.67	10.0	2	150	9,300
		RB[1]	6.7	6.3	17	18	6	50	0.03	3	27	1	1.00	0.81	10.0	2	230	9,300
Sewage Plan (SW-DN-11)		LB[1]	7.2	5.8	15	10	5	160	0.03	7	28	1	1.00	0.86	10.0	2	2400	11,000
	2011, May	MS[1]	7.0	5.8	35	11	6	200	0.03	11	50	1	1.00	1.78	10.0	2	380	2,800
		RB[1]	7.1	6.3	43	12	5	140	0.03	6	43	1	1.00	1.85	10.0	2	230	4,300
		LB[1]	6.5	5.1	30	19	8	80	0.05	11	160	1	1.00	16.10	10.0	2	150	46,000
	2011, April	MS[1]	6.6	4.2	28	13	7	60	0.07	14	120	1	1.00	1.52	10.0	2	230	4,300
		RB[1]	6.7	4.5	33	20	7	50	0.07	13	110	1	1.00	1.53	10.0	2	230	9,300
Kien Lung Wharf		LB[1]	6.8	5.9	14	11	4	200	0.05	4	44	1	2.00	0.96	10.0	2	4300	38,000
	2011, May	MS[1]	6.7	5.8	13	12	4	240	0.04	11	37	1	2.00	0.52	10.0	2	930	9,300
		RB[1]	6.7	5	15	11	4	200	0.04	12	38	1	1.00	0.52	10.0	2	930	9,300
		LB[1]	6.7	5.6	26	20	7	80	0.06	11	70	1	2.00	1.34	10.0	2	930	46,000
	2011, April	MS[1]	6.8	5	33	19	7	60	0.07	11	86	1	1.00	1.73	10.0	2	230	46,000
		RB[1]	6.8	5.5	29	17	6	70	0.06	10	71	1	1.00	1.16	10.0	2	430	9,300
Near Proconco Company		LB[1]	6.8	5.8	16	11	4	210	0.05	16	57	1	1.00	0.60	10.0	2	430	9,300
	2011, May	MS[1]	6.4	5.3	21	12	4	240	0.04	15	57	1	1.00	0.75	10.0	2	930	15,000
		RB[1]	6.3	5.5	23	11	4	200	0.05	16	44	1	1.00	1.11	10.0	2	640	4,300
		LB[1]	6.6	6.6	35	17	7	70	0.08	13	78	1	2.00	1.71	10.0	2	2400	46,000
	2011, April	MS[1]	6.6	6.2	11	17	6	60	0.05	8	45	1	1.00	0.64	10.0	2	1500	24,000
		RB[1]	6.8	6.4	15	15	6	60	0.05	8	47	1	1.00	1.05	10.0	2	750	9,300
Dong Nai Bridge (SW-DN-15)		LB[1]	6.7	5.3	33	12	3	120	0.12	18	48	1	2.00	1.38	10.0	2	9300	24,000
	2011, May	MS[1]	6.4	5.3	21	12	4	160	0.15	17	36	1	2.00	0.95	10.0	2	930	9,300
		RB[1]	6.5	5.4	13	13	4	180	0.14	15	44	1	2.00	1.36	10.0	2	430	4,300

Table E12: Dong Nai River water quality, 2011.

			pH	Oxygen (mg/l)	Total Matter Solids (TSS) (mg/l)	COD (mg/l)	BOD_5 (mg/l)	Ammonium (NH^{+}_{4}) µg/l	Salt (%)	Nitrite (NO^{-}_{2}) µg/l	Phosphate (PO_4^{3-}) µg/l	Arsenic (As) µg/l	Lead (Pb) µg/l	Iron (Fe) (mg/l)	Total Oil/ Grease µg/l	Phenol µg/l	E.Coli (MPN/100ml)	Coliform (MPN/100ml)
Fishing Village	**2011, April**	**LB**[1]	6.8	5.5	35	17	7	70	0.04	9	160	1	1.00	1.73	10.0	2	2400	46,000
		MS[1]	6.7	5.6	22	14	6	50	0.04	7	76	1	1.00	1.26	10.0	2	2400	46,000
		RB[1]	6.7	5.4	23	13	6	70	0.05	5	65	1	1.00	1.12	10.0	2	430	9,300
	2011, May	**LB**[1]	6.4	5.6	13	11	4	130	0.03	11	45	1	1.00	0.96	10.0	2	380	4,300
		MS[1]	6.1	6.1	13	12	4	200	0.04	11	40	1	1.00	0.67	10.0	2	750	4,300
		RB[1]	6.7	6.3	13	12	4	190	0.03	11	35	1	1.00	0.90	10.0	2	7500	24,000
Between Fishing Village (SW-DN-10)	**2011, April**	**LB**[1]	6.7	4.3	42	16	6	70	0.07	15	140	1	1.00	1.86	10.0	2	230	4,300
		MS[1]	6.7	4.5	38	16	6	60	0.07	14	110	1	2.00	1.85	10.0	2	930	2,400
		RB[1]	6.6	4.6	35	16	6	60	0.06	13	110	1	1	1.82	10.0	2	2400	46,000
	2011, May	**LB**[1]	6.7	6.3	20	12	4	170	0.04	10	49	1	1.00	1.18	10.0	2	930	9,300
		MS[1]	6.6	5.1	14	11	4	200	0.04	13	64	1	1.00	0.73	10.0	2	430	4,300
		RB[1]	6.8	4.9	15	12	4	260	0.04	13	50	1	1.00	0.85	10.0	2	4300	15,000
Wharf An Hao (SW-DN-14)	**2011, April**	**LB**[1]	6.7	4.9	23	13	5	80	0.1	12	76	1	1.00	1.12	10.0	2	2400	46,000
		MS[1]	6.7	4.6	32	16	6	50	0.12	17	72	1	1.00	1.52	10.0	2	2400	46,000
		RB[1]	7.0	5.4	45	21	6	60	0.08	15	85	1	1.00	2.42	10.0	2	930	9,300
	2011, May	**LB**[1]	6.9	5.9	18	10	4	190	0.06	15	40	1	1.00	1.51	10.0	2	4300	15,000
		MS[1]	6.9	6	26	12	4	200	0.06	17	44	1	2.00	0.68	10.0	2	430	2,300
		RB[1]	7.1	5.8	41	11	4	160	0.06	18	18	1	2.00	1.15	10.0	2	230	4,300

Source: Anon 2011a

* ***Notes*** :

- LB: left bank
- RB: right bank
- MS: midstream
- %: percent
- pH: power of hydrogen
- mg/l: milligrams per liter
- TSS: total suspended solids
- COD: chemical oxygen demand
- BOD: biochemical oxygen demand
- µg/l: microgram per liter
- MPN/100ml: most probable number per 100 millilitres

Standards from QCVN 08:2008

Table E13: Air quality in Bien Hoa industrial and urban areas.

Location	Variable	Units	TCVN	Sample Location			
				Station 1	Station 2	Station 3	Station 4
Bien Hoa City Industrial Areas							
	TSP	$\mu g/m^3$	300	423	267	353	340
	SO_2	$\mu g/m^3$	350	118	114	72	68
	NO_2	$\mu g/m^3$	200	88	78	105	85
	NO_x	$\mu g/m^3$		114	117	239	134
	CO	$\mu g/m^3$	30,000	12,300	13,374	11,840	26,276
Bien Hoa City: Urban Areas							
	TSP	$\mu g/m^3$	300	347	360	383	467
	SO_2	$\mu g/m^3$	350	120	68	87	70
	NO_2	$\mu g/m^3$	200	59	68	76	50
	NO_x	$\mu g/m^3$		115	104	112	91
	CO	$\mu g/m^3$	30,000	6,900	6,760	8,434	< 5,000

Source: Anon (2011b)

* ***Notes*** :

- TSP: total suspended particulates
- SO_2: sulfur dioxide
- NO_2: nitrogen dioxide
- NO_x: mono-nitrogen oxides (nitric oxide and nitrogen dioxide)
- CO: carbon monoxide
- $\mu g/m^3$: micrograms per cubic meter of air

Table E14: Concentration of acid pesticides and organochlorine pesticides in groundwater samples, from Dekonta (2014)

Parameter	Unit	Detection limit	Standard[1]	MW1	MW2	MW3	MW4	MW5	MW6a
Acid pesticides									
2,4-D	μg/l	0.05	**70**	<0.050	<0.050	<0.050	<0.050	<0.050	6.38
2,4-DB	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2,4,5-T	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	0.109	11
2,4,5-TP	μg/l	0.05	**50**	<0.050	<0.050	<0.050	0.151	<0.050	<0.050
4-CPP	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
dicamba	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
MCPA	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
MCPB	μg/l	0.05		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
picloram	μg/l	0.02	**500**	0.708	0.484	4.22	5.36	1050	2.11
Organochlorine pesticides									
1,2,3,4-tetrachlorbenzene	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
1,2,3,5- & 1,2,4,5-tetrachlorbenzene	μg/l	0.02		<0.020	<0.020	<0.020	<0.020	<0.010	<0.020
2,4-DDD	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2,4-DDE	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
2,4-DDT	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
4,4'-DDD	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
4,4'-DDE	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
4,4'-DDT	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
alachlor	μg/l	0.01	**2**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
aldrin	μg/l	0.01		<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
dieldrin	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
endrin	μg/l	0.01	**2**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
heptachlor	μg/l	0.01	**0.4**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
heptachlorepoxide-cis	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
teptachlorepoxide-trans	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
hexachlorbenzene (HCB)	μg/l	0.005		<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
hexachlorbutadiene	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HCH alfa	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HCH beta	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HCH delta	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
HCH gama	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
hexachlorethane	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
isodrin	μg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methoxychlor	μg/l	0.01	**40**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Table E14: Concentration of acid pesticides and organochlorine pesticides in groundwater samples, from Dekonta (2014)

Parameter	Unit	Detection limit	Standard[1]	MW1	MW2	MW3	MW4	MW5	MW6a
pentachlorbenzene	µg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
sum of 3 tetrachlorobenzenes	µg/l	0.03		<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
sum of 4 hexachlorocyklohexanes	µg/l	0.04		<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
sum of 4 isomers DDT	µg/l	0.04		<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
sum of 6 isomers DDT	µg/l	0.06		<0.060	<0.060	<0.060	<0.060	<0.060	<0.060
teldrin	µg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
trifluralin	µg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
alfa-endosulfan	µg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
beta-endosulfan	µg/l	0.01		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010

Source: Dekonta 2014

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

* ***Notes*** :

- µg/l: microgram per liter
- 2,4-D: 2,4-dichlorophenoxyacetic acid
- 2,4-DB: 2,4-dichlorophenoxybutyric acid
- 2,4,5-T: 2,4,5-trichlorophenoxyacetic acid
- 2,4,5-TP: 2,4,5-trichlorophenoxyacetic acid
- 4-CPP: 2-(4-chlorophenoxy)propanoic acid
- MCPA: 2-methyl-4-chlorophenoxyacetic acid
- MCPB: 4-(4-chloro-o-tolyloxy)butyric acid
- 2,4-DDD: 2,4-dichlorodiphenyldichloroethan
- 2,4-DDE: 2,4-dichlorodiphenyldichloroethylene
- 2,4-DDT: 2,4-dichlorodiphenyltrichloroethane
- 4,4'-DDD: 4,4'-dichlorodiphenyldichloroethan
- 4,4'-DDE: 4,4'-dichlorodiphenyldichloroethylene
- 4,4'-DDT: 4,4'-dichlorodiphenyltrichloroethane
- HCH alfa: α-hexachlorocyclohexane
- HCH beta: β-hexachlorocyclohexane
- HCH delta: δ-hexachlorocyclohexane
- HCH gama: γ-hexachlorocyclohexane

Table E15: Concentration of metals, major cations BTEX, and miscellaneous parameters in groundwater samples, from Dekonta (2014)

Parameter	Unit	Detection limit	Standard[1]	Standard[2]	MW1	MW2	MW3	MW4	MW5	MW6a
Metals/major cations										
Aluminium (Al)	mg/l	0.01			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic (As)	mg/l	0.005	**0.01**	**0.05**	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Barium (Ba)	mg/l	0.0005			0.00187	0.045	0.0764	0.00613	0.0538	0.198
Beryllium (Be)	mg/l	0.0002	**0.004**		<0.00020	<0.00020	0.00046	<0.00020	<0.00020	<0.00020
Cadmium (Cd)	mg/l	0.0004	**0.005**	**0.05**	<0.00040	0.00046	<0.00040	<0.00040	0.00164	<0.00040
Calcium (Ca)	mg/l	0.005			0.115	2.46	1.8	0.286	28.3	20.8
Chromium (Cr)	mg/l	0.001	**0.1**	**0.2**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt (Co)	mg/l	0.002			<0.0020	<0.0020	0.113	<0.0020	<0.0020	<0.0020
Copper (Cu)	mg/l	0.002	**1.3**	**2**	<0.0020	<0.0020	0.0207	<0.0020	<0.0020	0.0027
Iron (Fe)	mg/l	0.002		**1**	0.0903	<0.0020	0.0197	<0.0020	<0.0020	0.132
Lead (Pb)	mg/l	0.005	**0.015**	**0.1**	<0.005	<0.0050	<0.0050	<0.0050	0.121	<0.0050
Magnesium (Mg)	mg/l	0.003			0.0451	0.948	0.576	0.108	1.9	3.89
Manganese (Mn)	mg/l	0.0005		**0.5**	0.00415	0.0865	0.095	0.00912	0.0531	0.0263
Mercury (Hg)	mg/l	0.01	**0.002**	**0.005**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Molybdenum (Mo)	mg/l	0.002			<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0023
Nickel (Ni)	mg/l	0.002	**0.1**	**0.2**	<0.0020	<0.0020	0.0972	<0.0020	<0.0020	0.0023
Potassium (K)	mg/l	0.015			0.13	2.24	1.91	0.12	1.32	5.37
Sodium (Na)	mg/l	0.03			1.5	2.15	1.1	3.38	6.86	10.1
Vanadium (V)	mg/l	0.001			<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)	mg/l	0.002	**5.0**	**3.0**	0.0027	<0.0020	0.0185	<0.0020	0.0151	0.0031
BTEX										
benzene	µg/l	0.5	**5**		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
ethylbenzene	µg/l	0.5	**700**		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
sum of BTEX	µg/l	3.2			<3.20	<3.20	<3.20	<3.20	<3.20	<3.20
sum of xylenes	µg/l	1.7	**10000**		<1.70	<1.70	<1.70	<1.70	<1.70	<1.70
toluene	µg/l	0.5	**1000**		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
meta- & para-xylene	µg/l	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
ortho-xylene	µg/l	0.7			<0.70	<0.70	<0.70	<0.70	<0.70	<0.70
Inorganic parameters										
ammonia as N	mg/l	0.04		**5**	<0.040	<0.040	<0.040	<0.040	<0.040	1.7
nitrate as N	mg/l	0.5	**10**		-	27.5	-	-	91.7	125
nitrite as N	mg/l	0.002	**1**		<2.00	<2.00	<2.00	<2.00	11.9	<2.00
sulphate as SO4 (2-)	mg/l	5			<0.040	<0.040	<0.040	<0.040	<0.040	<0.040
conductivity (25^0 C)	mS/m	0.1			17.8	38.8	18.9	19	84.9	106
pH	-	1		**6 to 9**	4.77	6.22	5.34	5.56	6.47	6.74

* ***Notes*** :

- µg/l: micrograms per liter
- mg/l: milligrams per liter
- pH: power of hydrogen
- mS/m: millisiemens per meter

1 United States Environmental Protection Agency Maximum Contaminant Levels (MCLs)

2 QCVN 40:2011/BTMNT - National Technical Regulation on Industrial Wastewater

Laboratory Report on Physical and Thermal Properties of Z1 Landfill Sample

Laboratory Report for

KEMRON Environmental Services, Inc.

Bien Hoa Airbase, SH056202

July 15, 2015

Daniel B. Stephens & Associates, Inc.

4400 Alameda Blvd. NE, Suite C • Albuquerque, New Mexico 87113

July 15, 2015

Tommy A. Jordan
KEMRON Environmental Services, Inc.
1359-A Ellsworth Industrial Blvd NW
Atlanta, GA 30318
(404) 601-6908

Re: DBS&A Laboratory Report for the KEMRON Bien Hoa Airbase, SH056202 Project

Dear Mr. Jordan:

Enclosed is the report for the KEMRON Bien Hoa Airbase, SH056202 Project. Please review this report and provide any comments as samples will be held for a maximum of 30 days. After 30 days samples will be returned or disposed of in an appropriate manner.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

The testing utilized to generate the enclosed report employs methods that are standard for the industry. The results do not constitute a professional opinion by DBS&A, nor can the results affect any professional or expert opinions rendered with respect thereto by DBS&A. You have acknowledged that all the testing undertaken by us, and the report provided, constitutes mere test results using standardized methods, and cannot be used to disqualify DBS&A from rendering any professional or expert opinion, having waived any claim of conflict of interest by DBS&A.

We are pleased to provide this service to KEMRON and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.
SOIL TESTING & RESEARCH LABORATORY

Joleen Hines
Laboratory Supervising Manager

Enclosure

Summaries

Summary of Tests Performed

Laboratory Sample Number	Initial Soil Properties[1]			Saturated Hydraulic Conductivity[2]			Moisture Characteristics[3]								Particle Size[4]			Specific Gravity[5]		Air Perm-eability	Atterberg Limits	Thermal Properties
	G	VM	VD	CH	FH	FW	HC	PP	FP	DPP	RH	EP	WHC	K_{unsat}	DS	WS	H	F	C			
15BH-Z1-01-Landfill (109.1pcf)	X	X			X		X	X		X	X			X								X

[1] G = Gravimetric Moisture Content, VM = Volume Measurement Method, VD = Volume Displacement Method
[2] CH = Constant Head Rigid Wall, FH = Falling Head Rigid Wall, FW = Falling Head Rising Tail Flexible Wall
[3] HC = Hanging Column, PP = Pressure Plate, FP = Filter Paper, DPP = Dew Point Potentiometer, RH = Relative Humidity Box, EP = Effective Porosity, WHC = Water Holding Capacity, Kunsat = Calculated Unsaturated Hydraulic Conductivity
[4] DS = Dry Sieve, WS = Wet Sieve, H = Hydrometer
[5] F = Fine (<4.75mm), C = Coarse (>4.75mm)

Notes

Sample Receipt:
One sample arrived as loose material in a 1-gallon plastic bag (double bagged), on April 29, 2015. The sample was shipped in a box with bubble wrap, and was received in good order.

A representative portion of the material was removed and held for testing. The remaining material was returned to KEMRON Environmental Services, Inc. on May 7, 2015.

Sample Preparation and Testing Notes:
Based on testing direction provided by KEMRON Environmental Services, Inc., the sample was remolded into a testing ring to target 90% of the maximum dry bulk density at optimum moisture content, based on modified proctor compaction (ASTM D1557) test results provided by KEMRON. The actual density achieved (in pcf) was added to the sub-sample ID. The remolded sub-sample was subjected to initial properties analysis, saturated hydraulic conductivity testing, and the hanging column and pressure chamber portions of the moisture retention testing. In addition, the thermal properties were measured after remolding, after saturation, at several equilibrated hanging column and pressure chamber points, at several air drying points, and after oven drying.

Separate sub-samples were obtained for the dewpoint potentiometer and relative humidity chamber portions of the moisture retention testing.

Volumetric water contents were adjusted for changes in volume, where applicable. Due to the irregularities formed on the sample surfaces during swelling, volume measurements obtained after the initial reading should be considered estimates.

Porosity calculations are based on the use of an assumed specific gravity value of 2.65.

Summary of Sample Preparation/Volume Changes (g/cm^3)

	Target Remold Parameters[1]			Actual Remold Data			Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
Sample Number	Opt. Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Moist. Cont. (%, g/g)	Dry Bulk Density (g/cm^3)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)	Dry Bulk Density (g/cm^3)	% Volume Change (%)	% of Max. Density (%)
15BH-Z1-01-Landfill (109.1pcf)	13.5	1.94	90%	13.2	1.75	90.1%	1.71	+2.4%	88.0%	1.72	+1.9%	88.5%

[1]Target Remold Parameters: The sample was remolded to target 90% of the maximum dry bulk density at optimum moisture content, based on modified proctor compaction (ASTM D1557) test results provided by KEMRON.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

[3]Volume Change Post Drying Curve: Volume change measurements were obtained throughout hanging column and pressure plate testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last pressure plate point.

Notes:

(+) indicates sample swelling, (-) indicates sample settling, and "---" indicates no volume change occurred.

Summary of Sample Preparation/Volume Changes (pcf)

	Target Remold Parameters[1]			Actual Remold Data			Volume Change Post Saturation[2]			Volume Change Post Drying Curve[3]		
Sample Number	Opt. Moist. Cont. (%, g/g)	Dry Bulk Density (pcf)	% of Max. Density (%)	Moist. Cont. (%, g/g)	Dry Bulk Density (pcf)	% of Max. Density (%)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Max. Density (%)	Dry Bulk Density (pcf)	% Volume Change (%)	% of Max. Density (%)
15BH-Z1-01-Landfill (109.1pcf)	13.5	121.1	90%	13.2	109.1	90.1%	106.6	+2.4%	88.0%	107.1	+1.9%	88.5%

[1]Target Remold Parameters: The sample was remolded to target 90% of the maximum dry bulk density at optimum moisture content, based on modified proctor compaction (ASTM D1557) test results provided by KEMRON.

[2]Volume Change Post Saturation: Volume change measurements were obtained after saturated hydraulic conductivity testing.

[3]Volume Change Post Drying Curve: Volume change measurements were obtained throughout hanging column and pressure plate testing. The 'Volume Change Post Drying Curve' values represent the final sample dimensions after the last pressure plate point.

Notes:

(+) indicates sample swelling, (-) indicates sample settling, and "---" indicates no volume change occurred.

Summary of Initial Moisture Content, Dry Bulk Density Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received Gravimetric (%, g/g)	Moisture Content: As Received Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded Gravimetric (%, g/g)	Moisture Content: Remolded Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
15BH-Z1-01-Landfill (109.1pcf)	NA	NA	13.2	23.2	1.75	1.98	34.0

NA = Not analyzed
--- = This sample was not remolded

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
15BH-Z1-01-Landfill (109.1pcf)	6.8E-05	NA		X

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
15BH-Z1-01-Landfill (109.1pcf)	0	37.1 ‡‡
	17	35.5 ‡‡
	53	33.5 ‡‡
	130	30.5 ‡‡
	337	28.5 ‡‡
	2855	21.4 ‡‡
	4283	20.9 ‡‡
	15705	19.1 ‡‡
	41404	16.2 ‡‡
	71692	12.1 ‡‡
	89538	9.4 ‡‡
	139713	6.6 ‡‡
	199983	5.5 ‡‡
	434027	3.3 ‡‡
	848426	2.4 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
15BH-Z1-01-Landfill (109.1pcf)	0.0015	1.2567	0.00	34.03	NA	NA

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (pcf)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m³·K)	D mm²/s
15BH-Z1-01-Landfill (109.1pcf)	Initial	13.24	23.15	109.1	24.27	1.942	51.5	2.424	0.801
15BH-Z1-01-Landfill (109.1pcf)	Saturated	21.74	37.12	106.6	22.10	2.158	46.3	2.781	0.776
15BH-Z1-01-Landfill (109.1pcf)	17	20.79	35.50	106.6	21.83	2.023	49.4	2.461	0.822
15BH-Z1-01-Landfill (109.1pcf)	53	19.60	33.47	106.6	21.11	2.153	46.4	2.692	0.800
15BH-Z1-01-Landfill (109.1pcf)	130	17.79	30.53	107.1	20.96	2.039	49.0	2.282	0.894
15BH-Z1-01-Landfill (109.1pcf)	337	16.60	28.49	107.1	20.52	2.028	49.3	2.545	0.797
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #1	12.92	22.43	108.4	19.52	1.888	53.0	2.521	0.749
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #2	8.92	16.45	115.1	20.03	1.354	73.9	2.910	0.465
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #3	6.06	11.21	115.4	21.41	1.376	72.7	2.094	0.657
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #4	5.53	10.23	115.4	21.97	1.291	77.4	2.092	0.617
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #5	4.38	8.10	115.4	22.60	1.158	86.4	1.922	0.602
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #6	3.66	6.77	115.4	22.07	1.082	92.4	1.930	0.561
15BH-Z1-01-Landfill (109.1pcf)	Oven Dry	0.00	0.00	115.4	26.33	0.625	160.1	1.578	0.396

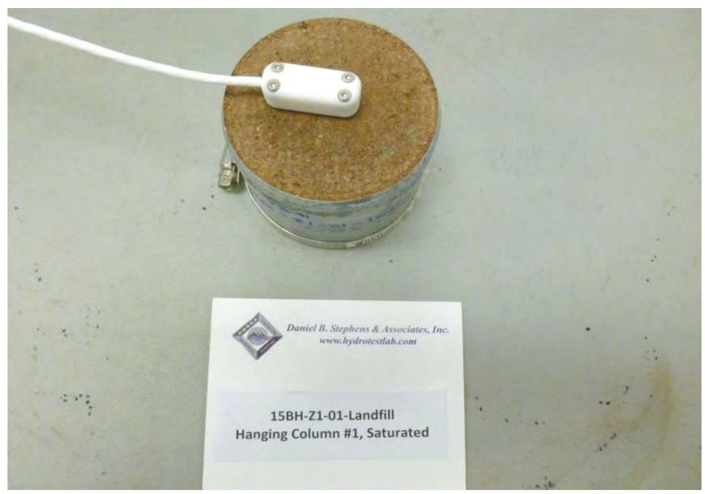
[1]Adjusted for volume changes during testing.

Photos


Daniel B. Stephens & Associates, Inc.
www.hydrotestlab.com
15BH-Z1-01-Landfill
As Received


Daniel B. Stephens & Associates, Inc.
www.hydrotestlab.com
15BH-Z1-01-Landfill
#4 Split


Daniel B. Stephens & Associates, Inc.
www.hydrotestlab.com
15BH-Z1-01-Landfill
Remolded (Initial)


Daniel B. Stephens & Associates, Inc.
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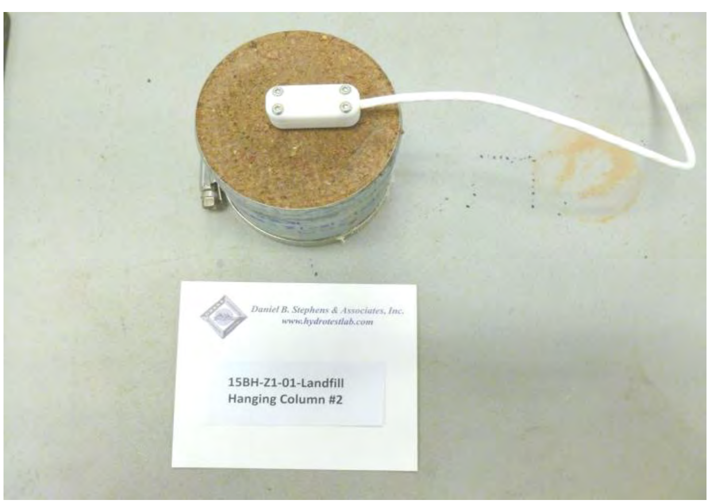
15BH-Z1-01-Landfill
Hanging Column #1, Saturated


Daniel B. Stephens & Associates, Inc.
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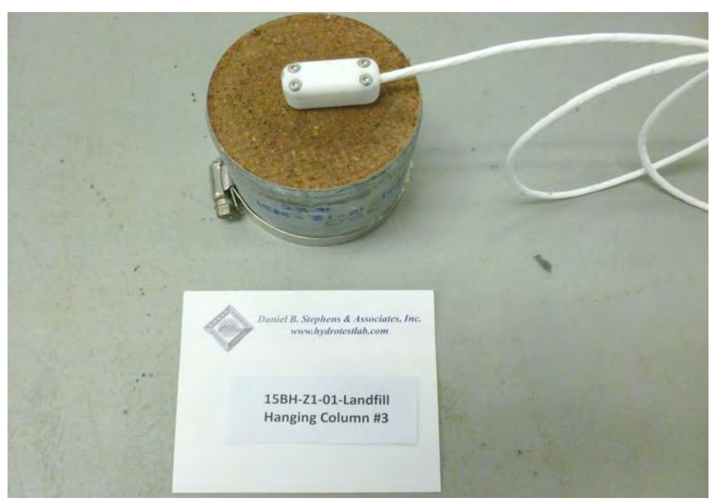
Hanging Column #2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Hanging Column #3

Photos


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Hanging Column #4


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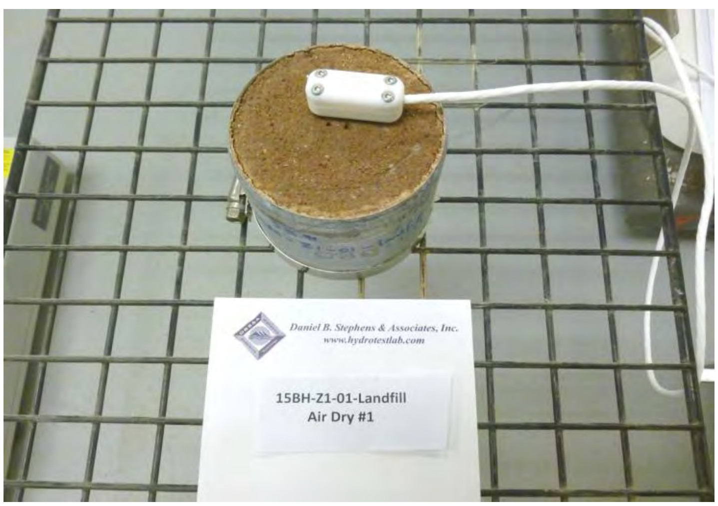
Pressure Chamber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15BH-Z1-01-Landfill
Air Dry #1


Daniel B. Stephens & Associates, Inc.
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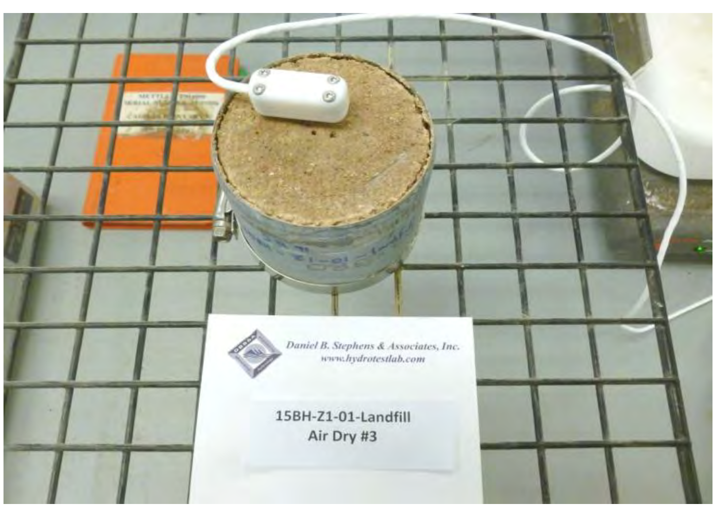
15BH-Z1-01-Landfill
Air Dry #2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15BH-Z1-01-Landfill
Air Dry #3


Daniel B. Stephens & Associates, Inc.
www.hydrotestlab.com
15BH-Z1-01-Landfill
Air Dry #4

Photos


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Air Dry #5


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15BH-Z1-01-Landfill
Air Dry #6


Daniel B. Stephens & Associates, Inc.
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15BH-Z1-01-Landfill
Oven Dry

Initial Properties

Summary of Initial Moisture Content, Dry Bulk Density
Wet Bulk Density and Calculated Porosity

Sample Number	Moisture Content: As Received: Gravimetric (%, g/g)	Moisture Content: As Received: Volumetric (%, cm^3/cm^3)	Moisture Content: Remolded: Gravimetric (%, g/g)	Moisture Content: Remolded: Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
15BH-Z1-01-Landfill (109.1pcf)	NA	NA	13.2	23.2	1.75	1.98	34.0

NA = Not analyzed
--- = This sample was not remolded

Data for Initial Moisture Content, Bulk Density, Porosity, and Percent Saturation

Job Name:	KEMRON Environmental Services, Inc.
Job Number:	NM15.0062.00
Sample Number:	15BH-Z1-01-Landfill (109.1pcf)
Project Name:	Bien Hoa Airbase
Project Number:	SH056202

	As Received	Remolded
Test Date:	NA	20-May-15
Field weight of sample* (g):		798.33
Tare weight, ring (g):		236.91
Tare weight, pan/plate (g):		0.00
Tare weight, other (g):		0.00
Dry weight of sample (g):		495.76
Sample volume (cm^3):		283.62
Assumed particle density (g/cm^3):		2.65
Gravimetric Moisture Content (% g/g):		13.2
Volumetric Moisture Content (% vol):		23.2
Dry bulk density (g/cm^3):		1.75
Wet bulk density (g/cm^3):		1.98
Calculated Porosity (% vol):		34.0
Percent Saturation:		68.0

Laboratory analysis by:	D. O'Dowd
Data entered by:	D. O'Dowd
Checked by:	J. Hines

Comments:

* Weight including tares
NA = Not analyzed
--- = This sample was not remolded

Saturated Hydraulic Conductivity

Summary of Saturated Hydraulic Conductivity Tests

Sample Number	K_{sat} (cm/sec)	Oversize Corrected K_{sat} (cm/sec)	Method of Analysis	
			Constant Head	Falling Head
15BH-Z1-01-Landfill (109.1pcf)	6.8E-05	NA		X

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Falling Head Method

Job Name:	KEMRON Environmental Services, Inc.	*Type of water used:*	TAP
Job Number:	NM15.0062.00	*Backpressure* (psi):	0.0
Sample Number:	15BH-Z1-01-Landfill (109.1pcf)	*Offset* (cm):	3.0
Project Name:	Bien Hoa Airbase	*Sample length* (cm):	6.97
Project Number:	SH056202	*Sample x-sectional area* (cm^2):	40.70
		Reservoir x-sectional area (cm^2):	0.70

Date	Time	Temp (°C)	Reservoir head (cm)	Corrected head (cm)	Elapsed time (sec)	Ksat (cm/sec)	Ksat @ 20°C (cm/sec)
Test # 1:							
22-May-15	7:36:44	23.0	17.6	14.6	22	7.5E-05	7.0E-05
22-May-15	7:37:06	23.0	17.4	14.4			
Test # 2:							
22-May-15	7:37:06	23.0	17.4	14.4	23	7.3E-05	6.8E-05
22-May-15	7:37:29	23.0	17.2	14.2			
Test # 3:							
22-May-15	7:37:29	23.0	17.2	14.2	24	7.1E-05	6.6E-05
22-May-15	7:37:53	23.0	17	14.0			

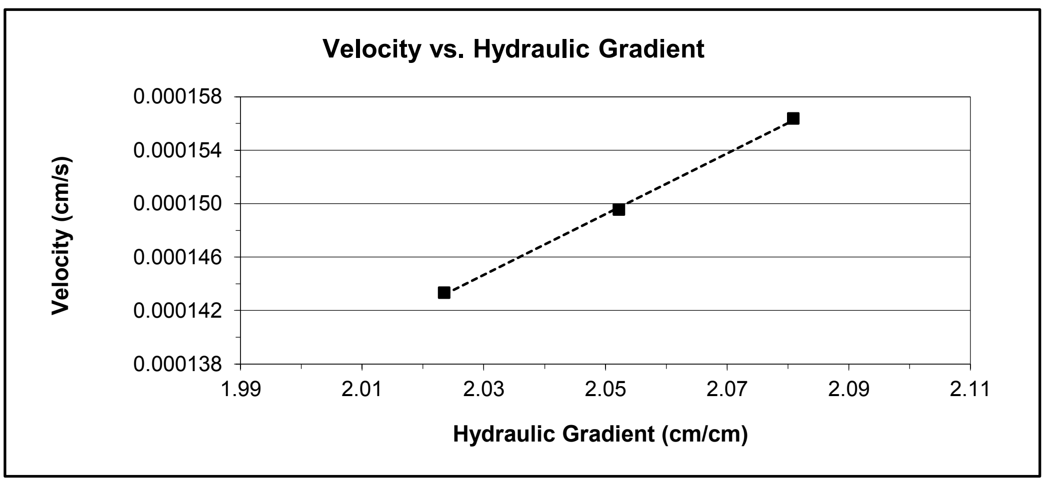
***Average Ksat* (cm/sec): 6.8E-05**

***Oversize Corrected Ksat* (cm/sec): NA**

Comments:

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass

NA = Not applicable



Laboratory analysis by: D. O'Dowd

Data entered by: D. O'Dowd

Checked by: J. Hines

Moisture Retention Characteristics

Summary of Moisture Characteristics of the Initial Drainage Curve

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
15BH-Z1-01-Landfill (109.1pcf)	0	37.1 ‡‡
	17	35.5 ‡‡
	53	33.5 ‡‡
	130	30.5 ‡‡
	337	28.5 ‡‡
	2855	21.4 ‡‡
	4283	20.9 ‡‡
	15705	19.1 ‡‡
	41404	16.2 ‡‡
	71692	12.1 ‡‡
	89538	9.4 ‡‡
	139713	6.6 ‡‡
	199983	5.5 ‡‡
	434027	3.3 ‡‡
	848426	2.4 ‡‡

‡‡ Volume adjustments are applicable at this matric potential (see data sheet for this sample).

Summary of Calculated Unsaturated Hydraulic Properties

Sample Number	α (cm^{-1})	N (dimensionless)	θ_r (% vol)	θ_s (% vol)	Oversize Corrected θ_r (% vol)	Oversize Corrected θ_s (% vol)
15BH-Z1-01-Landfill (109.1pcf)	0.0015	1.2567	0.00	34.03	NA	NA

--- = Oversize correction is unnecessary since coarse fraction < 5% of composite mass
NR = Not requested
NA = Not applicable

Daniel B. Stephens & Associates, Inc.

Moisture Retention Data
Hanging Column / Pressure Plate
(Soil-Water Characteristic Curve)

Job Name:	KEMRON Environmental Services, Inc.	*Dry wt. of sample* (g):	495.76
Job Number:	NM15.0062.00	*Tare wt., ring* (g):	236.91
Sample Number:	15BH-Z1-01-Landfill (109.1pcf)	*Tare wt., screen & clamp* (g):	27.54
Project Name:	Bien Hoa Airbase	*Initial sample volume* (cm^3):	283.62
Project Number:	SH056202	*Initial dry bulk density* (g/cm^3):	1.75
		Assumed particle density (g/cm^3):	2.65
		Initial calculated total porosity (%):	34.04

	Date	Time	Weight* (g)	Matric Potential (-cm water)	Moisture Content† (% vol)	
Hanging column:	22-May-15	9:00	868.00	0	37.12	‡‡
	28-May-15	7:55	863.30	17.0	35.50	‡‡
	11-Jun-15	11:00	857.40	53.0	33.47	‡‡
	18-Jun-15	10:15	848.40	130.0	30.53	‡‡
Pressure plate:	29-Jun-15	13:15	842.50	337	28.49	‡‡

Volume Adjusted Data [1]

	Matric Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calculated Porosity (%)
Hanging column:	0.0	290.38	+2.38%	1.71	35.57
	17.0	290.38	+2.38%	1.71	35.57
	53.0	290.38	+2.38%	1.71	35.57
	130.0	288.87	+1.85%	1.72	35.24
Pressure plate:	337	288.87	+1.85%	1.72	35.24

Comments:

[1] Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent each of the volume change measurements obtained after saturated hydraulic conductivity testing and throughout hanging column/pressure plate testing. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Assumed density of water is 1.0 g/cm^3

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Technician Notes:

Laboratory analysis by: D. O'Dowd
Data entered by: N. Candelaria
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)

Initial sample bulk density (g/cm^3)*:* 1.75
Fraction of bulk sample used (<2.00mm fraction) (%): 100.00

Dry weight of dew point potentiometer sample* (g)*:* 165.35
Tare weight, jar (g)*:* 116.39

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content† (% vol)	
Dew point potentiometer:	14-Jul-15	16:20	171.45	2855	21.39	‡‡
	18-Jun-15	14:00	171.32	4283	20.93	‡‡
	18-Jun-15	16:00	170.81	15705	19.14	‡‡
	12-Jun-15	15:15	169.97	41404	16.19	‡‡
	12-Jun-15	11:10	168.80	71692	12.09	‡‡
	12-Jun-15	8:45	168.02	89538	9.36	‡‡
	11-Jun-15	14:55	167.23	139713	6.59	‡‡
	11-Jun-15	13:45	166.92	199983	5.50	‡‡
	14-Jul-15	14:20	166.30	434027	3.33	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Dew point potentiometer:	2855	288.87	+1.85%	1.72	35.24
	4283	288.87	+1.85%	1.72	35.24
	15705	288.87	+1.85%	1.72	35.24
	41404	288.87	+1.85%	1.72	35.24
	71692	288.87	+1.85%	1.72	35.24
	89538	288.87	+1.85%	1.72	35.24
	139713	288.87	+1.85%	1.72	35.24
	199983	288.87	+1.85%	1.72	35.24
	434027	288.87	+1.85%	1.72	35.24

Comments:

1 Applicable if the sample experienced volume changes during testing. 'Volume Adjusted' values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

2 Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm^3.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1).

Laboratory analysis by: D. O'Dowd
Data entered by: N. Candelaria
Checked by: J. Hines

Moisture Retention Data

Dew Point Potentiometer / Relative Humidity Box

(Soil-Water Characteristic Curve)

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)

Initial sample bulk density (g/cm³)*:* 1.75
Fraction of bulk sample used (<2.00mm fraction) (%): 100.00

Dry weight of relative humidity box sample* (g)*:* 70.99
Tare weight (g)*:* 39.93

	Date	Time	Weight* (g)	Water Potential (-cm water)	Moisture Content † (% vol)	
Relative humidity box:	15-Jun-15	10:00	71.43	848426	2.41	‡‡

Volume Adjusted Data [1]

	Water Potential (-cm water)	Adjusted Volume (cm^3)	% Volume Change [2] (%)	Adjusted Density (g/cm^3)	Adjusted Calc. Porosity (%)
Relative humidity box:	848426	288.87	+1.85%	1.72	35.24

Comments:

[1] Applicable if the sample experienced volume changes during testing. ‘Volume Adjusted’ values represent the volume change measurements obtained after the last hanging column or pressure plate point. "---" indicates no volume changes occurred.

[2] Represents percent volume change from original sample volume. A '+' denotes measured sample swelling, a '-' denotes measured sample settling, and '---' denotes no volume change occurred.

* Weight including tares

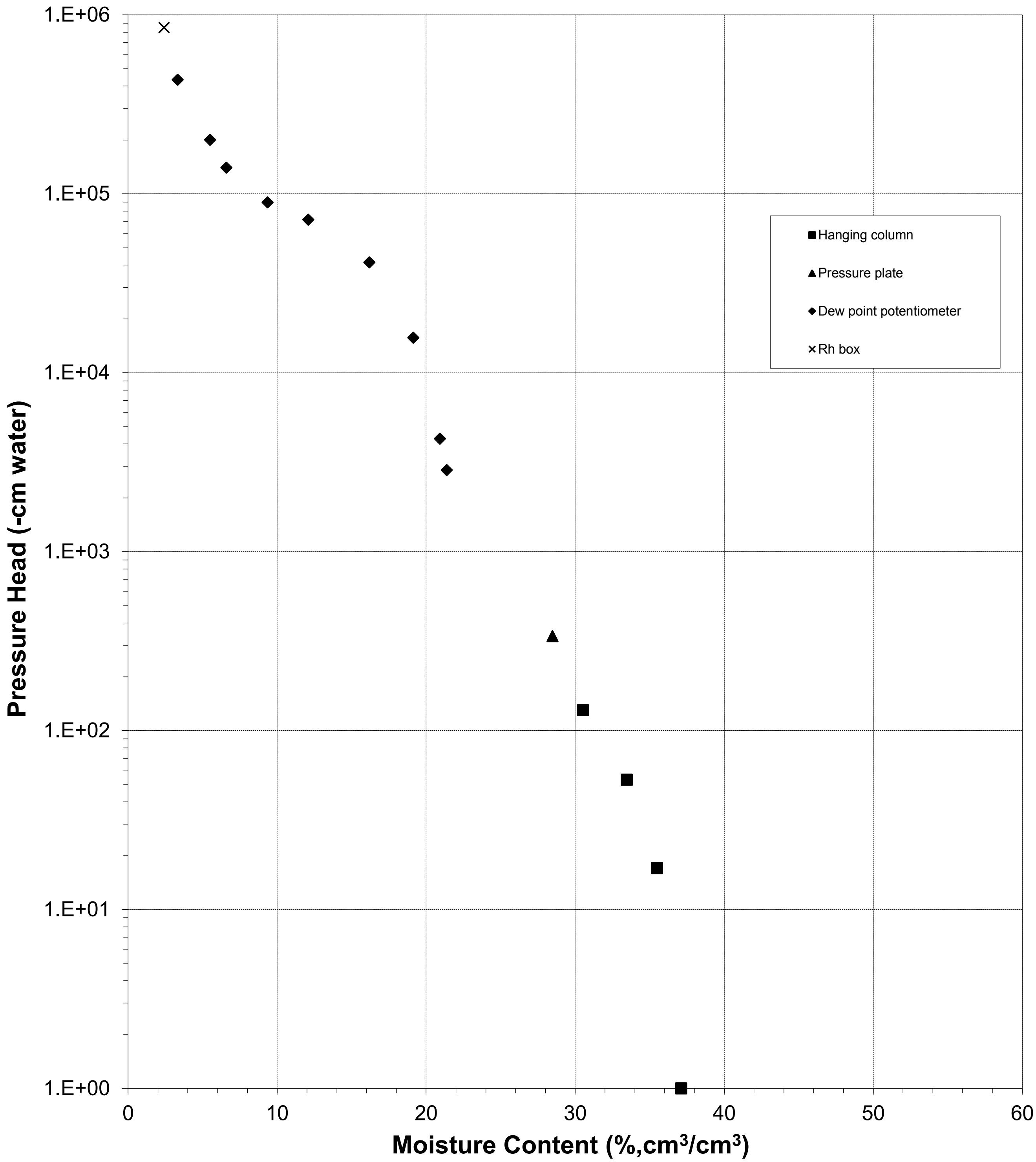
† Adjusted for >2.00mm (#10 sieve) material not used in DPP/RH testing. Assumed moisture content of material >2.00mm is zero, and assumed density of water is 1.0 g/cm³.

‡‡ Volume adjustments are applicable at this matric potential (see comment #1). Changes in volume, if applicable, are estimated based on obtainable measurements of changes in sample length and diameter.

Laboratory analysis by: D. O'Dowd
Data entered by: N. Candelaria
Checked by: J. Hines

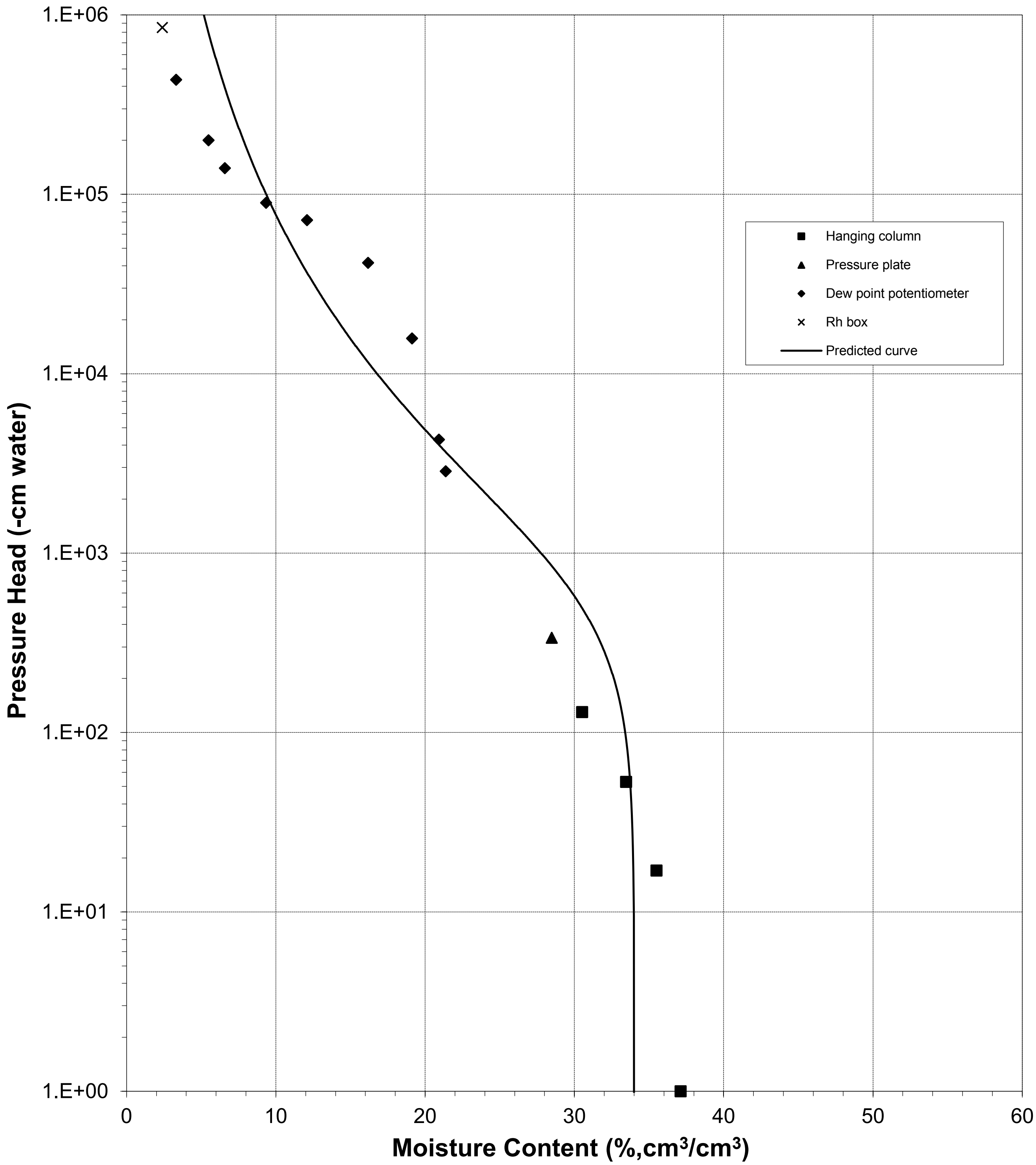
Water Retention Data Points

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



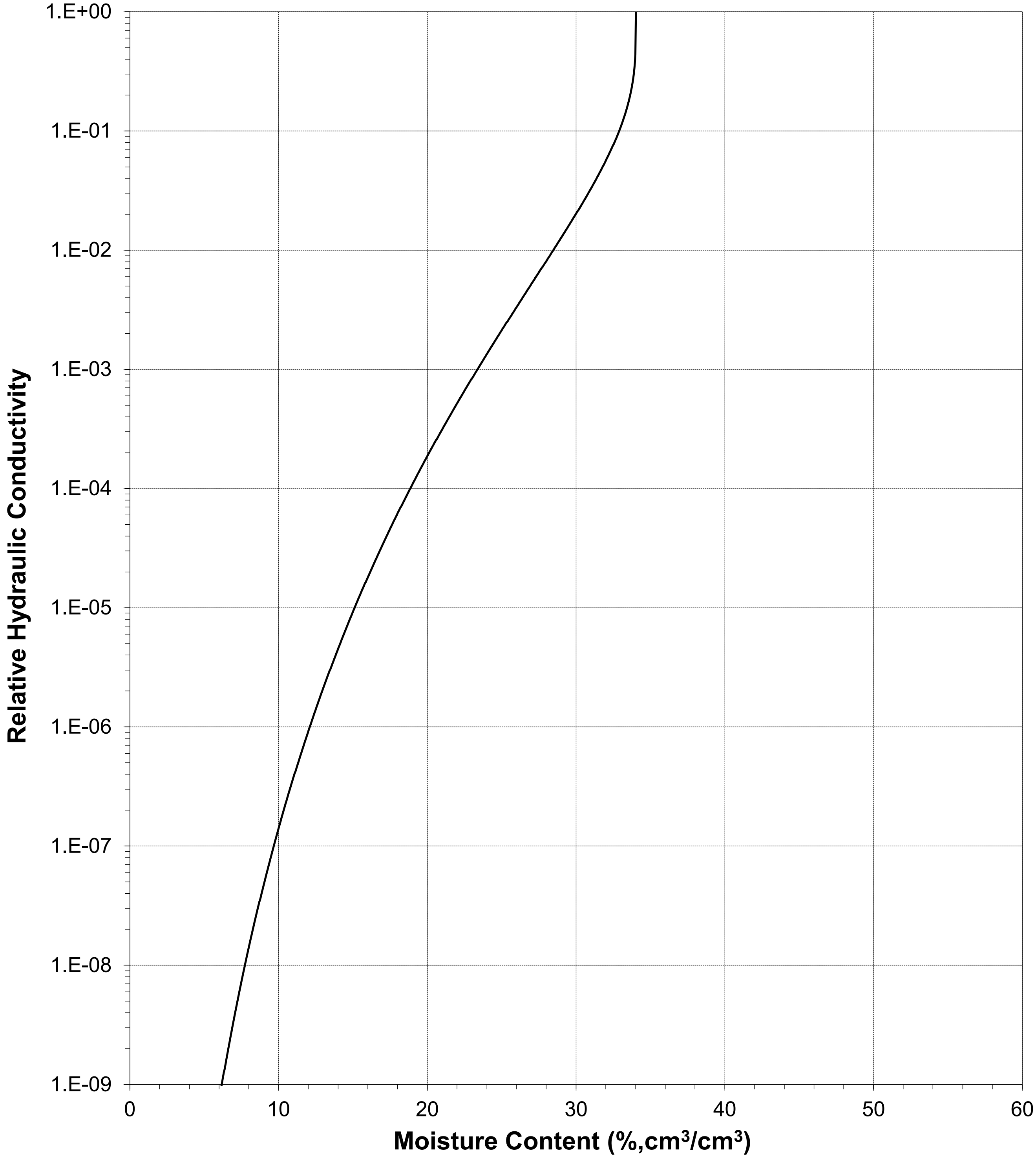
Predicted Water Retention Curve and Data Points

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



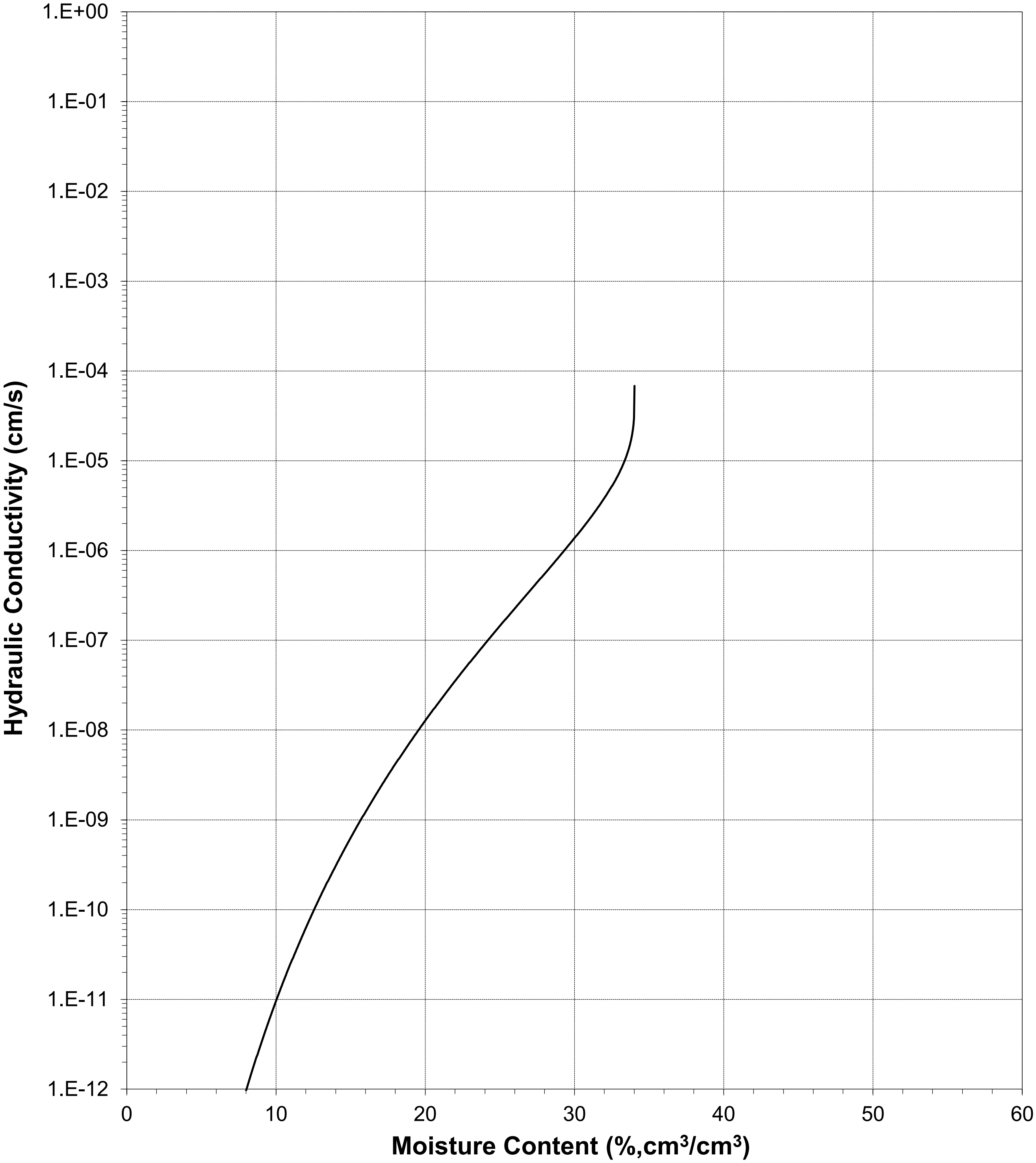
Plot of Relative Hydraulic Conductivity vs Moisture Content

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



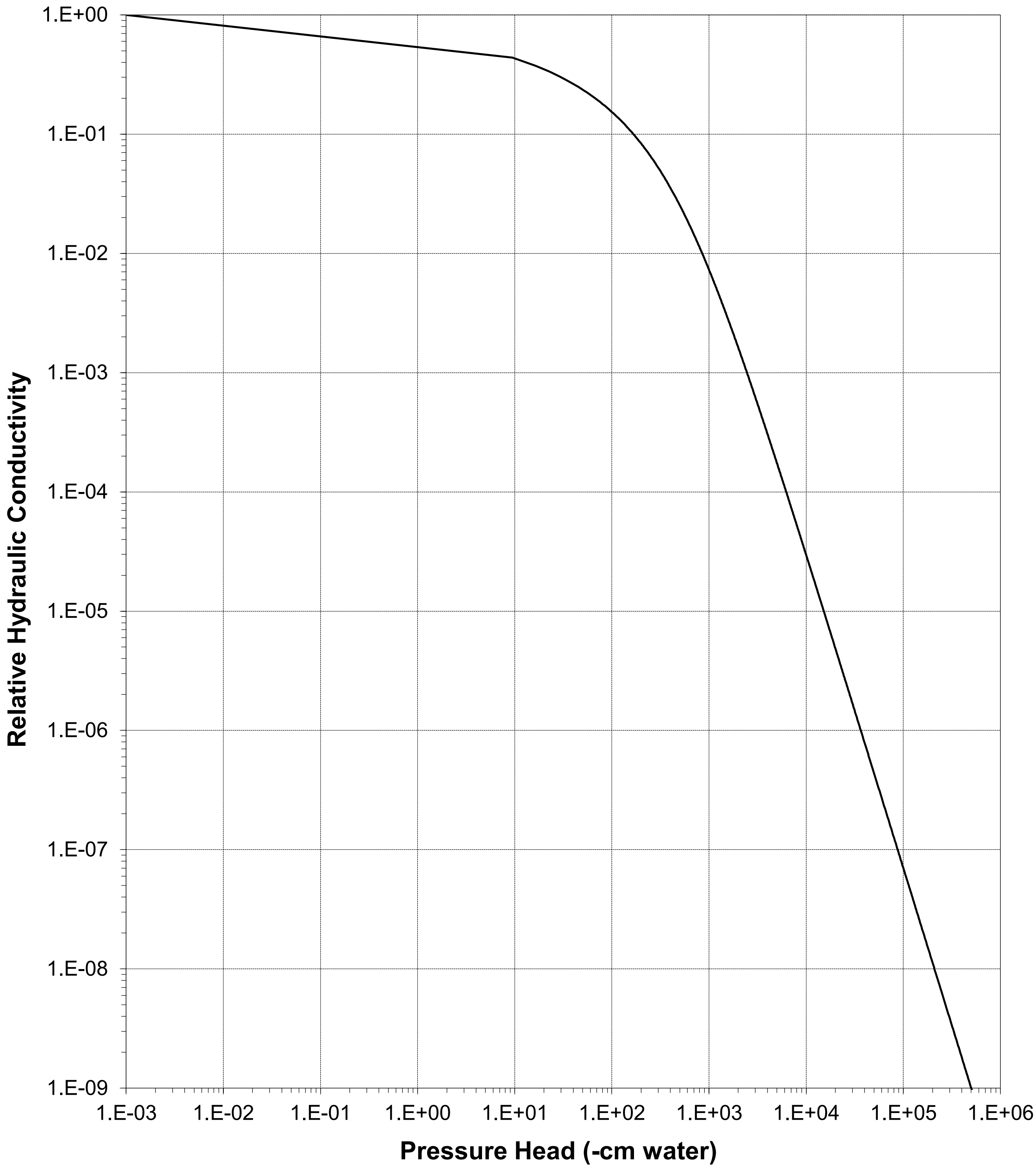
Plot of Hydraulic Conductivity vs Moisture Content

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



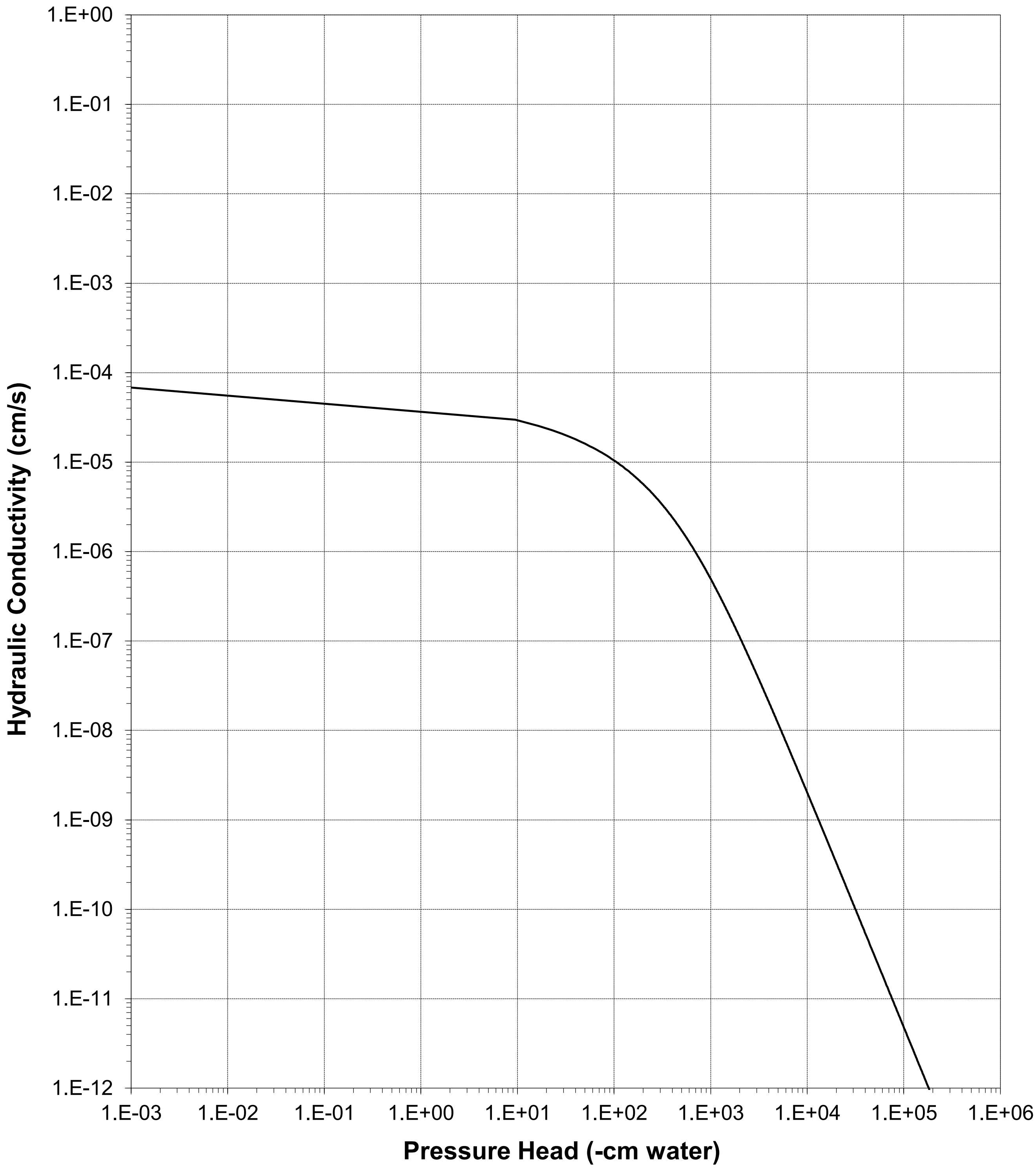
Plot of Relative Hydraulic Conductivity vs Pressure Head

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



Plot of Hydraulic Conductivity vs Pressure Head

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)



Thermal Properties

Summary of Thermal Properties

Sample	Reading	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (pcf)	Temp °C	K W/(m·K)	ρ °C·cm/W	C MJ/(m³·K)	D mm²/s
15BH-Z1-01-Landfill (109.1pcf)	Initial	13.24	23.15	109.1	24.27	1.942	51.5	2.424	0.801
15BH-Z1-01-Landfill (109.1pcf)	Saturated	21.74	37.12	106.6	22.10	2.158	46.3	2.781	0.776
15BH-Z1-01-Landfill (109.1pcf)	17	20.79	35.50	106.6	21.83	2.023	49.4	2.461	0.822
15BH-Z1-01-Landfill (109.1pcf)	53	19.60	33.47	106.6	21.11	2.153	46.4	2.692	0.800
15BH-Z1-01-Landfill (109.1pcf)	130	17.79	30.53	107.1	20.96	2.039	49.0	2.282	0.894
15BH-Z1-01-Landfill (109.1pcf)	337	16.60	28.49	107.1	20.52	2.028	49.3	2.545	0.797
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #1	12.92	22.43	108.4	19.52	1.888	53.0	2.521	0.749
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #2	8.92	16.45	115.1	20.03	1.354	73.9	2.910	0.465
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #3	6.06	11.21	115.4	21.41	1.376	72.7	2.094	0.657
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #4	5.53	10.23	115.4	21.97	1.291	77.4	2.092	0.617
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #5	4.38	8.10	115.4	22.60	1.158	86.4	1.922	0.602
15BH-Z1-01-Landfill (109.1pcf)	Air Dry #6	3.66	6.77	115.4	22.07	1.082	92.4	1.930	0.561
15BH-Z1-01-Landfill (109.1pcf)	Oven Dry	0.00	0.00	115.4	26.33	0.625	160.1	1.578	0.396

[1]Adjusted for volume changes during testing.

Thermal Properties Results Sheet for Sample: 15BH-Z1-01-Landfill (109.1pcf)

Job Name: KEMRON Environmental Services, Inc.
Job Number: NM15.0062.00
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Project Name: Bien Hoa Airbase
Project Number: SH056202

Instrument Description: Decagon KD2 Pro
Probe:
- ☐ KS-1, 6 cm length, 1.3 mm diameter, single needle
- ☐ TR-1, 10 cm length, 2.4 mm diameter, single needle
- ☑ SH-1, 3 cm length, 1.3 mm diameter, dual needle, 6 mm spacing

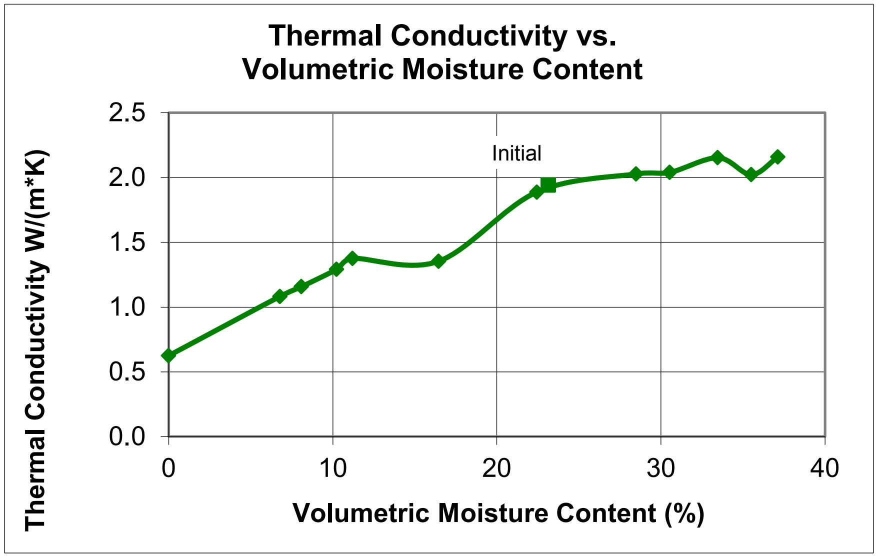
Test Start Date: 5/21/15

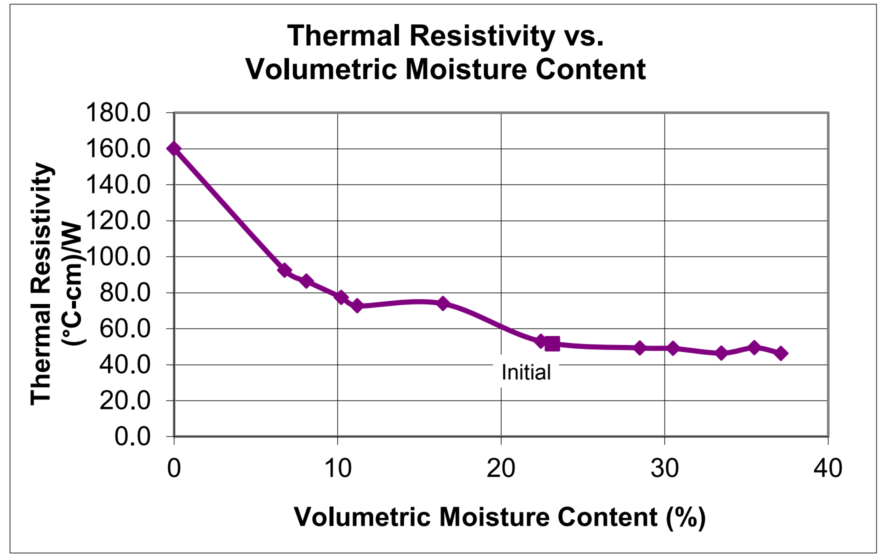
Reading	Water Potential (-cm water)	Gravimetric Moisture Content (g/g, %)	Volumetric Moisture Content[1] (vol/vol, %)	Dry Bulk Density[1] (pcf)	Test Temperature (°C)	K Thermal Conductivity W/(m·K)	ρ Thermal Resistivity °C·cm/W	C Specific Heat Capacity MJ/(m^3·K)	D Thermal Diffusivity (mm^2/s)
Initial	---	13.24	23.15	1.75	24.27	1.942	51.5	2.424	0.801
Saturated	0	21.74	37.12	1.71	22.10	2.158	46.3	2.781	0.776
17	17	20.79	35.50	1.71	21.83	2.023	49.4	2.461	0.822
53	53	19.60	33.47	1.71	21.11	2.153	46.4	2.692	0.800
130	130	17.79	30.53	1.72	20.96	2.039	49.0	2.282	0.894
337	337	16.60	28.49	1.72	20.52	2.028	49.3	2.545	0.797
Air Dry #1	---	12.92	22.43	1.74	19.52	1.888	53.0	2.521	0.749
Air Dry #2	---	8.92	16.45	1.84	20.03	1.354	73.9	2.910	0.465
Air Dry #3	---	6.06	11.21	1.85	21.41	1.376	72.7	2.094	0.657
Air Dry #4	---	5.53	10.23	1.85	21.97	1.291	77.4	2.092	0.617
Air Dry #5	---	4.38	8.10	1.85	22.60	1.158	86.4	1.922	0.602
Air Dry #6	---	3.66	6.77	1.85	22.07	1.082	92.4	1.930	0.561
Oven Dry	---	0.00	0.00	1.85	26.33	0.625	160.1	1.578	0.396

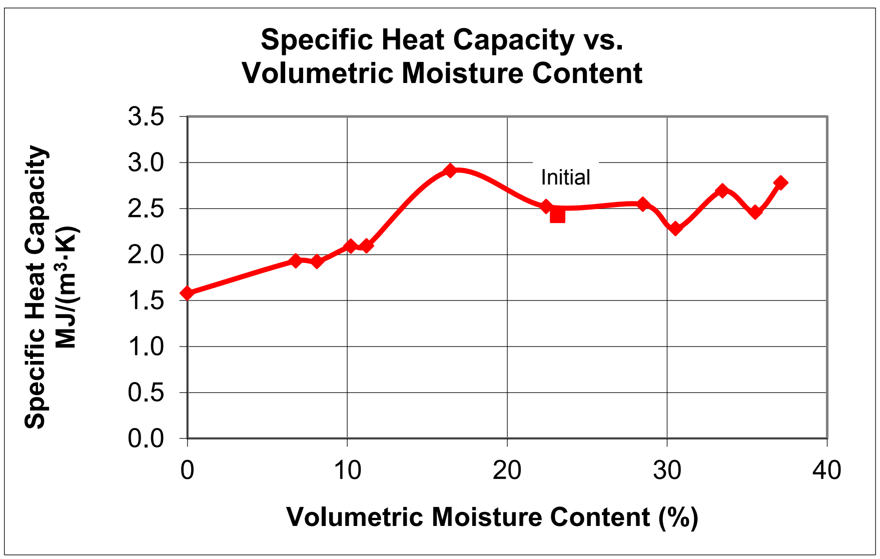
--- = Value not measured.

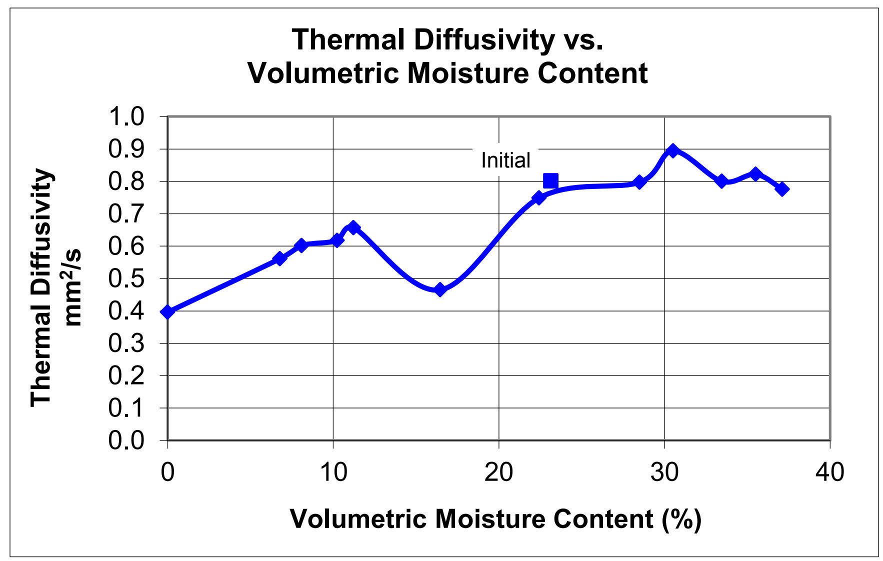
[1] Adjusted for volume changes during testing, if applicable.

Thermal Properties Results Sheet for Sample: 15BH-Z1-01-Landfill (109.1pcf)
Scatter Plots









Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

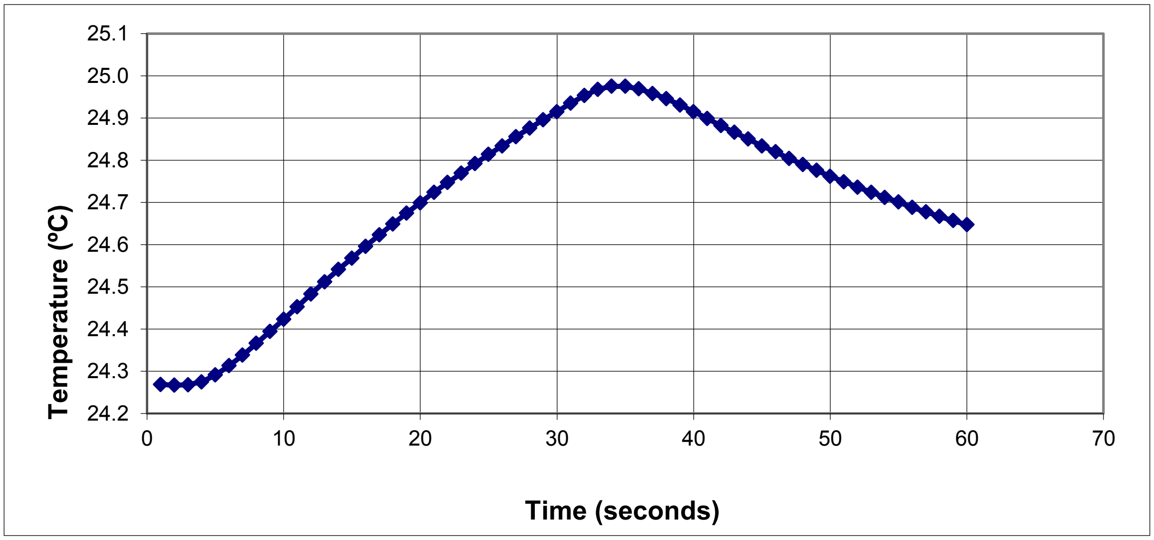
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Initial

Test Date/Time:	5/21/2015 8:49 AM	*K (W/(m·K)):*	1.942
Sensor:	SH-1	*ρ (°C·cm/W):*	51.5
Test Temp.(°C):	24.3	*C (MJ/(m³·K)):*	2.424
KD2 Pro Sample ID:	15B-5-21	*D (mm²/s):*	0.801
Power (W/m):	22.280	*Err:*	0.0027
Current (amps):	0.146		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	24.269	16	24.596	31	24.935	46	24.820
2	24.267	17	24.623	32	24.953	47	24.804
3	24.268	18	24.649	33	24.968	48	24.790
4	24.275	19	24.675	34	24.975	49	24.776
5	24.291	20	24.699	35	24.975	50	24.762
6	24.313	21	24.724	36	24.969	51	24.749
7	24.338	22	24.747	37	24.958	52	24.736
8	24.366	23	24.769	38	24.946	53	24.724
9	24.394	24	24.792	39	24.931	54	24.712
10	24.423	25	24.814	40	24.915	55	24.701
11	24.453	26	24.834	41	24.899	56	24.688
12	24.483	27	24.856	42	24.882	57	24.678
13	24.512	28	24.876	43	24.866	58	24.667
14	24.541	29	24.896	44	24.850	59	24.657
15	24.568	30	24.915	45	24.834	60	24.647

15BH-Z1-01-Landfill (109.1pcf),Potential: Initial - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

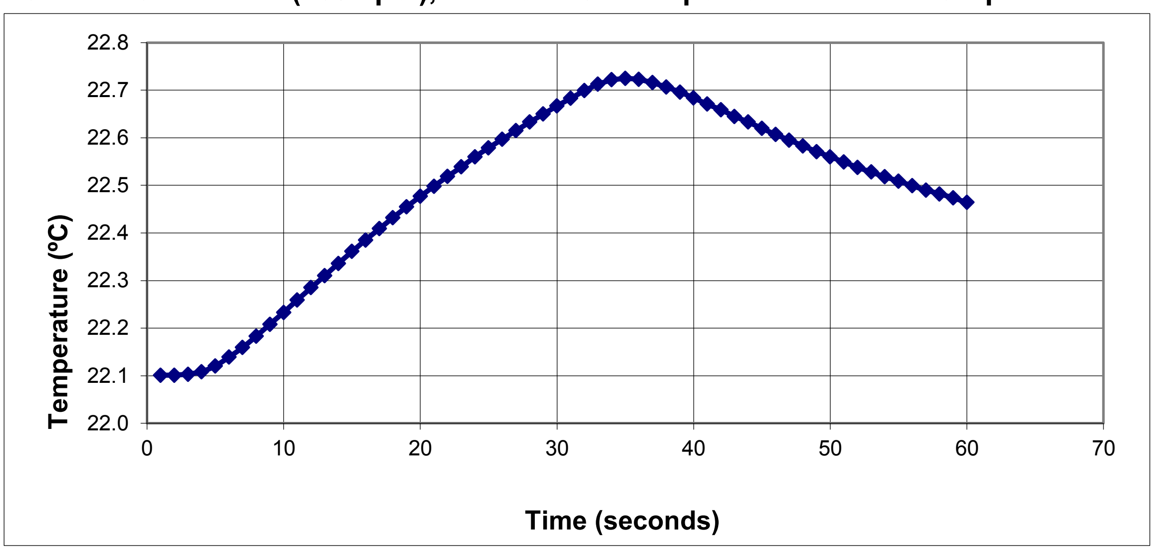
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): 0

Test Date/Time:	5/22/2015 9:26 AM	*K (W/(m·K)):*	2.158
Sensor:	SH-1	*ρ (°C·cm/W):*	46.3
Test Temp.(°C):	22.1	*C (MJ/(m³·K)):*	2.781
KD2 Pro Sample ID:	15B-5-22	*D (mm²/s):*	0.776
Power (W/m):	21.750	*Err:*	0.0031
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.101	16	22.385	31	22.683	46	22.607
2	22.101	17	22.409	32	22.699	47	22.595
3	22.103	18	22.432	33	22.713	48	22.583
4	22.108	19	22.455	34	22.722	49	22.571
5	22.120	20	22.477	35	22.725	50	22.560
6	22.139	21	22.498	36	22.723	51	22.549
7	22.159	22	22.519	37	22.716	52	22.538
8	22.183	23	22.539	38	22.707	53	22.528
9	22.208	24	22.560	39	22.696	54	22.518
10	22.233	25	22.579	40	22.684	55	22.509
11	22.259	26	22.597	41	22.671	56	22.499
12	22.285	27	22.615	42	22.659	57	22.490
13	22.310	28	22.633	43	22.645	58	22.482
14	22.336	29	22.650	44	22.633	59	22.474
15	22.361	30	22.667	45	22.620	60	22.464

15BH-Z1-01-Landfill (109.1pcf),Potential: 0 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

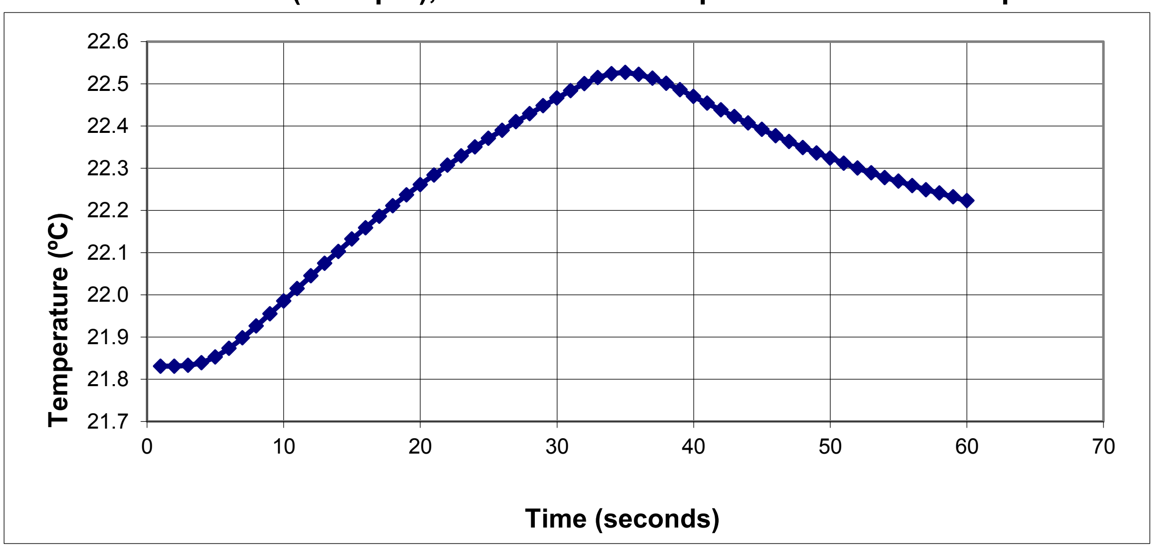
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): 17

Test Date/Time:	5/28/2015 7:57 AM	*K (W/(m·K)):*	2.023
Sensor:	SH-1	*ρ (°C·cm/W):*	49.4
Test Temp.(°C):	21.8	*C (MJ/(m³·K)):*	2.461
KD2 Pro Sample ID:	15B-5-28	*D (mm²/s):*	0.822
Power (W/m):	21.830	*Err:*	0.0051
Current (amps):	0.145		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.831	16	22.159	31	22.484	46	22.377
2	21.831	17	22.186	32	22.500	47	22.363
3	21.833	18	22.211	33	22.515	48	22.349
4	21.839	19	22.237	34	22.524	49	22.336
5	21.853	20	22.261	35	22.527	50	22.324
6	21.873	21	22.284	36	22.522	51	22.312
7	21.898	22	22.307	37	22.513	52	22.300
8	21.926	23	22.329	38	22.501	53	22.289
9	21.955	24	22.350	39	22.486	54	22.278
10	21.985	25	22.371	40	22.470	55	22.269
11	22.015	26	22.390	41	22.454	56	22.259
12	22.045	27	22.410	42	22.438	57	22.249
13	22.075	28	22.429	43	22.422	58	22.241
14	22.103	29	22.448	44	22.407	59	22.232
15	22.132	30	22.466	45	22.392	60	22.223

15BH-Z1-01-Landfill (109.1pcf),Potential: 17 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

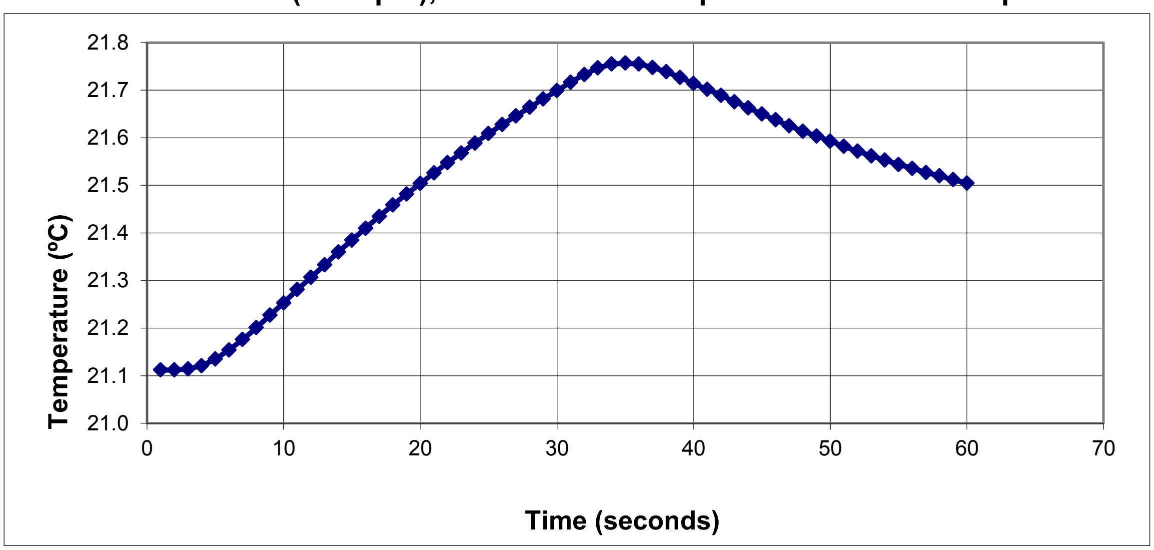
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): 53

Test Date/Time:	6/11/2015 11:05 AM	*K (W/(m·K)):*	2.153
Sensor:	SH-1	*ρ (°C·cm/W):*	46.4
Test Temp.(°C):	21.1	*C (MJ/(m³·K)):*	2.692
KD2 Pro Sample ID:	15B-6-11	*D (mm²/s):*	0.800
Power (W/m):	21.320	*Err:*	0.0030
Current (amps):	0.143		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.112	16	21.410	31	21.717	46	21.638
2	21.112	17	21.435	32	21.733	47	21.625
3	21.114	18	21.459	33	21.747	48	21.614
4	21.121	19	21.482	34	21.755	49	21.604
5	21.135	20	21.504	35	21.757	50	21.593
6	21.154	21	21.526	36	21.755	51	21.582
7	21.176	22	21.548	37	21.748	52	21.572
8	21.201	23	21.568	38	21.739	53	21.562
9	21.227	24	21.589	39	21.727	54	21.553
10	21.253	25	21.609	40	21.714	55	21.544
11	21.281	26	21.628	41	21.702	56	21.536
12	21.307	27	21.646	42	21.689	57	21.527
13	21.333	28	21.664	43	21.676	58	21.520
14	21.360	29	21.682	44	21.663	59	21.512
15	21.385	30	21.699	45	21.650	60	21.505

15BH-Z1-01-Landfill (109.1pcf),Potential: 53 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): 130

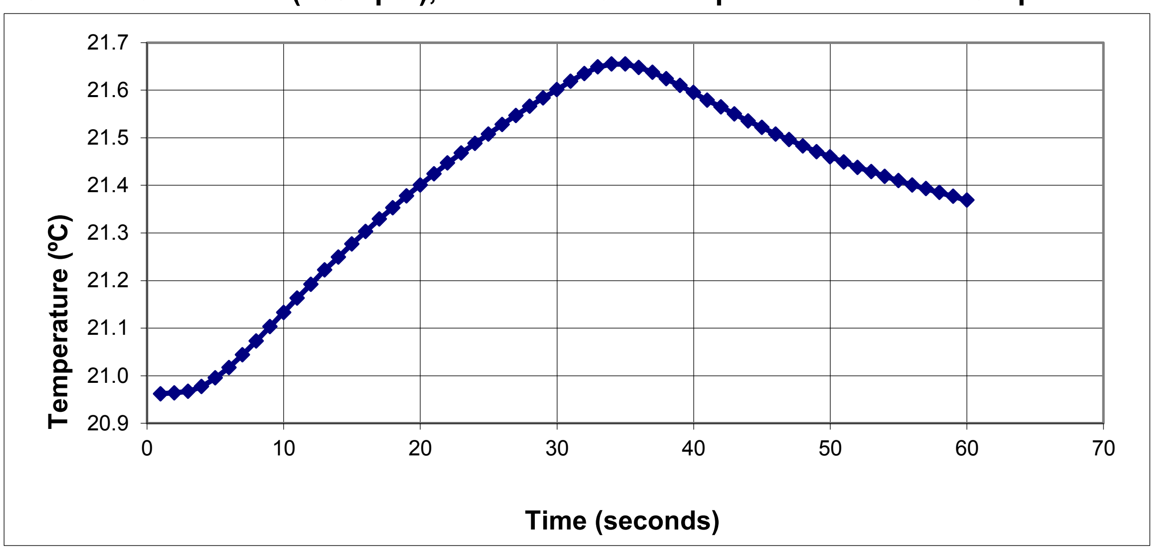
Test Date/Time: 6/18/2015 10:24 AM
Sensor: SH-1
Test Temp.(°C): 21.0
KD2 Pro Sample ID: 15B-6-18
Power (W/m): 19.740
Current (amps): 0.138

K (W/(m·K)): 2.039
ρ (°C·cm/W): 49.0
C (MJ/(m³·K)): 2.282
D (mm²/s): 0.894
Err: 0.0045

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.962	16	21.303	31	21.619	46	21.508
2	20.964	17	21.329	32	21.635	47	21.496
3	20.967	18	21.353	33	21.649	48	21.483
4	20.977	19	21.378	34	21.655	49	21.471
5	20.995	20	21.401	35	21.655	50	21.460
6	21.017	21	21.424	36	21.648	51	21.449
7	21.044	22	21.447	37	21.638	52	21.438
8	21.073	23	21.468	38	21.624	53	21.429
9	21.103	24	21.488	39	21.610	54	21.419
10	21.133	25	21.508	40	21.595	55	21.410
11	21.163	26	21.528	41	21.579	56	21.401
12	21.192	27	21.547	42	21.565	57	21.393
13	21.222	28	21.566	43	21.550	58	21.385
14	21.249	29	21.584	44	21.535	59	21.377
15	21.277	30	21.601	45	21.522	60	21.369

15BH-Z1-01-Landfill (109.1pcf),Potential: 130 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

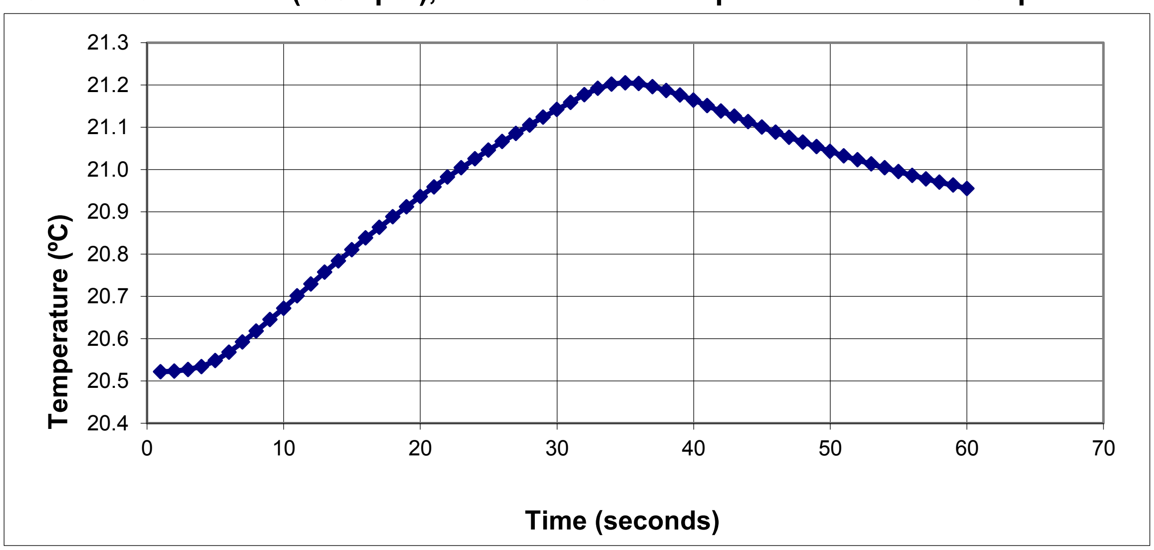
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): 337

Test Date/Time:	6/29/2015 1:19 PM	*K (W/(m·K)):*	2.028
Sensor:	SH-1	*ρ (°C·cm/W):*	49.3
Test Temp.(°C):	20.5	*C (MJ/(m³·K)):*	2.545
KD2 Pro Sample ID:	15B-6-29	*D (mm²/s):*	0.797
Power (W/m):	20.800	*Err:*	0.0028
Current (amps):	0.141		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.522	16	20.838	31	21.159	46	21.088
2	20.523	17	20.863	32	21.177	47	21.076
3	20.527	18	20.888	33	21.192	48	21.065
4	20.534	19	20.912	34	21.202	49	21.054
5	20.548	20	20.936	35	21.205	50	21.043
6	20.568	21	20.959	36	21.203	51	21.032
7	20.592	22	20.982	37	21.196	52	21.023
8	20.618	23	21.004	38	21.187	53	21.013
9	20.645	24	21.025	39	21.176	54	21.004
10	20.672	25	21.046	40	21.164	55	20.995
11	20.701	26	21.066	41	21.151	56	20.986
12	20.729	27	21.085	42	21.138	57	20.978
13	20.757	28	21.105	43	21.126	58	20.970
14	20.784	29	21.124	44	21.113	59	20.963
15	20.810	30	21.142	45	21.100	60	20.955

15BH-Z1-01-Landfill (109.1pcf),Potential: 337 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

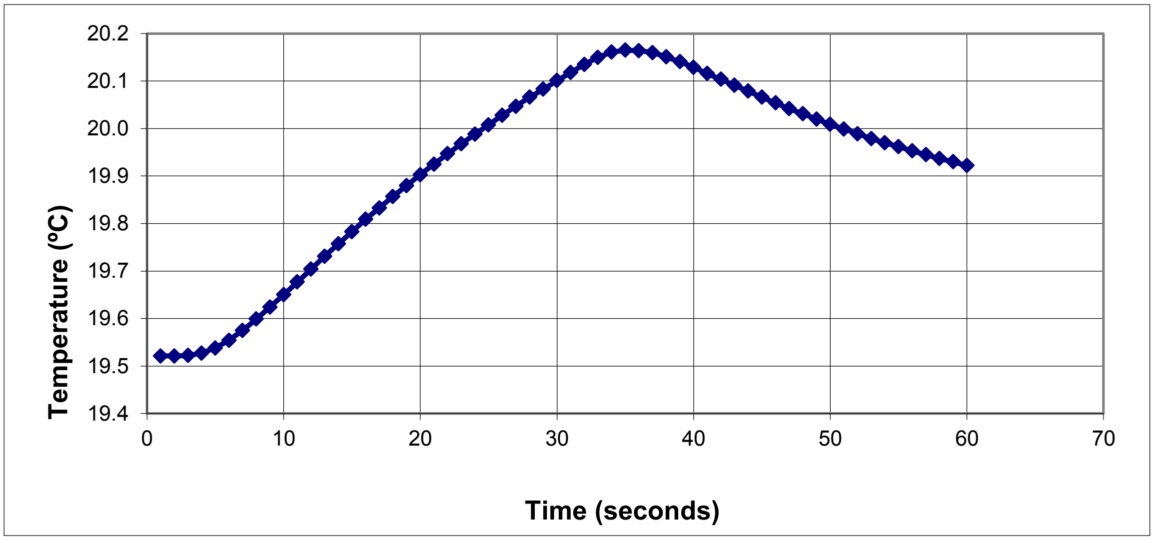
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #1

Test Date/Time:	6/30/2015 8:07 AM	*K (W/(m·K)):*	1.888
Sensor:	SH-1	*ρ (°C·cm/W):*	53.0
Test Temp.(°C):	19.5	*C (MJ/(m³·K)):*	2.521
KD2 Pro Sample ID:	15B-6-30	*D (mm²/s):*	0.749
Power (W/m):	19.750	*Err:*	0.0041
Current (amps):	0.138		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	19.521	16	19.809	31	20.118	46	20.054
2	19.521	17	19.833	32	20.135	47	20.042
3	19.522	18	19.857	33	20.150	48	20.031
4	19.527	19	19.880	34	20.161	49	20.020
5	19.538	20	19.903	35	20.165	50	20.009
6	19.554	21	19.925	36	20.164	51	19.999
7	19.575	22	19.947	37	20.160	52	19.989
8	19.599	23	19.968	38	20.151	53	19.979
9	19.624	24	19.988	39	20.141	54	19.970
10	19.650	25	20.008	40	20.129	55	19.962
11	19.677	26	20.028	41	20.116	56	19.953
12	19.704	27	20.047	42	20.104	57	19.945
13	19.731	28	20.066	43	20.091	58	19.937
14	19.757	29	20.083	44	20.079	59	19.930
15	19.783	30	20.101	45	20.066	60	19.922

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #1 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

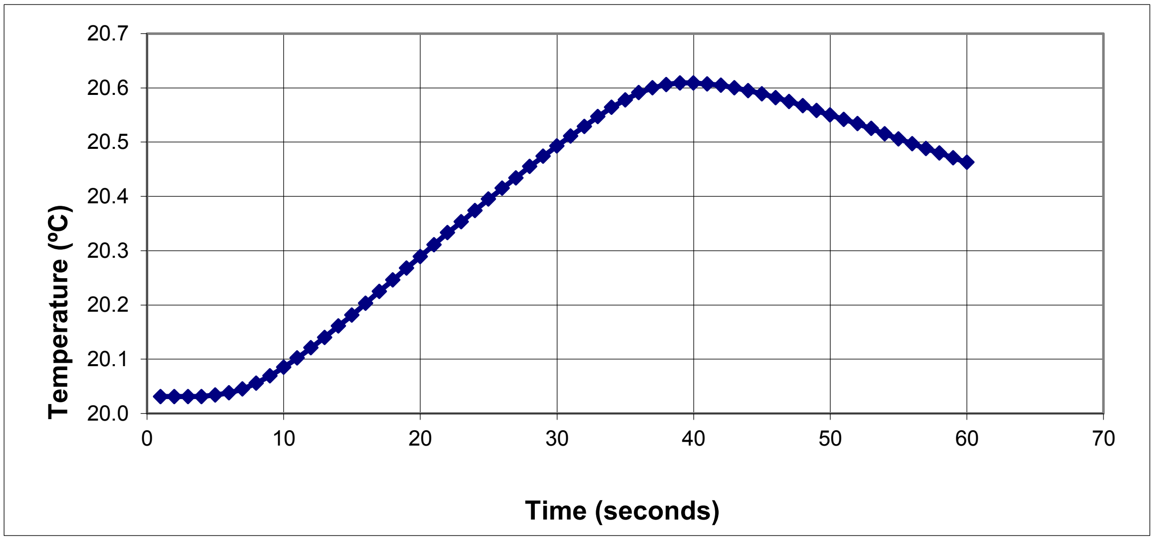
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #2

Test Date/Time:	7/1/2015 7:35 AM	*K (W/(m·K)):*	1.354
Sensor:	SH-1	*ρ (°C·cm/W):*	73.9
Test Temp.(°C):	20.0	*C (MJ/(m³·K)):*	2.910
KD2 Pro Sample ID:	15B-7-01	*D (mm²/s):*	0.465
Power (W/m):	19.850	*Err:*	0.0021
Current (amps):	0.138		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	20.031	16	20.203	31	20.511	46	20.582
2	20.031	17	20.225	32	20.529	47	20.575
3	20.031	18	20.246	33	20.547	48	20.567
4	20.031	19	20.268	34	20.564	49	20.558
5	20.034	20	20.289	35	20.578	50	20.550
6	20.038	21	20.311	36	20.591	51	20.542
7	20.045	22	20.333	37	20.600	52	20.534
8	20.056	23	20.353	38	20.606	53	20.525
9	20.069	24	20.374	39	20.609	54	20.515
10	20.085	25	20.395	40	20.609	55	20.506
11	20.102	26	20.415	41	20.607	56	20.497
12	20.121	27	20.434	42	20.605	57	20.488
13	20.140	28	20.455	43	20.600	58	20.480
14	20.161	29	20.474	44	20.595	59	20.471
15	20.181	30	20.493	45	20.589	60	20.463

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #2 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

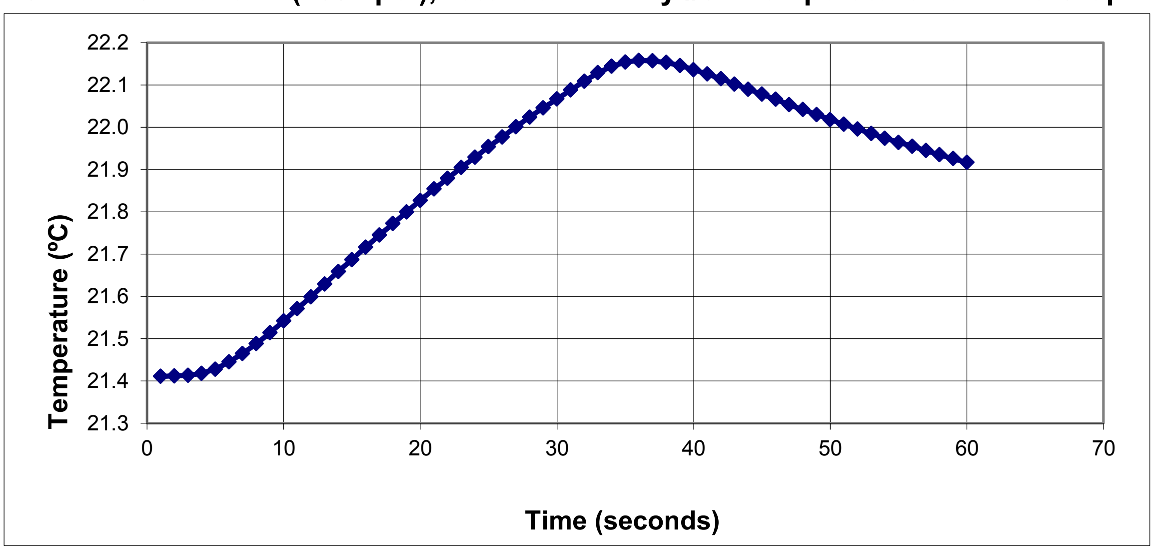
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #3

Test Date/Time:	7/2/2015 9:04 AM	*K (W/(m·K)):*	1.376
Sensor:	SH-1	*ρ (°C·cm/W):*	72.7
Test Temp.(°C):	21.4	*C (MJ/(m³·K)):*	2.094
KD2 Pro Sample ID:	15B-7-02	*D (mm²/s):*	0.657
Power (W/m):	18.290	*Err:*	0.0017
Current (amps):	0.133		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.411	16	21.716	31	22.088	46	22.066
2	21.412	17	21.745	32	22.109	47	22.053
3	21.413	18	21.772	33	22.129	48	22.042
4	21.418	19	21.800	34	22.144	49	22.030
5	21.428	20	21.827	35	22.154	50	22.018
6	21.445	21	21.854	36	22.158	51	22.007
7	21.465	22	21.879	37	22.157	52	21.996
8	21.488	23	21.905	38	22.153	53	21.985
9	21.514	24	21.929	39	22.146	54	21.974
10	21.542	25	21.954	40	22.136	55	21.964
11	21.571	26	21.977	41	22.126	56	21.955
12	21.599	27	22.001	42	22.115	57	21.945
13	21.629	28	22.024	43	22.102	58	21.935
14	21.659	29	22.046	44	22.090	59	21.926
15	21.687	30	22.067	45	22.078	60	21.917

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #3 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

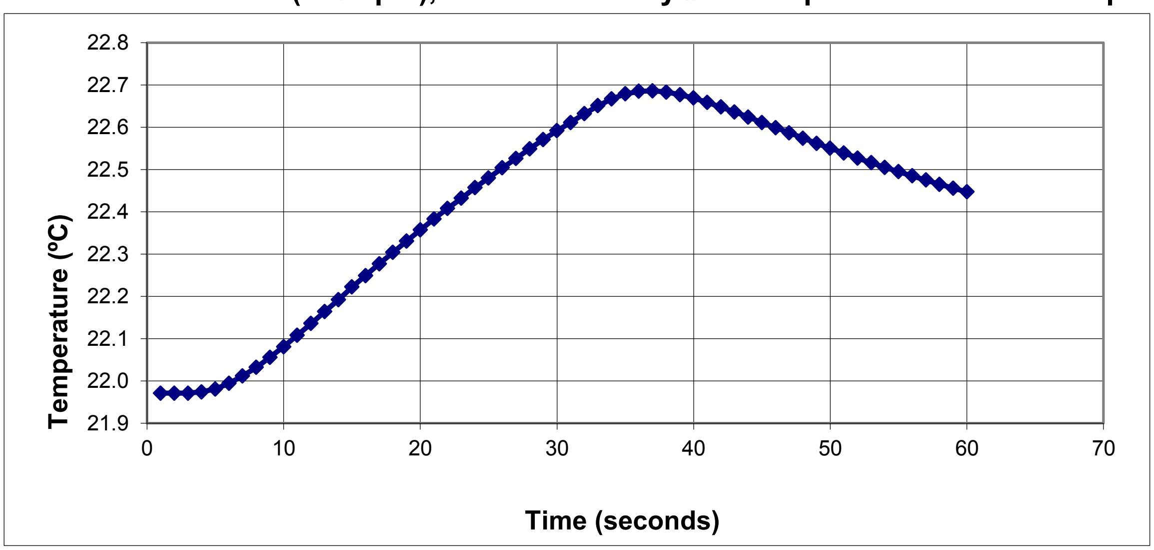
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #4

Test Date/Time:	7/6/2015 8:16 AM	*K (W/(m·K)):*	1.291
Sensor:	SH-1	*ρ (°C·cm/W):*	77.4
Test Temp.(°C):	22.0	*C (MJ/(m³·K)):*	2.092
KD2 Pro Sample ID:	15B-7-06	*D (mm²/s):*	0.617
Power (W/m):	17.930	*Err:*	0.0023
Current (amps):	0.131		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	21.971	16	22.249	31	22.611	46	22.599
2	21.971	17	22.277	32	22.632	47	22.587
3	21.971	18	22.304	33	22.651	48	22.574
4	21.974	19	22.331	34	22.667	49	22.562
5	21.981	20	22.357	35	22.679	50	22.550
6	21.994	21	22.383	36	22.685	51	22.539
7	22.012	22	22.408	37	22.686	52	22.527
8	22.032	23	22.432	38	22.683	53	22.516
9	22.056	24	22.457	39	22.677	54	22.505
10	22.081	25	22.480	40	22.669	55	22.495
11	22.108	26	22.504	41	22.659	56	22.485
12	22.136	27	22.526	42	22.648	57	22.475
13	22.164	28	22.549	43	22.636	58	22.465
14	22.192	29	22.571	44	22.624	59	22.456
15	22.222	30	22.592	45	22.611	60	22.447

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #4 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

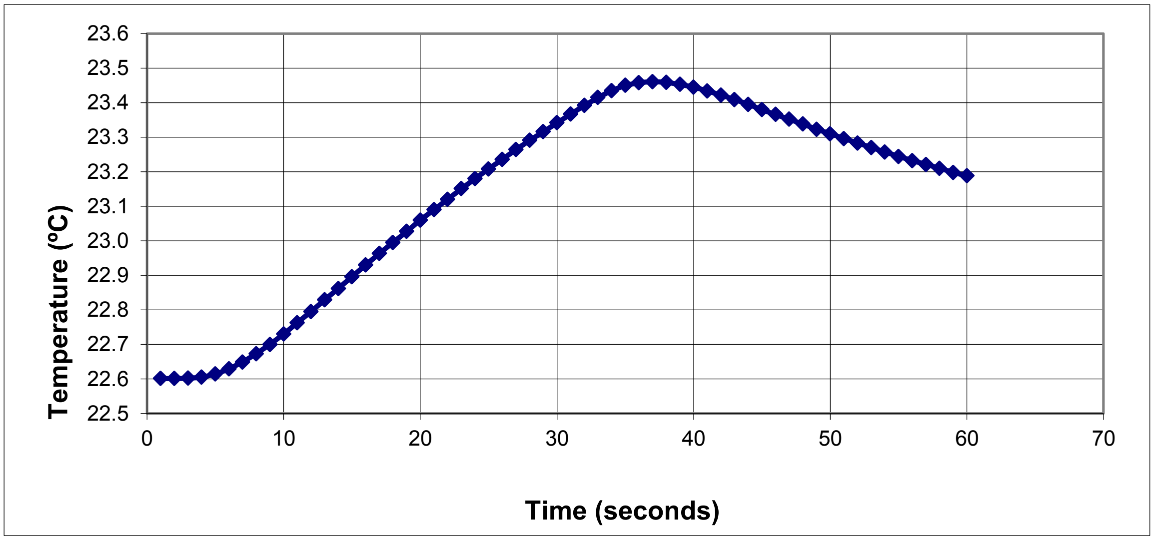
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #5

Test Date/Time:	7/7/2015 8:19 AM	*K (W/(m·K)):*	1.158
Sensor:	SH-1	*ρ (°C·cm/W):*	86.4
Test Temp.(°C):	22.6	*C (MJ/(m³·K)):*	1.922
KD2 Pro Sample ID:	15B-7-07	*D (mm²/s):*	0.602
Power (W/m):	19.580	*Err:*	0.0021
Current (amps):	0.137		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.601	16	22.930	31	23.367	46	23.366
2	22.601	17	22.963	32	23.392	47	23.352
3	22.602	18	22.995	33	23.415	48	23.338
4	22.605	19	23.027	34	23.435	49	23.323
5	22.614	20	23.060	35	23.450	50	23.310
6	22.629	21	23.090	36	23.458	51	23.296
7	22.649	22	23.120	37	23.461	52	23.283
8	22.673	23	23.151	38	23.459	53	23.270
9	22.700	24	23.180	39	23.453	54	23.257
10	22.730	25	23.208	40	23.445	55	23.244
11	22.763	26	23.236	41	23.434	56	23.232
12	22.795	27	23.264	42	23.422	57	23.221
13	22.829	28	23.291	43	23.409	58	23.210
14	22.862	29	23.316	44	23.395	59	23.198
15	22.896	30	23.342	45	23.380	60	23.188

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #5 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Daniel B. Stephens & Associates, Inc.

Thermal Properties Data

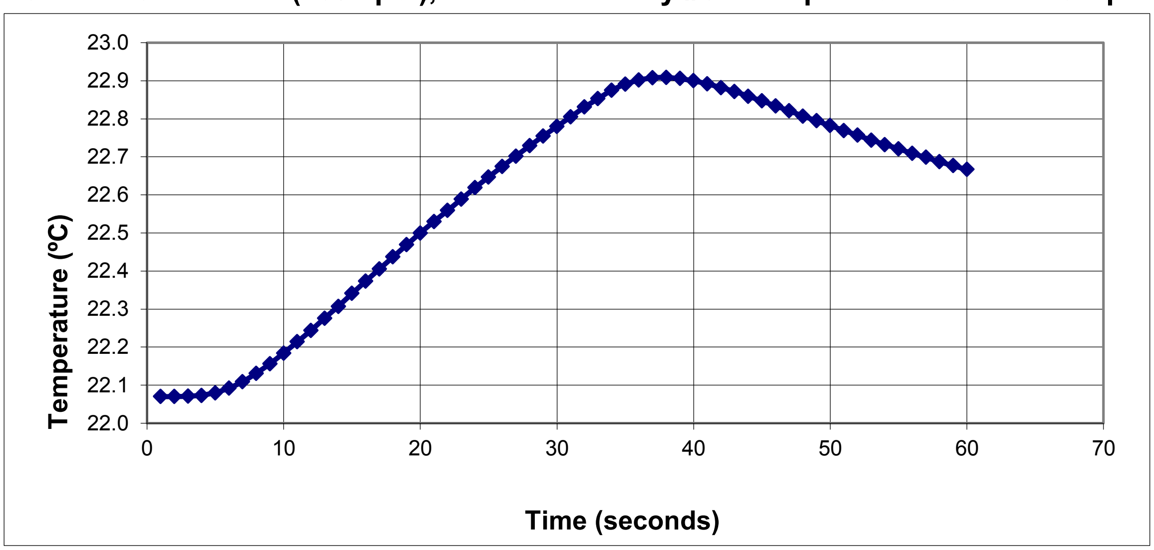
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Air Dry #6

Test Date/Time:	7/8/2015 9:05 AM	*K (W/(m·K)):*	1.082
Sensor:	SH-1	*ρ (°C·cm/W):*	92.4
Test Temp.(°C):	22.1	*C (MJ/(m³·K)):*	1.930
KD2 Pro Sample ID:	15B-7-08	*D (mm²/s):*	0.561
Power (W/m):	18.910	*Err:*	0.0019
Current (amps):	0.135		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	22.070	16	22.373	31	22.805	46	22.834
2	22.070	17	22.405	32	22.831	47	22.821
3	22.071	18	22.437	33	22.853	48	22.807
4	22.073	19	22.469	34	22.875	49	22.795
5	22.080	20	22.500	35	22.891	50	22.782
6	22.092	21	22.530	36	22.902	51	22.769
7	22.109	22	22.559	37	22.908	52	22.757
8	22.131	23	22.589	38	22.909	53	22.744
9	22.156	24	22.619	39	22.906	54	22.732
10	22.184	25	22.647	40	22.900	55	22.721
11	22.214	26	22.675	41	22.892	56	22.709
12	22.244	27	22.702	42	22.882	57	22.699
13	22.276	28	22.729	43	22.872	58	22.687
14	22.307	29	22.755	44	22.859	59	22.677
15	22.341	30	22.780	45	22.847	60	22.667

15BH-Z1-01-Landfill (109.1pcf),Potential: Air Dry #6 - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Thermal Properties Data

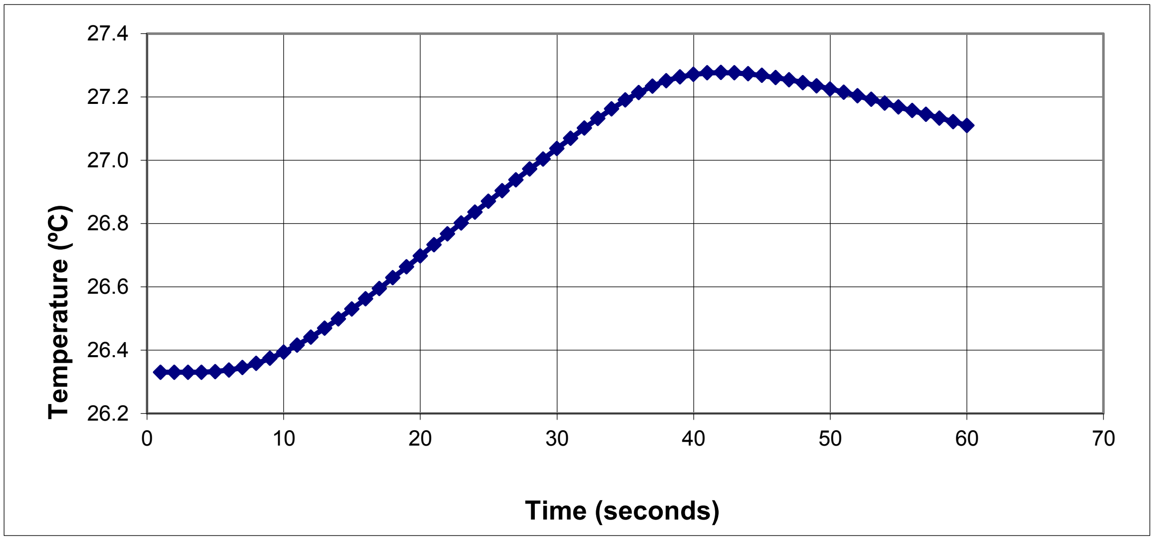
Sample Number: 15BH-Z1-01-Landfill (109.1pcf)
Potential (-cm water): Oven Dry

Test Date/Time:	7/9/2015 3:48 PM	*K (W/(m·K)):*	0.625
Sensor:	SH-1	*ρ (°C·cm/W):*	160.1
Test Temp.(°C):	26.3	*C (MJ/(m³·K)):*	1.578
KD2 Pro Sample ID:	15B-7-09	*D (mm²/s):*	0.396
Power (W/m):	17.210	*Err:*	0.0012
Current (amps):	0.129		

Raw Data

Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)	Second	Temp.(°C)
1	26.330	16	26.562	31	27.069	46	27.261
2	26.330	17	26.594	32	27.101	47	27.254
3	26.330	18	26.629	33	27.132	48	27.245
4	26.330	19	26.663	34	27.162	49	27.235
5	26.332	20	26.697	35	27.190	50	27.225
6	26.337	21	26.733	36	27.214	51	27.215
7	26.345	22	26.767	37	27.234	52	27.203
8	26.358	23	26.802	38	27.251	53	27.192
9	26.374	24	26.836	39	27.263	54	27.180
10	26.393	25	26.870	40	27.271	55	27.168
11	26.416	26	26.904	41	27.276	56	27.157
12	26.441	27	26.938	42	27.277	57	27.145
13	26.469	28	26.972	43	27.276	58	27.133
14	26.499	29	27.004	44	27.273	59	27.122
15	26.530	30	27.037	45	27.268	60	27.110

15BH-Z1-01-Landfill (109.1pcf),Potential: Oven Dry - Temperature vs. Time Graph



Laboratory analysis by: D. O'Dowd
Data entered by: C. Krous
Checked by: J. Hines

Laboratory Tests and Methods

Tests and Methods

Dry Bulk Density:	ASTM D7263
Moisture Content:	ASTM D7263, ASTM D2216
Calculated Porosity:	ASTM D7263
Saturated Hydraulic Conductivity:	
Falling Head: (Rigid Wall)	Klute, A. and C. Dirkson. 1986. Hydraulic Conductivity and Diffusivity: Laboratory Methods.Chp. 28, pp. 700-703, in A. Klute (ed.), Methods of Soil Analysis, Part 1, American Society of Agronomy, Madison, WI
Hanging Column Method:	ASTM D6836 (modified apparatus)
Pressure Plate Method:	ASTM D6836 (modified apparatus)
Water Potential (Dewpoint Potentiometer) Method:	ASTM D6836
Relative Humidity (Box) Method:	Campbell, G. and G. Gee. 1986. Water Potential: Miscellaneous Methods. Chp. 25, pp. 631-632, in A. Klute (ed.), Methods of Soil Analysis. Part 1. American Society of Agronomy, Madison, WI; Karathanasis & Hajek. 1982. Quantitative Evaluation of Water Adsorption on Soil Clays. SSA Journal 46:1321-1325
Moisture Retention Characteristics & Calculated Unsaturated Hydraulic Conductivity:	ASTM D6836; van Genuchten, M.T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. SSSAJ 44:892-898; van Genuchten, M.T., F.J. Leij, and S.R. Yates. 1991. The RETC code for quantifying the hydraulic functions of unsaturated soils. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Ada, Oklahoma. EPA/600/2091/065. December 1991
Thermal Properties:	ASTM D5334

APPENDIX F

SUPPORTING ANALYSES FOR ENVIRONMENTAL ASSESSMENT

Potential Effects on Greenhouse Gas Emissions

Table F.1-1 GHG Calculations for Alternative 2A Landfill

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[i]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
B.1	Landfill at Z1									
B.1.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	5	1120	282,240	36	74.1	752.9
B.1.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	8	1792	193,536	36	74.1	516.3
B.1.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	2	448	80,640	36	74.1	215.1
B.2	Landfill at Pacer Ivy Area									
B.2.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	6	1344	338,688	36	74.1	903.5
B.2.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	13	2912	314,496	36	74.1	838.9
B.2.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	3	672	120,960	36	74.1	322.7
C.	Backfilling of Excavation Areas with Offsite Clean Fill	Dozer, Compactor	**4**	36	20	4480	645,120	36	74.1	1,720.9
D.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
E.	Project Demobilization (haul road repair)	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	2	448	225,792	36	74.1	602.3
	TOTAL									**8,281.94**

Table F.1-1 GHG Calculations for Alternative 2A Landfill

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[J]	Haul trucks	18,000	14	20.0	1,414.3	28,285.7	1,414.3	28,285.7	1.8	20	45.2	0.159	89,948.6	203,283.8	293.2
A.	Hauling of clean fill for subgrade Pacer Ivy[J]	Haul trucks	32,700	14	20.0	2,569.3	51,385.7	2,569.3	51,385.7	1.8	20	45.2	0.159	163,406.6	369,298.9	532.7
B.	Hauling of clean fill for subgrade and leachate and cap to ZI	Haul trucks	54,000	14	20.0	4,242.9	84,857.1	4,242.9	84,857.1	1.8	20	45.2	0.159	269,845.7	609,851.3	879.7
B.	Hauling of clean fill for subgrade and leachate and cap to Pacer Ivy	Haul trucks	109,200	14	20.0	8,580.0	171,600.0	8,580.0	171,600.0	1.8	20	45.2	0.159	545,688.0	1,233,254.9	1,778.9
B.	Hauling of Geocomposite, GCL, HDPE liner to Z1	Haul trucks		14	20.0	0.0	0.0	0.0	0.0	1.8	20	45.2	0.159	0.0	0.0	0.0
B.	Hauling of Geocomposite, GCL, HDPE liner to Pacer Ivy	Haul trucks		14	20.0	0.0	0.0	0.0	0.0	1.8	20	45.2	0.159	0.0	0.0	0.0
B.	Hauling contaminated **soil** to dewatering/stockpile area - Z1	Haul trucks	141,600	14	3.1	11,125.7	34,934.7	11,125.7	34,934.7	1.8	20	45.2	0.159	111,092.5	251,069.0	362.2
B.	Hauling contaminated **sediment** to dewatering/stockpile area - Z1	Haul trucks	19,100	27	3.1	778.1	2,443.4	778.1	2,443.4	1.8	35	83.6	0.159	13,597.4	32,478.5	46.1
B.	Hauling contaminated **soil** to dewatering/stockpile area - Pacer Ivy	Haul trucks	200,200	14	3.1	15,730.0	49,392.2	15,730.0	49,392.2	1.8	20	45.2	0.159	157,067.2	354,971.9	512.0
B.	Hauling contaminated **sediment** to dewatering/stockpile area - Pacer Ivy	Haul trucks	73,700	27	3.1	3,002.6	9,428.1	3,002.6	9,428.1	1.8	35	83.6	0.159	52,467.6	125,322.6	177.8
B.	Loading of contaminated material from contaminated soil dewatering to landfill - Z1	Haul trucks	160,700	14	0.1	12,626.4	1,262.6	12,626.4	1,262.6	1.8	20	45.2	0.159	4,015.2	9,074.4	13.1
B.	Loading of contaminated material from contaminated soil dewatering to landfill - Pacer Ivy	Haul trucks	273,900	14	0.1	21,520.7	2,152.1	21,520.7	2,152.1	1.8	20	45.2	0.159	6,843.6	15,466.5	22.3
C.	Hauling clean fill for backfiling	Haul trucks	315,700	14	20.0	24,805.0	496,100.0	24,805.0	496,100.0	1.8	20	45.2	0.159	1,577,598.0	3,565,371.5	5,143.0
D.	Hauling for site restoration to Z1[L]	Haul trucks	3,000	14	20.0	235.7	4,714.3	235.7	4,714.3	1.8	20	45.2	0.159	14,991.4	33,880.6	48.9
D.	Hauling for site restoration tp Pacer Ivy[L]	Haul trucks	5,450	14	20.0	428.2	8,564.3	428.2	8,564.3	1.8	20	45.2	0.159	27,234.4	61,549.8	88.8
	TOTAL															**9,898.7**

TOTAL t CO_2	**18,181**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles provided by CDM Smith on October 29, 2015
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Assumption made by Hatfield as site specific data unavailable at time of analysis
[J] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[L] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-2 GHG Calculations for Alternative 2B Solidification/Stabilization

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[I]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	6	1,344	677,376	36	74.1	1,807.0
B.1	SS System at Pacer Ivy									
B.1.1	Excavation of Material	Dozer (2), Art-Wheel Loader	**3**	36	29	6,496	701,568	36	74.1	1,871.5
B.1.2	S/S Treatment at pacer ivy	Auger, Art-wheel loader, conveyor	**3**	36	52	11,648	1,257,984	36	74.1	3,355.8
B.1.3	Placement of Material in Pile	Art-wheel loader, dozer, 14 m3 Truck (2)	**4**	36	34	7,616	1,096,704	36	74.1	2,925.6
B.2	SS System at Z1									
B.2.1	Excavation of Material	Dozer (2), Art-Wheel Loader	**3**	36	17	3,808	411,264	36	74.1	1,097.1
B.2.2	S/S Treatment at Z1	Auger, Art-wheel loader, conveyor	**3**	36	28	6,272	677,376	36	74.1	1,807.0
B.2.3	Placement of Material in Pile	Art-wheel loader, dozer, 14 m3 Truck (2)	**4**	36	19	4,256	612,864	36	74.1	1,634.9
B.	Operation of Pugmill[J]	Diesel Generator	**1**	23	81	18,144	418,918	36	74.1	1,117.5
C	Backfilling of Excavation Areas with Offsite Clean Fill	Dozer, Compactor	**4**	36	27	6,048	870,912	36	74.1	2,323.2
D	Site Restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	6	1,344	677,376	36	74.1	1,807.0
E	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	7	1,568	790,272	36	74.1	2,108.1
	TOTAL									**21,854.6**

Table F.1-2 GHG Calculations for Alternative 2B Solidification/Stabilization

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[K]	Haul trucks	18,000	14	20.0	1,414.3	28,285.7	1,414.3	28,285.7	1.8	20	45.2	0.159	89,948.6	203,283.8	293.2
A.	Hauling of clean fill for subgrade Pacer Ivy[K]	Haul trucks	32,700	14	20.0	2,569.3	51,385.7	2,569.3	51,385.7	1.8	20	45.2	0.159	163,406.6	369,298.9	532.7
B.	Hauling of clean fill for subgrade and leachate and cap to ZI	Haul trucks	36,000	14	20.0	2,828.6	56,571.4	2,828.6	56,571.4	1.8	20	45.2	0.159	179,897.1	406,567.5	586.5
B.	Hauling of clean fill for subgrade and leachate and cap to Pacer Ivy	Haul trucks	81,900	14	20.0	6,435.0	128,700.0	6,435.0	128,700.0	1.8	20	45.2	0.159	409,266.0	924,941.2	1,334.2
B.	Hauling of admixture to Z1	Haul trucks	16,070	14	20.0	1,262.6	25,252.9	1,262.6	25,252.9	1.8	20	45.2	0.159	80,304.1	181,487.2	261.8
B.	Hauling of admixture to Pacer Ivy	Haul trucks	27,390	14	20.0	2,152.1	43,041.4	2,152.1	43,041.4	1.8	20	45.2	0.159	136,871.7	309,330.1	446.2
B.	Hauling contaminated **soil** to stockpile area - Z1	Haul trucks	141,600	14	3.1	11,125.7	34,934.7	11,125.7	34,934.7	1.8	20	45.2	0.159	111,092.5	251,069.0	362.2
B.	Hauling contaminated **sediment** to stockpile area - Z1	Haul trucks	19,100	27	3.1	778.1	2,443.4	778.1	2,443.4	1.8	20	45.2	0.159	7,770.0	17,560.1	25.3
B.	Hauling contaminated **soi**l to stockpile area - Pacer Ivy	Haul trucks	200,200	14	3.1	15,730.0	49,392.2	15,730.0	49,392.2	1.8	20	45.2	0.159	157,067.2	354,971.9	512.0
B.	Hauling contaminated **sediment** to stockpile area - Pacer Ivy	Haul trucks	73,700	27	3.1	3,002.6	9,428.1	3,002.6	9,428.1	1.8	20	45.2	0.159	29,981.5	67,758.2	97.7
B.	Loading of contaminated material from contaminated soil dewatering to SS area - Z1	Haul trucks	43,460	14	0.1	3,414.7	170.7	3,414.7	170.7	1.8	20	45.2	0.159	542.9	1,227.0	1.8
B.	Loading of contaminated material from contaminated soil dewatering to SS area - Pacer Ivy	Haul trucks	160,700	14	0.1	12,626.4	631.3	12,626.4	631.3	1.8	20	45.2	0.159	2,007.6	4,537.2	6.5
B.	Loading of treated material to landfill - Z1[L]	Haul trucks	176,770	14	0.1	13,889.1	694.5	13,889.1	694.5	1.8	20	45.2	0.159	2,208.4	4,990.9	7.2
B.	Loading of treated material f to landfill - Pacer Ivy[L]	Haul trucks	301,290	14	0.1	23,672.8	1,183.6	23,672.8	1,183.6	1.8	20	45.2	0.159	3,764.0	8,506.6	12.3
C.	Hauling clean fill for backfiling	Haul trucks	315,700	14	20.0	24,805.0	496,100.0	24,805.0	496,100.0	1.8	20	45.2	0.159	1,577,598.0	3,565,371.5	5,143.0
D.	Hauling for site restoration to Z1[M]	Haul trucks	3,000	14	20.0	235.7	4,714.3	235.7	4,714.3	1.8	20	45.2	0.159	14,991.4	33,880.6	48.9
D.	Hauling for site restoration tp Pacer IvyM	Haul trucks	5,450	14	20.0	428.2	8,564.3	428.2	8,564.3	1.8	20	45.2	0.159	27,234.4	61,549.8	88.8
	TOTAL															**9,760.3**

TOTAL t CO_2	**31,615**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles provided by CDM Smith on October 29, 2015
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Assumption made by Hatfield as site specific data unavailable at time of analysis
[J] Based on assumption of 2 hp diesel fueled generator (with fuel efficiency of 1.6 gal/hr - http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx)
[K] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[L] Hauling volumes were multiplied by 1.1 to account for admixture (at 10%)
[M] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-3 GHG Calculations for Alternative 3 Containment/Treatment Hybird (2,500 ppt)

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[K]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
B.1	Landfill at Z1									
B.1.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	4	896	225,792	36	74.1	602.3
B.1.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	7	1568	169,344	36	74.1	451.7
B.1.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	2	448	80,640	36	74.1	215.1
B.2	Landfill at Pacer Ivy Area									
B.2.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	5	1120	282,240	36	74.1	752.9
B.2.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	11	2464	266,112	36	74.1	709.9
B.2.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	3	672	120,960	36	74.1	322.7
B.3	Ex Situ TCH System at Pacer Ivy									
B.3.1	Ex Situ TCH System Construction	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**7**	36	8	1,792	451,584	36	74.1	1,204.6
B.3.2	Excavation and Hauling of Material	Dozer (2), Art-Wheel Loader	**3**	36	10	2,240	241,920	36	74.1	645.3
B.3.3	Filling the Pile	Dozer (2), Art-Wheel Loader	**3**	36	8	1,792	193,536	36	74.1	516.3
B.3.4	Capping and Completing the Pile	Dozer, Compactor (2), Grader, 14 m^3 Truck (2), auger or drill	**7**	36	12	2,688	677,376	36	74.1	1,807.0
B.3.5	Pile Unloading	Dozer (2), Art-Wheel Loader	**3**	36	6	1,344	145,152	36	74.1	387.2
C.	Backfilling Excavations (with offsite clean fill)	Dozer, Compactor, Art-Wheel Loader	**6**	36	2	448	96,768	36	74.1	258.1
C.	Backfilling Excavations (with treated soil)	Dozer, Compactor, Art-Wheel Loader	**6**	36	3	672	145,152	36	74.1	387.2
E.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	5	1,120	564,480	36	74.1	1,505.8
F.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	35	6	1,344	658,560	36	74.1	1,756.8
	TOTAL									**12,727.7**

Table F.1-3 GHG Calculations for Alternative 3 Containment/Treatment Hybird (2,500 ppt)

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[L]	Haul trucks	46,650	14.0	20.0	3665.4	73,307.1	3665.4	73,307.1	1.8	20	45.2	0.159	233,116.7	526,843.8	760.0
A.	Hauling of clean fill for subgrade Pacer Ivy[L]	Haul trucks	62,115	14.0	20.0	4,880.5	97,609.3	4,880.5	97,609.3	1.8	20	45.2	0.159	310,397.5	701,498.4	1,011.9
B.	Hauling of clean fill for subgrade to ZI landfill	Haul trucks	47,250	14.0	20.0	3,712.5	74,250.0	3,712.5	74,250.0	1.8	20	45.2	0.159	236,115.0	533,619.9	769.7
B.	Hauling of clean fill for subgrade Pacer Ivy landfill	Haul trucks	84,000	14.0	20.0	6,600.0	132,000.0	6,600.0	132,000.0	1.8	20	45.2	0.159	419,760.0	948,657.6	1,368.4
B.	Hauling of clean fill for subgrade Pacer Ivy Ex-situ TCH[M]	Haul trucks	27,300	14.0	20.0	2,145.0	42,900.0	2,145.0	42,900.0	1.8	20	45.2	0.159	136,422.0	308,313.7	444.7
B.	Hauling contaminated **soil** to landfill - Z1	Haul trucks	96,960	14.0	3.2	7,618.3	23,997.6	7,618.3	23,997.6	1.8	20	45.2	0.159	76,312.4	172,466.0	248.8
B.	Hauling contaminated **sediment** to landfill - Z1	Haul trucks	22,920	27.0	3.2	933.8	2,941.4	933.8	2,941.4	1.8	27	83.6	0.159	12,627.4	39,098.3	51.7
B.	Hauling contaminated **soil** frpm Z1 to Ex-situ TCH treatment at Pacer Ivy	Haul trucks	14,160	14.0	3.6	1,112.6	4,005.3	1,112.6	4,005.3	1.8	20	45.2	0.159	12,736.7	28,785.0	41.5
B.	Hauling contaminated **soil** to landfill - Pacer Ivy	Haul trucks	127,200	14.0	3.2	9,994.3	31,482.0	9,994.3	31,482.0	1.8	20	45.2	0.159	100,112.8	226,254.8	326.4
B.	Hauling contaminated **sediment** to landfill - Pacer Ivy	Haul trucks	69,960	27.0	3.2	2,850.2	8,978.2	2,850.2	8,978.2	1.8	27	83.6	0.159	38,543.4	119,341.8	157.9
B.	Hauling contaminated **soil** to Ex-situ TCH - Pacer Ivy	Haul trucks	67,680	14.0	3.2	5,317.7	16,750.8	5,317.7	16,750.8	1.8	20	45.2	0.159	53,267.5	120,384.6	173.7
B.	Hauling contaminated **sediment** to Ex-situ TCH - Pacer Ivy	Haul trucks	18,480	27.0	3.2	752.9	2,371.6	752.9	2,371.6	1.8	27	83.6	0.159	10,181.3	31,524.3	41.7
C.	Hauling clean fill for backfiling	Haul trucks	221,800	14.0	20.0	17,427.1	348,542.9	17,427.1	348,542.9	1.8	20	45.2	0.159	1,108,366.3	2,504,907.8	3,613.3
C.	Hauling treated soil for backfiling	Haul trucks	84,200	14.0	3.1	6,615.7	20,508.7	6,615.7	20,508.7	1.8	20	45.2	0.159	65,217.7	147,392.0	212.6
D.	Hauling for site restoration to Z1[N]	Haul trucks	7,775	14.0	20.0	610.9	12,217.9	610.9	12,217.9	1.8	20	45.2	0.159	38,852.8	87,807.3	126.7
D.	Hauling for site restoration to Pacer Ivy[N]	Haul trucks	10,353	14.0	20.0	813.4	16,268.2	813.4	16,268.2	1.8	20	45.2	0.159	51,732.9	116,916.4	168.6
	TOTAL															**9,517.6**

	Activities	Source of GHGs	kWh/pile[I]	Total kWh (2 pile)	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[J]	VN Electricity from Natural Gas[J]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[C]	Natural Gas (kg CO_2/GJ)[C]	t CO_2 (Coal)	t CO_2 (Natural Gas)
B.	Thermal Treatment System Operation	Electricity	21,000,000	42,000,000	3,600,000	151,200	36%	25%	54,432	37,800	98.3	56.1	5,350.7	2,120.6
	TOTAL													**7,471.2**

TOTAL t CO_2	**29,716**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles provided by CDM Smith on October 29, 2015
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Based on data provided by CDM Smith
[J] http://www.eia.gov/todayinenergy/detail.cfm?id=22332 https://cnpp.iaea.org/countryprofiles/Vietnam/Vietnam.htm
2015 Electricity Statistics: hydro - 33%; oil and natural gas - 25%; coal - 36%; renewables -6%
[K] Assumption made by Hatfield as site specific data unavailable at time of analysis
[L] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[M] Assumption made by Hatfield as site specific data unavailable at time of analysis; thermal system construction assumed to be equivalent to 'landfill contruction - establish subgrade and leachate collection system' adjusted for area differences between Ex-situ TCH pile and landfill area
[N] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-4 GHG Calculations for Alternative 4 Containment/Treatment Hybird (1,200 ppt)

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[K]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
B.1	Landfill at Z1									
B.1.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	4	896	225,792	36	74.1	602.3
B.1.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	6	1344	145,152	36	74.1	387.2
B.1.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	2	448	80,640	36	74.1	215.1
B.2	Landfill at Pacer Ivy Area									
B.2.1	Construction of Landfill Liner and Leachate Collection System	Dozer, Compactor (3), Grader, 14 m^3 Truck (2)	**7**	36	4	896	225,792	36	74.1	602.3
B.2.2	Excavation and Placement of Material	Dozer (2), Art-Wheel Loader	**3**	36	7	1568	169,344	36	74.1	451.7
B.2.3	Construction of Landfill Cap	Dozer (2), Compactor (2), Grader	**5**	36	2	448	80,640	36	74.1	215.1
B.4	Ex Situ TCH System at Z1									
B.4.1	Ex Situ TCH System Construction	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**7**	36	8	1,792	451,584	36	74.1	1,204.6
B.4.2	Excavation and Hauling of Material	Dozer (2), Art-Wheel Loader	**3**	36	15	3,360	362,880	36	74.1	968.0
B.4.3	Filling the Pile	Dozer (2), Art-Wheel Loader	**3**	36	12	2,688	290,304	36	74.1	774.4
B.4.4	Capping and Completing the Pile	Dozer, Compactor (2), Grader, 14 m^3 Truck (2), auger or drill	**7**	36	18	4,032	1,016,064	36	74.1	2,710.5
B.4.5	Pile Unloading	Dozer (2), Art-Wheel Loader	**3**	36	9	2,016	217,728	36	74.1	580.8
B.3	Ex Situ TCH System at Pacer Ivy									
B.3.1	Ex Situ TCH System Construction	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**7**	36	8	1,792	451,584	36	74.1	1,204.6
B.3.2	Excavation and Hauling of Material	Dozer (2), Art-Wheel Loader	**3**	36	10	2,240	241,920	36	74.1	645.3
B.3.3	Filling the Pile	Dozer (2), Art-Wheel Loader	**3**	36	8	1,792	193,536	36	74.1	516.3
B.3.4	Capping and Completing the Pile	Dozer, Compactor (2), Grader, 14 m^3 Truck (2), auger or drill	**7**	36	12	2,688	677,376	36	74.1	1,807.0
B.3.5	Pile Unloading	Dozer (2), Art-Wheel Loader	**3**	36	6	1,344	145,152	36	74.1	387.2
C.	Backfilling Excavations (with offsite clean fill)	Dozer, Compactor, Art-Wheel Loader	**6**	36	4	896	193,536	36	74.1	516.3
C.	Backfilling Excavations (with treated soil)	Dozer, Compactor, Art-Wheel Loader	**6**	36	9	2,016	435,456	36	74.1	1,161.6
E.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	9	2,016	1,016,064	36	74.1	2,710.5
F.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	9	2,016	1,016,064	36	74.1	2,710.5
	TOTAL									**21,576.1**

Table F.1-4 GHG Calculations for Alternative 4 Containment/Treatment Hybird (1,200 ppt)

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[L]	Haul trucks	73,365	14.0	20.0	5764.4	115,287.9	5764.4	115,287.9	1.8	20	45.2	0.159	366,615.4	828,550.8	1,195.2
A.	Hauling of clean fill for subgrade Pacer Ivy[L]	Haul trucks	55,815	14.0	20.0	4,385.5	87,709.3	4,385.5	87,709.3	1.8	20	45.2	0.159	278,915.5	630,349.1	909.3
B.	Hauling of clean fill for subgrade to ZI landfill	Haul trucks	47,250	14.0	20.0	3,712.5	74,250.0	3,712.5	74,250.0	1.8	20	45.2	0.159	236,115.0	533,619.9	769.7
B.	Hauling of clean fill for subgrade Pacer Ivy landfill	Haul trucks	109,200	14.0	20.0	8,580.0	171,600.0	8,580.0	171,600.0	1.8	20	45.2	0.159	545,688.0	1,233,254.9	1,778.9
B.	Hauling of clean fill for subgrade Z1 Ex-situ TCH[M]	Haul trucks	20,520	14.0	20.0	1,612.3	32,245.7	1,612.3	32,245.7	1.8	20	45.2	0.159	102,541.4	231,743.5	334.3
B.	Hauling of clean fill for subgrade Pacer Ivy Ex-situ TCH[M]	Haul trucks	27,300	14.0	20.0	2,145.0	42,900.0	2,145.0	42,900.0	1.8	20	45.2	0.159	136,422.0	308,313.7	444.7
B.	Hauling contaminated **soil** to landfill - Z1	Haul trucks	75,120	14.0	3.2	5,902.3	18,592.2	5,902.3	18,592.2	1.8	20	45.2	0.159	59,123.2	133,618.4	192.7
B.	Hauling contaminated **sediment** to landfill - Z1	Haul trucks	20,880	27.0	3.2	850.7	2,679.6	850.7	2,679.6	1.8	27	83.6	0.159	11,503.5	35,618.3	47.1
B.	Hauling contaminated **soil** to landfill - Pacer Ivy	Haul trucks	74,280	14.0	3.2	5,836.3	18,384.3	5,836.3	18,384.3	1.8	20	45.2	0.159	58,462.1	132,124.3	190.6
B.	Hauling contaminated **sediment** to landfill - Pacer Ivy	Haul trucks	60,600	27.0	3.2	2,468.9	7,777.0	2,468.9	7,777.0	1.8	27	83.6	0.159	33,386.7	103,375.0	136.8
B.	Hauling contaminated **soil** to Ex-Situ TCH - Z1	Haul trucks	108,840	14.0	3.2	8,551.7	26,937.9	8,551.7	26,937.9	1.8	20	45.2	0.159	85,662.5	193,597.3	279.3
B.	Hauling contaminated **sediment** to Ex-Situ TCH - Z1	Haul trucks	2,040	27.0	3.2	83.1	261.8	83.1	261.8	1.8	27	83.6	0.159	1,123.9	3,480.0	4.6
B.	Hauling contaminated **soil** to Ex-Situ TCH - Pacer Ivy	Haul trucks	120,600	14.0	3.2	9,475.7	29,848.5	9,475.7	29,848.5	1.8	20	45.2	0.159	94,918.2	214,515.2	309.4
B.	Hauling contaminated **sediment** to Ex-Situ TCH - Pacer Ivy	Haul trucks	27,840	27.0	3.2	1,134.2	3,572.8	1,134.2	3,572.8	1.8	27	83.6	0.159	15,338.0	47,491.1	62.8
C.	Hauling clean fill for backfiling	Haul trucks	200,400	14.0	20.0	15,745.7	314,914.3	15,745.7	314,914.3	1.8	20	45.2	0.159	1,001,427.4	2,263,226.0	3,264.7
C.	Hauling treated soil for backfiling	Haul trucks	178,440	14.0	3.1	14,020.3	43,462.9	14,020.3	43,462.9	1.8	20	45.2	0.159	138,212.0	312,359.1	450.6
D.	Hauling for site restoration to Z1[N]	Haul trucks	12,228	14.0	20.0	960.7	19,214.6	960.7	19,214.6	1.8	20	45.2	0.159	61,102.6	138,091.8	199.2
D.	Hauling for site restoration to Pacer Ivy[N]	Haul trucks	9,303	14.0	20.0	730.9	14,618.2	730.9	14,618.2	1.8	20	45.2	0.159	46,485.9	105,058.2	151.5
	TOTAL															**10,721.4**

	Activities	Source of GHGs	kWh/pile[I]	Total kWh (5 pile)	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[J]	VN Electricity from Natural Gas[J]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[C]	Natural Gas (kg CO_2/GJ)[C]	t CO_2 (Coal)	t CO_2 (Natural Gas)
B.	Thermal Treatment System Operation	Electricity	21,000,000	105,000,000	3,600,000	378,000	36%	25%	136,080	94,500	98.3	56.1	13,376.7	5,301.5
	TOTAL													**18,678.1**

TOTAL t CO_2	**50,976**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles is 3.1 km (+ 0.1 km from decomtamination site to treatment site)
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Based on data provided by CDM Smith
[J] http://www.eia.gov/todayinenergy/detail.cfm?id=22332 https://cnpp.iaea.org/countryprofiles/Vietnam/Vietnam.htm
2015 Electricity Statistics: hydro - 33%; oil and natural gas - 25%; coal - 36%; renewables -6%
[K] Assumption made by Hatfield as site specific data unavailable at time of analysis
[L] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[M] Assumption made by Hatfield as site specific data unavailable at time of analysis; incineration system construction assumed to be equivalent to 'landfill contruction - establish subgrade and leachate collection system' adjusted for area differences between incineration and landfill area
[N] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-5 GHG Calculations for Alternative 5A Incineration

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[K]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
B.1	Incineration at Pacer Ivy									
B.1.1	Excavation and Stockpiling of Material	Dozer (2), Art-Wheel Loader	**3**	36	20	4,480	483,840	36	74.1	1,290.7
B.1.2	Incinerator Operation - Pacer Ivy	art-wheel loader, dozer	**2**	36	36	8,064	580,608	36	74.1	1,548.8
B.1.3	Incineration - conveyor	Diesel Generator	**1**	6	36	8,064.0	48,835.6	36	74.1	130.3
B.2	Incineration at Z1									
B.2.1	Excavation and Stockpiling of Material	Dozer (2), Art-Wheel Loader	**3**	36	20	4,480	483,840	36	74.1	1,290.7
B.2.2	Incinerator Operation - Z1	art-wheel loader, dozer	**2**	36	26	5,824	419,328	36	74.1	1,118.6
B.2.3	Incineration Treatment - conveyor	Diesel Generator	**1**	6	26	5,824.0	35,270.1	36	74.1	94.1
C.	Backfilling Excavations (with offsite clean fill)	Dozer, Compactor, Art-Wheel Loader	**6**	36	3	672	145,152	36	74.1	387.2
C.	Backfilling Excavations (with treated soil)	Dozer, Compactor, Art-Wheel Loader	**6**	36	23	5,152	1,112,832	36	74.1	2,968.6
	Maintenance incinerator equipment	Dozer, Compactor	**2**	36	5	1,120	80,640	36	74.1	215.1
D.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
E.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	6	1,344	677,376	36	74.1	1,807.0
	TOTAL									**13,260.3**

Table F.1-5 GHG Calculations for Alternative 5A Incineration

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[L]	Haul trucks	88,800	14.0	20.0	6,977.1	139,542.9	6,977.1	139,542.9	1.8	20	45.2	0.159	443,746.3	1,002,866.6	1,446.6
A.	Hauling of clean fill for subgrade Pacer Ivy[L]	Haul trucks	60,000	14.0	20.0	4,714.3	94,285.7	4,714.3	94,285.7	1.8	20	45.2	0.159	299,828.6	677,612.6	977.4
B.	Hauling contaminated **soil** to contaminated stockpile - Z1	Haul trucks	183,960	14.0	3.2	14,454.0	46,252.8	14,454.0	46,252.8	1.8	20	45.2	0.159	147,083.9	332,409.6	479.5
B.	Hauling contaminated **sediment** to contaminated stockpile - Z1	Haul trucks	22,920	27.0	3.2	933.8	2,988.1	933.8	2,988.1	1.8	20	83.6	0.159	9,502.1	39,718.9	49.2
B.	Hauling contaminated **soil** to contaminated stockpile - Pacer Ivy	Haul trucks	194,880	14.0	3.2	15,312.0	48,998.4	15,312.0	48,998.4	1.8	20	45.2	0.159	155,814.9	352,141.7	508.0
B.	Hauling contaminated **sediment** to contaminated stockpile - Pacer Ivy	Haul trucks	88,440	27.0	3.2	3,603.1	11,530.0	3,603.1	11,530.0	1.8	20	83.6	0.159	36,665.3	153,260.8	189.9
C.	Hauling clean fill for backfiling	Haul trucks	39,600	14.0	20.0	3,111.4	62,228.6	3,111.4	62,228.6	1.8	20	45.2	0.159	197,886.9	447,224.3	645.1
C.	Hauling treated soil for backfiling	Haul trucks	339,240	14.0	3.1	26,654.6	82,629.2	26,654.6	82,629.2	1.8	20	45.2	0.159	262,760.8	593,839.3	856.6
C.	Removal of ash	Haul trucks		14.0	20.0	0.0	0.0	0.0	0.0	1.8	20	45.2	0.159	0.0	0.0	0.0
D.	Hauling for site restoration to Z1[M]	Haul trucks	14,800	14.0	20.0	1,162.9	23,257.1	1,162.9	23,257.1	1.8	20	45.2	0.159	73,957.7	167,144.4	241.1
D.	Hauling for site restoration to Pacer Ivy[M]	Haul trucks	10,000	14.0	20.0	785.7	15,714.3	785.7	15,714.3	1.8	20	45.2	0.159	49,971.4	112,935.4	162.9
	TOTAL															**5,556.4**

	Activities	Source of GHGs	Total kWh	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[J]	VN Electricity from Natural Gas[J]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[C]	Natural Gas (kg CO_2/GJ)[C]	t CO_2 (Coal)	t CO_2 (Natural Gas)
B.	Incineration Treatment System Operation	Electricity	1,000,000	3,600,000	3,600	36%	25%	1,296	900	98.3	56.1	127.4	50.5
B.	Incineration Treatment System Operation	Natural Gas	281,277,469	3,600,000	1,012,599	0%	100%	0	1,012,599	98.3	56.1	0.0	56,806.8
	TOTAL												**56,984.7**

TOTAL t CO_2 **75,801**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles is 3.1 km (+ 0.1 km from decomtamination site to treatment site)
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Based on data provided by CDM Smith
[J] http://www.eia.gov/todayinenergy/detail.cfm?id=22332 https://cnpp.iaea.org/countryprofiles/Vietnam/Vietnam.htm
<u>2015 Electricity Statistics:</u> hydro - 33%; oil and natural gas - 25%; coal - 36%; renewables -6%
[K] Assumption made by Hatfield as site specific data unavailable at time of analysis
[L] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[M] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-6 GHG Calculations for Alternative 5B Ex Situ TCH

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[K]	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	4	896	451,584	36	74.1	1,204.6
B.1	Ex Situ TCH System at Pacer Ivy									
B.1.1	Ex Situ TCH System Construction	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**7**	36	8	1,792	451,584	36	74.1	1,204.6
B.1.2	Excavation and Hauling of Material	Dozer (2), Art-Wheel Loader	**3**	36	20	4,480	483,840	36	74.1	1,290.7
B.1.3	Filling the Pile	Dozer (2), Art-Wheel Loader	**3**	36	16	3,584	387,072	36	74.1	1,032.6
B.1.4	Capping and Completing the Pile	Dozer, Compactor (2), Grader, 14 m^3 Truck (2), auger or drill	**7**	36	24	5,376	1,354,752	36	74.1	3,613.9
B.1.5	Pile Unloading	Dozer (2), Art-Wheel Loader	**3**	36	12	2,688	290,304	36	74.1	774.4
B.2	Ex Situ TCH System at Z1									
B.2.1	Ex Situ TCH System Construction	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**7**	36	8	1,792	451,584	36	74.1	1,204.6
B.2.2	Excavation and Hauling of Material	Dozer (2), Art-Wheel Loader	**3**	36	20	4,480	483,840	36	74.1	1,290.7
B.2.3	Filling the Pile	Dozer (2), Art-Wheel Loader	**3**	36	16	3,584	387,072	36	74.1	1,032.6
B.2.4	Capping and Completing the Pile	Dozer, Compactor (2), Grader, 14 m^3 Truck (2), auger or drill	**7**	36	24	5,376	1,354,752	36	74.1	3,613.9
B.2.5	Pile Unloading	Dozer (2), Art-Wheel Loader	**3**	36	12	2,688	290,304	36	74.1	774.4
C.	Backfilling Excavations (with offsite clean fill)	Dozer, Compactor, Art-Wheel Loader	**6**	36	4	896	193,536	36	74.1	516.3
C.	Backfilling Excavations (with treated soil)	Dozer, Compactor, Art-Wheel Loader	**6**	36	18	4,032	870,912	36	74.1	2,323.2
E.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	9	2,016	1,016,064	36	74.1	2,710.5
F.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	9	2,016	1,016,064	36	74.1	2,710.5
	TOTAL									**25,297.6**

Table F.1-6 GHG Calculations for Alternative 5B Ex Situ TCH

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[L]	Haul trucks	71,115	14.0	20.0	5587.6	111,752.1	5587.6	111,752.1	1.8	20	45.2	0.159	355,371.8	803,140.3	1,158.5
A.	Hauling of clean fill for subgrade Pacer Ivy[L]	Haul trucks	53,115	14.0	20.0	4,173.3	83,466.4	4,173.3	83,466.4	1.8	20	45.2	0.159	265,423.2	599,856.5	865.3
B.	Hauling of clean fill for subgrade Z1 Ex-situ TCH[M]	Haul trucks	20,520	14.0	20.0	1,612.3	32,245.7	1,612.3	32,245.7	1.8	20	45.2	0.159	102,541.4	231,743.5	334.3
B.	Hauling of clean fill for subgrade Pacer Ivy Ex-situ TCH[M]	Haul trucks	27,300	14.0	20.0	2,145.0	42,900.0	2,145.0	42,900.0	1.8	20	45.2	0.159	136,422.0	308,313.7	444.7
B.	Hauling contaminated **soil** to contaminated stockpile - Z1	Haul trucks	183,960	14.0	3.2	14,454.0	46,252.8	14,454.0	46,252.8	1.8	20	45.2	0.159	147,083.9	332,409.6	479.5
B.	Hauling contaminated **sediment** to contaminated stockpile - Z1	Haul trucks	22,920	27.0	3.2	933.8	2,988.1	933.8	2,988.1	1.8	27	83.6	0.159	12,827.9	39,718.9	52.5
B.	Hauling contaminated **soil** to contaminated stockpile - Pacer Ivy	Haul trucks	194,880	14.0	3.2	15,312.0	48,998.4	15,312.0	48,998.4	1.8	20	45.2	0.159	155,814.9	352,141.7	508.0
B.	Hauling contaminated **sediment** to contaminated stockpile - Pacer Ivy	Haul trucks	88,440	27.0	3.2	3,603.1	11,530.0	3,603.1	11,530.0	1.8	27	83.6	0.159	49,498.1	153,260.8	202.8
B.	Hauling treated sediment and soil from treatment site to treated stockpile area Z1	Haul trucks	128,040	14.0	0.4	10,060.3	4,024.1	10,060.3	4,024.1	1.8	20	45.2	0.159	12,796.7	28,920.5	41.7
B.	Hauling treated sediment from PI treatment site to treated stockpile area Z1	Haul trucks	22,920	14.0	3.6	1,800.9	6,483.1	1,800.9	6,483.1	1.8	20	45.2	0.159	20,616.2	46,592.6	67.2
C.	Hauling clean fill for backfiling	Haul trucks	39,600	14.0	20.0	3,111.4	62,228.6	3,111.4	62,228.6	1.8	20	45.2	0.159	197,886.9	447,224.3	645.1
C.	Hauling treated soil for backfiling	Haul trucks	276,100	14.0	3.1	21,693.6	67,250.1	21,693.6	67,250.1	1.8	20	45.2	0.159	213,855.2	483,312.8	697.2
D.	Hauling for site restoration to Z1[N]	Haul trucks	11,853	14.0	20.0	931.3	18,625.4	931.3	18,625.4	1.8	20	45.2	0.159	59,228.6	133,856.7	193.1
D.	Hauling for site restoration to Pacer Ivy[N]	Haul trucks	8,853	14.0	20.0	695.6	13,911.1	695.6	13,911.1	1.8	20	45.2	0.159	44,237.2	99,976.1	144.2
	TOTAL															**5,834.1**

	Activities	Source of GHGs	kWh/pile[I]	Total kWh (8 pile)	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[J]	VN Electricity from Natural Gas[J]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[C]	Natural Gas (kg CO_2/GJ)[C]	t CO_2 (Coal)	t CO_2 (Natural Gas)
B.	Thermal Treatment System Operation	Electricity	21,000,000	168,000,000	3,600,000	604,800	36%	25%	217,728	151,200	98.3	56.1	21,402.7	8,482.3
	TOTAL													**29,885.0**

TOTAL t CO_2	**61,017**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.

[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.

[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles is 3.1 km (+ 0.1 km from decomtamination site to treatment site); 3.6 km between treatment area in PI and Permanent Stockpile in Z1

[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill

[F] Based on Cat 770 Off Hwy Truck (www.cat.com)

[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)

[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.

[I] Based on data provided by CDM Smith

[J] http://www.eia.gov/todayinenergy/detail.cfm?id=22332 https://cnpp.iaea.org/countryprofiles/Vietnam/Vietnam.htm

2015 Electricity Statistics: hydro - 33%; oil and natural gas - 25%; coal - 36%; renewables -6%

[K] Assumption made by Hatfield as site specific data unavailable at time of analysis

[L] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required

[M] Assumption made by Hatfield as site specific data unavailable at time of analysis; thermal system construction assumed to be equivalent to 'landfill contruction - establish subgrade and leachate collection system' adjusted for area differences between Ex-situ TCH pile and landfill area

[N] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Table F.1-7 GHG Calculations for Alternative 5C MCD

	Activities	Source of GHGs	# of Units	Fuel Efficiency (L/hr)[A]	Duration (mths)	Duration (hours)	Total Fuel Usage (L)	LHV Diesel (MJ/L)[B]	kg CO_2/GJ[C]	t CO_2
A.	Equipment, Facilities, and Project Area Setup[K]	Dozer (2), Compactor (4), Grader, Paver, 14 m^3 Truck (2)	**20**	36	4	896.0	645,120.0	36	74.1	1,720.9
B.1	MCD System Z1									
B.1.2	Excavation and Hauling of Material; Air Drying & Preliminary Heat Drying	Dozer (2), Art-Wheel Loader	**3**	36	24.5	5,488.0	592,704.0	36	74.1	1,581.1
B.1.3	MCD Treatment	Dozer, Art-Wheel Loader	**2**	36	24.5	5,488.0	395,136.0	36	74.1	1,054.1
B.1.4	MCD Treatment - conveyor	Diesel Generator	**1**	6.05	24.5	5,488.0	33,202.4	36	74.1	88.6
B.2	MCD System Pacer Ivy									
B.2.2	Excavation and Hauling of Material; Air Drying & Preliminary Heat Drying	Dozer (2), Art-Wheel Loader	**3**	36	24.5	5,488.0	592,704.0	36	74.1	1,581.1
B.2.3	MCD Treatment	Dozer, Art-Wheel Loader	**2**	36	24.5	5,488.0	395,136.0	36	74.1	1,054.1
B.2.4	MCD Treatment - conveyor	Diesel Generator	**1**	6.05	24.5	5,488.0	33,202.4	36	74.1	88.6
B	System Operation and Maintenance	Dozer, Compactor	**4**	36	12	2,688.0	387,072.0	36	74.1	1,032.6
C.	Backfilling Excavations	Dozer, Compactor, Art-Wheel Loader	**6**	36	35	7,840.0	1,693,440.0	36	74.1	4,517.4
E.	Site restoration	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	6	1,344.0	677,376.0	36	74.1	1,807.0
F.	Project Demobilization	Dozer, Compactor (2), Grader, Paver, 14 m^3 Truck (2)	**14**	36	7	1,568.0	790,272.0	36	74.1	2,108.1
	TOTAL									**16,633.5**

Table F.1-7 GHG Calculations for Alternative 5C MCD

	Activities	Source of GHGs	Volume to Move (m^3)	Load (m^3)	Distance per one-way trip (km)[D]	# of Full Loads[E]	Total Loaded Distance (km)	# of Empty Loads	Total Empty Distance (km)	Conversion factor (t/m^3)	Empty Truck Weight (t)[F]	Full Load + Truck Weight (t)[G]	Emission Factor (kg CO2-e/ton-km)[H]	kg CO_2-e Empty	kg CO_2-e Loaded	Total t CO_2-e
A.	Hauling of clean fill for subgrade to ZI[L]	Haul trucks	88,800	14.0	20.0	6,977.1	139542.9	6,977.1	139,542.9	1.8	20.0	45.2	0.2	443,746.3	1,002,866.6	1,446.6
A.	Hauling of clean fill for subgrade Pacer Ivy[L]	Haul trucks	60,000	14.0	20.0	4,714.3	94285.7	4,714.3	94,285.7	1.8	20.0	45.2	0.2	299,828.6	677,612.6	977.4
B.	Hauling contaminated **soil** to air drying - Z1	Haul trucks	183,960	14.0	3.3	14,454.0	47,698.2	14,454.0	47,698.2	1.8	20	45.2	0.159	151,680.3	342,797.4	494.5
B.	Hauling contaminated **sediment** to air drying - Z1	Haul trucks	22,920	27.0	3.3	933.8	3,081.5	933.8	3,081.5	1.8	20	83.6	0.159	9,799.1	40,960.1	50.8
B.	Hauling contaminated **soil** to air drying - Pacer Ivy	Haul trucks	194,880	14.0	3.3	15,312.0	50,529.6	15,312.0	50,529.6	1.8	20	45.2	0.159	160,684.1	363,146.1	523.8
B.	Hauling contaminated **sediment** to air drying - Pacer Ivy	Haul trucks	88,440	27.0	3.3	3,603.1	11,890.3	3,603.1	11,890.3	1.8	20	83.6	0.159	37,811.0	158,050.2	195.9
C.	Hauling clean fill for backfiling	Haul trucks	39,600	14.0	20.0	3,111.4	62,228.6	3,111.4	62,228.6	1.8	20	45.2	0.159	197,886.9	447,224.3	645.1
C.	Hauling treated soil for backfiling	Haul trucks	276,100	14.0	3.1	21,693.6	67,250.1	21,693.6	67,250.1	1.8	20	45.2	0.159	213,855.2	483,312.8	697.2
D.	Hauling for site restoration to Z1[N]	Haul trucks	14,800	14.0	20.0	1,162.9	23,257.1	1,162.9	23,257.1	1.8	20	45.2	0.159	73,957.7	167,144.4	241.1
E.	Hauling for site restoration to Pacer Ivy[N]	Haul trucks	10,000	14.0	20.0	785.7	15,714.3	785.7	15,714.3	1.8	20	45.2	0.159	49,971.4	112,935.4	162.9
	TOTAL															**5,435.3**

	Activities	Source of GHGs	kWh/ton	Total kWh	Conversion Factor (J/kWh)	Total GJ	VN Electricity from Coal[J]	VN Electricity from Natural Gas[J]	GJ (coal)	GJ (NG)	Coal (kg CO_2/GJ)[C]	Natural Gas (kg CO_2/GJ)[C]	t CO_2 (Coal)	t CO_2 (Natural Gas)
B.	MCD Treatment System Operation	Pre-heating system (elec.)	25	17,616,563	3,600,000	63,420	36%	25%	22,831	15,855	98.3	56.1	2,244.3	889.5
B.	MCD Treatment System Operation	Electricity	32	28,186,500	3,600,000	101,471	36%	25%	36,530	25,368	98.3	56.1	3,590.9	1,423.1
	TOTAL													**8,147.8**

TOTAL t CO_2	**30,216**

[A] As fuel efficiency varies significantly by type of equipment/make/model, assumed 45 L/hr average (based on www.heavyequipmentforums.com, www.answers.com, various dealers) .Assume equipment runs 8 hours/day, 7 days/week.
[B] LHV From Wildfish. 2015. Biofuel Production in Vietnam: Cost Effectiveness, Energy and GHG Balances. Available from http://www.eepsea.org/pub/rr/2015-RR6_Loan_web.pdf.
[C] Based on the assumption that all heavy machinery use deisel http://www.theclimateregistry.org/wp-content/uploads/2014/11/2014-Climate-Registry-Default-Emissions-Factors.pdf; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[D] Assumption made by Hatfield that the average distance from source of clean fill to treatment site would be 10 km; Average distance from excavated areas to treatments sites/stockpiles is 3.1 km (+ 0.1 km from decomtamination site to treatment site; additional 0.1 km assumed for handling between drying and treatment)
[E] Volume expansion due to excavation - factor of 1.1 assumed (based on www.eng-tips.com and www.contractortalk.com); 1.1 assumed for transporting imported fill
[F] Based on Cat 770 Off Hwy Truck (www.cat.com)
[G] Based on the weight assessed for the Environmental Remediation at Danang Airbase (45.2 t for truck load of soil; 83.6 t for truck load of sediment)
[H] Fuel type is diesel, Energy use 2.275 MJ/ton km, Fuel GHG emission factor 70.0 g CO_2-e/MJ - Yan, H., Q. Shen, L.C.H. Fan, Y.Wang, L.Zhang. 2010. Greenhouse gas emissions in building construction: A case study of One Peking in Hong Kong.
[I] Based on data provided by CDM Smith
[J] http://www.eia.gov/todayinenergy/detail.cfm?id=22332 https://cnpp.iaea.org/countryprofiles/Vietnam/Vietnam.htm
2015 Electricity Statistics: hydro - 33%; oil and natural gas - 25%; coal - 36%; renewables -6%
[K] Assumption made by Hatfield as site specific data unavailable at time of analysis
[L] Assumption made by Hatfield that clean fill at 0.6 depth for the area of General Facilities, Stockpiles etc will be required
[M] Assumption made by Hatfield as site specific data unavailable at time of analysis; thermal system construction assumed to be equivalent to 'landfill contruction - establish subgrade and leachate collection system' adjusted for area differences between Ex-situ TCH pile and landfill area
[N] Assumption made by Hatfield that clean fill required for site restoration would be equivalent to General Facilities Area at 0.1 depth

Potential Effects on Surface Water Quality

Table F2.1 Project Affected Water – Landfill.

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	0.5	84,500	0.7	--	195	5,767	--	--	244	20618
Equipment, Facilities, and Project Area Setup - Dry Season	2	0.5	84,500	0.3	21.7	--	275	60	1,521	--	--
Pacer Ivy: Excavation and Placement of Material and Construction of Landfill Cap - Dry Season	15	3.75	298,296	0.3	21.7	--	7,282	60	5,369	--	--
Pacer Ivy: Operation of Temporary Storage and Dewatering Area - Dry Season	15	15	19,886	0.2	21.7		1,295	60	239		
Pacer Ivy: Construction of Landfill Cap - Wet Season	1	1	45,500	0.7	--	195	6,211	--	--	244	11102
Z1: Excavation and Placement of Material and Construction of Landfill Cap - Dry Season	9	2.25	183,604	0.3	21.7	--	2,689	60	3,305	--	--
Z1: Operation of Temporary Storage and Dewatering Area - Dry Season	9	2.25	20,400	0.2	21.7		199	60	245		
Z1: Construction of Landfill Cap - Wet Season	1	1	30,000	0.7	--	195	4,095	--	--	244	7320
TOTAL							**27,813**		**10,679**		**39,040**

Table F2.1 Project Affected Water – Landfill.

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	Volume $_{min}$ (m^3)	Volume $_{max}$ (m^3)
Pacer Ivy: Construction of Landfill Liner and Leachate Collection System	91,000	22,750	6	45	603	1.2	0.1	60	1.42	19	0.0004	0.03	0.46	1.5	20.6
Pacer Ivy: Excavation and Placement of Material - Wet Season	323,366	80,842	15	113	1137	1.2	0.1	114	1.42	19	0.0004	0.06	0.86	7.3	97.2
Pacer Ivy: Excavation and Placement of Material - Dry Season	323,366	80,842	1	8	1137	1.2	0.1	114	1.42	19	0.0004	0.06	0.86	0.5	6.5
Z1: Construction of Landfill Liner and Leachate Collection System	60,000	15,000	5	38	490	1.2	0.1	49	1.42	19	0.0004	0.03	0.37	1.0	14.0
Z1: Excavation and Placement of Material - Wet Season	199,034	49,759	1	8	892	1.2	0.1	89	1.42	19	0.0004	0.05	0.68	0.4	5.1
Z1: Excavation and Placement of Material - Dry Season	199,034	49,759	9	68	892	1.2	0.1	89	1.42	19	0.0004	0.05	0.68	3.4	45.8

Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL				**9,744**

Table F2.1 Project Affected Water – Landfill.

Activity	Lifespan (years)	Area (m^2) - excluding support facilities	Wet Season Long Term Annual Average Rainfall (mm)	Annual Average Leachate (1% leaching of 60% of Precipitation) (mm)	Total Lifespan Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Max 24 hr Leachate (1% leaching of 60% of Precipitation) (mm)	Max 24 hr Volume (m^3)
Operation of Landfill - leachate[7]	50	75,500	167	1.002	3,783	244	1.464	111
TOTAL					**3,783**			**111**
TOTAL VOLUME (m^3)					**41,529**			

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl}KA$ Q is the total groundwater discharge (m^3/d)

Table F2.2 Project Affected Water – Solidification and Stablization

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	0.5	100,500	0.7	--	195	6,859.1	--	--	244	24,522
Equipment, Facilities, and Project Area Setup - Dry Season	5	1.25	100,500	0.3	21.7	--	817.8	60	1,809	--	--
Pacer Ivy - Excavation and Hauling of Material - Wet Season	4	1	298,296	0.7	--	195	40,717.4	--	--	244	72,784
Pacer Ivy - Excavation and Hauling of Material - Dry Season	25	6.25	298,296	0.3	21.7	--	12,136.9	60	5,369	--	--
Pacer Ivy - Maintenance of Temporary Stockpiles - Wet Season	25	25	5,628	0.7		195	19,206.3	--	--	244	1,373
Pacer Ivy - Maintenance of Temporary Stockpiles - Dry Season	28	28	5,628	0.2	21.7	--	683.9	60	68	--	--
Pacer Ivy - S/S Treatment - Wet Season	25	6.25	45,500	0.7	--	195	38,817.2	--	--	244	11,102
Pacer Ivy - S/S Treatment - Dry Season	28	7	45,500	0.3	21.7	--	2,073.4	60	819	--	--
Pacer Ivy - Placement of Material in Pile - Wet Season	10	2.5	45,500	0.7	--	195	15,526.9	--	--	244	11,102
Pacer Ivy - Placement of Material in Pile - Dry Season Season	26	6.5	45,500	0.3	21.7	--	1,925.3	60	819	--	--
Z1 - Excavation and Hauling of Material - Wet Season	2	0.5	183,604	0.7	--	195	12,531.0	--	--	244	44,799
Z1 - Excavation and Hauling of Material - Dry Season	15	3.75	183,604	0.3	21.7	--	4,482.2	60	3,305	--	--
Z1 - Maintenance of Temporary Stockpiles - Wet Season	12	12	6,557	0.7		195	10,740.8	--	--	244	1,600
Z1 - Maintenance of Temporary Stockpiles - Dry Season	16	16	6,557	0.2	21.7	--	455.3	60	79	--	--
Z1 - S/S Treatment - Wet Season	12	3	30,000	0.7	--	195	12,285.0	--	--	244	7,320
Z1 - S/S Treatment - Dry Season	16	4	30,000	0.3	21.7	--	781.2	60	540	--	--
Z1 - Placement of Material in Pile - Wet Season	4	1	30,000	0.7	--	195	4,095.0	--	--	244	7,320
Z1 - Placement of Material in Pile - Dry Season Season	15	3.75	30,000	0.3	21.7	--	732.4	60	540	--	--
TOTAL							**184,867**		**13,347**		**181,923**

Table F2.2 Project Affected Water – Solidification and Stablization

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	Volume $_{min}$ (m^3)	Volume $_{max}$ (m^3)
Pacer Ivy - Excavation and Hauling of Material - Wet Season	329,112	82,278	4	30	1147	1.2	0.1	115	1.42	19	0.0004	0.07	0.87	1.96	26.16
Pacer Ivy - Excavation and Hauling of Material - Dry Season	329,112	82,278	25	188	1147	1.2	0.1	115	1.42	19	0.0004	0.07	0.87	12.22	163.50
Z1 - Excavation and Hauling of Material - Wet Season	192,766	48,192	2	15	878	1.2	0.1	88	1.42	19	0.0004	0.05	0.67	0.75	10.01
Z1 - Excavation and Hauling of Material - Dry Season	192,766	48,192	15	113	878	1.2	0.1	88	1.42	19	0.0004	0.05	0.67	5.61	75.08

Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL				**9,744**

TOTAL VOLUME (m^3)	**194,886**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl}KA$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

Table F2.3 Project Affected Water – Landfill <2500 ppt> Ex Situ TCH

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	0.5	166,275	0.7	--	195	11,348.3	--	--	244	40,571
Equipment, Facilities, and Project Area Setup - Dry Season	2	0.5	166,275	0.3	21.7	--	541.2	60	2,993	--	--
Pacer Ivy Landfill - Excavation and Placement of Material and Construction of Landfill Cap	14	3.5	205,251	0.3	21.7	--	4,676.6	60	3,695	--	--
Pacer Ivy: Operation of Temporary Storage and Dewatering Area for Landfill - Dry Season	14	14	14,661	0.3	21.7	--	1,336.2	60	264	--	--
Z1 Landfill - Excavation and Placement of Material and Construction of Landfill Cap	9	2.25	130,600	0.3	21.7	--	1,913.0	60	2,351	--	--
Z1: Operation of Temporary Storage and Dewatering Area for Landfill - Dry Season	9	9	14,511	0.2	21.7	--	566.8	60	174	--	--
Ex Situ TCH System Construction - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
Ex Situ TCH System Construction - Dry Season	6	6	11,475	0.3	21.7	--	448.2	60	207	--	--
Ex Situ TCH Excavation and Hauling of Material	10	2.5	186,549	0.3	21.7	---	3,036.1	60	3,358	--	--
Operation of Temporary Storage and Dewatering Area for TCH	10	10	18,655	0.2	21.7	--	809.6	60	224	--	--
Ex Situ TCH Filling the Pile - Wet Season	1	1	11,475	0.7	--	195	1,566.3	--	--	244	2,800
Ex Situ TCH Filling the Pile - Dry Season	7	7	11,475	0.3	21.7	---	522.9	60	207	--	--
Ex Situ TCH Capping and Completing the Pile - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
Ex Situ TCH Capping and Completing the Pile - Dry Season	10	10	11,475	0.3	21.7	--	747.0	60	207	--	--

Table F2.3 Project Affected Water – Landfill <2500 ppt> Ex Situ TCH

	Ex Situ TCH Thermal Treatment - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
	Ex Situ TCH Thermal Treatment - Dry Season	10	10	11,475	0.3	21.7	--	747.0	60	207	--	--
	Ex Situ TCH Pile Unloading - Wet Season	6	6	11,475	0.7	--	195	9,398.0	--	--	244	2,800
TOTAL								**47,055**		**13,884**		**54,571**

Activities Affected by Groundwater Seepage[1]		Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	Volume $_{min}$ (m^3)	Volume $_{max}$ (m^3)
	Pacer Ivy Landfill - Construction of Landfill Liner and Leachate Collection System	35,000	8,750	5	38	374	1.2	0.1	37	1.42	19	0.0004	0.02	0.28	0.80	10.66
	Pacer Ivy Landfill - Excavation and Placement of Material	205,251	51,313	14	105	906	1.2	0.1	91	1.42	19	0.0004	0.05	0.69	5.40	72.31
	Z1 Landfill - Construction of Landfill Liner and Leachate Collection System	26,250	6,563	4	30	324	1.2	0.1	32	1.42	19	0.0004	0.02	0.25	0.55	7.39
	Z1 Landfill - Excavation and Placement of Material	130,600	32,650	9	68	723	1.2	0.1	72	1.42	19	0.0004	0.04	0.55	2.77	37.08
	Ex Situ TCH Excavation and Hauling of Material	186,549	46,637	10	75	864	1.2	0.1	86	1.42	19	0.0004	0.05	0.66	3.68	49.24

Activity		Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
	Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL					**9,744**

Table F2.3 Project Affected Water – Landfill <2500 ppt> Ex Situ TCH

Activity	Lifespan (years)	Area (m^2) - excluding support facilities	Wet Season Long Term Annual Average Rainfall (mm)	Annual Average Leachate (1% leaching of 60% of Precipitation) (mm)	Total Lifespan Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Max 24 hr Leachate (1% leaching of 60% of Precipitation) (mm)	Max 24 hr Volume (m^3)
Operation of Landfill - leachate[7]	50	61,250	195	1.17	3,583	244	1.464	**90**
TOTAL					**3,583**			**90**

TOTAL VOLUME (m^3)	**60,559**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl} KA$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

[7] Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate (Visvanathan C., Trankler, P. Kuruparan, Q. Xiaoning 2003).

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

Table F2.4 Project Affected Water – Landfill <1200 ppt> Ex Situ TCH

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	0.5	191,700	0.7	--	195	13,083.5	--	--	244	46,775
Equipment, Facilities, and Project Area Setup - Dry Season	2	0.5	191,700	0.3	21.7	--	624.0	60	3,451	--	--
Pacer Ivy Landfill - Excavation and Placement of Material and Construction of Landfill Cap	9	2.25	96,226	0.3	21.7	--	1,409.5	60	1,732	--	--
Pacer Ivy: Operation of Temporary Storage and Dewatering Area for Landfill - Dry Season	9	9	10,692	0.2	21.7	--	417.6	60	128	--	--
Z1 Landfill - Excavation and Placement of Material and Construction of Landfill Cap	8	2	82,487	0.3	21.7	--	1,074.0	60	1,485	--	--
Z1: Operation of Temporary Storage and Dewatering Area for Landfill - Dry Season	8	8	10,311	0.2	21.7	--	358.0	60	124	--	--
Pacer Ivy - Ex Situ TCH System Construction - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
Pacer Ivy - Ex Situ TCH System Construction - Dry Season	6	6	11,475	0.3	21.7	--	448.2	60	207	--	--
Pacer Ivy - Ex Situ TCH Excavation and Hauling of Material	15	3.75	206,191	0.3	21.7	---	5,033.6	60	3,711	--	--
Pacer Ivy - Maintenance of Temporary Stockpiles	15	15	13,746	0.2	21.7	--	894.9	60	165	--	--
Pacer Ivy - Ex Situ TCH Filling the Pile - Wet Season	1	1	11,475	0.7	--	195	1,566.3	--	--	244	2,800
Pacer Ivy - Ex Situ TCH Filling the Pile - Dry Season	11	11	11,475	0.3	21.7	---	821.7	60	207	--	--
Pacer Ivy - Ex Situ TCH Capping and Completing the Pile - Wet Season	3	3	11,475	0.7	--	195	4,699.0	--	--	244	2,800
Pacer Ivy - Ex Situ TCH Capping and Completing the Pile - Dry Season	15	15	11,475	0.3	21.7	--	1,120.5	60	207	--	--

Table F2.4 Project Affected Water – Landfill <1200 ppt> Ex Situ TCH

	Pacer Ivy - Ex Situ TCH Thermal Treatment - Wet Season	3	3	11,475	0.7	--	195	4,699.0	--	--	244	2,800
	Pacer Ivy - Ex Situ TCH Thermal Treatment - Dry Season	15	15	11,475	0.3	21.7	--	1,120.5	60	207	--	--
	Pacer Ivy - Ex Situ TCH Pile Unloading - Wet Season	9	9	11,475	0.7	--	195	14,097.0	--	--	244	2,800
	Z1 - Ex Situ TCH System Construction - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
	Z1 - Ex Situ TCH System Construction - Dry Season	6	6	11,475	0.3	21.7	--	448.2	60	207	--	--
	Z1 - Ex Situ TCH Excavation and Hauling of Material	10	2.5	137,496	0.3	21.7	---	2,237.7	60	2,475	--	--
	Z1 - Maintenance of Temporary Stockpiles	10	10	13,750	0.2	21.7	--	596.7	60	165	--	--
	Z1 - Ex Situ TCH Filling the Pile - Wet Season	1	1	11,475	0.7	--	195	1,566.3	--	--	244	2,800
	Z1 - Ex Situ TCH Filling the Pile - Dry Season	7	7	11,475	0.3	21.7	---	522.9	60	207	--	--
	Z1 - Ex Situ TCH Capping and Completing the Pile - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
	Z1 - Ex Situ TCH Capping and Completing the Pile - Dry Season	10	10	11,475	0.3	21.7	--	747.0	60	207	--	--
	Z1 - Ex Situ TCH Thermal Treatment - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
	Z1 - Ex Situ TCH Thermal Treatment - Dry Season	10	10	11,475	0.3	21.7	--	747.0	60	207	--	--
	Z1 - Ex Situ TCH Pile Unloading - Wet Season	6	6	11,475	0.7	--	195	9,398.0	--	--	244	2,800
TOTAL								**80,262**		**15,088**		**74,774**

Table F2.4 Project Affected Water – Landfill <1200 ppt> Ex Situ TCH

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	Volume $_{min}$ (m^3)	Volume $_{max}$ (m^3)
Pacer Ivy Landfill - Construction of Landfill Liner and Leachate Collection System	30,000	7,500	4	30	346	1.2	0.1	35	1.42	19	0.0004	0.02	0.26	0.59	7.90
Pacer Ivy Landfill - Excavation and Placement of Material	96,226	24,057	9	68	620	1.2	0.1	62	1.42	19	0.0004	0.04	0.47	2.38	31.83
Z1 Landfill - Construction of Landfill Liner and Leachate Collection System	26,250	6,563	4	30	324	1.2	0.1	32	1.42	19	0.0004	0.02	0.25	0.55	7.39
Z1 Landfill - Excavation and Placement of Material	82,487	20,622	8	60	574	1.2	0.1	57	1.42	19	0.0004	0.03	0.44	1.96	26.19
Pacer Ivy - Ex Situ TCH Excavation and Hauling of Material	206,191	51,548	15	113	908	1.2	0.1	91	1.42	19	0.0004	0.05	0.69	5.80	77.65
Z1 - Ex Situ TCH Excavation and Hauling of Material	8,400	2,100	10	75	183	1.2	0.1	18	1.42	19	0.0004	0.01	0.14	0.78	10.45

Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL				**9,744**

Activity	Lifespan (years)	Area (m^2) - excluding support facilities	Wet Season Long Term Annual Average Rainfall (mm)	Annual Average Leachate (1% leaching of 60% of Precipitation) (mm)	Total Lifespan Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Max 24 hr Leachate (1% leaching of 60% of Precipitation) (mm)	Max 24 hr Volume (m^3)
Operation of Landfill - leachate[7]	50	56,250	195	1.17	3,291	244	1.464	**82**
TOTAL					**3,291**			**82**

Table F2.4 Project Affected Water – Landfill <1200 ppt> Ex Situ TCH

TOTAL VOLUME (m^3)	**93,458**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $$Q = \frac{dh}{dl} K A$$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

[7] Leachate generation estimated at zero during the dry season, ~ 60% of precipitation during the wet season appears as leachate (Visvanathan C., Trankler, P. Kuruparan, Q. Xiaoning 2003).

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

Table F2.5 Project Affected Water – Incineration

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	2	191,400	0.7	--	195	52,252.2	--	--	244	46,702
Equipment, Facilities, and Project Area Setup - Dry Season	2	2	191,400	0.3	21.7	--	2,492.0	60	3,445	--	--
Incineration Equipment Installation - Wet Season	1	1	5,000	0.7	--	195	682.5	--	--	244	1,220
Incineration Equipment Installation - Dry Season	5	5	5,000	0.3	21.7	--	162.8	60	90	--	--
Excavation and Stockpiling of Material	39	9.75	522,400	0.3	21.7	--	33,158.0	61	9,560	--	--
Contaminated Soil Stockpile Areas (2) - Wet Season	27	27	10,000	0.7	--	195	36,855.0	--	--	244	2,440
Contaminated Soil Stockpile Areas (2) - Dry Season	34	34	10,000	0.2	21.7	--	1,475.6	60	120	--	--
Incinerator Operation at Pacer Ivy - Wet Season	17	18	5,000	0.7	--	195	12,285.0	--	--	244	1,220
Incinerator Operation at Pacer Ivy - Dry Season	18	18	5,000	0.3	21.7	--	585.9	60	90	--	--
Incinerator Operation at Z1 - Wet Season	10	10	5,000	0.7	--	195	6,825.0	--	--	244	1,220
Incinerator Operation at Z1 - Dry Season	16	16	5,000	0.3	21.7	--	520.8	60	90	--	--
TOTAL							**147,295**		**13,395**		**52,802**

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	Volume $_{min}$ (m^3)	Volume $_{max}$ (m^3)
Excavation and Stockpiling of Material	522,400	130,600	39	293	1446	1.2	0.1	145	1.42	19	0.0004	0.08	1.10	24.02	321.34

Table F2.5 Project Affected Water – Incineration

	Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
	Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL					**9,744**

TOTAL VOLUME (m^3)	**157,360**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl} KA$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

Table 2.6 Project Affected Water – Ex Situ TCH

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	2	175,450	0.7	--	195	47,897.9	--	--	244	42,810
Equipment, Facilities, and Project Area Setup - Dry Season	2	2	175,450	0.3	21.7	--	2,284.4	60	3,158	--	--
Pacer Ivy - Ex Situ TCH System Construction - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
Pacer Ivy - Ex Situ TCH System Construction - Dry Season	6	6	11,475	0.3	21.7	--	448.2	60	207	--	--
Pacer Ivy - Ex Situ TCH Excavation and Hauling of Material	20	5	261,200	0.3	21.7	---	8,502.1	60	4,702	--	--
Pacer Ivy - Maintenance of Temporary Stockpiles - Wet Season	1	1	12,438	0.7	--	195	1,697.8	--	--	244	3,035
Pacer Ivy - Maintenance of Temporary Stockpiles - Dry Season	20	20	12,438	0.3	21.7	---	1,619.4	60	224	--	--
Pacer Ivy - Ex Situ TCH Filling the Pile - Wet Season	1	1	11,475	0.7	--	195	1,566.3	--	--	244	2,800
Pacer Ivy - Ex Situ TCH Filling the Pile - Dry Season	15	15	11,475	0.3	21.7	---	1,120.5	60	207	--	--
Pacer Ivy - Ex Situ TCH Capping and Completing the Pile - Wet Season	4	4	11,475	0.7	--	195	6,265.4	--	--	244	2,800
Pacer Ivy - Ex Situ TCH Capping and Completing the Pile - Dry Season	20	20	11,475	0.3	21.7	--	1,494.0	60	207	--	--
Pacer Ivy - Ex Situ TCH Thermal Treatment - Wet Season	4	4	11,475	0.7	--	195	6,265.4	--	--	244	2,800
Pacer Ivy - Ex Situ TCH Thermal Treatment - Dry Season	20	20	11,475	0.3	21.7	--	1,494.0	60	207	--	--
Pacer Ivy - Ex Situ TCH Pile Unloading - Wet Season	12	12	11,475	0.7	--	195	18,796.1	--	--	244	2,800
Z1 - Ex Situ TCH System Construction - Wet Season	2	2	11,475	0.7	--	195	3,132.7	--	--	244	2,800
Z1 - Ex Situ TCH System Construction - Dry Season	6	6	11,475	0.3	21.7	--	448.2	60	207	--	--

Table 2.6 Project Affected Water – Ex Situ TCH

	Z1 - Ex Situ TCH Excavation and Hauling of Material	20	5	261,200	0.3	21.7	---	8,502.1	60	4,702	--	--
	Z1 - Maintenance of Temporary Stockpiles - Wet Season	1	1	12,438	0.7	--	195	1,697.8	--	--	244	3,035
	Z1 - Maintenance of Temporary Stockpiles - Dry Season	20	20	12,438	0.2	21.7	---	1,079.6	60	149	--	--
	Z1 - Ex Situ TCH Filling the Pile - Wet Season	1	0.25	11,475	0.7	--	195	391.6	--	--	244	2,800
	Z1 - Ex Situ TCH Filling the Pile - Dry Season	15	15	11,475	0.3	21.7	---	1,120.5	60	207	--	--
	Z1 - Ex Situ TCH Capping and Completing the Pile - Wet Season	4	4	11,475	0.7	--	195	6,265.4	--	--	244	2,800
	Z1 - Ex Situ TCH Capping and Completing the Pile - Dry Season	20	20	11,475	0.3	21.7	--	1,494.0	60	207	--	--
	Z1 - Ex Situ TCH Thermal Treatment - Wet Season	4	4	11,475	0.7	--	195	6,265.4	--	--	244	2,800
	Z1 - Ex Situ TCH Thermal Treatment - Dry Season	20	20	11,475	0.3	21.7	--	1,494.0	60	207	--	--
	Z1 - Ex Situ TCH Pile Unloading - Wet Season	12	12	11,475	0.7	--	195	18,796.1	--	--	244	2,800
TOTAL								**153,271**		**14,587**		**76,879**

Table 2.6 Project Affected Water – Ex Situ TCH

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	$Volume_{min}$ (m^3)	$Volume_{max}$ (m^3)
Pacer Ivy - Ex Situ TCH Excavation and Hauling of Material	261,200	65,300	20	150	1022	1.2	0.1	102	1.42	19	0.0004	0.06	0.78	8.71	116.53
Z1 - Ex Situ TCH Excavation and Hauling of Material	261,200	65,300	20	150	1022	1.2	0.1	102	1.42	19	0.0004	0.06	0.78	8.71	116.53

Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL				**9,744**

TOTAL VOLUME (m^3)	**163,248**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl} K A$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

Table F2.7 Project Affected Water – MCD

Activities Affected by Precipitation	Total Duration (months)	Duration Exposed (months)[1]	Exposed Area (m^2)	Runoff Coefficient (C)	Dry Season Long Term Monthly Average Rainfall (mm)	Wet Season Long Term Monthly Average Rainfall (mm)	Volume (m^3)	Dry Season Max 24 hr Rainfall (mm)	Dry Season Max 24 hr Volume (m^3)	Wet Season Max 24 hr Rainfall (mm)	Wet Season Max 24 hr Volume (m^3)
Equipment, Facilities, and Project Area Setup - Wet Season	2	2	76,400	0.7	--	195	20,857.2	--	--	244	18,642
Equipment, Facilities, and Project Area Setup - Dry Season	2	2	76,400	0.3	21.7	--	994.7	60	1,375	--	--
Excavation of Contaminated Materials - Wet Season	7	1.75	522,400	0.7	--	195	124,788.3	--	--	244	127,466
Excavation of Contaminated Materials - Dry Season	42	10.5	522,400	0.3	21.7	--	35,708.7	60	9,403	--	--
MCD Treatment - Wet Season	35	35	5,000	0.7	--	195	23,887.5	--	--	244	1,220
MCD Treatment - Dry Season	14	14	5,000	0.3	21.7	--	455.7	60	90	--	--
Contaminated Soil Stockpile Area - Wet Season	35	35	10,000	0.7	--	195	47,775.0	--	--	244	2,440
Contaminated Soil Stockpile Area - Dry Season	14	14	10,000	0.2	21.7	--	607.6	60	120	--	--
System O&M - Wet Season	6	6	5,000	0.7	--	195	4,095.0	--	--	244	1,220
System O&M - Dry Season	6	6	5,000	0.3	21.7	--	195.3	60	90	--	--
TOTAL							**259,365**		**11,078**		**150,987**

Activities Affected by Groundwater Seepage[1]	Total Excavation Area (m^2)	Max Open Excavation (m^2)[1]	Total Duration (months)	Duration Exposed (days)[1]	Total Length of Open Excavation Perimeter[2] (m)	Proposed Excavation Depth Below Ground (m)	Thickness of Excavation Subject to Inflow (m)	Cross Sectional Area (A) (m^2)	K_{min} (m/d)[3]	K_{max} (m/d)[3]	dh/dl[4]	Q_{min} (m^3/d)[5]	Q_{max} (m^3/d)[5]	$Volume_{min}$ (m^3)	$Volume_{max}$ (m^3)
Excavation of Contaminated Materials, Air Drying & Preliminary Heat Drying - Wet Season	522,400	130,600	7	53	1446	1.2	0.1	145	1.42	19	0.0004	0.08	1.10	4.31	57.68
Excavation of Contaminated Materials, Air Drying & Preliminary Heat Drying - Dry Season	522,400	130,600	42	315	1446	1.2	0.1	145	1.42	19	0.0004	0.08	1.10	25.86	346.06

Table F2.7 Project Affected Water – MCD

Activity	Sediment Total Volume (V) (m^3)	Initial Saturation (S)	Porosity Volume (Vv) (m^3)	Volume Water (Vw) (m^3)
Sediment Excavation[6]	92800	30%	32,480	9,744
TOTAL				**9,744**

TOTAL VOLUME (m^3)	**269,513**

[1] Assuming 1/4 of the total excavation area is open for 1/4 of the total excavation duration

[2] To calculate the worst case, inflows were modeled to occur through the total length of open excavation perimeter.

[3] Hydraulic conductivity (K) values for the shallow aquifer on the Airbase have not been validated in terms of the location of wells tested or how the k values were calculated. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[4] Hydraulic gradient (dh/dl) - no shallow groundwater elevations measurements were available. Ground elevation data was also unavailable. For the purpose of these calculations, groundwater flow is assumed to follow a 2 m difference in topographic elevation. An estimate of ground surface gradient was calculated at 0.0004. Subsurface hydraulic gradient was assumed to be the same at 0.0004. The values used here were used in the Da Nang Environmental Assessment and are expected to be the same in Bien Hoa given similar soil types and precipitation patterns.

[5] $Q = \frac{dh}{dl} KA$ Q is the total groundwater discharge (m^3/d)

[6] Degree of saturation (S) = volume of water (Vw)/porosity volume (Vv), where Vv = volume of water (Vw) + volume of air (Va). Values provided by Terratherm IPTD-ISTD Cost Estimate, 5-Jan-2010. Porosity (n) = Vv/V, where n = 0.35

Please refer to section 5.2.1 in the main Environmental Assessment document for rainfall data.

APPENDIX G

RESULTS OF ADDITIONAL SAMPLING PERFORMED BY AMST, DECEMBER 2015 TO JANUARY 2016

SUMMARY OF ANALYSES RESULTS ON ADDITIONAL SAMPLES
BIEN HOA AIRBASE

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ_{2005} (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
I	**Area VN01 (NW-5)**				
1	VN01A (0-30)	Land	40.16	41.408	97.0
2	VN01A (30-60)	Land	4.9	5.104	96.0
3	VN01A (60-90)	Land	2.92	3.089	94.5
4	VN01B (0-30)	Land	35.08	37.114	94.5
5	VN01B (30-60)	Land	20.41	21.314	95.8
6	VN01B (60-90)	Land	170	172.86	98.3
7	VN01C (0-30)	Land	179.47	183.86	97.6
8	VN01C (30-60)	Land	82.65	85.490	96.7
9	VN01C (60-90)	Land	16.4	16.825	97.5
10	VN01MIS (0-30)	Land	111.09	113.59	97.8
11	VN01MIS (30-60)	Land	34.24	35.803	95.6
12	VN01MIS (60-90)	Land	65.85	67.179	98.0
	Avg. surface (n=3)		84.9	87.46	96.4
	Avg. layer 2 (n=3)		35.99	37.3	96.1
	Avg. layer 3 (n=3)		63.11	64.26	96.8
II	**VN02 (Piot Houses)**				
13	VN02A (0-30)	Land	16.67	22.62	73.7
14	VN02A (30-60)	Land	10.12	20.404	49.6
15	VN02B (0-30)	Land	15.25	18.888	80.7
16	VN02B (30-60)	Land	5.22	10.914	47.8
17	VN02C (0-30)	Land	14.85	19.158	77.5
18	VN02C (30-60)	Land	3.51	5.904	59.5
19	VN02D (0-30)	Land	31.98	39.742	80.5
20	VN02D (30-60)	Land	5.02	7.827	64.1
21	VN02E (0-30)	Land	52.49	61.559	85.3
22	VN02E (30-60)	Land	3.67	5.411	67.8

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ_{2005} (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
23	VN02F (0-30)	Land	37.98	44.93	84.5
24	VN02F (30-60)	Land	10.32	24.111	42.8
25	VN02G (0-30)	Land	36.76	41.063	89.5
26	VN02G (30-60)	Land	4.77	6.602	72.3
27	VN02H (0-30)	Land	36.64	39.953	91.7
28	VN02H (30-60)	Land	9.93	12.05	82.4
29	VN02I (0-30)	Land	40.8	58.536	69.7
30	VN02I (30-60)	Land	7.99	11.534	69.3
31	VN02J (0-30)	Land	17.53	40.478	43.3
32	VN02J (30-60)	Land	11.74	27.192	43.2
	Avg. surface (n=10)		30.1	38.69	77.8
	Avg. layer 2 (n=10)		7.23	13.19	54.8
III	**Area VN03 (SW-5)**				
33	VN03A (0-30)	Land	115.66	138.7	83.4
34	VN03A (30-60)	Land	36.58	52.643	69.5
35	VN03A (60-90)	Land	40.76	63.069	64.6
36	VN03B (0-30)	Land	30.09	50.92	59.1
37	VN03B (30-60)	Land	14.77	24.228	61.0
38	VN03C (0-30)	Land	32.86	54.828	59.9
39	VN03C (30-60)	Land	9.81	21.333	46.0
40	VN03C (60-90)	Land	2.84	5.912	48.0
41	VN03MIS (0-30)	Land	65.1	87.961	74.0
42	VN03MIS (30-60)	Land	23.86	39.21	60.9
43	VN03MIS (60-90)	Land	22.14	36.455	60.7
	Avg. surface (n=3)		51.19	81.48	62.8
	Avg. layer 2 (n=3)		20.39	32.73	62.3
	Avg. layer 3 (n=2)		21.8	34.49	63.2
IV	**Area VN04 (ZT-3)**				
44	VN04A (0-30)	Land	42.25	42.51	99.4

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ_{2005} (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
45	VN04A (30-60)	Land	3.05	3.369	90.5
46	VN04A (60-90)	Land	1.63	1.753	93.0
47	VN04B (0-30)	Land	14.6	15.006	97.3
48	VN04B (30-60)	Land	0.98	1.194	82.1
49	VN04C (0-30)	Land	11.94	12.25	97.5
50	VN04C (30-60)	Land	13.36	13.611	98.2
51	VN04MIS (0-30)	Land	13.89	14.159	98.1
52	VN04MIS (60-90)	Land	1.92	2.081	92.3
	Avg. surface (n=4)		20.67	20.98	98.5
	Avg. layer 2 (n=3)		5.8	6.06	95.7
	Avg. layer 3 (n=2)		1.78	1.92	92.7
V	**Area VN05 (Z1-14) (Petroleum Storage)**				
53	VN05A (0-30)	Land	46.39	58.45	79.4
54	VN05A (30-60)	Land	58.98	86.136	68.5
55	VN05A (60-90)	Land	49.89	108.93	45.8
56	VN05B (0-30)	Land	187.27	322.3	58.1
57	VN05B (30-60)	Land	207.33	323.81	64.0
58	VN05B (60-90)	Land	80.79	142.77	56.6
59	VN05C (0-30)	Land	65.15	95.485	68.2
60	VN05C (30-60)	Land	42.17	67.024	62.9
61	VN05C (60-90)	Land	51.57	84.931	60.7
62	VN05MIS (0-30)	Land	106.04	162.53	65.2
63	VN05MIS (30-60)	Land	72.72	131.64	55.2
64	VN05MIS (60-90)	Land	57.78	105.6	54.7
	Avg. surface (n=3)		99.6	158.75	62.7
	Avg. layer 2 (n=3)		102.83	158.99	64.7
	Avg. layer 3 (n=3)		60.75	112.21	54.1
VI	**Area VN06 (Z1-15)**				
65	VN06A (0-30)	Land	32.16	58.608	54.9

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ2005 (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
66	VN06A (30-60)	Land	5.65	28.585	19.8
67	VN06B (0-30)	Land	2.09	3.154	66.3
68	VN06C (0-30)	Land	3.04	11.073	27.5
69	VN06MIS (0-30)	Land	30.11	41.309	72.9
70	VN06MIS (30-60)	Land	3.43	14.295	24.0
71	VN06MIS (60-90)	Land	3.21	11.538	27.8
	Avg. surface (n=4)		12.43	24.28	51.2
VII	**Area VN07 (Radar Station 51)**				
72	VN07A (0-30)	Land	49.56	52.387	94.6
73	VN07B (0-30)	Land	14.25	15.713	90.7
74	VN07C (0-30)	Land	14.98	15.843	94.6
75	VN07D (0-30)	Land	17.11	19.175	89.2
76	VN07E (0-30)	Land	15.6	16.268	95.9
77	VN07F (0-30)	Land	53.97	62.195	86.8
78	VN07F (30-60)	Land	2.31	2.595	89.0
79	VN07G (0-30)	Land	18.22	20.122	90.5
80	VN07H (0-30)	Land	8.8	9.314	94.5
81	VN07I (0-30)	Land	57.31	61.494	93.2
82	VN07I (30-60)	Land	3.4	3.743	90.8
83	VN07J (0-30)	Land	9.33	10.42	89.5
	Avg. surface (n=10)		25.91	28.29	91.6
	Avg. layer 2 (n=2)		2.86	3.17	90.2
VIII	**Area VN08 (Residence along Airbase wall)**				
84	VN08A (0-30)	Land	20.33	24.536	82.9
85	VN08B (0-30)	Land	61.38	71.43	85.9
86	VN08B (30-60)	Land	7.17	9.043	79.3
87	VN08C (0-30)	Land	9.09	14.035	64.8
88	VN08D (30-60)	Land	10.47	11.453	91.4
89	VN08E (0-30)	Land	11.24	42.786	26.3

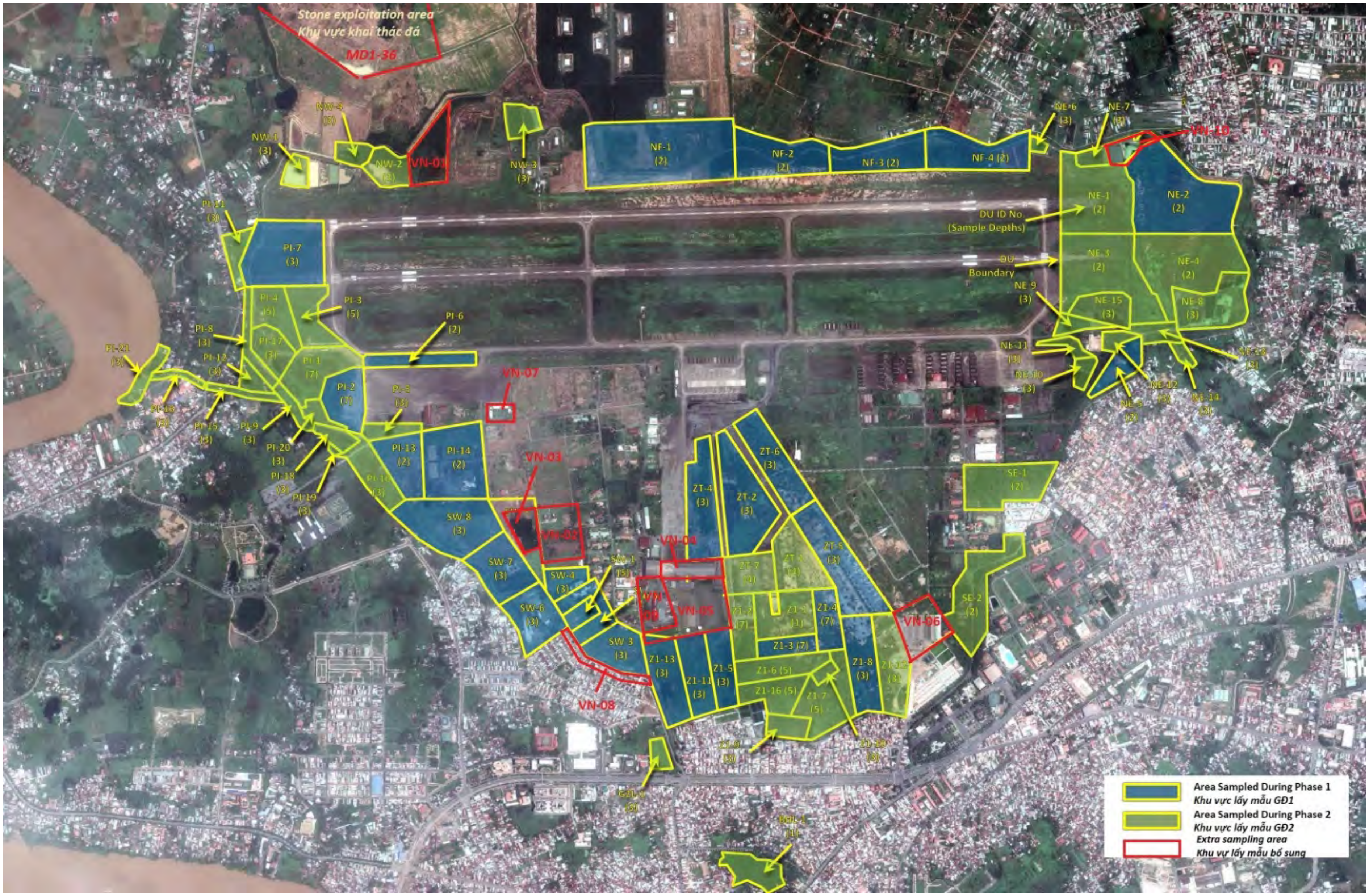
No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ_{2005} (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
90	VN08F (0-30)	Land	6.13	13.432	45.6
91	VN08G (0-30)	Land	8.52	42.892	19.9
92	VN08G (30-60)	Land	12.08	33.022	36.6
93	VN08H (0-30)	Land	2.64	6.216	42.5
94	VN08I (0-30)	Land	167.39	215.06	77.8
95	VN08I (60-90)	Land	51.58	52.268	98.7
96	VN08J (0-30)	Land	60.09	97.667	61.5
97	VN08J (30-60)	Land	31.9	55.789	57.2
	Avg. surface (n=10)		70.74	89.66	78.9
	Avg. layer 2 (n=5)		80.78	92.73	87.1
IX	**Area VN09 (Petrol)**				
98	VN09A (0-30)	Land	8.65	9.478	91.3
99	VN09B (0-30)	Land	25.33	88.028	28.8
100	VN09C (0-30)	Land	69.61	90.433	77.0
101	VN09C (30-60)	Land	6.48	7.677	84.4
102	VN09D (0-30)	Land	12.72	14.352	88.6
103	VN09E (0-30)	Land	42.47	93.049	45.6
104	VN09E (30-60)	Land	11.67	29.08	40.1
105	VN09F (0-30)	Land	37.74	56.89	66.3
106	VN09F (30-60)	Land	1.67	4.294	38.9
107	VN09G (0-30)	Land	39.07	86.602	45.1
108	VN09G (30-60)	Land	2.88	5.26	54.8
109	VN09H (0-30)	Land	0.74	0.913	81.1
	Avg. surface (n=8)		29.54	54.97	53.7
	Avg. layer 2 (n=4)		5.68	11.58	49.1
X	**Area VN10 (NE-16)**				
110	VN10A (0-30)	Land	7.1	8.623	82.3
111	VN10B (0-30)	Land	7.33	9.055	80.9
112	VN10C (0-30)	Land	20.13	25.617	78.6

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ2005 (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
113	VN10MIS (0-30)	Land	11.44	14.269	80.2
114	VN10MIS (30-60)	Land	7.23	9.397	76.9
115	VN10MIS (60-90)	Land	7.87	9.725	80.9
	Avg. surface (n=3)		11.52	14.43	79.8
XI	**Area MĐ2 quarry**				
A	**Results from Round 1**				
116	MD1 (0-30)	Land	29.02	32.18	90.2
117	MD1 (30-60)	Land	7.77	8.937	86.9
118	MD1 - KS (670-700)	Land	0.155	0.331	46.8
119	MD2A (0-30)	Land	0.84	1.31	64.1
120	MD2 (30-60)	Land	2.61	3.055	85.4
121	MD2 (60-90)	Land	0.01	0.079	12.7
122	MD3 (0-30)	Land	0.48	0.721	66.6
123	MD3 (30-60)	Land	0.07	0.361	19.4
124	MD3 - KS (1070-100)	Land	0.01	0.073	13.7
125	MD4 (0-30)	Land	0.98	1.725	56.8
126	MD4 (30-60)	Land	0.66	0.747	88.4
127	MD4 (60-90)	Land	0.09	0.154	58.4
128	MD5 (0-30)	Land	3.61	4.144	87.1
129	MD5 (30-60)	Land	0.6	0.772	77.7
130	MD5 (60-90)	Land	0.035	0.106	33.0
131	MD6 (0-30)	Land	14.49	34.57	41.9
132	MD6 (30-60)	Land	0.35	0.692	50.6
133	MD6A - KS (2370-2400)	Land	0.01	0.116	8.6
134	MD7 (0-30)	Land	0.2	0.495	40.4
135	MD7 (30-60)	Land	0.48	0.571	84.1
136	MD7 - KS (2270-2300)	Land	0.25	0.404	61.9
137	MD8 (0-30)	Land	1.130	1.632	69.2
138	MD8A (30-60)	Land	0.045	0.453	9.9
139	MD8 (60-90)	Land	0.07	0.132	53.0

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ2005 (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
140	MD9 (0-30)	Land	0.71	4.295	16.5
141	MD9 (30-60)	Land	0.39	0.943	41.4
142	MD9 - KS (1670-1700)	Land	0.14	0.287	48.8
143	MD10 (0-30)	Land	0.48	1.759	27.3
144	MD10 (30-60)	Land	0.115	0.782	14.7
145	MD10 - KS (470-500)	Land	0.29	0.659	44.0
146	MD - Đ01B	Surface	0.2	0.276	72.5
147	MD - Đ02	Surface	0.42	0.524	80.2
148	0815BHKK01	Air	0.002	0.063	3.2
149	0815BHKK02	Air	0.009	0.213	4.2
	Avg. surface: 0-30cm (n=10)		5.190	8.283	62.7
	Avg. layer 2: 30-60cm (n=10)		1.31	1.731	75.7
	Avg. layer 3: 60-90cm (n=4)		0.05	0.118	42.4
	Avg. deepest layer (n=6)		0.14	0.312	44.9
	Avg. Surface (n=2)		0.31	0.4	77.5
	Avg. Air (n=2)		0.006	0.138	4.3
B	**Results from Round 2**				
150	MĐ2A (0-30)	Land	11.5	12.432	92.5
151	MĐ2B (0-30)	Land	5.93	6.437	92.1
152	MĐ2C (0-30)	Land	21.45	22.047	97.3
153	MĐ2D (0-30)	Land	1.85	3.059	60.5
154	MĐ2E (0-30)	Land	5.43	5.537	98.1
155	MĐ2F (0-30)	Land	5.95	6.163	96.5
156	MĐ2G (0-30)	Land	15.38	15.626	98.4
157	MĐ2H (0-30)	Land	5.2	5.311	97.9
158	MĐ2I (0-30)	Land	13.47	14.365	93.8
159	MĐ2J (0-30)	Land	8.38	8.72	96.1
	Avg. surface (n=10)		9.45	9.97	94.8
XII	**MIS**				
160	VN07MIS (0-30)	Land	26.47	28.576	92.6

No.	Location	Sample Type	Concentration 2,3,7,8-TCDD (pg/g) (ND = ½ DL)	WHO-TEQ2005 (pg/g) (ND = ½ DL)	Proportion of 2,3,7,8-TCDD/TEQ (%)
XIII	**Air Samples**				
161	KKMĐ-2	Air	0.116	0.172	67.4
162	KKMĐ-3	Air	0.048	0.092	52.2
163	KKVN08-1	Air	0.538	0.563	95.6
164	KKVN08-2	Air	0.054	0.091	59.3
165	KKVN08-3	Air	0.044	0.153	28.8
166	KKVN09-1	Air	0.171	0.218	78.4
167	KKVN02-1	Air	0.236	0.284	83.1
168	KKVN07-1	Air	0.158	0.198	79.8
	Avg. air samples (n=8)		0.17	0.22	68.1

Additional Sampling Areas at Bien Hoa Airbase



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