Human Health Risk Assessment of Fugitive Dust and Surface Soils

PVT Landfill

O'ahu Hawai'i

(June 2005)

Prepared for:

Hawai'i State Department of Health
Hazard Evaluation and Emergency Response Office
919 Ala Moana Boulevard
Honolulu, Hawai'i 96814

Prepared by:
AMEC Earth and Environmental, Inc.
3375 Koapaka Street
Suite F-251
Honolulu, Hawai'i 96819

Executive Summary

This document presents the final Human Health Risk Assessment of contaminated soil disposal operations at PVT Landfill in Nanakuli, O'ahu, Hawai'i. The purpose of the study was to determine if fugitive dust from soil delivery or soil disposal at the landfill pose a long-term health risk to downwind residents. This assessment is based on a review of data at the landfill over the past 2 years. The conclusions of the study are based on the assumption that past and current landfill activities will be adequately representative of future activities. This includes an assumption that concentrations of chemicals of concern in soil disposed of at the landfill will be similar to or lower to those assumed in this study. This also assumes that dust control measures will be adequate to prevent a significant, future increase in fugitive dust levels in the landfill area and in downwind areas.

The results of this evaluation and risk assessment indicate activities associated with contaminated soil disposal do not pose a significant health risk to residents in the nearby community. The study considered 1) potential soil impacts to residential access roads during contaminated soil delivery, 2) potential soil impacts via wind dispersion during disposal operations and 3) potential soil impacts via wind erosion of the landfill surface if contaminated deliveries are left uncovered following disposal.

Soil sampling performed at the entrance gate of the landfill indicate that residential neighborhood roads and soils which might be accessed prior to delivery to PVT are safe for residential contact. Analytical data from soil samples taken from the entrance gate area were far below their respective United States Environmental Protection Agency (USEPA) Region 9 Residential Soil Preliminary Remediation Goals (PRGs) (USEPA 2004a). USEPA Region 9 PRGs are risk-based concentrations in soil, tap water or ambient air that if not exceeded indicate that health effects are not likely to occur

Respirable dust concentrations were measured during disposal activities at PVT Landfill. PM_{10} was measured with personal DataRams during the disposal of 17 truckloads of soil and a single application of clean cover. The 8-hour air monitoring demonstration project was performed on May 25, 2005. The maximum average respirable dust concentration taken from the disposal floor was 53.4 $\mu g/m^3$ at location PDR.918. This value was used to estimate the amount of

respirable dust at receptor locations within the community using the USEPA approved SCREEN3 air dispersion model. The SCREEN3 air dispersion model is a simple screening model that determines if a source clearly poses an air quality problem. Although the model utilizes a relatively large degree of conservatism to ensure that maximum concentrations are not underestimated, a dilution of the source concentration at a distance away from the source is inherent to the model and expected. Assuming that the measured dust was generated from disposal activities, the estimated 1-hr maximum PM_{10} concentration in the community approximately ¼ mile away from the Site was 0.2251 $\mu g/m^3$. Based on the maximum average measured PM_{10} concentration over an 8-hr period (53.4 $\mu g/m^3$) and the estimated maximum concentration for an 8-hr period from the SCREEN3 model, 0.158 $\mu g/m^3$ [0.2251 $\mu g/m^3$ x 0.7 (adjustment factor for maximum 8-hr average)], the dilution attenuation factor ¼ mile downwind of the source area is 338. After applying a 0.2 adjustment factor (health protective adjustment factor which considers Hawaii-specific wind and meteorological conditions), the annual average respirable dust concentration is 0.045 $\mu g/m^3$ at a distance of ¼ mile away for dust generating activities. This annual average is significantly lower than the National Ambient Air Quality Standards (NAAQS) PM_{10} annual limit of 50 $\mu g/m^3$.

Respirable dust concentrations within the community were also estimated using the Unlimited Erosion model. This model assumes that soil is left uncovered and may be dispersed via wind erosion. It does not require measured dust concentrations. Instead the model generates an emission rate based on assumptions such as the fraction of vegetative cover and mean annual wind speed. Assuming that contaminated soil is left uncovered and dispersed by wind erosion, the estimated 1-hr maximum PM_{10} concentration ¼ mile from the Site was 0.00099 $\mu g/m^3$. After applying the 0.2 adjustment factor, the annual average respirable dust concentration is 0.0002 $\mu g/m^3$ at a distance of ¼ mile away for dust generating activities. This annual average is significantly lower than the NAAQS PM_{10} annual limit of 50 $\mu g/m^3$.

PM_{10} concentrations at receptor locations were then used in conjunction with the higher of the maximum chemical concentrations detected in previously delivered soils to PVT or the USEPA Region 9 Industrial soil PRGs to estimate chemical concentrations. Chemical concentrations at receptor location (Table 2-4) were compared to USEPA Region 9 Ambient Air PRGs to evaluate potential health effects via inhalation. All concentrations were below their respective PRGs.

Chemical concentrations at receptor locations were also used to estimate carcinogenic and noncarcinogenic risks. The risk assessment evaluated the health effects of 9 chemicals of potential concern, including arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver and PCBs. Risks posed by lead were evaluated separately using the California Department of Toxic Substances Control (DTSC) residential soil lead model which allows for the prediction of blood lead concentrations in adults and children.

Potential receptors evaluated were defined as adults and children residents who live in nearby residential neighborhoods approximately ¼ mile from the site. Exposures assumptions used in the risk assessment were extremely conservative and health protective. For example, it was assumed that all dust measured in the dust monitors was derived from contaminated soil. In reality, most of the observed dust was generated by truck traffic atop uncontaminated soil surfaces. In addition, the risk assessment assumed that residents were exposed to dust generated from disposal activities 24 hrs per day for either a 1 year or 30 year period (i.e., soil disposal operations were assumed to be continuous). Another health protective assumption assumed that contaminants in soil may be dispersed by wind (if left uncovered following disposal activities) and that receptors may be exposed to this fugitive dust 24 hrs per day for either a 1-year or 30-year period. The use of overly protective exposure assumptions was used to demonstrate that even under the conditions assumed in the risk assessment, risks were negligible. Had more realistic exposure assumptions been used, the risk would have been substantially lower.

Noncarcinogenic risk values for all receptors resulted in Hazard Indices orders of magnitude lower than the USEPA and HDOH regulatory level of concern of 1.0. Estimated carcinogenic risks ranged from 5E-08 to 1E-09. These do not exceed the Hawai'i Department of Health's regulatory benchmark for residential sites and are well below the USEPA's target risk range of 1E-04 to 1E-06.

Results of the final lead risk assessment indicate that the estimated 99th percentile blood lead level would be 0.7 and 1.7 micrograms lead per deciliter (µg Pb/dL) blood for the adult and child residents exposed to contaminated soil from the landfill. This is well below the acceptable benchmark level of 10 µg Pb/dL blood for children and females of childbearing age.

Additionally, the actual contribution of lead in blood from the landfill is less than 1% of the child's blood lead level.

The results of the risk assessment, based on site-specific measured data, demonstrate that the disposal of soil containing heavy metals and PCBs at previously accepted concentrations or their industrial PRGs (for PCBs, below 50 ppm) is an acceptable practice that does not compromise public health in any way.

1.0 INTRODUCTION

This document presents the results of a surface soil sampling investigation, a respirable dust air monitoring event and human health risk assessment (HHRA) of heavy metals and polychlorinated biphenyls (PCBs) at PVT Landfill on O'ahu, Hawai'i. The methodology and approach to this study have been previously described in the Sampling and Analysis Plan (AMEC 2005) and are discussed herein. Deviations from the sampling plan are noted in this report.

1.1 Site or Sampling area Location

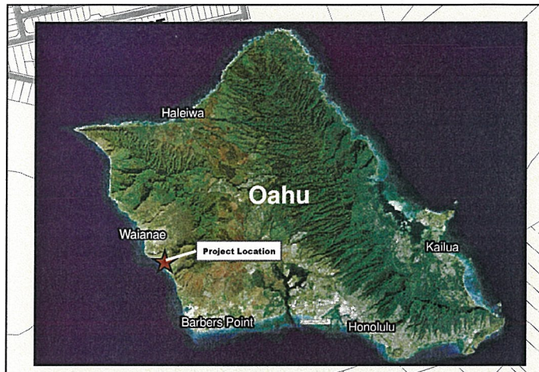
The PVT Landfill Site is located at 87-2020 Farrington Highway on the western side of the island of O'ahu, in Nanakuli, Hawai'i (Figure 1-1). The PVT Landfill Site consists of an irregularly shaped 15.44-acre parcel of land (Latitude/Longitude: 21º 23' 50" N/158º 09' 00"W). The Site is bounded by residential areas at its southern and western borders.

1.2 Responsible Agency

The Hawai'i State Department of Health (HDOH) has contracted AMEC Earth and Environmental (AMEC) under a non-emergency response contract (ASO Log No. 02-131) to conduct an assessment of human health impact from disposal activities of contaminated soil at PVT Landfill. AMEC is an environmental consulting company that has provided professional services to clients in Hawai'i for over ten years. AMEC's technical staff includes geologists, engineers, toxicologists, and biologists.

1.3 Project Organization

Organization/Responsibility	Name	Phone Number
PVT Project Manager	Albert Shigemura	808-668-4561
HDOH Project Manager	Barbara Brooks	808-586-4249
AMEC Project Manager	Russell Okoji	808-545-2462



KUUALOHA RD
KAPIKI RD
ULEHAWA RD
HAKIMO RD
KAUKAI RD
KANAHALE RD
KALEIWOHI ST
AKOWAI RD
LUALEI PL
WAIOLU ST
PUALEILANI ST
LAIKU ST
LAANUI ST
Ulehawa Stream
LUALUALEI NAVAL RD
Nanakuli Stream

Project Location

PVT Landfill Site
TMK: 87009025

MOHIHI PL
MOHIHI ST
KAHAU ST
HOLOPONO ST
HOLOMALIA PL
AUYONG HMSTD RD
MAALOA ST
MAIA ST
MIKANA ST
FARRINGTON HWY
NANAIKEOLA ST
HELELUA ST
HALEAKALA AVE
MANO AVE
KAUWAHI AVE
KAWAO AVE
PILILAAU AVE
MAIAPOLUA PL
NANAKULI AVE
PALIKEA ST
MOKIAWE ST
OPUHE ST
PUAKOLU ST
ULEI LP
LAHIKIOLA PL
NANAIKALA ST
NANIAHIAHI ST

0 500 1,000 2,000 Feet

N

PVT Landfill: Project Location

Source: Base GIS Data from State of Hawaii, Hawaii GIS Program

amec

W.O.	325190008
DESIGN	LRK
DRAWN	LRK
DATE	06/23/2005

FIGURE 1-1
PVT LANDFILL
87-2020 FARRINGTON HWY
WAIANAE, HAWAII 96792

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1.4 Statement of Specific Problem

The PVT Landfill is a permitted facility for the disposal of construction and demolition waste (C&D waste). Contaminated C&D waste such as non-Toxic Substances Control Act (TSCA) regulated PCB-containing soils or other contaminated soils may be accepted for disposal provided such materials are not regulated hazardous waste or TSCA regulated waste. The PVT permit further states that contaminated soils may be used as daily cover if analyses indicate they are under the current USEPA Region 9 Industrial PRGs and the TPH requirements described below.

TPH-gasoline 2000 ppm
TPH (middle distillates and residual fuels) 5000 ppm
Above 5000 ppm may be accepted with written approval from HDOH

Although PVT Landfill does reserve the right to refuse contaminated soils, the permit also stipulates additional operational conditions for disposal of contaminated soil. In addition to the requirements previously described (i.e., must not be a regulated hazardous waste and must not be TSCA-regulated waste) other stipulations include, but are not limited to, covering incoming truckloads, dust control measures and cut off periods during high wind condition.

The current air and soil sampling efforts are being conducted to validate that the permit conditions adequately protect offsite residents. This study addresses issues related to the potential health effects associated with landfilling heavy metal contaminated soil. Specific issues include the health impact of contaminated respirable dust generation during disposal events at neighborhood locations and the health impact of soil spilled on roadways in the community during transport activities.

1.5 Study Objective

The purpose of this study is to determine if fugitive dust from soil delivery or soil disposal operations at the landfill pose a long-term health risk to nearby residents.

1.6 Approach

The investigation adopted a 4-phased approach. Each phase or task was relevant to the primary goal of determining the health effects of disposal activities associated with potentially contaminated soil. Study tasks are presented in order of conduct and are discussed in detail in Sections 2 through 5.

- Pre-meetings (Section 2.1)
  - AMEC and HDOH staff convened with PVT Landfill representatives to discuss sampling dates and locations.

- Ambient Air Monitoring (Section 2.2)
  - Respirable dust concentrations (PM_{10}) were measured at 2 upwind and 2 downwind locations during a single multiple load soil disposal event. Approximately 17 soil loads from 0800 to 1630 HST were monitored.
  - Meteorological data including wind direction and velocity was provided to AMEC by PVT Landfill for the sampling day as well as for the time period January 2001 through May 2005. Average wind speed and direction were considered for use in air dispersion model.

- Surface Soil Sampling (Section 2.3)
  - Surface soil samples from the PVT side of the entrance gate of PVT Landfill were collected and analyzed for the eight Resource Conservation and Recovery Act (RCRA) metals and PCBs. Soil impacts at the entrance gate are assumed to be equivalent to impacts at areas adjacent to the delivery access road.

- Human Health Risk Assessment (Section 2.4)
  - Soil samples collected from the entrance to PVT Landfill were compared to USEPA Region 9 Residential PRGs. USEPA Region 9 PRGs are preliminary goals that if are not exceeded indicates little potential for health risks in a residential setting.

- Respirable particulate data were used in conjunction with soil analytical data (collected by PVT Landfill from June 2003 to present) to estimate concentrations at specific receptor locations in the adjacent community. Soil analytical data collected by PVT encompasses data of all contaminated soil disposed of at PVT during the permitted years. Utilization of historical data ensures that soil concentrations from many events are considered in the assessment. If analytical data was not available for any analyte USEPA Region 9 Industrial Soil PRGs were used. Potential health risks via the inhalation pathway were estimated for adult and child residents. Respirable dust concentrations were modeled to the nearest residential receptor approximately ¼ mile from disposal site. Risks were estimated assuming health protective exposure assumptions as described.

2.0 RESULTS

This section details the results of the investigation at PVT Landfill. It is organized according to the study tasks set forth in Section 1.6.

2.1 Pre-meetings

It was assumed that PVT Landfill would not have extensive notice prior to soil disposal events. Due to the difficulty in coordinating the 4 proposed monitoring events within the short time period of the study, 2 pre-meetings between representatives of AMEC, PVT Landfill and HDOH were required. *Note: Due to a lack of soil deliveries to PVT Landfill, only a single disposal event was monitored.* Pre-meetings prepared PVT Landfill staff for AMEC presence, ensured the availability of AMEC field personnel for the proposed air monitoring events, permitted the confluence of schedules and ensured all were in agreement with potential monitoring locations and health and safety issues.

Issues addressed and agreed upon during pre-meetings included:

- PVT would provide AMEC with a minimum of 2 days notice prior to field investigation.
- Location of disposal activity – AMEC personnel would monitor both at disposal level as well as at the perimeter of the working face approximately 50 feet above disposal activities.
- PVT Landfill disposal protocols.
- Health and safety – Both AMEC and PVT Landfill Health and Safety procedures would be followed.
- PVT would provide AMEC with contaminant data of all previously accepted waste for use in the human health risk assessment.
- PVT would provide AMEC with all recent meteorological data for use in the human health risk assessment.
- PVT would provide AMEC with GPS points for all air monitoring locations.
- PVT would provide access to AMEC to sample surface soils at the entrance of the landfill.

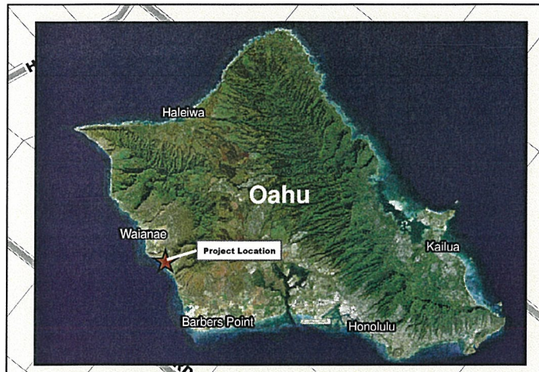
2.2 Ambient Air Monitoring

The human health risk assessment for the PVT Landfill required available respirable dust data associated with disposal of potentially contaminated soil. Several activities associated with disposal operations at the PVT Landfill have the potential to create fugitive dust and were therefore monitored. The activities during which PM_{10} monitoring was performed included:

- delivery of potentially contaminated soils for landfill
- pushing and compacting newly delivered soils
- pushing and compacting daily cover over newly delivered soils

To capture the heterogeneity of delivered materials over time, the study protocol called for the evaluation of dust generated by 4 separate and distinct soil disposal events. During the 6-month study time period, however, PVT received only one consignment of soil (approximately 1900 tons of sand blast grit material). For the purposes of this assessment, this single event, albeit multiple dumping events, was assumed to be representative of historical and future soil deliveries to PVT and adequate for evaluating risk to residential neighborhoods in the area. Representativeness was based on several criteria: 1) the disposal was of large volume, 2) the disposal event utilized multiple truckloads over an approximately 8-hour time period (sufficient to evaluate the dust generating potential of soil disposal), 3) the delivered sand blast grit consisted of a range of particle sizes including those less than 10 µm in diameter, the particle size fraction relevant to respiration, 4) pushing, compacting and the application of soil cover was of sufficient time to evaluate dust generation potential of these activities. Pushing, compacting and applying clean cover was completed in about 1 hour.

Respirable dust (PM_{10}) dust concentrations in ambient air were monitored upwind and downwind of soil delivery and disposal areas. GPS locations of air monitoring locations are provided in Figure 2-1. General designations for sampling locations include: UP (upwind perimeter of the soil delivery pit), DP (downwind perimeter of the soil delivery pit), UD (upwind at disposal level), DD (Downwind at disposal level). Monitoring was conducted for the length of the disposal activity (includes soil dumping, pushing and compacting soil and applying clean cover) from 0800 to approximately 1630 HST. Respirable dust (PM_{10}) data was not collected after contaminated soil was covered by daily cover.



KAPIKI RD

Ulehawa Stream

Ulehawa Stream

Ulehawa Stream

Sampling Area
(See Inset 1)

PVT Landfill Site
TMK: 87009025

KAHAU ST

HOLOPONO ST

MOHIHI ST

HOLOMALIA PL

AUYONG HMSTD RD

MAALOA ST

MAIA ST

MIKANA ST

LUALUALEI NAVAL RD

0 250 500 1,000 Feet

INSET 1: SAMPLE LOCATIONS

ULEHAWA RD

Ulehawa Stream

Ulehawa Stream

Ulehawa Stream

pDR.1043 DP
(Perimeter Monitoring Location)

pDR.AMEC UP
(Perimeter Monitoring Location)

pDR.1135 UD
(NOTE: This was a moving sample taken at disposal level to capture dust plume)

pDR.918 DD
(Disposal Level Location)

0 75 150 300 Feet

N

Air Sampling Locations

Source: Base GIS Data from State of Hawaii, Hawaii GIS Program

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DRAWN	LRK
DATE	06/23/2005

FIGURE 2-1
PVT LANDFILL
87-2020 FARRINGTON HWY
WAIANAE, HAWAII 96792

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PM_{10} data were collected using 4 Personal Data Rams (PDR) to represent respirable dust concentrations associated with the above listed specific activities. Model PDR-1000 Particulate Monitor (MIE, Inc., Bedford, MA) is a direct reading personal aerosol monitor that measures mass concentrations of dust, smoke, mists, and fumes in real-time. The instrument sensitivity ranges between 0.001 - 400 mg/m^3. The instrument was zeroed using filtered air. 15-second average measurements were taken at each location, approximately 4 feet above ground surface. Data were logged continuously by the PDR. PDR data for each of the 4 monitoring locations is provided in Appendix A and is summarized in Table 2-1.

Note: Delivered soils were left uncovered until all truckloads were delivered. A single compacting and covering event occurred at approximately 1500 to 1630 HST.

TABLE 2-1

Ambient Air Monitoring Results

May 25, 2005

Location	Maximum Concentration (mg/m^3)	Minimum Concentration (mg/m^3)	Average Concentration (mg/m^3)	Mean + 95%UCL Concentration (mg/m^3)
PDR.1043 (DP)	0.001	0.098	0.006	0.006
PDR.1135 (UD)	0.001	1.575	0.045	0.053
PDR.918 (DD)	0.004	0.838	0.017	0.020
PDR.AMEC (UP)	0	0.523	0.020	0.024

DD – Disposal Area, Downwind DP – Perimeter Area, Downwind
UD – Disposal Area, Upwind UP – Perimeter Area, Upwind

Meteorological Observations

In lieu of a handheld wind meter to measure wind speed and direction, meteorological data from the PVT onsite meteorological station was provided to AMEC by PVT for use in estimating respirable particulate dust concentrations at specific receptor locations via SCREEN3 (See Section 2.4). PVT employs an on-site meteorological weather station (MicroMet Station) to collect wind speed, wind direction, rainfall, solar radiation, air temperature, and humidity. The MicroMet Station is positioned 12 feet above ground and is located between the entrance and working face of the landfill. Data from the PVT meteorological station are provided in Appendix B. Wind direction and wind speed data were provided at 1-hour average time intervals for the monitoring day (05-25-2005). Average wind speed for the disposal period (0800 to 1700 HST) was 6.2 miles per hour. As noted in the field logs and the PVT meteorological data, wind direction was variable, blowing from the Northeast from 0100 to 0800 HST and from the southwest from 0900 to 1900 HST. The majority of the monitoring event was therefore performed during Kona wind conditions (i.e., from the southwest). Based on a reconnaissance of the area and available land use maps this is in the opposite direction of the residential district.

In addition to meteorological data for the monitoring day, wind direction data and average wind speed data are provided by day for the years 2001 to 2005 (Appendix B). Average wind speed for the monitored years was 5.9 miles per hour. As expected, wind speed and direction are variable. The data indicates that wind originates from various directions and does not blow in the direction of the residents 100% of the time.

In an effort to be health protective, the SCREEN3 modeling (described in Section 2.4.2) assumed that dust was 100% derived from disposal activities and was blowing to the residents 100% of the time. Additionally, the evaluation assumed that wind speed was equal to the higher of the average wind speed for the monitoring day or the average for the years 2001 to 2005. As mentioned above, the average wind speeds for the monitoring day was 6.2 miles per hour and 5.9 miles per hour for the years 2001 to 2005. 6.2 miles per hour was therefore used in this assessment.

2.3 Surface Soils Evaluation

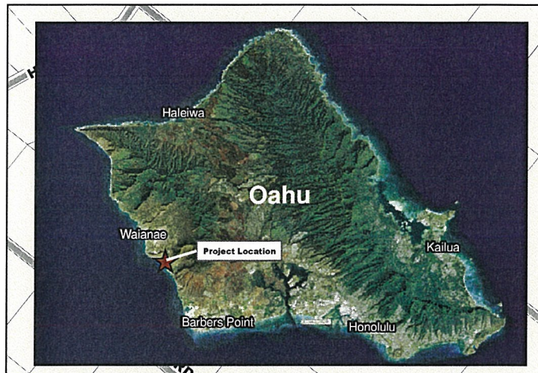
Additional concerns were raised regarding potential spills by disposal trucks transporting contaminated waste prior to landfilling. Consequently, the investigation included the collection of 10 soil samples inside the boundary of PVT Landfill near the entrance gate to evaluate the effectiveness of spill and overflow mitigation efforts during delivery of contaminated soil. Chemical contaminants in PVT surface soils near the entrance gate will be assumed to be similar to contributions of transportation activities on soils near other roads within nearby residential communities.

10 surface soil samples were collected inside the boundary of PVT Landfill adjacent to the entrance gate and analyzed for RCRA 8 metals and PCBs. Analytical data as provided to AMEC by Oceanic Laboratories are provided in Appendix C. Analytical results were screened against USEPA Region 9 Residential PRGs. Results of the screening level assessment are provided in Section 2.4.

Sampling Locations

Sample locations were predetermined to the degree possible during a pre-meeting site visit. 9 grab surface soil samples were collected from the entrance gate area. The entrance gate was judged by HDOH and PVT personnel to be representative of surface road areas within the community that might be impacted by the delivery of contaminated soil to the landfill. A single duplicate surface soil sample for EG09 was collected (EG10).

Prior to sampling, all debris and vegetation was cleared from the sampling locations where possible and/or feasible. Sample locations were documented with a Global Positioning System (GPS) unit. Since all samples were collected manually from 0-2 inches below ground surface, no geophysical survey was performed to determine the presence and location of general subsurface utilities under the proposed sampling locations. Sampling locations are presented in Figure 2-2.



KAPIKI RD

PVT Landfill Site
TMK: 87009025

KAHAU ST
HOLOPONO ST
MOHIHI ST
HOLOMALIA PL
AUYONG HMSTD RD
MAALOA ST
MAIA ST
MIKANA ST
MOHIHI ST
LUALUALEI NAVAL RD

Sampling Area
(See Inset 1)

Feet
0 255 510 1,020

INSET 1: SAMPLE LOCATIONS

EG-5
EG-6
EG-9
EG-3
EG-4
EG-7
EG-1
EG-2
EG-8

LUALUALEI NAVAL RD

Site Gate

MIKANA ST
MOHIHI ST

Feet
0 25 50 100

N

Surface Soil Sampling Locations - Entrance Gate to PVT Landfill Site

Source: Base GIS Data from State of Hawaii, Hawaii GIS Program

amec

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DESIGN	LRK
DRAWN	LRK
DATE	06/23/2005

FIGURE 2-2
PVT LANDFILL
87-2020 FARRINGTON HWY
WAIANAE, HAWAII 96792

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2.4 Human Health Risk Assessment

Human health risk assessments were conducted for direct residential exposures to surficial soil and fugitive dust. The surficial soils assessment called for a simple screening level assessment in which maximum detected chemical concentrations were compared to USEPA Region 9 Residential PRGs. The results of the screening level assessment are provided in Section 2.4.1.

The human health risk assessment of chemicals transported by fugitive dust during disposal activities at PVT Landfill is described in Section 2.4.2. The first step in evaluating risk to residential receptors required AMEC to collect dust generation data during disposal activities. Emission rates based on PDR dust data were then used in SCREEN3 to estimate respirable dust concentrations at the nearest residential area. Chemical exposures were assumed to be 100% site soil-derived and equal to the maximum of either the concentration of previously contaminated soil delivered to PVT or USEPA Region 9 Industrial PRG. If data for a particular chemical of potential concern (COPC) was not available, then the USEPA Region 9 Industrial PRG was used. The industrial PRG was chosen as a surrogate concentration because PVT may use soil containing up to, but not exceeding this value as clean cover for contaminated soil.

Risks were quantified for adult and children residents who might breath site-related chemicals associated with disposal activities from the landfill. Carcinogenic and noncarcinogenic risks were evaluated for COPCs including arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver and PCBs.

2.4.1 Surface Soils Screening Risk Assessment

As stated above, a screening human health risk assessment was performed for chemicals detected in surface soils collected from the PVT entrance gate area. The entrance gate area was assumed to be representative of residential areas that might be impacted by the delivery of contaminated soils. As noted in Table 2-2, maximum detected concentrations were below the USEPA Region 9 residential PRGs indicating that site soils are not impacted by contaminated soil deliveries and therefore would also not present a health risk to children or adults living in nearby residential areas. No further investigation, mitigation or remediation is recommended for site soils near the entrance gate of PVT. It is also assumed from this evaluation that trucks that

deliver contaminated soil to PVT Landfill do not impact roads adjacent to residential areas or residential properties themselves.

TABLE 2-2

Surface Soil Sampling Results

Screening Human Health Risk Assessment

Chemical	Maximum Concentration (mg/kg)/Location	Region 9 Residential PRG (mg/kg)	Above PRG?
Arsenic	7.69/EG7	2.2 E+01	NO
Barium	113/EG8	5.4E+03 [a]	NO
Cadmium	3.15/EG6	3.7E+01	NO
Chromium (total)	109/EG6	2.1E+02	NO
Lead	62.8/EG8	4E+02	NO
Mercury	<0.2	2.3E+01	NO
Selenium	<10	3.9E+02	NO
Silver	<5	3.9E+02	NO
Total PCBs	<0.0333	2.2E-01 (High Risk)	NO

- [a]PRG based on noncancer endpoint
- RCRA 8 Metals – USEPA Method 6010
- Total PCBs – USEPA Method 8082
- Mercury – USEPA Method 7471

2.4.2 Human Health Risk Assessment of Fugitive Dust

The evaluation of human health risk from COPC contaminated fugitive dust generated from the disposal of contaminated soil at PVT Landfill involved several phases of work. The first step in the process consisted of obtaining respirable dust concentrations from the landfill during contaminated soil disposal operations. This has been previously described in Section 2.2. The second step (described in *Exposure Assessment* of this section) involved the estimation of respirable dust concentrations at residential areas for use in developing exposure point concentrations. The remaining phases of the risk process are described herein. The protocol adopted is consistent with the approach recommended by the National Research Council (NRC). The NRC, established by the National Academy of Sciences (NAS) to further scientific knowledge and to advise the federal government, has established a four-step paradigm for conducting health-based risk assessments (NAS 1983). This paradigm has been adopted by USEPA as well as many federal and state regulatory agencies. In accordance with the NRC recommendations, this risk assessment is organized into the following four steps:

- Hazard Identification;
- Toxicity Assessment;
- Exposure Assessment; and
- Risk Characterization.

Each of these steps is briefly described below and detailed in Sections 2.4.2.1 through 2.4.2.4.

Hazard Identification

In this step, compounds assumed to be of concern are selected for inclusion in the quantitative risk assessment. These compounds are designated as COPCs. COPC designated for this evaluation are the eight RCRA metals and total PCBs.

Toxicity Assessment

The purpose of the Toxicity Assessment is to determine the relationship between the magnitude of exposure for each COPC (dose) and the occurrence of specific health effects for a potential receptor (response). The risk assessment will include an evaluation of both potentially carcinogenic and potentially noncarcinogenic effects. The most current USEPA-verified dose-

response criteria are used. In the case of lead, there is no USEPA-verified Reference Dose. Accordingly, the risks posed by lead exposure were evaluated separately using the California Department of Toxic Substances Control (DTSC) lead model (DTSC 2000).

Exposure Assessment

In the Exposure Assessment, the magnitude and frequency of a receptors' potential exposure to COPCs is quantified. The following bulleted list describes the process:

- Description of study area (Section 2.4.2.3.1).
- Identification of receptors (Section 2.4.2.3.2).
- Identification of potential exposure pathways (Section 2.4.2.3.3).
- Identification of exposure scenarios (Section 2.4.2.3.4).
- Estimation of exposure point concentrations (Section 2.4.2.3.5).
- Estimation of exposure doses (Section 2.4.2.3.6).

Risk Characterization

The Risk Characterization combines the results of the Exposure Assessment with the results of the Toxicity Assessment to derive quantitative estimates of the potential for adverse health effects to occur as a result of potential exposure to PVT Landfill materials. The potential for both noncarcinogenic and carcinogenic effects are estimated for each receptor for each potential exposure pathway identified in the Exposure Assessment. The risks from each exposure pathway are summed to obtain an estimate of total risk for each receptor.

2.4.2.1 Hazard Identification

The selection of COPCs for this investigation is based upon historical information regarding previously accepted waste soils by PVT Landfill. Landfill bound samples have been analyzed for several inorganic parameters (RCRA 8 Metals) as well as Total PCBs, as appropriate. Analytical data are available for soil samples collected from June 2003 to present. Metals analyses have included arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver, as appropriate. As a health protective measure, chromium is conservatively assumed as chromium VI. PCB analyses have included total PCBs, as aroclors. The proposed COPCs for evaluation in the ambient air risk assessment are therefore the above listed chemicals.

2.4.2.2 Toxicity Assessment

The purpose of the Toxicity Assessment is to identify both the types of adverse health effects a COPC may potentially cause as well as the relationship between the magnitude of COPCs to which receptors may be exposed (dose) and the likelihood of an adverse health effect (response). Adverse health effects are characterized by USEPA as carcinogenic or noncarcinogenic. Dose-response relationships are defined by USEPA for oral and inhalation routes of exposure. The results of the Toxicity Assessment, when combined with the results of the Exposure Assessment provide an estimate of potential risk.

This section provides dose-response information for the COPCs evaluated in the risk assessment at PVT Landfill. Section 2.4.2.2.1 describes USEPA's approach for developing noncarcinogenic dose-response values. The carcinogenic dose-response relationships developed by USEPA are discussed in Section 2.4.2.2.2. Dose-response information will be obtained, in order of preference, from the USEPA's Integrated Risk Information System (IRIS) (USEPA 2005), National Center for Environmental Assessment (NCEA) (USEPA 2004b) and the Health Effects Assessment Summary Tables (HEAST) (USEPA 1997a).

2.4.2.2.1 Noncarcinogenic Dose-Response

Compounds with known or potential noncarcinogenic effects are assumed to have a dose below which no adverse effect occurs, or conversely, above which an effect may be seen. This dose is called the threshold dose. In the laboratory experiments, this dose is known as the No Observed Adverse Effect Level (NOAEL). The lowest dose at which an adverse effect is seen is called the Lowest Observed Adverse Effect Level (LOAEL). By applying uncertainty factors to the NOAEL or the LOAEL, the USEPA has developed Reference Doses (RfDs) for chronic exposures to compounds with potential noncarcinogenic effects (USEPA 2005).

The uncertainty factors account for uncertainties associated with the dose-response value, such as the effect of using an animal study to derive a human dose-response value, extrapolating from the high doses used in the laboratory experiment to the low doses typically encountered in environmental settings, and evaluating sensitive subpopulations. For compounds with potential noncarcinogenic effects, the RfD provides reasonable certainty that if the specified exposure

dose is below the threshold, then no noncarcinogenic health effects are expected to occur even if daily exposure were to occur for a lifetime. RfDs are expressed in terms of milligrams of compound per kilogram of body weight per day (mg/kg-day).

Dose-response information for both oral and inhalation routes of exposure are used when available. To evaluate inhalation exposure, USEPA has derived reference concentrations (RfCs) for certain compounds. For use in estimating intake, these RfCs (in units of mg/m^3) are converted to RfDs (in units of mg/kg-day) by multiplying by a 20 m^3/day inhalation rate and dividing by the adult body weight of 70 kg (USEPA 1997b). This conversion allows the risk assessment to consider activity-specific inhalation rates described in the exposure assessment.

2.4.2.2.2 Carcinogenic Dose-Response

In 1999, the USEPA proposed new guidelines for evaluating carcinogenic risk in which a new weight of evidence approach considers all scientific information in determining whether and under what conditions an agent may cause cancer in humans, and provides a narrative approach to characterizing carcinogenicity rather than using specific categories (i.e., Group A, Group B). Although the July 1999 draft revised guidelines are the basis of USEPA's interim guidance to evaluating cancer risk, not all compounds in the IRIS database have been revised under the new guidelines.

Under the previous cancer risk assessment guidelines (USEPA 1986), the underlying assumption of regulatory risk assessment for compounds with known or assumed potential carcinogenic effects was that no threshold dose exists. In other words, it was assumed that a finite level of risk is associated with any dose above zero, theoretically even a single molecule could cause some level of risk. For carcinogenic effects, the USEPA risk assessment guidelines (1986) used a two-step evaluation in which the chemical was assigned a weight-of-evidence classification, and then a cancer slope factor (CSF) was calculated. CSFs are a numerical estimate of the carcinogenic potency of a compound. The weight-of-evidence classification was based on the likelihood of the compound being a human carcinogen. Under this system, which is still in place for compounds in IRIS that have not been revised since 1999, Group A compounds are classified as human carcinogens, Group B compounds are probable human carcinogens, Group C compounds are possible human carcinogens, Group D compounds are not classifiable as to human carcinogenicity, and for Group E compounds there

is evidence of noncarcinogenicity for humans. Furthermore, in the second part of the evaluation, CSFs were calculated for compounds that are known or probable human carcinogens. The risk assessment guidelines (USEPA 1986) used models that are linear in the low dose region (which represents environmental exposure) as a default to estimate CSFs. The USEPA's approach was to use the upper 95% confidence bound on the slope of the line generated by the linear model to estimate the potency of carcinogens. Such potencies were then used to estimate risks at various exposures.

Under the proposed new cancer guidelines (USEPA 1999), one of the most important features is the greater emphasis on the mechanisms for carcinogenic action. The USEPA has proposed a departure from using linearized models to relate doses to responses when the mode of action is deemed not to be genotoxic. In these cases, the guidelines propose to use a benchmark dose approach to risk assessment (USEPA 1999). A benchmark approach uses a model to determine the dose that would result in a defined rate of an outcome, usually 5 or 10 percent. Safety factors can then be applied to this benchmark dose level.

Carcinogenic dose-response values for oral exposure are CSFs and are expressed in terms of $(mg/kg\text{-}day)^{-1}$; carcinogenic dose-response values for inhalation exposures are inhalation unit risk (UR) values and are expressed in terms of $(\mu g/m^3)^{-1}$. Oral CSFs and inhalation UR values are available from USEPA sources (USEPA 1997a, 2005) for arsenic. Hexavalent chromium and cadmium are classified as carcinogenic only for the inhalation route of exposure and therefore, only inhalation UR values are available for these COPCs. UR values are defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air (USEPA 2005). For this assessment, UR values are converted to an inhalation CSF correcting for body weight, inhalation rates, and units using the following equation:

$$CSF_{inh} = \frac{UR_{inh} \times 70\ kg}{20\ m^3/day} \times 1000\ \mu g/mg$$

where:

CSF_{inh} = inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$

Ur_{inh}	=	inhalation unit risk $(\mu g/m^3)^{-1}$
70 kg	=	body weight
1000 µg/mg	=	conversion factor; and
20 m^3/day	=	inhalation rate.

Dose-Response for Lead

There is currently no USEPA-verified Reference Dose for lead. Risk assessments for lead commonly use the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model (2001a) or the California EPA's (CalEPA) Department of Toxic Substances Control's (DTSC) lead model, entitled, "Assessment of Health Risks from Inorganic Lead in Soil," or LeadSpread Version 7 (DTSC 2000). These models predict blood lead levels which are then compared to benchmark levels of blood lead that have been determined by regulatory agencies to present no significant risk of harm. The IEUBK model predicts blood lead levels in children: It estimates the risk to children exposed to lead from environmental exposures (i.e., inhalation of dust, ingestion of soil and water) by estimating a distribution of blood lead concentrations based on a predicted geometric mean blood lead concentration for a hypothetical population of children. The DTSC model was specifically developed to evaluate the risks posed by the presence of lead in residential soil, and it is designed to be protective of a one-year-old child. The algorithms in the DTSC model were adapted to predict blood lead levels in children and adults. For this risk assessment, blood lead levels in children and adults are predicted using the DTSC model.

2.4.2.3 Exposure Assessment

The Exposure Assessment identifies the type and magnitude of potential incremental exposures due to COPCs in contaminated soil disposed of at PVT Landfill. The first phase of this process requires the identification of the study area, current and future site usage scenarios and the identification of potential receptors. Additional phases in the exposure assessment requires that potential routes of exposure are identified for each receptor and the exposure scenarios are defined based on information about activities which typically occur in the area. Exposure factors including length and duration of exposure, inhalation rates and absorption adjustment factors are designated during this phase of work. Based on the results of above-described tasks, the final phase of the exposure assessment is the derivation of exposure point concentrations and

the calculation of average daily doses. The results of the exposure assessment are described in the following subsections.

2.4.2.3.1 Description of Study Area

The study area has previously been described (Section 1.1). Briefly, the PVT Landfill Site is located at 87-2020 Farrington Highway on the western side of the island of O'ahu, in Nanakuli, Hawai'i (Figure 1-1). PVT Landfill is a construction and demolition landfill permitted for the disposal of C&D waste and contaminated soil. The Site is bounded by residential areas at its southern and western borders. Nearest residents are approximately ½ miles to the west and south of the landfill. Wind direction and speed at the landfill are variable, but are frequently in the direction of the residential districts.

2.4.2.3.2 Identification of Receptors

Potential human receptors for this investigation are adult and children residents who may breath fugitive dust containing COPCs. Adult and child residents were identified based on characteristics of the site and surrounding area and the specific concerns of the neighboring community.

2.4.2.3.3 Identification of Potential Exposure Pathways

Potential exposure pathways are the mechanisms by which the receptors in the study area may be exposed to compounds emitted from the landfill during disposal events. According to USEPA (1989), four elements must be present in order for a potential human exposure pathway to be complete:

- a source and mechanism of compound release to the environment (in this case, placement of soil at the site and wind erosion of soil);
- an environmental transport medium (in this case, air);
- an exposure point, or point of potential contact with the potentially impacted medium; and
- a receptor (i.e., a person) with a route of exposure at the point of contact.

The pathways examined in this risk assessment include:

- Inhalation of fugitive dust offsite.

2.4.2.3.4 Identification of Exposure Scenarios

Exposure scenarios describe the frequency and magnitude of exposure to chemicals as they relate to specific receptors and exposure pathways. The exposure scenarios evaluated in this risk assessment include the following:

- Resident Adult and Child presumed to be exposed to contaminants in soil via fugitive dust generation during soil disposal operations (soil disposal operations are assumed to occur 24 hrs/day for a 1 year period);
- Resident Adult and Child presumed to be exposed to contaminants in soil via fugitive dust generation during soil disposal operations (soil disposal operations are assumed to occur 24 hrs/day for a 30 year period);
- Resident Adult and Child exposed to contaminants in soil if soil is left uncovered for a period of 1 year; and
- Resident Adult and Child exposed to contaminants in soil if soil is left uncovered for a period of 30 years.

2.4.2.3.5 Estimation of Exposure Point Concentrations

In order to estimate the concentration of chemicals transported by fugitive dust to resident locations it was first necessary to estimate the respirable dust concentration at receptor locations. This process required the derivation of two scenario-specific PM_{10} emission rates (Q). The first emission rate (hereafter called Soil Disposal Activities Emission Rate) estimated via the Box Model (Stern 1984) describes the dust generating potential caused by various human activities at the landfill (i.e., dumping, pushing, compacting). The second emission rate is based on the unlimited erosion model (hereafter called the Unlimited Erosion Model Emission Rate) and estimates the PM_{10} emission rate due to atmospheric dispersion generated from wind erosion of site soils (assuming contaminated soils are left uncovered).

Soil Disposal Activities Emission Rate

PM_{10} emissions would be generated by several landfill activities including pushing and compacting contaminated soil and pushing and compacting clean cover over contaminated soil. The PM_{10} emission rate (Q) during these activities was determined using a Box Model (Stern 1984). As stated below, estimation of the soil disposal activities PM_{10} emission rate could either be based on the maximum average PM_{10} concentration at any monitoring location or on the average PM_{10} concentration at all four monitoring locations. The maximum average PM_{10} concentration from any monitoring location (53.4 $\mu g/m^3$) was significantly higher than the average based on the four monitoring locations (21.8 $\mu g/m^3$) and was conservatively chosen as the PM_{10} concentration for modeling purposes. Health risks estimated using the average PM_{10} concentration at all four monitoring locations would be lower than if the highest average at any location were used.

The Box Model is presented as below:

$$E_{10} = (L \times Q / (h \times u_{mean})) \times 10^6$$

or

$$Q = (E_{10} \times h \times u_{mean}) / (L \times 10^6)$$

where:

Q: PM_{10} emission rate ($g/s\text{-}m^2$)
E_{10}: PM_{10} concentration ($\mu g/m^3$)
h: mixing height
u_{mean}: mean wind speed (m/s), and
L: landfill length.

The PM_{10} concentration (E_{10}) was derived from site-specific data obtained during the May 25th 2005 monitoring event. As stated above, the maximum onsite average PM_{10} concentration for any of the four monitoring locations was 53.4 $\mu g/m^3$. The emission rate based on this value is 6.6E-06 $g/s\text{-}m^2$. Calculations are presented below.

$Q = (E_{10} \times h \times u_{mean}) / (L \times 10^6)$

Parameters		Value	Reference
Q:	PM_{10} emission rate (g/s-m^2)		calculated
E_{10}:	PM_{10} concentrations (µg/m^3)	53.4	
h:	mixing height	2	
u_{mean}:	mean wind speed (m/s)	2.8	site-specific
L:	landfill length	45	site-specific

Q = 6.6E-06

Unlimited Erosion Model Emission Rate

The second emission rate was derived using the unlimited erosion factor. The unlimited erosion factor equation is used to determine the emission rate due to atmospheric dispersion generated from wind erosion of site soils (assuming contaminated soils are left uncovered). Site-specific PM_{10} data are not required. The equation used to estimate the emission rate assuming wind dispersion of uncovered soil is provided below.

$$Q = 0.036 \times (1 - V) \times (u_{mean} / u_t)^3 \times F(y) \times (1/3600)$$

where:

Q: PM_{10} emission factor (g/s-m^2)
V: fraction of surface vegetative cover, V = 0 (assumption)
u_{mean}: mean annual wind speed (m/s), u_{mean} = 2.8 m/s (site-specific data)
u_t: threshold value of wind speed at 7 m (m/s)
y: $y = 0.886\ u_t / u_{mean}$ (dimensionless ratio), and
F(y): function of y (USEPA 1985).

For this equation, the fraction of surface vegetative cover was assumed to be zero. As mentioned above, the site-specific wind speed is 2.8 m/s (6.2 mph). Parameters for u_t and F(y) were obtained from USEPA (2004a) and are equal to 11.32 and 0.194 m/s, respectively. Using these variables and the above equation, the emission factor for PM_{10} (PM_{10} emission rate, or Q) was calculated as 2.9E-08 g/s-m^2. Calculations are presented below.

$Q = 0.036 \times (1-V) \times (u_{mean} / u_t)^3 \times F(y) \times (1/3600)$

Parameters		Value	Reference
Q:	PM_{10} emission factor ($g/s\text{-}m^2$)		calculated
V:	fraction of surface vegetative cover	0	
u_{mean}:	mean annual wind speed (m/s)	2.8	site-specific
F(y):	function of y [0.886 u_t / umean (dimensionless ratio)]	0.194	default (USEPA 2004a)
u_t:	threshold value of wind speed at 7 m (m/s)	11.32	default (USEPA 2004a)

Q = 2.9E-08

SCREEN3 PM_{10} Concentrations

The SCREEN3 air dispersion model (Version 96043) (USEPA 1995) was used to predict off-site ambient PM_{10} concentrations for various scenarios based on the calculated emission rates for both contaminated soil disposal operations and wind erosion of the landfill surface. SCREEN3 is a USEPA-preferred model and is recommended by USEPA for a screening-level air dispersion modeling (USEPA 1995). SCREEN3 determines 1-hour maximum chemical concentrations under worst-case wind conditions. It assumes that fugitive dust blows in the direction of the receptor continuously, 100% of the time. The model does not allow for an adjustment to be made to the percentage of time wind blows in the direction of the residents over a longer averaging time. To account for this, USEPA states that annual average PM_{10} concentrations should be calculated by multiplying the 1-hour maximum concentration by a factor of 0.08 (USEPA 1992). However, this assessment utilized a Hawaii-specific value of 0.2 (Personal Communication with Dr. Barbara Brooks, HEER Office). 0.2 is a health protective adjustment factor which considers Hawaii-specific wind and meteorological conditions.

The full meteorological data provided in the SCREEN3 model was used in the model runs. The source areas at the contaminated soil disposal area of the landfill site were modeled as ground-level sources of 45 x 45 square meters (0.5 acre). 0.5 acres is the USEPA Region 9 default source size as well as the approximate area of disposal zone at PVT Landfill. The receptors were deployed using the SCREEN3 receptor distance array ranging from 402 meters (1/4 mile) out to 8,047 meters with a receptor height of 1.8 m. It was assumed that the entire area was an emission source.

As noted above, air dispersion modeling was conducted for 2 sets of respirable dust data in order to conservatively estimate the amount of wind blown dust to nearby residential areas.

(1) A hypothetical respirable dust concentration average/year was estimated at resident locations based on the maximum average dust generated from any singular monitoring point during the monitoring event (See Section 2.4.2.3.4). The Box Model (Stern 1984) was used to determine the PM_{10} emission rate (Q) for these activities. Corresponding dust-derived chemical concentrations were assumed to impact neighboring communities during potential dust generation activities and that these activities occurred 24 hrs per day for 365 days per year. This is an extremely health protective measure that assumes that respirable dust is generated constantly at a rate equal to that generated during disposal activities. Had the modeling and risk assessment been conducted using more realistic assumptions, the risk would certainly be reduced. SCREEN3 air dispersion modeling results for this data set resulted in a maximum respirable dust concentration of 0.2251 $\mu g/m^3$ at a distance of ¼ mile away for dust generating activities. After applying the 0.2 adjustment factor, the annual average respirable dust concentration is 0.045 $\mu g/m^3$ at a distance of ¼ mile away for dust generating activities. This annual average is significantly lower than the National Ambient Air Quality Standards (NAAQS) PM_{10} annual limit of 50 $\mu g/m^3$.

(2) A hypothetical respirable dust concentration average/year was estimated at resident locations based on the average dust generated from due to wind erosion. The unlimited erosion model was used to determine the PM_{10} emission rate (Q) for this exposure scenario. This approach does not use measure concentrations from the landfill. Corresponding dust-derived chemical concentrations were assumed to impact neighboring communities 24 hrs per day for a 1-year period or 24 hrs per day for a 30-year period. These scenarios are extremely health protective and assume that soil is left uncovered after disposal. In reality soil is covered at the end of the day's activities. SCREEN3 air dispersion modeling results for this data set result in a maximum respirable dust concentration of 0.00099 $\mu g/m^3$ at a distance of ¼ mile away for dust generating activities. After applying the 0.2 adjustment factor, the annual average respirable dust concentration is 0.0002 $\mu g/m^3$ at a distance of ¼ mile away for dust

generating activities. This annual average is significantly lower than the National Ambient Air Quality Standards (NAAQS) PM_{10} annual limit of 50 $\mu g/m^3$.

The SCREEN3 air dispersion model calculations are presented in Appendix D. Table 2-3 lists the measured PM_{10} concentration at the site and SCREEN3 results at ¼ mile.

TABLE 2-3

PM_{10} Respirable Dust Concentrations

Screening Human Health Risk Assessment

	Measured Concentration ($\mu g/m^3$)	Estimated Concentration at ¼ mile* ($\mu g/m^3$)
Soil Disposal Activities		
pDR.1043	6.03	0.0256
pDR.1135	*53.36*	*0.2251*
pDR.918	20.33	0.0853
pDR.AMEC	23.71	0.1023
Unlimited Erosion Model		
	NA	*0.00099*

Italicize values were used in the risk assessment.
NA = Not Applicable
Measured concentration is the mean + 95%UCL value.
*As computed by SCREEN3 based on the following assumptions:

Parameter	Value
Source type	area
Emission rate	
pDR 1043	7.5E-7 g/sm^2
pDRr 1135	6.6E-6 g/sm^2
pDR 918	2.5E-6 g/sm^2
pDR AMEC	3.0E-6 g/sm^2
Source release height	0.1 m
Length of larger side for area	45 m
Length of smaller side of area	45 m
Receptor height above ground	1.8 m
Urban or Rural Area	Rural
Meteorology	
Stability class	1 – Unstable/Turbulent
Anemometer height wind speed	2.8 m/s

Estimation of COPC Concentrations at Offsite Locations

PVT Landfill has collected analytical data from previously disposed of soil accepted by the landfill for permitted years 2003 to present. Raw data as provided to AMEC by PVT Landfill are provided in Appendix E. It was originally proposed that summary statistics including, mean and upper 95th confidence levels of the mean were to be calculated for arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver and PCBs, as available, from previously collected chemical analytical data of landfill-bound soils. However, due to the relative infrequency of contaminated soil disposal, data was extremely limited. This assessment therefore used the higher of the maximum detected concentration in any delivered soil or the USEPA Region 9 Industrial PRG to estimate COPC concentrations in fugitive dust at receptor locations. This practice is a health protective measure that allows for the evaluation of potential health risks in light of limited data. Estimated dust concentrations, both via soil disposal activities as well as the unlimited erosion model, as determined by the SCREEN3 were multiplied by the concentration of the COPC in soil to estimate the concentration at potential receptor locations (Table 2-4). In addition to the quantification of potential health risk described below, these values were screened against USEPA Region 9 Ambient Air PRGs. As stated earlier, Region 9 PRGs are risk-based concentrations that it not exceeded suggest that health effects are not likely to occur. All COPC concentrations as estimated by the SCREEN3 model are below their respective Region 9 Ambient Air PRGs.

2.4.2.3.6 Exposure Dose Calculations

This section describes the equations and assumptions used to evaluate a receptor's potential exposure to compounds in fugitive dust. The equations used to evaluate potential exposures in this risk assessment are consistent with equations presented in USEPA (1989, 1991, 1997b, 1998, 2000, 2001b, 2001c) and are described qualitatively below.

The equation used to calculate Chronic Average Daily Dose (CADD) estimates a receptor's potential daily intake from exposure to compounds with potential noncarcinogenic effects. According to USEPA (1989), the exposure dose is calculated by averaging over the period of time for which the receptor is assumed to be exposed. The CADD for each compound via each route of exposure is compared to the noncarcinogenic reference dose for that compound in

TABLE 2-4

Estimated COPC Concentrations at ¼ mile distance

Screening Human Health Risk Assessment

Chemical	Estimated Concentration ($\mu g/m^3$)	Region 9 Ambient Air PRG ($\mu g/m^3$)	Above PRG?
Soil Disposal Activities			
Arsenic	8.6E-12	4.5E-4	No
Barium	1.5E-09	5.2E-1 [a]	No
Cadmium	1.0E-11	1.1E-3	No
Chromium (VI)	1.1E-11	2.3E-5	No
Mercury	7.0E-12	*NA*	*NA*
Selenium	1.1E-10	*NA*	*NA*
Silver	1.1E-10	*NA*	*NA*
Total PCBs	1.1E-12	3.4E-3	No
Unlimited Erosion Model			
Arsenic	3.8E-14	4.5E-4	No
Barium	6.6E-12	5.2E-1 [a]	No
Cadmium	4.5E-14	1.1E-3	No
Chromium (VI)	4.7E-14	2.3E-5	No
Mercury	3.1E-14	*NA*	*NA*
Selenium	5.0E-13	*NA*	*NA*
Silver	5.0E-13	*NA*	*NA*
Total PCBs	4.9E-15	3.4E-3	No

[a]PRG based on noncancer endpoint

*Analytical data was not available. In such cases, USEPA Region 9 Industrial Soil PRGs were used.

NA – Ambient Air PRG Not Available

order to estimate the potential noncarcinogenic hazard index due to exposure to that compound via that route of exposure (see Section 2.4.3).

For compounds with potential carcinogenic effects, the equation for Lifetime Average Daily Dose (LADD) is employed to estimate potential exposures. In accordance with USEPA (1989), the LADD is calculated by averaging the assumed exposure over the receptor's entire lifetime (assumed to be 70 years). The LADD for each compound via each route of exposure is combined with the cancer slope factor for that compound in order to estimate the potential carcinogenic risk due to exposure to that compound via that route of exposure (see Section 2.4.3).

The equations for estimating a receptor's average daily dose (both lifetime and chronic) are presented in the following subsections. The exposure parameters used in each potential exposure pathway are also discussed in the following subsections.

Estimation of Potential Exposure via Inhalation

Residents living in the vicinity of the Site may inhale compounds derived from contaminated soil during disposal operations. Inhalation of particulate-bound chemicals can result in COPC deposition both in the lung and in the gastrointestinal tract. Particles that are deposited in the deep lung are removed slowly in humans. On the other hand, particles that are deposited in the upper respiratory system are removed very quickly. When potential receptors are breathing through their noses, many of the particles deposited in the nose are completely removed. In this risk assessment, however, it is conservatively assumed that receptors are breathing through their mouths and that the protective function of the nasal passages is circumvented. Therefore, all particles that are deposited in the upper respiratory tract are assumed to be deposited in the trachea and the bronchial tubes. When particles are removed from these areas by the upward movement of mucous, they are ultimately swallowed and enter the gastrointestinal tract. Thus, it is assumed that all deposited particles result in an exposure dose either in the lung or the gastrointestinal tract.

Calculations of potential risk resulting from the inhalation of the respirable fraction of particulates in air (i.e., particles < 10 µm in diameter) are presented in Appendix F. The equation used to calculate the CADD and LADD due to inhalation exposure is as follows:

$$A = \frac{B \times C \times D \times E \times F \times G \times H}{I \times J}$$

where:

A = Average Daily Dose following Inhalation (mg/kg-day)
B = Compound Concentration in Soil(mg/kg)
C = Concentration of Respirable Particulates in Air (mg/m^3)
D = Inhalation Rate (m^3/hr)
E = Exposure Time (hr/day)
F = Exposure Frequency (days/year)
G = Exposure duration (years)
H = Inhalation Absorption Adjustment Factor (unitless)
I = Body Weight (kg)
J = Averaging Time (days)

Each of the parameters in these equations is described below.

Compound Concentration in Soil

Compound concentrations in soil have been measured in numerous samples. The data used in this risk assessment are provided in Appendix E. Soil concentrations used in the assessment are shown in Table 2-5.

Concentration of Respirable Particulates in Air

The methodology used to estimate the concentration of respirable particulates in air is presented in Section 2.4.2.3.4. Particulate concentrations in air at offsite locations are shown in Appendix D. It was assumed that 100% of the respirable particles are soil-derived.

TABLE 2-5

Risk Assessment Compound Concentrations

Screening Human Health Risk Assessment

Compound	Concentration (mg/kg)
Arsenic	380
Barium*	6.70E+04
Cadmium	450
Chromium - Hexavalent	480
Lead	3190
Mercury*	3.10E+02
Selenium*	5.10E+03
Silver*	5.10E+03
PCBs	50

*Analytical data was not available. In such cases, USEPA Region 9 Industrial Soil PRGs were used.

Inhalation Rate

The inhalation rates assumed for the receptors in this risk assessment are presented in Table 2-6, Exposure Assumptions. Inhalation of particulate matter is a function of the ambient concentration of particulate matter, inhalation rate, relative bioavailability, and human body weight.

It is assumed that the average inhalation rate is age and activity dependent. Average hourly inhalation rates were calculated for children and adults based on human inhalation rate data for various activity levels (USEPA 1997b, 2000).

Exposure Time and Frequency

The exposure times and frequencies assumed for all potential receptors are described below and presented in Table 2-6.

Exposure via Soil Disposal Activities: Assuming that contaminated soil is immediately covered upon disposal, offsite residents would be exposed to contaminants only for the duration of disposal operations. For this assessment it was assumed that soil disposal operations are occurring 24 hrs/day for the entire exposure duration period.

Exposure via Wind dispersion: Residents may also be exposed to contaminants in fugitive dust following disposal activities if contaminated soil were left uncovered. Accordingly, offsite adult and children residents were also assumed to be continuously exposed to fugitive dust via wind dispersion generated from the site 24 hours/day, 365 days/year.

Exposure Duration

The exposure durations assumed for all receptors are presented in Table 2-6. As previously described, the risk assessment assumes that potential offsite adult and child receptors are exposed for either a 1 year period or 30 year period. For the child 30 year exposure, an integrated LADD was calculated assuming the receptor spends 6 years as a child and 24 years as an adult. Thus for the cancer risk evaluation, the exposures are summed to determine the cumulative risk.

Absorption Adjustment Factors

Absorption is assumed to be 100% via the inhalation route of exposure for all COPCs.

Body Weight

As shown in Table 2-6, the body weights assumed in this risk assessment are 16.6 kg for the child and 70 kg for the adult receptors (USEPA 2000 and 2001c, respectively).

Averaging Time

The average daily dose of COPCs used to calculate noncarcinogenic risks must be averaged over the duration which the receptor is assumed to be exposed (USEPA 1989). Therefore, in the CADD calculations, the averaging time is equal to the exposure duration (above).

The average daily dose used to determine potential carcinogenic effects, however, must be averaged over the entire lifetime (70 years), regardless of the length of time which the receptor is assumed to be exposed (USEPA 1989).

TABLE 2-6

Exposure Assumptions

Screening Human Health Risk Assessment

Receptor	Parameter (units)	Value	
Adult Resident	Exposure Duration (hr/d)	24	
	Exposure Frequency (d/y)	365	
	Exposure Period (y)	1/30	
	Body Weight (kg)	70	
	Averaging Period - Lifetime (d)	25550	
	Averaging Period - Chronic Noncancer (d)	365/10950	
	Inhalation Rate	0.55 m^3/hr 13.2 m^3/day	
	Respirable particulate concentration in air (mg/m^3)*	SDA: 4.5E-05 mg/m^3 UEM: 2.0E-07 mg/m^3	
	Fraction from Site (unitless)	1	
Child Resident	Exposure Duration (hr/d)	24	24
	Exposure Frequency (d/y)	365	365
	Exposure Period (y)	1/6	NA/24
	Body Weight (kg)	16.6	70
	Averaging Period - Lifetime (d)	25550	25550
	Averaging Period - Noncancer (d)	365/2190	NA/8760
	Inhalation Rate	0.41 m^3/hr 9.8 m^3/day	0.55 m^3/hr 13.2 m^3/day
	Respirable particulate concentration in air (mg/m^3)*	SDA: 4.5E-05 mg/m^3 UEM: 2.0E-07 mg/m^3	SDA: 4.5E-05 mg/m^3 UEM: 2.0E-07 mg/m^3
	Fraction from Site (unitless)	1	1

SDA = Soil Disposal Activities Scenario UEM = Unlimited Erosion Model Scenario

For parameters with two values, the first value is for a 1-year exposure scenario, the second value is for a 30-year scenario.

* 1 hour max concentration x 0.2 (as described in Section 2.4.2.3.5)

2.4.2.3.7 Exposure Assessment for Lead

This risk assessment calculates exposures to lead via California's DTSC lead model Version 7, entitled "Assessment of Health Risks from Inorganic Lead in Soil" (DTSC 2000). The major input parameters of the DTSC model were used as presented in DTSC. Specifically, the intake-blood lead slope factors (termed "constants" in the DTSC model) were not modified. The DTSC model is designed to be protective of a one-year-old child: "For this method, a one-year-old child shall represent all children, based on the assumption that protecting the one-year-old child will protect all children." Because the model was specifically developed to evaluate the risks posed by the presence of lead in residential soil, this assumption is not unreasonable for the model's intended purpose. Accordingly, slope factors and exposure assumptions specific for such infants are very health-protective and will overestimate the lead blood levels for older children, such as 6-10-year-olds.

Despite the overestimations that will occur using the above assumptions, this risk assessment does not modify the DTSC approach. Instead, it is merely noted that the results should be viewed as health-protective estimates of lead risks.

However, several of the site-specific default exposure parameters were modified as allowed by DTSC guidance, so that they were applicable to the assessment of human health specific to the investigation at PVT Landfill. These include modifying the background levels of lead in air and water. Site-specific factors for background lead exposures were substituted for the default factors, which are based on California-specific data and not Hawai'i-specific data.

Background Lead Concentration in Ambient Air

The HDOH has been monitoring air quality in the State of Hawai'i since 1957. Sampling for lead has been conducted at the Liliha and the HDOH-Punchbowl monitoring sites. The Liliha monitoring site is closer to the PVT Landfill than is the Punchbowl site. The most recent HDOH report on air quality is entitled Hawai'i Air Quality Data 1991-1993 (HDOH 1993). According to this report, the average lead concentration for all four quarters of 1993 was 0 $\mu g/m^3$ for both monitoring stations. In fact, 0 $\mu g/m^3$ of lead has been reported as the annual average for both stations since 1987. In lieu of using 0 $\mu g/m^3$ as the site-specific ambient lead concentration,

AMEC has determined that one-half the detection limit of the measurements should be used, as is customary in the practice of risk assessment. According to the document, the detection limit is less than or equal to 0.02 µg/m^3. Thus, it is assumed that the ambient lead concentration at the site is 0.01 µg/m^3.

Background Lead Concentration in Drinking Water

HDOH was asked to provide recent monitoring data for drinking water in the Waimanalo Gulch Sanitary area to determine the background level of lead in local drinking water. As noted in Table 2-7, lead was not detected in any sample at a method detection limit of 0.005 mg/L. As is typical in the practice of risk assessment, it is assumed that lead is present at the background level of 0.0025 mg/L, which is one-half the method detection limit.

2.4.3 Risk Characterization

The risk characterization is the step in the risk assessment process that combines the results of the exposure assessment and the toxicity assessment for each compound of concern in order to estimate the potential for carcinogenic and noncarcinogenic human health effects from chronic exposure to that compound. This section summarizes the results of the risk characterization for each receptor evaluated in the risk assessment.

2.4.3.1 Noncarcinogenic Risk Characterization

The potential for exposures to COPCs to result in adverse noncarcinogenic health effects is estimated for each receptor by comparing the Chronic Average Daily Dose (CADD) for each compound (Section 2.4.2.3.5) with the Reference Dose for that compound (discussed in Section 2.4.2.2.1). The resulting ratio, which is unitless, is known as the Hazard Quotient (HQ) for that compound. The HQ is calculated using the following formula:

$$A = \frac{B}{C}$$

TABLE 2-7

BACKGROUND LEAD CONCENTRATIONS IN DRINKING WATER IN PROXIMITY TO WAIMANALO GULCH SANITARY LANDFILL (mg/L)[1]

Kunia I, Pump 1, 2/92	<0.005
Kunia I, Pump 3, 2/92	<0.005
Honouliuli Well I, Pump 1, 7/92	<0.005
Honouliuli Well I, 2/91	<0.005
Honouliuli Wells II, P-1, 9/93	<0.005
Waimanalo Gulch Sanitary I GAC East PAD EF 1 to 4, 5/92	<0.005
Waimanalo Gulch Sanitary I GAC East PAD EF 5 & 6, 5/92	<0.005
Waimanalo Gulch Sanitary I GAC West PAD EF 1-4, 5/92	<0.005
Waimanalo Gulch Sanitary I GAC West PAD EF 5,6,7,8, 5/92	<0.005
Waimanalo Gulch Sanitary I, Pump 1, 5/92	<0.005
Waimanalo Gulch Sanitary GAC East 1, 1/91	<0.005
Waimanalo Gulch Sanitary GAC East 5, 1/91	<0.005
Waimanalo Gulch Sanitary GAC Influent East, 1/91	<0.005
Waimanalo Gulch Sanitary GAC West 1, 1/91	<0.005
Waimanalo Gulch Sanitary GAC West 6, 1/91	<0.005
Waimanalo Gulch Sanitary GAC Influent West, 1/91	<0.005
Waimanalo Gulch Sanitary Wells II GAC 1-2 EFF, 2/92	<0.005
Schofield PAC (AFTER) Tower, 2/92	<0.005
Schofield PAC After PAC Tower, 1/91	<0.005
Schofield PAC Before Tower, 1/91	<0.005
Barber's Point Shaft, 7/92	<0.005
Barber's Point Shaft, 1/91	<0.005

[1]Data provided by Glenn Kashiwabara, Safe Drinking Water Branch, Hawai'i Department of Health

where:

A = Hazard Quotient (unitless);
B = Chronic Average Daily Dose (mg/kg-day); and
C = Reference Dose (mg/kg-day).

When the Hazard Quotient for a given compound does not exceed 1, the Reference Dose has not been exceeded, and no adverse noncarcinogenic health effects are expected to occur as a result of exposure to that compound via that route. The HQs for each compound are summed to yield the Hazard Index (HI) for that pathway. An HI is calculated for each receptor for each pathway by which the receptor is assumed to be exposed. A Total Hazard Index for a chemical is then calculated for each receptor by summing the pathway-specific HIs. A Total HI for a chemical that does not exceed 1 for a given receptor indicates that no adverse noncarcinogenic health effects are expected to occur as a result of that receptor's potential exposure to a chemical in the environmental media. The HIs calculated for this assessment are presented in Table 2-8. All HIs were substantially lower than the USEPA and HDOH criterion goal of 1.

TABLE 2-8

Noncarcinogenic Risk

Screening Human Health Risk Assessment

RECEPTOR	HAZARD QUOTIENT
Soil Disposal Activities	
Adult Resident, 1-year exposure	6E-3
Adult Resident, 30-year exposure	6E-3
Child Resident, 1-year exposure	2E-2
Child Resident, 30-year exposure	2E-2
Unlimited Erosion Model	
Adult Resident, 1-year exposure	3E-5
Adult Resident, 30-year exposure	3E-5
Child Resident, 1-year exposure	8E-5
Child Resident, 30-year exposure	8E-5

2.4.3.2 Carcinogenic Risk Characterization

The purpose of carcinogenic risk characterization is to estimate the likelihood, over and above the background cancer rate, that a receptor will develop cancer in his or her lifetime as a result of facility-related exposures to COPCs in various environmental media. This likelihood is a function of the dose of a compound and the Cancer Slope Factor (CSF) for that compound. The relationship between the Excess Lifetime Cancer Risk (ELCR) and the estimated Lifetime Average Daily Dose (LADD) of a compound may be expressed as:

$$A = 1 - e^{-BC}$$

where:

A = Excess Lifetime Cancer Risk (unitless);
B = Cancer Slope Factor (1/(mg/kg-day)); and
C = Lifetime Average Daily Dose (mg/kg-day).

When the product of the CSF and the LADD is much greater than 1, the ELCR approaches 1 (i.e., 100% probability). When the product is less than 0.01 ($1x10^{-2}$), the equation can be closely approximated by:

$$A = B \times C$$

where:

A = Excess Lifetime Cancer Risk (unitless);
B = Cancer Slope Factor (1/(mg/kg-day)); and
C = Lifetime Average Daily Dose (mg/kg-day).

The product of the CSF and the LADD is unitless, and provides an estimate of the potential carcinogenic risk associated with a receptor's exposure to that compound via that pathway. ELCRs are calculated for each potentially carcinogenic compound. For each receptor, the ELCRs for each pathway by which the receptor is assumed to be exposed are calculated by

summing the potential risks derived for each compound. A Total Excess Lifetime Cancer Risk is then calculated by summing the pathway-specific ELCRs. The ELCRs calculated for this assessment are presented in Table 2-9. All risks were substantially lower than the USEPA and HDOH point of departure value of 1E-06.

TABLE 2-9

Carcinogenic Risk

Screening Human Health Risk Assessment

RECEPTOR	Cancer Risk
Soil Disposal Activities	
Adult Resident, 1-year exposure	1E-9
Adult Resident, 30-year exposure	3E-8
Child Resident, 1-year exposure	3E-9
Child Resident, 30-year exposure	5E-8
Unlimited Erosion Model	
Adult Resident, 1-year exposure	5E-12
Adult Resident, 30-year exposure	1E-10
Child Resident, 1-year exposure	1E-11
Child Resident, 30-year exposure	2E-10

2.4.3.3 Risk Characterization for Lead

The risk characterization for lead utilizes the approach derived by the California Department of Toxic Substances Control (DTSC) for all receptors. The approach used by the models consists of estimating blood lead concentrations by combining estimated exposures to lead in environmental media with empirically determined route-specific constants (factors that relate blood lead concentration to exposure). The blood lead concentration of concern in children is 10 µg/dL, in adult workers is 25 µg/dL, and in pregnant female visitors is 10 µg/dL. As detailed in Appendix G, blood lead concentrations for the adult and child residents under all scenarios evaluated in the risk assessment are below the USEPA and HDOH standard of 10 µg/dl. No adverse health impacts are anticipated from lead derived from contaminated soil at PVT Landfill. The inhalation risk from site-derived lead contributed less than 1% of total blood lead.

3.0 UNCERTAINTY ANALYSIS

The risk assessment of disposal operations of contaminated soil at PVT Landfill contains many assumptions that lead to significant uncertainty. The assumptions that introduce the greatest amount of uncertainty in this risk assessment are discussed in this section. They are discussed in general terms, because for most of the assumptions there is not enough information to assign a numerical value that can be factored into the calculation of risk.

Within any of the four steps of the risk assessment process, assumptions must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that the health of local residents is protected. Therefore, when all of the assumptions are combined, it is much more likely that actual risks, if any, are overestimated rather than underestimated.

3.1 Hazard Identification

During the Hazard Identification step, compounds are selected for inclusion in the quantitative risk assessment. For this assessment RCRA 8 metals and PCBs were selected as COPCs. PVT Landfill may however, also accept contaminated soil containing other chemicals. The PVT permit specifically states that TPH may be accepted. The risk assessment presented herein does not consider any other chemicals than that which has previously been described. The exclusion of TPH and other chemicals potentially accepted by PVT introduces significant uncertainty into the assessment.

3.2 Toxicity Assessment

Dose-response values are usually based on limited toxicological data. For this reason, a margin of safety is built into estimates of both carcinogenic and noncarcinogenic risk, and actual risks are lower than those estimated. The two major areas of uncertainty introduced in the dose-response assessment are: (1) animal to human extrapolation; and (2) high to low dose extrapolation. Such sources of uncertainty are discussed in the following subsections.

3.2.1 Animal to Human Extrapolation

Human dose-response values are often extrapolated, or estimated, using the results of animal studies. Extrapolation from animals to humans introduces a great deal of uncertainty in the risk assessment because in most instances, it is not known how differently a human may react to the chemical compared to the animal species used to test the compound. The procedures used to extrapolate from animals to humans involve conservative assumptions and incorporate several uncertainty factors that overestimate the adverse effects associated with a specific dose. As a result, overestimation of the potential for adverse effects to humans is more likely than underestimation.

3.2.2 High to Low Dose Extrapolation

Predicting potential health effects from the facility emissions requires the use of models to extrapolate the observed health effects from the high doses used in laboratory studies to the anticipated human health effects from low doses experienced in the environment. The models contain conservative assumptions to account for the large degree of uncertainty associated with this extrapolation (especially for potential carcinogens) and therefore, tend to be more likely to overestimate than underestimate the risks.

3.3 Exposure Assessment

During the exposure assessment, exposure point concentrations are estimated, and exposure doses are calculated. Exposure point concentrations are the estimated concentrations of compounds to which humans may be exposed. Because ambient air chemical concentrations do not exist at receptor locations and direct measurement of would be confounded by non-relevant sources and would likely be below analytical detection limits exposure point concentrations were estimated using models containing numerous assumptions, such as the amount of compound released from the site, the dispersion of the compound in air and its fate and transport in the environment, and the location of people potentially exposed to released compounds. Once the concentrations in an environmental medium such as air have been predicted, the calculation of human exposure and dose involves making additional assumptions. The major sources of uncertainty associated with these assumptions are discussed below.

3.3.1 Estimation of Particulate Emission Factors

Offsite concentrations of COPCs for this risk assessment were either derived from a single 8-hr ambient air-monitoring event or estimated via the use of USEPA's emission equation for "wind erosion from surfaces with unlimited erosion potential" (U.S. EPA, 1985). Both approaches are extremely health-protective because they overestimate the amount of dust that could result from disposal operations or from surfaces having a limited reservoir of erodible material. For example, the particulate emission factor for disposal operations was derived from the PM10 concentration from the location with the maximum particulate reading. Had the average of the two monitors at the disposal level or the average at all four locations been used, PM10 concentrations would have been significantly lower. Similarly, the use of the *average* concentration at the monitoring location with the highest values also introduces significant uncertainty. For example, it was assumed that all dust measured in the dust monitors was derived from contaminated soil. In reality, most of the observed dust was generated by truck traffic atop uncontaminated soil surfaces. If truck traffic over uncontaminated surfaces was excluded, emission would certainly be lower.

3.3.2 Estimation of Airborne Dust Concentrations

There is some uncertainty in the estimation of airborne dust concentrations, because the risk assessment does not separately consider dust concentrations on days when winds are high. This uncertainty is minimal, however, as described below. The current risk assessment utilizes an EPA screening air dispersion model that assumes winds are blowing towards residential receptors 24 hours a day, 365 days a year at 2.8 m/s for either a 1-year or 30-year period. The USEPA states that a 0.08 times multiplication factor should be used to convert the 1-hr maximum average to an annual average. This was not done in this evaluation. Instead, an adjustment factor of 0.2 was applied to estimate the annual average (personal communication with Dr. Barbara Brooks, HEER Office). Under these conditions, no significant risk resulted from wind-blown dust off-site. In fact, the highest cancer risk calculated was 5E-08 and the noncancer hazard index was .02. Both risk values are far below any regulatory Levels of Concern. Had a more realistic air dispersion model been used, the ambient dust concentrations at receptor locations would have been lower.

3.3.3 Estimation of Exposure Dose

Once the concentrations of the potentially released compounds in air have been predicted through modeling, the extent of human exposure must be estimated. This requires making assumptions about the frequency and duration of human exposure.

Uncertainty may be associated with some of the assumptions used to estimate how often exposure occurs. Such assumptions include location, accessibility, and use of an area. With this in mind, the receptor, or person who may potentially be exposed, and the location of exposure were defined for this risk assessment. The locations where certain activities were assumed to take place have been purposely selected because chemical concentrations and frequency of exposure are expected to be high (i.e., use of the maximally affected areas). However, actual frequencies of exposure are likely to be much lower than assumed, because residents are not likely to stay in one place and may, for instance, work far away or move to another location. Furthermore the remaining lifetime of the landfill will probably not approach the estimated duration of lifetime, residence, or employment. In these cases, the person's potential exposure would be reduced, and the health risks discussed here would be overestimated.

3.4 Risk Characterization

The risk of adverse human health effects depends on estimated levels of exposure and dose-response relationships. Once exposure to and risk from each of the selected compounds is calculated, the total risk posed by disposal operations is determined by combining the health risk contributed by each compound. For virtually all combinations of compounds present in chemicals evaluated in this assessment, there is little or no evidence of interaction. However, in order not to understate the risk, it is assumed that the effects of different compounds may be added together.

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