Final Report

BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT, UPLAND OPERABLE UNIT

Bradford Island
Cascade Locks, Oregon

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ACRONYMS AND ABBREVIATIONS

%	percent/percentile
AAF	absorption adjustment factor
ACH	air changes per hour
ADAF	age-dependent adjustment factors
AF	attenuation factors
ALM	adult lead model
AOPC	area of potential concern
AST	aboveground storage tank
AT	average time
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	area use factor
BAF	bioaccumulation factor
BaPeq	benzo(a)pyrene-equivalent carcinogenic potency
BHHRA	baseline human health risk assessment
BERA	baseline ecological risk assessment
bgs	below ground surface
BHC	benzene hexachloride
BISB	Bradford Island Service Building
BW	body weight
CDC	U.S. Center for Disease Control
CEC	contaminant of ecological concern
CEM	conceptual exposure model
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
COC	contaminant of concern (human health)
COI	contaminant of interest
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPEC	contaminant of potential ecological concern
C_{soil}	concentration in soil
CTE	central tendency exposure
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DDx	DDT, DDD, and DDE
DEHP	bis(2-ethylhexyl)phthalate dL deciliter
EcoSSL	Ecological Soil Screening Level
ECSI	Environmental Cleanup Site Information
EF	exposure frequency
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
FI	fraction ingested
foc	fraction of organic carbon

FS	feasibility study
ft	foot/feet
GSDI	geometric standard deviation
HHRA	human health risk assessment
HI	hazard index
HMSA	hazardous material storage area
HPAH	high molecular weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IR	ingestion rate
IRS	soil ingestion rate
IRAF	infant risk adjustment factors
IRIS	Integrated Risk Information System
IUR	inhalation unit risk
JEM	Johnson and Ettinger (Vapor Intrusion) Model
K_d	partitioning coefficient for inorganics
kg	kilogram(s)
K_{oc}	partitioning coefficient for organic chemicals
L	liter(s)
LD50	lethal dose to 50% of test organisms
LOAEL	lowest observable adverse effect level
$\log K_{ow}$	octanol-water partition coefficient
µg	microgram(s)
µm	micrometer(s)
m^3	cubic meter
MDL	method detection limit
mg	milligram(s)
MP	Management Plan
MW	monitoring well
NOAEL	no observable adverse effect level
ODEQ	Oregon Department of Environmental Quality
ORNL	Oak Ridge National Laboratory
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PbB	blood lead concentration
PbB0	baseline blood lead concentration
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PPRTV	provisional peer-reviewed toxicity value
PRG	preliminary remediation goals
Q/C	inverse of the mean concentration at the center of a 0.5 acre-square source
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RAL	remedial action levels
RAO	remedial action objective

ACRONYMS AND ABBREVIATIONS

RBA	relative bioavailability factor
RBC	Risk-Based Concentrations
RfD_o	Reference Dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RM	river mile
RME	reasonable maximum exposure
RSL	Regional Screening Levels
SFo	oral slope factors
SLERA	Screening Level Ecological Risk Assessment
SLV	screening level value
SVOC	semivolatile organic compound
TAG	Technical Advisory Group
TCE	trichloroethene
TEF	toxicity equivalence factors
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
TRW	Technical Review Workgroup
UCL	upper confidence limit
UPL	upper prediction limit
URS	URS Corporation
USACE	United States Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VDEQ	Virginia Department of Environmental Quality
VF	volatilization factor
VOC	volatile organic compound
WP	work plan

EXECUTIVE SUMMARY

This report presents the baseline human health risk assessment (BHHRA) and the baseline ecological risk assessment (BERA) for the Upland Operable Unit (OU), Bradford Island, Bonneville Dam Complex. The Portland District of the United States Army Corps of Engineers (USACE) has characterized and evaluated the contamination arising from historical practices at Bradford Island in Oregon. Bradford Island is part of the Bonneville Dam complex, which is located on the Columbia River at river mile (RM) 146.1, approximately 40 miles east of Portland, Oregon. The site is a multipurpose facility that consists of the First and Second Powerhouses, the old and new navigation locks, and a spillway with a capacity of 1.6 million cubic feet per second.

USACE and their contractors have performed numerous investigations since 1997, focusing on two OUs: the Upland OU, and the River OU. The investigations have identified four areas of potential concern (AOPCs) in the Upland OU: the Landfill, Sandblast Area, Pistol Range, and the Bulb Slope. The primary contaminants of interest (COIs) that have been identified in soil and/or groundwater in the four AOPCs include certain metals; polychlorinated biphenyl (PCBs); semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbon (PAHs); butyltins; volatile organic compounds (VOCs); and a few pesticides and herbicides.

The Final Remedial Investigation (RI) report (URS Corporation [URS] 2012) documented the investigation, identified source areas at Bradford Island, defined the nature and extent of the environmental contamination, and identified the contaminants of potential concern (COPCs) for human health and contaminants of potential ecological concern (CPECs) in the media from the two OUs. On the basis of the screening level risk assessments, the Final RI recommended site-specific BHHRAs and BERAs for the Landfill and Sandblast Area AOPCs and site-specific BERAs for the Pistol Range and Bulb Slope AOPCs. After the Final RI was completed, USACE later elected to include a Fishing Platform scenario for human health at all four AOPCs as part of the BHHRA.

The Upland OU BHHRA and BERA build on the data and findings of the Final RI (URS 2012) and will be attached as an appendix to the Upland OU Feasibility Study (FS). Due to the anticipated outcome of the baseline risk assessments (RAs) that will document the need for risk management in an Upland OU FS, this RA document goes beyond the traditional assessment of the presence/absence and magnitude of baseline risk. To maximize use of these site datasets and develop an RA that is most beneficial to the FS, site-specific risk-based concentrations (RBCs) were calculated for the chemicals recommended for further evaluation in the Upland OU FS. Exceedances of these RBCs were illustrated for purposes of risk interpretation and to allow for general observations of the spatial distribution of potentially impacted areas.

Only upland exposure pathways were addressed in these baseline RAs. The Upland OU to River OU pathways (i.e., potential mass wasting and soil erosion) that were evaluated at a screening level in the Final RI were not addressed herein, as these possible pathways will be considered in the Upland OU FS or the River OU FS.

Baseline Human Health Risk Assessment

The screening RA performed in the Final RI (URS 2012) evaluated only occupational scenarios at the Upland OU AOPCs and recommended further evaluation of occupational exposures at the

Landfill and Sandblast Area AOPCs. Following the later decision by USACE to include a Fishing Platform scenario, it was necessary to perform a risk screening for all four of the Upland OU AOPCs for the Fishing Platform receptor, followed by a site-specific baseline risk assessment, as warranted. Therefore, this BHHRA includes the limited occupational scenario evaluation for only the Landfill and Sandblast Area AOPCs (as recommended in the Final RI) and evaluation of the Fishing Platform receptor at all of the four Upland AOPCs (as decided after completion of the Final RI).

Media and COPCs evaluated at the Landfill included metals (arsenic, chromium, lead); carcinogenic PAHs (cPAHs); and chlorinated volatile organic compounds (CVOCs), including tetrachloroethylene (PCE), trichloroethylene (TCE), and associated degradation products in soil and groundwater, as well as mercury, total PCBs as Aroclors, MCPP, and naphthalene in soil only. The Sandblast Area AOPC included similar COPCs in soil, groundwater, and soil gas. A larger number of COPCs were evaluated for the Hypothetical Fishing Platform User than for the occupational scenarios. For both the Pistol Range and Bulb Slope AOPCs, the only COPC was lead in soil for the Hypothetical Fishing Platform User.

In accordance with the Final RI findings, the human receptors evaluated included the following: outdoor maintenance workers exposed to shallow soils, defined as 0 to 3 feet (ft) below the ground surface (bgs), by direct contact at the Landfill and Sandblast Area AOPCs; construction and excavation workers exposed to deeper soils, defined as 0 to10 ft bgs; excavation and trench workers exposed by incidental contact with shallow groundwater at the Landfill and Sandblast Area AOPCs; and indoor office workers exposed by vapor intrusion of soil gas at the Sandblast Area AOPC. Vapor intrusion at the Landfill AOPC is not a concern since there are currently no buildings at the Landfill AOPC, and construction of future buildings is not considered feasible from an engineering standpoint.

Subsequent to the approval of the Update to RA Work Plan (WP), Upland OU (WP Update) (URS 2014), newly identified receptors with potential for direct contact with shallow soils in the Upland OU include adults and children of the four treaty tribes who, in the future, may exercise their treaty rights to engage in fishing from Bradford Island as a usual and accustomed fishing ground. Their activities may include the construction and use of fishing platforms along the upland shoreline of the Island as well as camping and other recreational activities in the interior of the Island. Fishing platform usage does not currently occur at Bradford Island, and the likelihood of such usage in the future is unknown. It is therefore considered a future hypothetical exposure scenario in its potential to result in direct contact with soils at the four Upland OU AOPCs.

Due to the lack of site-specific information to adjust the exposure durations to more realistic values, the Hypothetical Fishing Platform Users were conservatively treated as comparable to a residential scenario in the BHHRA. For this reason, risks to the Hypothetical Fishing Platform User should be understood to be overly conservative in nature. Additionally, in the future, soil management measures to meet acceptable risk levels for occupational uses may be implemented at the Landfill and Sandblast Area AOPCs. In this case, future concentrations of COPCs in soil may be different and lower than under current conditions.

Nursing infants who may be exposed through ingestion of maternal milk were also included as newly added receptors for selected bioaccumulative COPCs. This is consistent with Oregon Department of Environmental Quality (ODEQ) guidance (ODEQ 2010a) published after the

Remedial Investigation/Feasibility Study (RI/FS) Management Plan (MP) (URS 2007) was approved (URS 2007).

Both reasonable maximum exposure (RME) and central tendency exposure (CTE) were evaluated for the occupational receptors, to represent a range of upper-end and average exposures. Excess lifetime cancer risk (ELCR) and noncancer hazard quotient (HQ) and summed hazard index (HI) were reported for all chemicals. The estimated risks for each receptor-pathway combination were characterized with regard to whether they were:

1) less than the U.S. Environmental Protection Agency (USEPA) risk level of 1×10^{-6} (also expressed as one in a million) or HI of 1, whereby risk at or below these thresholds have an insignificant contribution to risk (i.e., *de minimis*);
2) within the USEPA acceptable risk range of 1×10^{-4} to 1×10^{-6}; or
3) exceeding the USEPA acceptable risk range, i.e., greater than 1×10^{-4}.

In addition, ODEQ's acceptable risk thresholds of 1×10^{-6} for individual carcinogens and 1×10^{-5} for multiple carcinogens were also considered. Due to this, individual chemicals associated with risk levels greater than the ODEQ thresholds of 1×10^{-6} or HQ greater than 1 were identified as contaminants of concern (COCs), except arsenic, for which background levels were also considered. Since the individual compounds that make up the cPAHs all act by the same mode of action, risks for PAHs were calculated by individual compound and also summed to present risks for cPAHs as a group. It is important to note that, since ELCRs are only expressions of likelihood of cancer incidence, and HIs are estimated ratios to safe doses, exceedance of the ODEQ risk thresholds or USEPA acceptable risk range does not automatically mean that adverse effects may have occurred or will occur (e.g., does not automatically mean that the COC will be recommended for further evaluation in the FS).

For occupational receptors, estimated risks were either below the ODEQ threshold or within the USEPA acceptable risk range at both the Landfill and Sandblast Area AOPCs for all exposure media. At both AOPCs, RME exposure to surface and deeper soils resulted in risks that fell within the USEPA acceptable risk range for outdoor maintenance workers and construction workers. Risks for construction workers were lower than ODEQ's threshold of 1×10^{-5} for multiple carcinogens. Incidental exposure to groundwater for excavation/trench workers were *de minimis* at both AOPCs. Risks related to vapor intrusion and indoor inhalation were also *de minimis* for both current and future indoor workers at the Sandblast Area AOPC. Only outdoor maintenance workers at the Landfill AOPC had a CTE risk within the USEPA acceptable risk range and for all other receptors, CTE risks were insignificant contributors to risk (i.e., below 1×10^{-6}).

For the future Hypothetical Fishing Platform User, estimated risks exceeded the USEPA acceptable risk range under current conditions for the Landfill and Sandblast Area AOPCs. Risks and noncancer hazards for nursing infants were close to or less than the ODEQ threshold of 1×10^{-6} for selected bioaccumulative COPCs under current conditions at both of these AOPCs. Risks related to lead at the Pistol Range and Bulb Slope AOPCs were at acceptable levels.

Table ES-1 summarizes COCs in soil that are recommended for further evaluation in the Upland OU FS.

Table ES-1
Summary of Upland OU Soil COCs for Further Evaluation in the Upland OU FS

AOPC	Outdoor Maintenance Worker	Construction Worker	Excavation/ Trench Worker	Indoor Office Worker	Hypothetical Fishing Platform User
Landfill	cPAHs	Benzo(a)pyrene	None	None	Arsenic, PCBs, cPAHs
Sandblast Area	cPAHs	Benzo(a)pyrene	None	None	Arsenic, PCBs, cPAHs, DEHP
Pistol Range	NA	NA	NA	NA	None
Bulb Slope	NA	NA	NA	NA	None

DEHP = bis(2-ethylhexyl)phthalate

No further evaluation or action is warranted for groundwater at either the Landfill or Sandblast Area AOPCs or for soil gas at the Sandblast Area AOPC. No further evaluation of soils at the Pistol Range or Bulb Slope is warranted for the upland evaluation. Further evaluation in the Upland OU FS is recommended for soils at the Landfill and Sandblast Area AOPCs based on risks falling above the ODEQ risk thresholds, although they are within the USEPA acceptable risk range for the receptors listed in Table ES-1.

Site-specific RBCs, corresponding to a target risk of 1×10^{-6} for cPAHs (expressed as benzo(a)pyrene equivalents) for the outdoor maintenance worker and for benzo(a)pyrene as an individual chemical for the construction worker, were calculated for the COCs identified in Table ES-1. Figures 2-5 and 2-6 identify locations at the two AOPCs that exceed the RBCs for the occupational scenarios.

The smaller sub-set of locations that also exceed ODEQ's acceptable risk level of 1×10^{-5} for multiple carcinogens (cPAHs) are also indicated in these figures.

Exceedances of cPAHs above the occupational RBCs are limited to a few areas, as follows:

- **Landfill AOPC –** northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, far eastern portion of the Landfill, and one isolated spot northeast of the Pesticide/Herbicide Wash Area (Figure 2-5).
- **Sandblast Area AOPC –**the Erodible Unit, Current Hazardous Material Storage Area (HMSA), Equipment Laydown Area, and the Former HMSA (Figure 2-6).

Site-specific RBCs were also calculated for the COCs identified for the Hypothetical Fishing Platform User (arsenic, PCBs, DEHP, cPAHs), as shown in Table ES-1. Figures 2-7 and 2-8 illustrate the locations where RBCs for the Hypothetical Fishing Platform User were exceeded in shallow soils at the Landfill and Sandblast Area AOPCs under current site exposure conditions. These are more numerous than the exceedances of occupational RBCs. At most locations with exceedances, several COCs exceeded the USEPA acceptable risk range, indicating that measures to address multiple COCs may be possible. As noted earlier, risks to the Hypothetical Fishing Platform User should be understood to be overly conservative in nature since that receptor scenario was treated as comparable to a residential scenario. In addition, soil management measures to meet acceptable risk levels for occupational uses may be implemented in the future at the Landfill and Sandblast Area AOPCs. In this case, future concentrations of COPCs in soil may be different and lower than under current conditions.

The primary purpose of adding the Hypothetical Fishing Platform User receptor scenario is to help guide site management decisions in the Upland OU FS. The RBC for cPAHs for the Hypothetical Fishing Platform User is lower than the Reference upper prediction limit (UPL) for cPAHs. The RBC is also conservative since it assumes an overly high degree of oral and dermal bioavailability of PAHs. Incorporation of literature-based or site-specific measures of bioavailability of PAHs may result in more realistic RBCs.

Baseline Ecological Risk Assessment

All four AOPCs in the Upland OU were retained for evaluation in the BERA. Only soil was identified as a medium of concern for terrestrial ecological receptors. The CPECs carried into the BERA include metals, total high-molecular-weight PAHs (HPAHs), tributyltin, organochlorine pesticides, VOCs, and SVOCs for the Landfill and Sandblast Area, lead for the Pistol Range AOPC, and lead and mercury for the Bulb Slope AOPC. These CPECs were included in the Upland OU-wide evaluation in which wide-ranging receptors were assumed to forage in all four AOPCs combined. Risk estimates were calculated for each CPEC for all receptors potentially present at a given AOPC.

The following list of receptors and exposure pathways were included in the Upland BERA:

- Terrestrial plants and soil invertebrates exposed through direct contact with surface and shallow soil.
- Canada goose (*Branta canadensis*) exposed through incidental ingestion of surface and shallow soil, prey (100% plants), and water.
- American robin (*Turdus migratorius*) exposed through incidental ingestion of surface and shallow soil, prey (100% soil invertebrates), and water.
- American kestrel (*Falco sparverius*) exposed through incidental ingestion of surface and shallow soil, prey (100% small mammals), and water.
- Vagrant shrew (*Sorex vagrans*) exposed through incidental ingestion of surface and shallow soil, prey (100% soil invertebrates), and water.
- American mink exposed through incidental ingestion of surface soil, upland prey (15% small mammals), and water.

Based on the available data, surface soil is defined as 0 to 1 ft bgs for all AOPCs except for the Pistol Range, for which surface soil is defined as 0 to 1.5 ft bgs. Shallow soil is defined as 0 to 3 ft bgs, and this depth interval only applies to the Landfill and Sandblast Area AOPCs, as deeper data are not available for the Bulb Slope and Pistol Range.

Both low screening level values (SLVs)/no observable adverse effect levels (NOAELs) and high SLVs/lowest observable adverse effect levels (LOAELs) were selected for each receptor to develop a range of HQs and HIs for consideration by risk managers. Table ES-2 summarizes the

AOPCs and contaminants of ecological concern (CECs) identified in surface through the BERA that are recommended for further evaluation in the Upland OU FS. All of the NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the wide-ranging receptors (kestrel and mink), and no additional evaluation is needed for these receptors on an individual AOPC basis or on a combined AOPC/Upland OU-wide basis.

Table ES-2
Summary of Upland OU Soil CECs for Further Evaluation in the Upland OU FS

AOPC	Terrestrial Plants	Soil Invertebrates	American Robin	Vagrant Shrew
Landfill	Mercury, Nickel, Chlordane, HPAHs	Mercury and HPAHs	Chromium, Copper, Lead, Mercury, Nickel, Chlordane	Chromium, Copper, Lead, Mercury, Nickel, Chlordane, HPAHs
Sandblast Area	Nickel and HPAHs	None	Chromium, Lead, Nickel	Antimony, Chromium, Lead, Nickel, HPAHs
Pistol Range	None	None	Lead	None
Bulb Slope	None	None	None	None

Chlordane = chlordane (technical mixture and metabolites)

No further upland evaluation of the Bulb Slope is recommended based on the low risk estimates. Further evaluation in the Upland OU FS is recommended for the three remaining AOPCs based on exceedances of site-specific RBCs for one or more of the ecological receptors listed in Table ES-2.

Site-specific ecological RBCs were used to identify the areas within each AOPC that warrant specific attention in the Upland OU FS, which are summarizes as follows:

- **Landfill AOPC –** northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, and two locations within and northeast of the Pesticide/Herbicide Wash Area.
- **Sandblast Area AOPC –** Spent Sandblast Grit Disposal Area, northern boundary of the Former HMSA, Catch Basin #1, localized areas within the Erodible Unit Sampling Area, and Equipment Laydown Area.
- **Pistol Range AOPC –** around the approximate location of the backstop, and north and east of the approximate location of the Former Firing Shed.

To protect ecological receptors, AOPC-wide average concentrations for each AOPC should be below the lowest site-specific RBCs. When the 95% UCL concentrations for the identified CECs are below the RBCs for each AOPC, acceptable levels of ecological risk will be achieved.

1.0 INTRODUCTION

This report presents the Upland Operable Unit (OU) baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA) for the Bradford Island, Bonneville Dam Complex. The Portland District of the United States Army Corps of Engineers (USACE) has characterized and evaluated the contamination arising from historical practices at Bradford Island in Oregon. Bradford Island is part of the Bonneville Dam Complex, which is located on the Columbia River at river mile (RM) 146.1, approximately 40 miles east of Portland, Oregon (Figure 1-1). The site is a multipurpose facility that consists of the First and Second Powerhouses, the old and new navigation locks, and a spillway with a capacity of 1.6 million cubic feet per second (USACE 2000). Figure 1-2 shows features of the Bonneville Dam Complex.

Site investigations on Bradford Island began with the Landfill. The Landfill was used from the early 1940s until the early 1980s. The USACE informed the U.S. Environmental Protection Agency (USEPA) and the Oregon Department of Environmental Quality (ODEQ) of the presence of the Landfill in 1996. The Landfill was added to the ODEQ Environmental Cleanup Site Information (ECSI) database in April 1997, and the Bonneville Dam Project Manager signed an ODEQ Voluntary Cleanup Agreement letter for the Landfill in February 18, 1998, under the ODEQ Voluntary Cleanup Program. In 2005, USACE continued investigation of Bradford Island under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The USACE is currently working with the ODEQ to address the state's concerns regarding this investigation and any associated cleanup.

USACE and their contractors have conducted numerous investigations since 1997, focusing on two OUs: the Upland OU and the River OU (Figure 1-3). The investigations identified four areas of potential concern (AOPCs) in the Upland OU: the Landfill, Sandblast Area, Pistol Range, and the Bulb Slope (Figure 1-4). The primary contaminants of interest (COIs) that have been identified in soil and/or groundwater in the four AOPCs include certain metals; polychlorinated biphenyl (PCBs); semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbon (PAHs); butyltins; volatile organic compounds (VOCs); and a few pesticides and herbicides.

The Final Remedial Investigation (RI) report (URS Corporation [URS] 2012) documented the investigation, identified source areas at Bradford Island, defined the nature and extent of the environmental contamination, and identified the contaminants of potential concern (COPCs) for human health and contaminants of potential ecological concern (CPECs) in the media from the two OUs. On the basis of the screening level risk assessments (RAs), the Final RI recommended site-specific BHHRAs and BERAs for the Landfill and Sandblast Area AOPCs, and site-specific BERAs for the Pistol Range and Bulb Slope AOPCs.

The USACE and the external stakeholders for the project are collectively referred to as the Technical Advisory Group (TAG) and include federal, state, and Tribal natural resource trustees. Section 2.6 of the Final RI (URS 2012) details these officials, responsibilities, and involvement on the project. The federal and state TAG trustees actively participating in this project include the USACE, United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration, ODEQ, Oregon Department of Fish and Wildlife, Oregon Department of Human Services, and Washington Department of Ecology. Several Indian Tribes have interests in the Columbia River and the Bradford Island site, including the Yakama Nation, the Warm Springs Tribe, the Cowlitz Tribe, the Chinook Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Reservation. At the request of the TAG, USACE elected to evaluate a Hypothetical Fishing Platform User scenario for human health at all four AOPCs in the BHHRA, subsequent to the completion of the Final RI.

Soil exposure at all four AOPCs was evaluated in the BHHRA and BERA, whereas exposure to lagoon sediment at the Pistol Range AOPC, soil gas at the Sandblast Area AOPC, and groundwater at the Landfill and Sandblast Areas AOPCs are only evaluated in the BHHRA. In addition, the BERA evaluated exposure of soil from all four AOPCs combined for wide-ranging mobile receptors. As described in the Final RI (URS 2012), some soil samples in the northern portion of the Sandblast Area AOPC were divided into two subgroups based on samples that were noted for having higher soil or higher sandblast grit composition (noted as “soil” and “grit” in the Sandblast Area AOPC Section 5 tables of the Final RI); however, both subgroups were utilized as soil in the screening-level RAs in the Final RI and in these baseline RAs.

Tables 1-1 through 1-4 summarize statistics for the COPCs/CPECs in soil for the Landfill, Sandblast Area, Pistol Range, and Bulb Slope AOPCs, per relevant depth intervals. Consistent with the Final RI (URS 2012), the depth intervals for Sandblast and Landfill AOPCs are characterized as surface (0-1 foot [ft] below ground surface[bgs]), shallow (0-3 ft bgs) and deeper (0-10 ft bgs), and the Bulb Slope and Pistol Range AOPCs only have surface soil depth intervals of 0-1 ft bgs and 0-1.5 ft bgs, respectively. Table 1-5 presents the statistical summary for the CPECs in soil for all four AOPCs combined (Upland OU-wide for mobile receptors). Table 1-6 lists the summary statistics for the COPCs in soil gas, and Tables 1-7 and 1-8 list the summary statistics for the COPCs in groundwater at the Landfill and Sandblast Area AOPCs. Table 1-9 provides summary statistics for chemicals in the Reference Area soil and groundwater at Bradford Island.

The Upland OU BHHRA and BERA presented herein build upon on the data and findings of the Final RI (URS 2012) and will be attached as an appendix to the Upland OU FS. Due to the anticipated outcome of the baseline RAs that will document the need for further evaluation in an Upland OU FS, this RA document goes beyond the traditional assessment of the presence/absence and magnitude of baseline risk. To maximize use of these site datasets and develop an RA that is most beneficial to the FS, site-specific risk-based concentrations (RBCs) were calculated for the chemicals recommended for further evaluation in the Upland OU FS. Exceedances of these RBCs were illustrated for purposes of risk interpretation and to allow for general observations of the spatial distribution of potentially impacted areas.

The following topics were presented in the RI and are not repeated herein unless an approach has been modified or updated:

- Site Description (RI Section 3)
- Conceptual Site Model (RI Section 4)
- Pre-RI and RI Investigations (RI Sections 5 and 6)
- RI Data Quality (RI Section 7)
- RI Screening Human Health Risk Assessment (HHRA) Discussion (RI Section 11)
- RI Screening HHRA Tables (RI Appendix M)

- RI Screening Level Ecological Risk Assessment (SLERA) Discussion (RI Section 12)
- RI SLERA Tables (RI Appendix N)
- RI Data Management (RI Appendix H)
- RI Data Sensitivity (RI Appendix K)
- RI Uncertainty Section (RI Appendix O)

The methodology for the BHHRA and BERA was originally presented in the Remedial Investigation/Feasibility Study (RI/FS) Management Plan (MP) (URS 2007) and recently refined in the Update to RA Work Plan (WP), Upland OU (WP Update) (URS 2014). The WP Update is included as Appendix C. As described in the WP Update (URS 2014), only upland exposure pathways were addressed in the BHHRA and BERA. The Upland OU to River OU pathways (i.e., potential mass wasting and soil erosion) that were evaluated at a screening level in the Final RI (URS 2012) were not addressed in the Upland OU baseline RAs. These possible pathways will be considered in the Upland Feasibility Study (FS) or River FS.

1.1 Objectives

The objectives of this report are as follows:

- Conduct a BHHRA and BERA to identify any unacceptable risks to occupational human and ecological receptors at the Landfill and Sandblast Area AOPCs.
- Conduct a BHHRA to identify any unacceptable risks to future Hypothetical Fishing Platform Users (under current conditions of site exposure point concentrations) at the Landfill, Sandblast Area, Pistol Range, and Bulb Slope AOPCs.
- Conduct a BERA to identify any unacceptable risks to ecological receptors at the Pistol Range and Bulb Slope AOPCs.
- Determine which contaminants of concern (COCs) for human health/contaminants of ecological concern (CECs) in which portions of the AOPCs need to be addressed in the subsequent FS.
- Determine which COPCs/CPECs require no additional risk evaluation and will not be carried forward to the FS.

This report will provide the basis for the Upland OU FS to be conducted later. The objectives of the Upland FS will include the following:

- Identify Remedial Action Objectives (RAOs).
- Identify and evaluate cleanup alternatives.
- Recommend proposed cleanup remedies.

1.2 Organization

This report is organized as follows:

Executive Summary

Section 1 – Introduction

Section 2 – BHHRA

Section 3 – BERA

Section 4 – Summary

Section 5 – References

2.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The BHHRA is the next step in the screening process, following the Upland OU screening-level RA presented in the Final RI (URS 2012).

At the time of completion of the Upland OU screening HHRA in the Final RI, no further evaluation of occupational exposures was recommended for the Bulb Slope and Pistol Range AOPCs. Only the Landfill and Sandblast Area AOPCs were recommended to be carried forward for the BHHRA for occupational exposures. For the Landfill and Sandblast Area AOPCs, Tables 11-1 and 11-2 of the Final RI identified the potentially exposed occupational receptors, exposure media (soil, groundwater, and soil gas), and the COPCs. However, all AOPCs, including the Bulb Slope and Pistol Range AOPCs, were considered in this BHHRA due to the addition of non-occupational new receptors as discussed below.

Updates and additions to the WP Update (URS 2014 and subsequent discussions) are as follows:

- Eliminated use of groundwater as a hypothetical potable water supply source based on ODEQ’s acceptance that such use of on-site groundwater was not feasible under current or future conditions (Bob Schwarz [ODEQ], pers. comm. 2014).
- Updated exposure factors based on changes in the USEPA standard default exposure factors (USEPA 2014).
- Evaluated detected VOCs in groundwater for the trench exposure scenario.
- Added trivalent chromium as a COPC for the Landfill AOPC Outdoor Maintenance Worker.
- Added Hypothetical Fishing Platform User as a new receptor for all four AOPCs, as described in Section 2.1 and Section 2.2. This future receptor scenario is a conservative evaluation under current site exposure conditions.
- Added Nursing Infant pathway for all four AOPCs, as described in Section 2.1 and Section 2.2.

The BHHRA follows the methods described in the RI/FS MP (URS 2007) and the WP Update (URS 2014), primarily following USEPA guidance (1989, 1991, 1992a, 2002a, 2002b, 2013a, 2014, 2015a). ODEQ (2010a, 2010b) guidance documents were used during the RI HHRA screening process and are also considered in the BHHRA.

2.1 AOPCs, Exposure Media, and COPCs

Exposure media and associated COPCs for occupational receptors were identified in the Final RI (URS 2012) based on a rigorous screening exercise using occupational screening level values. For the newly added Hypothetical Fishing Platform User, a new COPC selection process using residential screening values was initiated, as described in Section 2.1.1.

As identified at the end of the Final RI, the contaminated media for occupational receptors are soil and groundwater at the Landfill AOPC and soil, groundwater, and soil gas at the Sandblast Area AOPC. The media-specific chemical groups of COPCs are as follows:

Media and COPCs for Landfill AOPC

- **Soil** Metals: arsenic, chromium, lead

  Carcinogenic PAHs (cPAHs): benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzofluoranthenes, total, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene

  Chlorinated VOCs (CVOCs): tetrachloroethylene (PCE) and PCE degradation products

- **Groundwater** (incidental exposure in trench setting for Excavation/Trench Worker only)
  Metals: antimony, iron, mercury, thallium, zinc
  Phthalates: di-n-octyl phthalate
  VOCs: seven detected VOCs in groundwater (see Table 1-7)

Media and COPCs for Sandblast Area AOPC

- **Soil** Metals: arsenic, chromium, lead
  cPAHs: benzo(a)pyrene, benzofluoranthenes, total
  CVOCs: PCE and PCE degradation products

- **Groundwater** (incidental exposure in trench setting for Excavation/Trench Worker only)
  Metals: vanadium
  VOCs: 18 detected VOCs in groundwater (see Table 1-8)

- **Soil Gas** CVOCs: PCE and PCE degradation products, trichloroethylene (TCE)

TCE is a solvent used in degreasing and a degradation product of PCE. TCE was identified as a COPC when it was detected above its screening level in specific media (e.g., soil gas at Sandblast Area AOPC). TCE is also included as a COPC, even if it was not detected or detected at levels below TCE screening values, in a medium where PCE was detected (e.g., Landfill and Sandblast Area soils and groundwater). Other degradation products of PCE that are included as COPCs, even if they were not detected or detected below their screening levels, include cis-1,2-dichloroethene, 1,1-dichloroethene, and vinyl chloride. The rationale for including degradation products as COPCs is based on ODEQ guidance that degradation products may have the potential to occur at higher concentrations in the future as long as the parent compound is present under current conditions.

2.1.1 Hypothetical Fishing Platform User - COPC Selection

At the request of the TAG, an additional exposure scenario is included in this BHHRA for the Upland OU that was not included in the Final RI (URS 2012) or WP Update (URS 2014). A Hypothetical Fishing Platform User was considered in the BHHRA because adults and children of the four treaty tribes may, in the future, exercise their treaty rights to engage in fishing from Bradford Island as a usual and accustomed fishing ground. The tribes include the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Warm Springs Reservation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation, and are referred to herein as the four treaty tribes. Their activities may include erecting fishing platforms along the shoreline, fishing with nets or lines from the platforms, and camping at the Island. These uses may bring adults and children into direct contact with surface soils at the Island. Fish ingestion was considered in the River OU BHHRA.

At the current time, fishing platform activities do not occur at Bradford Island. If such activities were to be carried out in the future, they would likely be limited to the south shore of Bradford Island, which is the most accessible area for fishing. However, under treaty rights, such uses may be extended to the entire shoreline and the entire eastern portion of the Island. Therefore, the objective of this risk evaluation is to assess whether there are unacceptable risks to adults and children under worst-case assumptions, i.e., assuming unrestricted access to all four of the Upland OU AOPCs resulting in exposures generally comparable to residential levels to shallow soils at the AOPCs. Thus, exposure to a lifetime of unrestricted direct contact with shallow soils (i.e., incidental ingestion, dermal contact, and outdoor inhalation of dusts and vapors) was assumed. No exposure to groundwater or indoor exposure to soil gas is likely.

In summary, the Hypothetical Fishing Platform User scenario does not occur under current conditions and is hypothetical even under future conditions. However, it is included in the BHHRA as a potential, allowable use using current surface soil concentrations.

A new COPC selection process was carried out for this receptor since the earlier COPC selection process completed during the RI used only occupational screening values. For the Hypothetical Fishing Platform User, COPCs were selected by comparing COI concentrations in soil with modified residential screening values to account for an overall more conservative exposure scenario.

Consistent with ODEQ guidance, the COIs identified for shallow soils (0-3 ft bgs) in the Final RI (URS 2012) omitted chemicals detected below a 5% detection frequency and inorganics with concentrations lower than the Reference Area. The soil exposure point concentrations (EPCs) for each AOPC were the lesser of the 95th percentile (%) upper confidence limit (UCL) and the maximum detected concentration (see Tables 2-1 to 2-4).

When calculating the 95% UCL using the ProUCL software, the software may recommend a method and value for the 95% UCL that is a higher percentile (e.g., recommending a 99% UCL). The UCL recommended by the ProUCL software was automatically selected, following USEPA's statistical methodology guidance (2013b). For simplicity and clarity, the term used throughout the text is "95% UCL"; however, the specific UCLs recommended by ProUCL are shown in Tables 1-1 through 1-9.

At the request of the TAG, for the modified residential screening level values (SLVs), it was assumed that tribal members may spend 365 days a year for 26 years on the Island, which is an intentionally more conservative assumption than the RSLs. Since the residential RSLs (USEPA 2014, 2015a) assume an exposure duration of 350 days/year for 26 years, the residential soil RSLs (USEPA 2014, 2015a) were modified to account for 365 days exposure frequency (EF) for the Hypothetical Fishing Platform scenario.

$$\text{(RSL Scaling Factor)} = 350 \text{ days} / 365 \text{ days} = 0.96$$

The generic residential soil RSL was multiplied by the scaling factor to yield a modified screening value that was lower (more stringent) than the generic RSL. COPCs for the Hypothetical Fishing Platform scenario were selected if the EPC exceeded the modified RSL for carcinogenic COIs. To account for multi-chemical exposure, non-carcinogenic COIs were selected as COPCs if the ratio of exceedance of the modified RSL was greater than 0.1, consistent with ODEQ guidance and Final RI methodology.

A few COIs required special handling:

- **Lead –** Lead was included as a COPC for all the AOPCs since a linear adjustment of the RSL may not be appropriate. Lead is evaluated independently using adult and child lead models.
- **Chromium –** Due to the lack of speciation data, chromium was compared to the RSL for hexavalent chromium for the initial COPC selection. This is consistent with the process followed for other receptors in the Final RI. However, there is no reason to believe that hexavalent chromium may be present at the site and chromium is treated as trivalent chromium in the BHHRA.
- **PCBs –** Three individual Aroclors were detected at the site: Aroclors 1248, 1254, and 1260. Total PCBs represent the sum of these three detected Aroclors, using their method detection limits (MDLs) when not detected in an individual sample total. Total PCBs and Aroclor 1248 exceeded the screening RA in the Final RI. To avoid double counting for Aroclor 1248, only Total PCBs were carried forward to the BHHRA.
- **Degradation Products of PCE & TCE –** PCE and TCE were selected as COPCs for the BHHRA. The degradation products for these volatile compounds were never detected in landfill soils (see Table 9-1 of the Final RI; URS 2012). At the Sandblast Area, only two degradation products were detected (cis-1,2-dichloroethene [DCE] and trans 1,2-DCE), both at low detection frequencies (2-4%) and at concentrations that were orders of magnitude lower than the SLVs (see Table 2-2). Therefore, they were not included at COPCs for this receptor. The uncertainty regarding degradation products is discussed in Section 2.6.
- **Total Petroleum Hydrocarbons (TPH) –** TPH compounds were excluded as COPCs due to petroleum hydrocarbon exclusion under the CERCLA process. This is discussed further in the Uncertainty Assessment (Section 2.6).

For each of the AOPCs, the screening of soil EPCs to modified USEPA soil RSLs are presented in Tables 2-1 through 2-4. The COPCs identified for the BHHRA for the Hypothetical Fishing Platform scenario are presented in Table 2-5 and are summarized below:

- **Landfill AOPC –** Inorganics (arsenic, chromium, lead, mercury), PCBs, VOCs (naphthalene), pesticides (MCPP), and cPAHs
- **Sandblast Area AOPC –** Inorganics (arsenic, chromium, lead, nickel), PCBs, VOCs (PCE, TCE), SVOCs (bis(2-ethylhexyl)phthalate [DEHP]), and cPAHs
- **Pistol Range AOPC**
    - Soils – Lead
    - Lagoon Sediments –Lead
- **Bulb Slope AOPC –** Lead

Based on these screening results, COPCs at the Landfill and Sandblast Area AOPCs were carried forward to the quantitative risk assessment. Lead was evaluated for all four AOPCs for adult and child.

2.1.2 COPC Selection for the Nursing Infant

The nursing infant was added as a new receptor to the BHHRA, following the publication of ODEQ's HHRA guidance (ODEQ 2010a). This receptor may be exposed to selected bioaccumulative COPCs in maternal milk during the first year of life and is recommended for inclusion as a receptor at any site where maternal exposure to selected bioaccumulative chemicals may occur, particularly by dietary and ingestion pathways.

ODEQ (2010a) published screening-level infant risk adjustment factors (IRAFs) for PCBs and for pesticides DDx (i.e., DDT, DDD, and DDE), which are presented and discussed later in Section 2.4. The nursing infant's cancer risks are typically estimated to be similar to, or lower than, the mother's risks. The noncancer hazard quotient (HQ) for the infant, however, may significantly exceed the mother's adult exposure-based HQ for some chemicals such as PCBs (ODEQ 2010a, Appendix D).

The IRAFs from ODEQ (2010a) were used to modify the residential and commercial RSLs to derive SLVs for PCBs and DDx, which were used to screen for potential Nursing Infant COPCs at each of the four AOPCs (see Table 2-6). Since PCB data for the Upland OUs are available as Aroclor data, the IRAF for PCBs as Aroclors was used. The modified residential RSLs were used to represent the Hypothetical Fishing Platform User, and the modified commercial RSLs were used to represent the occupational exposures.

DDx was eliminated as a potential Nursing Infant COPC for all receptors at all four AOPCs. PCBs were retained as a Nursing Infant COPC for the Hypothetical Fishing Platform User at both the Landfill and Sandblast Area AOPCs, but eliminated for Pistol Range and Bulb Slope AOPCs. PCBs were eliminated for occupational exposure at all four AOPCs.

2.2 Receptors and Exposure Pathways Evaluated in BHHRA

The eastern portion of Bradford Island is a restricted-access area managed by USACE. Due to the industrial nature of land use at the site, there are no residential receptors. On-site groundwater is not used at Bradford Island for any purpose. Potable use of groundwater is infeasible under both current and future conditions (Bob Schwarz [ODEQ], pers. comm. 2014).

Activities by employees on the eastern side of the Island include grounds maintenance, vegetation clearing, painting, building maintenance, and administrative duties. The grounds crew typically works up to 3 days per week during peak season. The building crews typically work up to 40 hours per week. The workers are supplied with drinking water. Construction activities (less than 1-year duration) and short-term excavation involving utility repair or other types of soil-disturbing activities in a trench setting may occur.

Although there are no such current uses, fishing platform activities by tribal members may result in exposures to shallow soils by adults and children at any of the AOPCs in the future. Exposure pathways may include incidental ingestion, dermal contact, and inhalation of dusts and vapors from shallow soils (0-3 ft bgs).

The human health conceptual exposure models (CEMs) depicted in Figures 2-1 through 2-4 present potential exposures of humans to various media (i.e., soil gas, soil, and groundwater). Those receptors and pathways that were recommended for further evaluation at the end of the RI are described below.

2.2.1 Landfill AOPC

The landfill is fully vegetated with no bare soils. Vegetation clearing occurs along a 3 to 4 ft wide strip along roadsides when needed. There are no built or occupied structures at the landfill or in its vicinity. There are no current plans to construct enclosed structures at this AOPC nor is it considered feasible from an engineering standpoint. Therefore, vapor intrusion pathways for indoor inhalation are incomplete and will remain incomplete.

Receptors who may be exposed to COPCs in soil and groundwater (incidental exposure in trench setting only) at the Landfill AOPC (Figure 2-1) and will be evaluated in the BHHRA include the following:

- **Adult Outdoor Maintenance Worker** engaged in site maintenance activities that do not involve a significant degree of soil disturbance (e.g., landscape workers). These receptors at the landfill may be exposed to COPCs in surface soil (0-3 ft bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil.
- **Construction Workers** may be exposed to COPCs in surface and subsurface soil (0-10 ft bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Occasionally, Construction Workers and short-term excavation workers also may be exposed to COPCs in shallow groundwater by incidental ingestion and dermal contact if they undertake activities at depths that may bring them in contact with shallow groundwater due to groundwater elevations as shallow as 6 ft bgs (as noted in the Final RI Appendix B logs and Appendix D tables [URS 2012]). These pathways were evaluated by assuming that a worker may be in a trench or excavation subject to pooling water seeping in from the shallow groundwater. The exposure assessment assumes employment of safe work practices will prevent anything more than incidental contact to groundwater. Based on the COPCs identified in the initial screening, at the Landfill AOPC, workers in a trench may come into dermal contact with metals and phthalate COPCs in groundwater and may experience some minimal incidental ingestion of groundwater, dermal contact, and inhalation of vapors volatilizing from groundwater.
- **Hypothetical Fishing Platform Users** were presumed to make temporary camps near their fishing locations, and their exposure would be limited to surface soil (0-3 ft bgs). For the Upland OU, these receptors at Bradford Island may be exposed to COPCs in surface soil by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Since fishing excursions may include all the members of the household, the exposure for all the age groups for this receptor (adult, child, and nursing infant) were evaluated.

2.2.2 Sandblast Area AOPC

The Sandblast Area AOPC is a mixture of vegetated and non-vegetated areas. The former Sandblast Building has been demolished, and the former Hazardous Material Storage Area

(HMSA) exists only as a lean-to area that is open to the outdoors. The two remaining buildings in the vicinity are the Service Building and the Equipment Building, and both are in active occupational use. The Service Building provides work space for approximately 27 people and may support additional full-time employees in the future. The Equipment Building includes office space for two people. The receptors and pathways for the Sandblast Area AOPC (Figure 2-2) include:

- **Adult Outdoor Maintenance Worker** engaged in site maintenance activities that do not involve a significant degree of soil disturbance (e.g., landscape workers). These receptors at the Sandblast Area AOPC may be exposed to COPCs in surface soil (0-3 ft bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil.
- **Construction Workers and Short-term Excavation Workers** may be exposed to COPCs in surface and subsurface soil (0-10 ft bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Occasionally, they also may be exposed to COPCs in shallow groundwater by incidental ingestion and dermal contact. Based on the results of the RI screening, incidental contact with vanadium in groundwater within a trench scenario at the Sandblast Area AOPC is evaluated in this BHHRA.
- **Adult Indoor Workers** may be exposed to VOCs emanating from soil gas entering the indoor environment by vapor intrusion in the existing Service Building and Equipment Building. Vapor intrusion pathways would also be complete if new buildings were to be constructed at this AOPC in the future.
- **Hypothetical Fishing Platform Users** were presumed to make temporary camps near their fishing locations; therefore, their exposure will be limited to surface soil. Exposure is assumed to be in an outdoor setting away from the buildings, and any incidental exposure to VOCs emanating from the ground would be intermixed with ambient air and insignificant. These receptors may be exposed to COPCs in surface soil (0-3 ft bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Since fishing excursions may include all the members of the household, the exposure for all the age groups for this receptor (adult, child, and nursing infant) are evaluated.

2.2.3 Pistol Range AOPC

In the Final RI (URS 2012), no potential COPCs were identified for occupational receptors at the Pistol Range AOPC. The Hypothetical Fishing Platform Users may access all of the Upland OU and, therefore, the Pistol Range AOPC was also considered (Figure 2-3). As noted earlier, this receptor is presumed to camp near fishing locations and may be exposed to contaminants in surface soil (incidental ingestion, dermal contact, and outdoor inhalation). Since fishing excursions may include all the members of the household, the exposure for all the age groups for this receptor (adult, child, and nursing infant) are evaluated.

2.2.4 Bulb Slope AOPC

In the Final RI, no potential COPCs were identified for occupational receptors at the Bulb Slope AOPC. The Hypothetical Fishing Platform Users may access all of the Upland OU and, therefore, the Bulb Slope AOPC was also considered (Figure 2-4). As noted earlier, this receptor is presumed to camp near fishing locations and may be exposed to contaminants in surface soil (incidental ingestion, dermal contact, and outdoor inhalation). Since fishing excursions may include all the members of the household, the exposure for all the age groups for this receptor (adult, child, and nursing infant) are evaluated.

2.3 Exposure Assessment

Quantifying exposure involves estimating chemical intake rates based on the evaluation of chemical releases from the site and estimation of EPCs for specific pathways.

The methods for calculating potential chemical intakes from soil, groundwater, and soil gas (vapor intrusion into indoor air) for the populations and exposure pathways selected for quantitative evaluation primarily followed USEPA guidance and also considered ODEQ guidance, as appropriate. Exposure factor values are drawn from the Risk Assessment Guidance for Superfund (RAGS) Part A (USEPA 1989) and all succeeding guidance documents including USEPA guidance (2014) and the most current updates to exposure factors in developing RSLs (USEPA 2015a). ODEQ's HHRA guidance, Vapor Intrusion guidance, and current tables for Calculating RBCs for Individual Chemicals were also consulted (ODEQ 2010a, 2010b, 2012).

There is generally close agreement between USEPA and ODEQ for the exposure factor values. Where exposure factor values are not available from USEPA, ODEQ's recommended values were used.

2.3.1 Exposure Point Concentrations

The EPC is a chemical-specific and media-specific value that represents a reasonable maximum exposure (RME) or central tendency exposure (CTE) estimate of the concentration to which a receptor is exposed. In accordance with USEPA guidance (USEPA 1989), and to address comments received on the Final RI (URS 2012), both RME and CTE estimates were used in the BHHRA in the following manner: RME risk estimates were developed for all receptors and pathways that were evaluated. CTE estimates were developed only for those receptors and pathways where the RME risk or hazard levels exceeded *de minimis* risk levels (cancer risk of 1 x 10^{-6} or hazard index [HI] of 1), as described in Section 2.5. If the RME-based risk levels were below *de minimis* risk levels, CTE estimates were not developed. The following sections discuss development of EPCs for specific media.

Data management rules and procedures are presented in detail in the Final RI (URS 2012) and summarized below.

2.3.1.1 Soil

As described in Appendix A of the RI/FS MP (URS 2007) and in the WP Update (URS 2014; Appendix C) and in accordance with the most recent USEPA guidance regarding statistical methodology to be used in EPC estimation (USEPA 2002a), the 95% UCL (soil and groundwater for trench setting) was used as the EPC representing the RME. In general, if duplicates exist, the average of the duplicate results is used as a single data point. As described in Section 5.1 of the Final RI (URS 2012), detected values from field duplicates were averaged with corresponding primary detected sample values to create a single result; if the analyte was detected in only one of the pair, the detected result was used.

Where samples sizes are less than eight, the maximum or single location data may be used, as appropriate. As previously agreed, the 95% UCL is also acceptable to ODEQ and is more conservative than ODEQ's suggested 90% UCL. The EPC representing the CTE scenario also used the 95% UCL (USEPA 1992b). The EPCs were estimated using statistical methods and values recommended by USEPA's ProUCL software, as represented in the Final RI (URS 2012). EPCs for soil were based on 0 to 3 ft bgs depth interval for Outdoor Maintenance Workers, and 0 to 10 ft bgs depth interval for Construction Workers. The soil exposure depth for the Hypothetical Fishing Platform User is assumed to be 0 to 3 ft bgs. This is consistent with ODEQ (2010a) guidance for developing exposure point concentrations for residential and occupational uses (other than construction activities). Therefore, soil data from the 0 to 3 ft bgs interval were used to evaluate the Hypothetical Fishing Platform scenario. There were two exceptions to this usage:

1) At the Pistol Range and Bulb Slope AOPCs, the total soil depth extends only to 1.5 ft bgs and 1 ft bgs, respectively. These data were used to represent EPCs for all receptors at these two AOPCs since they represent the entire soil column at these AOPCs.
2) At the Sandblast Area AOPC, additional data were collected from the 0 to 1 ft bgs interval for lead alone, using methodologies based on USEPA's guidance for lead, as described in the WP (URS 2007). These lead data from sieved and unsieved soil samples were used for the blood-lead modeling.

2.3.1.2 Groundwater

Maximum detected concentrations in groundwater were used to represent incidental ingestion and dermal contact with groundwater by an excavation/trench worker.

The groundwater screening performed in the RI (URS 2012) utilized ODEQ RBCs that only consider dermal contact in their groundwater exposure in a trench. To be consistent with general USEPA practices, the evaluation of the Trench/Excavation Worker at the Landfill and Sandblast Area AOPCs includes an evaluation of inhalation of VOCs volatilizing from groundwater, even though VOCs were not identified as dermal COPCs in groundwater for the trench setting. The Virginia Department of Environmental Quality (VDEQ 2014) trench model was used to derive trench air concentrations for VOCs in groundwater. Details of the VDEQ model and model tables are presented in Appendix B-1. In summary, the model assumed a trench dimension of 3 ft wide and 8 ft deep, which yielded a width to depth ratio of 0.38. This ratio corresponded with the use of the most conservative exchange rate of 2 air changes per hour (ACH), which is similar to an indoor space.

2.3.1.3 Soil Gas

Vapor intrusion is a dynamic exposure pathway with multiple factors that influence the concentrations in indoor air. Ever-changing conditions such as weather and groundwater flow, variations in elevation, and building interior climate changes due to heating, ventilating, and air conditioning, and even individual habits such as opening a window or closing an office door could directly and dramatically change a receptor's exposure. Static features such as the design and condition of the building foundation, utilities design, and the site-specific soil properties are all key factors that either mitigate or enhance the migration of vapors from the subsurface into the office buildings. As described in the WP Update (URS 2014), a lines-of-evidence approach that included vapor intrusion modeling was used to evaluate this pathway, consistent with USEPA and ODEQ guidance.

The following constitute the lines-of-evidence approach for soil gas exposures:

- Develop site-specific risk estimates based on the Johnson and Ettinger (Vapor Intrusion) Model (JEM).
- Consider VOC data from all the media focusing on spatial correlations.
- Consider other site data such as historical activity and identified sources.
- Consider the strengths and uncertainties associated with the results.

Modeled Risk Estimates

Risk estimates were quantified using USEPA's current versions of the JEM for soil gas data for deriving site-specific attenuation factors (AFs) (USEPA 2004a, 2004b, 2013c). Model tables are presented in Appendix B. The AF is the ratio of the concentration in indoor air to the concentration in soil gas. The JEM-derived AF incorporates the attenuating effects of the subsurface soil and building foundation/floor and the diluting effects of the indoor space, but does not account for biodegradation of the soil gas. The AFs were used to estimate the indoor air concentration or EPC for the risk calculations as follows:

Indoor Air Concentration = Soil Gas Concentration x AF

The two existing buildings at the Sandblast Area AOPC and a hypothetical future building were modeled using JEM. A combination of USEPA default and site-specific values (i.e., dimensions of existing inhabited buildings and available site-specific soil parameters) were used to represent building and soil properties.

The data from the soil gas sample locations that were closest to the existing buildings were used to represent the EPC for those buildings. This included location SB-13 to represent the Service Building and location SB-14 to represent the Equipment Building. The maximum detected concentrations from all five soil gas samples were used to represent future buildings. The maximum concentrations for PCE, TCE, and vinyl chloride were reported at location SB-12, near the former Sandblast Building, which has now been demolished. In keeping with USEPA methodology, only detected chemicals were included in the vapor intrusion risk estimation. However, inclusion of non-detected degradation compounds was also considered per ODEQ guidance and as described in Section 2.1. These results are presented in the Uncertainty Assessment (Section 2.6).

Spatial Comparison of VOC Detections in All Media

Within each medium (i.e., soil, soil gas, and groundwater), the detections of VOCs were evaluated spatially to identify areas or depths of elevated concentrations. From the Sandblast Area AOPC, there were five soil gas samples (Table 1-6 and also Figure 9-8 of the RI), 49 soil samples for depth range 0-10 ft bgs, of which 46 were surface samples of 0-3 ft bgs (Table 1-2 and also Figures 9-5j and 9-5k of the RI), and10 groundwater samples (Table 1-8 and also Figure

9-7b of the RI). Next, the VOC detection locations were compared between all three media at the Sandblast Area AOPC for patterns or correlations.

Other Site Data and Overall Vapor Intrusion Assessment

The historical activities and RI findings were reviewed to identify any correlations to VOC sample data. The nature and location of known VOC sources were reviewed in relation to the available data in all three media.

Strengths and Uncertainties

All of the various lines of evidence were evaluated comprehensively to characterize receptor risk to vapor intrusion concerns. The strengths and weaknesses associated with convergence or divergence of the findings drawn from each line of evidence were described and final conclusions were drawn.

2.3.2 Exposure Factors

Tables 2-7a and 2-7b list the exposure factors for occupational exposures and Hypothetical Fishing Platform User exposures, respectively, that were used in the BHHRA for the receptors noted above. USEPA (2014, 2015a) RME exposure factors were used as the primary source. When USEPA values are not available, such as for the CTE exposure factors, ODEQ values are used. USEPA updated its exposure factors in June of 2015 (USEPA 2015a), after consideration of recommendations developed in the Exposure Factors Handbook (USEPA 2011). Where different, the updated factors are used in place of those listed in the WP Update (URS 2014).

2.3.2.1 Occupational Exposures

The selection of RME and CTE values generally exceeds the likely exposures of on-island personnel with respect to exposure duration, EF, and other uptake parameters (Table 2-7a). For example, there are both part-time and full-time employees at Bradford Island. Also it is doubtful that workers will truly have an exposure duration of 25 years on the Island. Many of the maintenance staff are seasonal or have part-time work schedules, as described in Section 2.2.

The key differences between the exposure assumptions for the CTE Outdoor Maintenance Worker are 6 years of exposure compared to 25 years for the RME, half the soil ingestion rate (IRS), and a lower soil adherence factor (ODEQ 2010a). For the Construction Worker, the CTE scenario assumes a half year of exposure compared to 1 year for the RME, a third of the IRS, and a lower soil adherence factor (ODEQ 2010a).

For outdoor inhalation, a regionally site-specific value for Q/C (defined as the inverse of the mean concentration at the center of a 0.5 acre-square source) was used in place of the nation-wide default value in the calculation of the volatilization factor (VF). The Q/C measured in Salem, Oregon, was used as recommended by USEPA (2002b).

Another factor involved bioavailability of arsenic. As noted in Sections 9.2.1 and 9.3 of the Final RI (URS 2012), arsenic in Landfill and Sandblast Area soils is considered to be naturally occurring, although it is slightly higher than background levels. A relative bioavailability factor (RBA) of 60% was applied to arsenic in soil, following USEPA recommendations (USEPA 2012a, 2012b). In the absence of site-specific bioavailability data, this represents an upper-bound estimate by USEPA, in recognition of the fact that soil-bound arsenic is not 100% bioavailable.

Lead is a special case COPC with toxicity evaluated based on statistical probabilities of exceeding target blood lead levels instead of standard cancer risk and noncancer hazard estimates. Exposure to soil-borne lead is derived primarily from incidental ingestion of lead associated with fine soil particles that may adhere to the hands and face when a person comes in direct contact with soil. USEPA guidance (USEPA 2003b) recommends analysis of lead in sieved samples (<250 micrometers [μm]) from shallow surficial soils to obtain the most likely exposure concentrations. Therefore, the EPC to evaluate lead exposure was developed from shallow surface samples (0-1 and 0-3 ft bgs).

2.3.2.2 Hypothetical Fishing Platform User Exposures

The exposure factors used for the Hypothetical Fishing Platform User scenario generally corresponded to the RME values used for residential receptors under current USEPA guidance (USEPA 2014, 2015a). They included 6 years of childhood and 20 years of adult exposure duration for 24 hours a day. One factor that is more conservative than USEPA usage is the assumption of 365 days/year EF. The CTE values differed from the RME mainly by less exposure duration (3 years for adult), less EF (152 days per year), less conservative soil adherence factors, and a lower IRS (50 milligrams (mg) per day for adult and 100 mg/day for child). The exposure factor values are provided in Table 2-7b. Similar to the other receptors in Section 2.0, each AOPC was evaluated independently, i.e., the receptors were conservatively assumed to be present at each AOPC for 100% of the exposure duration.

For the Pistol Range and Bulb Slope AOPCs, the only retained COPC was lead, which was evaluated differently from other chemicals (see Section 2.4.1).

2.3.3 Dose Calculations

The overall dose for each receptor and exposure pathway depends on receptor specific exposure factors (Table 2-7a and Table 2-7b) and the concentration of the chemical in the exposure medium. Once the dose is calculated, it can be applied to chemical specific toxicity data to estimate either cancer risk or noncancer health hazard. Example equations for a worker (w) are shown below.

The following equation is an example of the cancer risk and noncancer health hazard dose equations and risk equations used in the BHHRA (in this case, soil ingestion by a worker). The equations and variables vary for the different receptors, media, and exposure pathways and are presented and defined in their respective tables in Appendix A.

$$Risk = SF_o \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365\,day/year} \right] \right\}$$

$$Hazard = \frac{1}{RfD_o} \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,a} \times 365\,day/year} \right] \right\}$$

Where,

SF_o	=	Slope Factor (oral): (mg per kilogram [kg]-day)$^{-1}$
C_{soil}	=	COPC Concentration in soil: mg/kg
IRS_w	=	Soil Ingestion Rate (worker): mg/day
EF_w	=	Exposure Frequency (worker): day/year
ED_w	=	Exposure Duration (worker): years
FI_w	=	Fraction Ingested (worker): unitless
CF_o	=	Conversion Factor (oral): units dependent
BW_a	=	Body Weight (adult): kg
AT_c	=	Average Time (cancer): days
RfD_o	=	Reference Dose (oral): mg/kg-day
$AT_{nc,a}$	=	Average Time noncancer (adult): days

Nursing Infant

The Nursing Infant evaluation does not calculate dose for the infant; rather to calculate the infant's cancer risk and noncancer hazard, the mother's cancer risk and noncancer HI is modified by an IRAF that is both chemical- and pathway-specific. The Nursing Infant cancer risk and noncancer hazard are calculated using the following equation from ODEQ (2010a):

$$\text{Infant Cancer Risk} = \text{Mother's Risk x } IRAF_c$$

$$\text{Infant Noncancer Hazard} = \text{Mother's HQ x } IRAF_{nc}$$

For certain scenarios where only the child noncancer HQ is available, the child HQ is modified using the ODEQ Residential Soil (Direct Contact) IRAFs. See Section 2.4.7 for further discussion on IRAFs.

Relative Bioavailability

An RBA of 60% was applied to arsenic in soil, using current USEPA defaults (USEPA 2012a, 2012b). Although other COPCs in soil may also have less than 100% bioavailability, no other bioavailability factors were applied. This is discussed further in the Uncertainty Section (Section 2.6).

2.4 Toxicity Values

The selection of toxicity values followed the hierarchy of sources that is recommended by USEPA (2003a) and represented in the listing provided in USEPA (2015a), as follows:

- Integrated Risk Information System (IRIS) (USEPA)
- Provisional Peer-Reviewed Toxicity Values (PPRTVs) (USEPA)
- Minimal Risk Levels (Agency for Toxic Substances Disease Registry [ATSDR])
- Chronic Reference Exposure Levels (California Environmental Protection Agency)
- Appendices to PPRTVs (USEPA)
- Health Effects Assessment Summary Tables

This hierarchy follows ODEQ's hierarchy with some minor variations as discussed below in Sections 2.4.1 to 2.4.5. Toxicity values for most of the COPCs are available from IRIS or as

PPRTVs. A few selected COPCs are discussed in more detail below. The toxicity values used in the BHHRA are presented in Table 2-8 and within receptor- and media-specific tables of the risk calculations tables in Appendix A.

2.4.1 Lead

The evaluation of lead as a COPC differed for occupational exposures and Hypothetical Fishing Platform User exposures. Appendix B presents the lead models and their supporting tables and output figures.

Occupational Exposure

Exposure to lead in Sandblast Area AOPC soils was evaluated using the current version of the Adult Lead Model, as recommended by USEPA (2015a, undated). Risk from exposure to lead in surface soil by outdoor maintenance workers was evaluated using USEPA's adult lead model (ALM) spreadsheet (USEPA 2009a). Four exposure scenarios were evaluated, including Outdoor Maintenance Workers exposed to:

- Surface material (0-1 ft bgs) in the Landfill AOPC
- Surface and subsurface material (0-3 ft bgs) in the Landfill AOPC
- Surface material (0-1 ft bgs) in the Sandblast Area AOPC
- Surface and subsurface material (0-3 ft bgs) in the Sandblast Area AOPC

Surface soil from the Sandblast Area AOPC was sieved to <250 μm (USEPA 2000) and then analyzed for lead.

USEPA (2003b) default parameter values for commercial/industrial workers were used. The arithmetic mean lead concentrations were used as the EPCs, as recommended by USEPA (2010). Updated ALM default values for baseline blood lead concentration (PbB0) (1.0 microgram [μg] per deciliter [dL]) and individual blood lead geometric standard deviation (GSDi) (1.8) were used in the ALM as recommended by USEPA (2009b). PbB0 and GSDi values have been updated by USEPA (2009b) based on an analysis of more recent blood lead concentration (PbB) data (USEPA 2002e) from the Third National Health and Nutrition Examination Survey, which showed decreases in PbBs among age and ethnic groups. USEPA's Technical Review Workgroup (TRW) has indicated that the updated PbB0 and GSDi values are appropriate for lead RAs for non-residential exposures both in assessing risk and in developing preliminary remediation goals (PRGs) for sites (USEPA 2010).

A target fetal PbB of 10 μg/dL was recommended by USEPA (2003b) for use in the ALM, based on the assumption that the PbB of concern for fetuses is the same as that for children. The National Research Council (1993) has supported this PbB of concern for fetuses. More recent concerns that adverse effects may occur in children at levels below 10 μg/dL may also pertain to the ALM. USEPA does not have a PbB of concern for teenagers or adults. USEPA's ALM (USEPA 2003b) was used to provide conservative estimates of PbBs in fetuses of women of child-bearing age who are exposed to lead in surface material. PbBs that are protective of fetuses and children are also considered protective for teenagers and adults (USEPA 2010).

However, the TRW has cautioned that lead RAs that include non-residential land use should report new toxicity information from USEPA (2006) indicating adverse health effects at PbBs below 10 µg/dL down to 5 µg/dL and possibly lower (USEPA 2010). The new toxicity information for lead has not, as yet, been incorporated into any USEPA methodologies for evaluating the exposure of children or adults to lead. USEPA currently considers 10 µg/dL to be the PbB of concern for fetuses and children. For non-residential settings, the U.S. Center for Disease Control (CDC) has replaced its former Level of Concern of 10 µg/dL with a reference value of 5 µg/dL (CDC 2012).

The ALM predicts the chance that fetuses of adults exposed to surface material at the site would have a PbB exceeding a level of concern. USEPA's target for women of child-bearing age is to limit the risk to a typical developing fetus of a woman exposed at a site to no more than a 5% chance of exceeding the 10 µg/dL PbB of concern (USEPA 2003a).

To be conservative, the non-residential ALM model was run with both the USEPA target PbB and the CDC Level of Concern PbB.

Hypothetical Fishing Platform User Exposure

Lead was evaluated for adults using the ALM as noted above and for children using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children. USEPA (2009a) default parameter values for were used for the adult resident, with the exception of the EF value. ALM guidance recommends using CTE values for EF (e.g., the CTE value for EF for residents is 234 days/year, USEPA 1993). However, to be protective and consistent with the EF used to evaluate non-lead chemicals at the site, an EF of 365 days/year was used in the ALM.

USEPA (2010) default parameter values in the IEUBK model were used for the child resident. The exception was that the EPCs for lead in soil and sediment in AOPCs were used as the outdoor soil concentration instead of the default value of 200 mg/kg. In addition, the concentration of lead in indoor household dust was estimated using the model's Multiple Source Analysis, which assumes that the concentration of lead in indoor household dust is 0.7 times the concentration of lead in outdoor soil plus the contribution from soil in outdoor air (10 mg/kg). For example, in the Sandblast Area AOPC, the EPC for lead in soil was 300 mg/kg. The 300 mg/kg value was entered into the IEUBK model as the outdoor soil concentration. The concentration of lead in indoor household dust was assumed to be 220 mg/kg, based on the following equation:

$$220 \text{ mg/kg} = (300 \text{ mg/kg} \times 0.7) + 10 \text{ mg/kg}$$

To be protective, young children were also assumed to be exposed to background levels of lead in air at the residence, background lead in the diet, and background lead in drinking water. Risk from exposure to lead in soil or sediments by child receptor was evaluated using USEPA's IEUBK model (USEPA 2010).

Ten exposure scenarios were evaluated, including exposure of child and adult to:

- Soil (0-1 ft bgs) in the Landfill AOPC
- Soil (0-1 ft bgs) in the Sandblast Area AOPC
- Soil in the Pistol Range AOPC
- Sediment in the Pistol Range AOPC
- Soil in the Bulb Slope AOPC

2.4.2 Polycyclic Aromatic Hydrocarbons

cPAHs were evaluated by the use of Toxicity Equivalence Factors (TEFs) relative to benzo(a)pyrene, as listed below from USEPA (2015a) and ODEQ (2010a).

Compound	TEF
Benzo(a)pyrene	1.0
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

PAHs are evaluated as individual chemicals and their cancer risk is presented individually and also summed separately from other COPCs to provide risk to cPAHs as a group.

2.4.3 Mutagenic Mode of Action

Certain cPAHs are considered to be mutagenic in activity and may be more potent during early-life-stage exposures (USEPA 2005b). Mutagenic toxicity was assumed for the risk estimation process for cPAHs consistent with USEPA (2005b) and ODEQ recommendations (ODEQ 2010a) methods by applying age-dependent adjustment factors (ADAFs) to the dose equation to account for the greater vulnerability of younger age groups.

The following equation was used for mutagenic risk (See Section 2.3.3 for general definitions of terms and Tables 2-7a and 2-7b for receptor specific values):

$$Risk = SF_O \times \Bigg[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRF_c \times ED_{0-2} \times ADAF_{0-2}}{BW_{\boldsymbol{c}} \times AT_{\boldsymbol{c}} \times 365\ days/year} + \frac{IRFc \times ED_{2-6} \times ADAF_{2-6}}{BW_{\boldsymbol{c}} \times AT_{\boldsymbol{c}} \times 365\ days/year} + \frac{IRF_a \times ED_{6-16} \times ADAF_{6-16}}{BW_{\boldsymbol{a}} \times AT_{\boldsymbol{c}} \times 365\ days/year} + \frac{IRF_a \times ED_{16-26} \times ADAF_{16-26}}{BW_{\boldsymbol{a}} \times AT_{\boldsymbol{c}} \times 365\ days/year}\right)\Bigg]$$

The following ADAFs and EDs were used:

Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	dimensionless
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	dimensionless
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	dimensionless
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	dimensionless
Exposure Duration, child 0-2	ED_{0-2}	2	years
Exposure Duration, child 2-6	ED_{2-6}	4	years
Exposure Duration, child 6-16	ED_{6-16}	10	years
Exposure Duration, adult 16-26	ED_{16-26}	10	years

2.4.4 Trichloroethylene

Toxicity values for TCE are based on USEPA's current recommendations as listed in IRIS and USEPA (2015b). These include the following:

- SFo – 4.6 x 10^{-02} (mg/kg-day)-1
- Inhalation Unit Risk – 4.1 x 10^{-06} (μg per cubic meter [m^3])-1
- Oral Reference Dose – 5.0 x 10^{-04} mg/kg/day
- Inhalation Reference Concentration – 2.0 x 10^{-03} mg/m^3

2.4.5 Benzofluoranthenes, Total

Total benzofluoranthenes were listed as a COPC in the WP Update (URS 2014) and represent an older sampling event that did not report the individual benzofluoranthenes. The newer data report individual benzofluoranthenes but do not report total benzofluoranthenes. Due to the lack of toxicity data and chemical properties for (total) benzofluoranthenes, benzo(b)fluoranthene values were used as a surrogate to evaluate total benzofluoranthenes.

The total benzofluoranthene data includes benzo(b), benzo(j), and benzo(k)fluoranthenes, with different toxicity values for each isomer. Benzo(b)fluoranthene has a SFo that is10 times more potent than benzo(k)fluoranthene.

In the initial risk screening, total benzofluoranthenes were assumed conservatively to consist entirely of the most potent benzo(b)fluoranthene. For this BHHRA, the total benzofluoranthene soil data was reviewed to derive a scaling factor to account for the percent of benzo(b)fluoranthene in the total benzofluoranthenes. Benzo(j)fluoranthene has not been detected at the site. Using individual benzo(b)fluoranthene and benzo(k)fluoranthene concentrations from the more recent data where individual benzofluoranthenes are reported, a percent benzo(b)fluoranthene of total benzofluoranthenes was calculated for each sample. Then the average percentage was derived for all samples (30 samples from both Landfill and Sandblast Area AOPCs). The percent benzo(b)fluoranthene was 60%. The scaling was applied as follows:

(Benzofluoranthene, Total EPC) x (60%) = New Benzofluoranthene, Total EPC

2.4.6 Chromium

Chromium was identified as a COPC in the Final RI (URS 2012) due to initial use of SLVs based on hexavalent chromium. Total chromium levels were similar in both Landfill (594 mg/kg) and Sandblast Area (579 mg/kg) soils. As noted in Section 9 of the Final RI, the source of the chromium is thought to be nickel-chromium coatings for equipment that was likely sand-blasted from the Sandblast Building. In groundwater at both AOPCs, total chromium was detected in a few samples at levels of 0.03 mg per liter (L) or lower. Speciation data for the total chromium are not available for either soil or groundwater. Trivalent chromium is the most stable form of chromium in the environment and has very low solubility (ATSDR 2012a). Dissolved chromium was not detected at all in groundwater at the Landfill AOPC and was detected at very low concentrations in groundwater at the Sandblast Area AOPC (maximum concentration of 4 μg/L) (see Final RI [URS 2012], Tables I-1 and I-2). Based on these considerations, chromium in soil is most likely to be trivalent chromium and corresponding toxicity values for trivalent chromium were used. The uncertainty related to the possibility of hexavalent chromium is discussed further in the Uncertainty Assessment.

2.4.7 Nursing Infant Risk

The Nursing Infant risk was evaluated using the ODEQ (2010a) approach of applying IRAF for PCBs to calculate maternal cancer risk and noncancer hazard. ODEQ (2010a) assumes that the concentration of a chemical in milk can be calculated from the long-term body burden in the mother and provides IRAFs for conversion of the mother's risk and hazard estimates to Nursing Infant risks and hazards.

The mother's cancer risks for the scenarios included in this BHHRA assume time-integrated exposure during childhood and adulthood. The IRAFs used in this risk assessment are as follows:

Nursing Infant Risk Adjustment Factors

Chemical	Residential IRAF	Source
Carcinogenic IRAF		
Total PCB	0.6	ODEQ 2010a
Noncancer IRAF		
Total PCB	4	ODEQ 2010a

Only PCBs were identified as COPCs. In general, total PCB cancer risk for the Nursing Infant would be lower than the mother. For total PCBs, the noncancer HQ for the Nursing Infant would be four times greater than the mother's hazard for total PCBs.

2.5 Risk Characterization

The BHHRA evaluated the Landfill, Sandblast Area, Pistol Range, and Bulb Slope AOPCs of the Upland OU. Both excess lifetime cancer risks and, if appropriate, noncancer hazards were estimated for the carcinogenic COPCs, for each combination of receptor, exposure medium and exposure scenario as presented in the WP Update (URS 2014). For non-carcinogenic chemicals, only noncancer hazards were estimated. The results were summed to provide quantitative estimates of multi-pathway and multi-media risks and hazards for each receptor for the RME and CTE scenarios. The CTE estimates are presented to provide a range and represent the average exposure whereas RME represents the more conservative, upper-bound reasonable maximum estimates. The estimated risks, HQs, and HIs are presented in the context of whether they were:

1) less than the USEPA risk level of 1×10^{-6} (also expressed as one in a million) or HI of 1, whereby risk at or below these thresholds have an insignificant contribution to risk (*i.e., de minimis*);
2) within the USEPA's acceptable risk range of 1×10^{-6} to 1×10^{-4} for cancer and HQ or HI of 1 for noncancer COPCs (USEPA 1991); or
3) exceeding the USEPA acceptable risk range, i.e., greater than 1×10^{-4}.

In addition, ODEQ's acceptable risk thresholds of 1×10^{-6} for individual carcinogens and 1×10^{-5} for multiple carcinogens were also considered (ODEQ 2010a). Due to this, individual chemicals associated with risk levels greater than the ODEQ thresholds of 1×10^{-6} or noncancer

HQ greater than 1 were identified as COCs, except arsenic, for which background levels were also considered. Since the individual compounds that make up the cPAHs all act by the same mode of action, risks for PAHs were calculated by individual compound and also summed to present risks for cPAHs as a group. It is important to note that, since excess lifetime cancer risks (ELCRs) are only expressions of likelihood of cancer incidence, and HIs are estimated ratios to safe doses, exceedance of the ODEQ risk thresholds or USEPA acceptable risk range does not automatically mean that adverse effects may have occurred or will occur (e.g., does not automatically mean that the COC will be recommended for further evaluation in the FS).

Cancer risks are presented to one significant figure and noncancer hazards to two significant figures (ODEQ 2010a, USEPA 1989).Cancer risks are discussed using 1×10^{-6} , 1×10^{-5}, and 1×10^{-4} convention in the text and are represented using 1E-06, 1E-05, and 1E-04 scientific notation in the tables for clarity and legibility. The terms are equivalent to each other.

Tables 2-9 through Table 2-24 present summary cancer risk and noncancer hazards for each receptor. Table 2-25 presents a summary of the findings of the blood-lead evaluation. Table 2-26 summarizes the cancer risk and noncancer health hazard for each receptor by AOPC. Results are grouped by AOPC and presented by media and receptors for RME and then CTE. Where the cancer risk and/or the noncancer health hazard exceed the ODEQ cancer risk threshold of 1×10^{-6} risk or HI of 1, the primary contributors to risk are described further and may be considered as COCs recommended for further evaluation in the FS. Results of the lead evaluation are also presented for each AOPC with the modeling details presented in Appendix B.

2.5.1 Landfill AOPC

The BHHRA evaluated exposures to COPCs in soil and groundwater at the Landfill AOPCs. Three occupational receptors and the Hypothetical Fishing Platform User were evaluated, and Appendix A presents the equations and risk calculations for each receptor. The receptors and their summary cancer risk and noncancer health tables are listed below:

- Outdoor Maintenance Worker: RME Summary (Table 2-9)
- Outdoor Maintenance Worker: CTE Summary (Table 2-10)

- Construction Worker: RME Summary (Table 2-11)
- Construction Worker: CTE Summary (Table 2-12)

- Hypothetical Fishing Platform User: RME Summary (Table 2-13)
- Hypothetical Fishing Platform User: CTE Summary (Table 2-14)

- Excavation/Trench Worker, Exposure to Groundwater: RME Summary (Table 2-15)

2.5.1.1 Landfill AOPC Soil

Landfill soils were evaluated for risks to the Outdoor Maintenance Worker (0-3 ft bgs), Construction Worker (0-10 ft bgs), and Hypothetical Fishing Platform User (0-3 ft bgs).

2.5.1.1.1 Landfill – Outdoor Maintenance Worker

RME

As presented in Table 2-9, the Outdoor Maintenance Worker exposure to surface soil had RME cancer risk of 6 x 10^{-5}, which exceeds the ODEQ cancer threshold of 1 x 10^{-6} but falls within the USEPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The noncancer HI was acceptable at 0.02. The cumulative risk level associated with cPAHs exceeds the ODEQ threshold for multiple carcinogens of 1 x 10^{-5}. The primary contributors to risk are arsenic and cPAHs.

Arsenic – Incidental ingestion was the only significant exposure route for arsenic, yielding 3 x 10^{-6} cancer risk, and was based on a surface soil EPC of 10.5 mg/kg. Following USEPA guidance (USEPA 2002c), the contributions from background arsenic and site-related arsenic were evaluated further. The Reference Area upper prediction limit (UPL) for arsenic is 5.4 mg/kg (Table 1-9). Therefore, the incremental risk from site-related arsenic is 1 x 10^{-6}, which is at the ODEQ threshold, as shown below:

Summary of Total, Background, and Site-Related Risk for Arsenic Outdoor Maintenance Worker

Data Grouping	Arsenic EPC (mg/kg)	Arsenic Cancer Risk	Arsenic HQ
RME Landfill	10.5	3 x 10^{-6}	0.02
Reference UPL	5.4	2 x 10^{-6}	0.01
Site-related Increment	5.1	1 x 10^{-6}	0.01

Based on this comparison, arsenic is not considered a COC since the site-related contribution to risk is at acceptable levels and is barely distinguishable from background risk. This is consistent with USEPA guidance that further evaluation is not warranted for chemicals whose risks do not exceed background levels (USEPA 2002c, 2002d).

cPAHs – Ingestion and dermal contact with cPAHs were the significant exposure routes, with the ingestion route yielding approximately twice the risk as dermal contact. Benzo(a)pyrene was the primary contributor to risk among the cPAHs, and its contribution to risk from cPAHs is approximately an order of magnitude greater than any other cPAH or 60% of the risk from cPAHs (6 x 10^{-5}). Benzo(a)pyrene was detected consistently throughout the surface soil of the Landfill AOPC (31 detections out of 33 samples) with the EPC being 11.2 mg/kg as compared to the Reference Area 95% UPL of 0.037 mg/kg. The Reference Area UPL for all cPAHs was 0.051 mg/kg benzo(a)pyrene-equivalent carcinogenic potency (BaPeq) (Table 1-9).

Based on RME estimates, cPAHs are the only COC (i.e., primary contributors to risk) for surface soil in the Landfill AOPC. The individual PAH COCs are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and benzofluoranthenes, total.

CTE

As presented in Table 2-10, the Outdoor Maintenance Worker had CTE cancer risk of 6 x 10^{-6}, which exceeds the ODEQ threshold of 1 x 10^{-6} but falls within the USEPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The noncancer HI was acceptable at 0.009. The primary contributor to risk is one individual cPAH, benzo(a)pyrene, with ingestion risk yielding 3 x 10^{-6}, or 57% of the total cPAH risk (5 x 10^{-6}).

Exposure to Lead in Surface Soil

USEPA's target for women of child-bearing age is to limit the risk to a typical developing fetus of a woman exposed at a site to no more than a 5% chance of exceeding the 10 µg/dL PbB of concern (USEPA 2003a). For both available surface soil depth ranges, the USEPA ALM estimated acceptable percent probability of exceeding the target blood lead concentration for the Outdoor Maintenance Worker due to exposure to surface soil (see Table 2-25 and the summary of results below). A complete description of the lead modeling is provided in Appendix B.

Landfill Surface Soil Adult Lead Model (ALM) Summary

Depth Range	Lead Concentration in Soil	Percent Chance of Exceeding Acceptable Threshold (10 µg/dL PbB)
0-1 ft bgs	211 mg/kg	0.013%
0-3 ft bgs	342 mg/kg	0.032%

Notes: Appendix B presents the ALM inputs and outputs

In addition, it was shown that a typical fetus of an adult commercial/industrial worker exposed to lead in surface and subsurface material at the site would have a 0.65 – 1.3% chance of PbBs exceeding the CDC reference value of 5 µg/dL (CDC 2012). Therefore, lead does not pose a threat of unacceptable PbB levels to fetuses in adult commercial/industrial receptors exposed to surface and subsurface material in the Landfill AOPC (Appendix B).

2.5.1.1.2 Landfill – Construction Worker

RME

As presented in Table 2-11, the Construction Worker exposure to deep soil had a RME cancer risk of 5 x 10^{-6}, which exceeds the ODEQ threshold of 1 x 10^{-6} but falls within the USEPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The cumulative cancer risk is below ODEQ's acceptable risk level of 1 x 10^{-5}. The noncancer HI of 1 was at the ODEQ and USACE threshold, primarily based on inhalation exposure for PCE. Due to the dilution and mixing that occur in outdoor situations and since the HI is at the risk threshold, this HI is acceptable and PCE was not selected as a COC.

The primary contributor to risk is benzo(a)pyrene through ingestion (3 x 10^{-6}) and dermal contact (1 x 10^{-6}). No other cPAHs were COPCs for this receptor exposure to deep soil.

Based on RME estimates, the COC for subsurface soil in the Landfill AOPC is benzo(a)pyrene.

CTE

As presented in Table 2-12, CTE resulted in a low cancer risk of 7 x 10^{-7}, which is below the ODEQ cancer threshold and had an acceptable HI of 0.02.

2.5.1.1.3 Landfill – Future Hypothetical Fishing Platform User

RME

As presented in Table 2-13, the Hypothetical Fishing Platform User exposure to current surface soil concentrations resulted in a RME risk of 1 x 10^{-3} and HI of 1. Cancer risks exceeded the USEPA acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. The primary contributors to risk were the cPAHs (primarily benzo(a)pyrene), with minor contributions from arsenic.

The noncancer hazard was at the noncancer threshold value of 1. No single chemical exceeded a HQ of 1. The greatest relative contributions to hazard came from total PCBs, arsenic, and mercury, although their individual HQs were less than 0.5. The target organs and effects associated with the non-cancer effects of these chemicals vary widely and are unlikely to result in cumulative effects. For example, arsenic may primarily affect the skin (hyperpigmentation, keratosis), mercury may affect the kidney (auto-immune effects), and PCBs may affect ocular glands (exudates) and digits (distorted fingers and toes) (USEPA 2015b). Based on the low potential for toxicity to individual target organs and an HI equal to the threshold, risk is considered insignificant.

Following USEPA guidance (USEPA 2002c), the contribution from background arsenic and site-related arsenic were evaluated further. The Reference Area UPL for arsenic is 5.4 mg/kg, which is almost half of the arsenic EPCs for both the Landfill and Sandblast Area AOPCs. Therefore, the incremental risk from site-related arsenic is 1 x 10^{-5}, which exceeds the ODEQ threshold, but falls within the USEPA acceptable risk range.

The Nursing Infant receptor was evaluated for this receptor using the ODEQ (2010a) IRAF, as detailed in Section 2.4.7. As presented in Table 2-14, the RME Nursing Infant cancer risk was acceptable at 1 x 10^{-6}, but had an HI slightly greater than 1 (2) based on PCB exposure.

CTE

As presented in Table 2-14, the Hypothetical Fishing Platform User exposure to surface soil had a CTE risk of 2 x 10^{-4} and HI of 0.46. The cancer risks exceeded the USEPA acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}, but the noncancer HI was acceptable. The primary contributors to risk, similar to RME, were cPAHs. The Nursing Infant CTE cancer risk was acceptable at 1 x 10^{-7} and the noncancer HI was acceptable at 0.3.

Lead

Based on the lead evaluation, the probability of exceeding the target blood lead levels for the Hypothetical Fishing Platform User who may be exposed to Landfill soils was 0.034% for the fetus of an adult residential-like exposure and 0.36% for a child residential-like exposure for the evaluated data sets (Table 2-25). Therefore, lead concentrations are not a concern. See Appendix B for model details.

2.5.1.2 Landfill AOPC Groundwater

Excavation/Trench Worker

As presented in Table 2-15, the Excavation/Trench Worker RME exposure to contaminants in groundwater yielded cancer risk of 5 x 10^{-8} and noncancer HI of 0.04. Both are well below acceptable thresholds. This pathway considered incidental ingestion and dermal contact to

COPCs in groundwater and inhalation of VOCs that volatilized from the groundwater into trench air. CTE calculations were not performed due to low RME results and because this is a minor exposure pathway.

2.5.2 Sandblast Area AOPC

The BHHRA evaluated exposures to COPCs in soil, soil gas, and groundwater at the Sandblast Area AOPC. Four occupational receptors and the Hypothetical Fishing Platform User were evaluated and Appendix A presents the risk equations and calculations tables. The receptors and their summary cancer risk and noncancer health tables are listed below:

- Outdoor Maintenance Worker: RME Summary (Table 2-16)
- Outdoor Maintenance Worker: CTE Summary (Table 2-17)

- Construction Worker: RME Summary (Table 2-18)
- Construction Worker: CTE Summary (Table 2-19)

- Hypothetical Fishing Platform User: RME Summary (Table 2-20)
- Hypothetical Fishing Platform User: CTE Summary (Table 2-21)

- Excavation /Trench Worker, Exposure to Groundwater: RME Summary (Table 2-22)

- Indoor Worker, Exposure to Indoor Air: RME Summary (Table 2-23)
- Indoor Worker, Exposure to Indoor Air: CTE Summary (Table 2-24)

2.5.2.1 Sandblast Area AOPC Soil

2.5.2.1.1 Sandblast Area – Outdoor Maintenance Worker

RME

As presented in Table 2-16, the Outdoor Maintenance Worker exposure to surface soil had RME cancer risk of 1 x 10^{-5}, which exceeds the ODEQ threshold of 1 x 10^{-6} but falls within the USEPA's acceptable risk range of 1 x 10^{-6} to 1 x 10^{-4}. The noncancer HI was acceptable at 0.07. The cumulative cancer risk was greater than ODEQ's acceptable risk level of 1 x 10^{-5} (ODEQ 2010a). The primary contributors to risk are arsenic and cPAHs.

An evaluation of total, background, and site-related incremental risk was performed, similar to Landfill soils. The results are summarized below:

Summary of Total, Background, and Site-Related Risk for Arsenic Outdoor Maintenance Worker[1]

Data Grouping	Arsenic EPC (mg/kg)	Arsenic Cancer Risk	Arsenic HQ
RME Sandblast Area	9.7	3 x 10^{-6}	0.02
Reference UPL	5.4	2 x 10^{-6}	0.01
Site-related Increment	4.3	1 x 10^{-6}	0.01

[1]Rounded values

Based on this comparison, arsenic is not considered a COC since the site-related contribution to risk is at acceptable levels (USEPA 2002c, 2002d).

Ingestion and dermal contact of cPAHs were the significant exposure routes with the ingestion route yielding approximately twice the risk as dermal contact. Risk from benzo(a)pyrene was about double that of benzofluoranthenes, total, and the overall cPAHs yielded a risk of 1×10^{-5}. Benzo(a)pyrene was detected consistently throughout the surface soil of the Sandblast Area AOPC (36 detections out of 40 samples) (Table 1-2) with an EPC of 2.4 mg/kg, as compared to the Reference Area UPL of 0.037 mg/kg.

Based on RME estimates, the only COCs for surface soil in the Sandblast Area AOPC are cPAHs, consisting of benzo(a)pyrene and benzofluoranthenes, total.

CTE

As presented in Table 2-17, CTE resulted in a low cancer risk of 1×10^{-6}, which is at the ODEQ cancer threshold, and an acceptable HI of 0.008.

Exposure to Lead in Surface Soil

For both available surface soil depth ranges, the USEPA ALM estimated acceptable percent chance of exceeding the target blood lead concentration for the Outdoor Maintenance Worker due to exposure to surface soil (see Table 2-25 and the summary of results below).

Sandblast Area Surface Soil Adult Lead Model (ALM) Summary

Depth Range	Lead Concentration in Soil	Percent Chance of Exceeding Acceptable Threshold (10 µg/dL PbB)
0-1 ft bgs	300 mg/kg	0.025%
0-3 ft bgs	202 mg/kg	0.013%

Note: Appendix B presents the ALM inputs and outputs

Similar to the Landfill, it was shown that a typical fetus of an adult commercial/industrial worker exposed to lead in surface and subsurface material at the site would have a 0.65 to 1.1% chance of PbBs exceeding the CDC reference value of 5 µg/dL (CDC 2012). Therefore, lead does not pose a threat of unacceptable PbB levels to fetuses in adult commercial/industrial receptors exposed to surface and subsurface material in the Sandblast Area AOPC (Appendix B).

2.5.2.1.2 Sandblast Area – Construction Worker

RME

As presented in Table 2-18, the Construction Worker exposure to sub-surface soil had a RME cancer risk of 2×10^{-6}, which exceeds the ODEQ threshold of 1×10^{-6} but falls within the USEPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}. The noncancer HI was acceptable at 1. The cumulative cancer risk is less than ODEQ's threshold of 1×10^{-5}.

The primary contributor to risk is benzo(a)pyrene, with a cumulative multi-pathway cancer risk of 2×10^{-6}. No other cPAHs were COPCs for this receptor exposure to sub-surface soil.

Based on RME estimates, the only COC for subsurface soil in the Sandblast Area AOPC is benzo(a)pyrene.

CTE

As presented in Table 2-19, the CTE evaluation resulted in a low cancer risk of 3 x 10^{-7}, which is below the ODEQ cancer threshold, and an acceptable HI of 0.01.

2.5.2.1.3 Sandblast Area – Future Hypothetical Fishing Platform User

RME

As presented in Table 2-20, the Hypothetical Fishing Platform User exposure to current surface soil concentrations had a RME risk of 3 x 10^{-4} and HI of 1.8. At the Sandblast Area AOPC, cancer risks also exceeded the USEPA acceptable risk range. Non-cancer hazards were at or slightly higher than 1. COCs contributing to risk were similar to Landfill soils, consisting primarily of cPAHs, but with minor contributions from more chemicals, including arsenic, total PCBs, and DEHP. No individual COPC had a HQ greater than 1, but the cumulative evaluation resulted in a total HI of 2 due to arsenic, nickel, Total PCBs, PCE, and TCE. Similar to the noncancer chemicals at the Landfill, the target organs and effects associated with these chemicals are also variable. In addition to the previously described arsenic and PCBs, nickel may result in generalized decreased body weight, PCE may affect the nervous system (neurotoxicity), and TCE may affect the thymus gland (decreased weight), vascular system (decreased plaque cell-forming response), and heart (cardiac malformation) (USEPA 2015b). Based on the low potential for toxicity to individual target organs, the marginal HI of 2 is considered acceptable.

The Nursing Infant receptor was evaluated for this receptor using the ODEQ (2010a) IRAF, as detailed in Section 2.4.7. As presented in Table 2-20, the Nursing Infant cancer risk was acceptable at 1 x 10-6 and had an HI of 2, slightly greater than the threshold of 1, based on PCB exposure.

CTE

As presented in Table 2-21, the Hypothetical Fishing Platform User exposure to surface soil had a CTE risk of x 10^{-5} and HI of 0.7. The cancer risk is within the USEPA acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}, and the HI was acceptable. The primary contributors to risk, similar to RME, were cPAHs. The Nursing Infant CTE HI was acceptable at 0.3.

Lead

Based on the lead evaluation, the probability of exceeding the target blood lead levels for the Hypothetical Fishing Platform User who may be exposed to Sandblast Area AOPC soils was 0.075% for adult residential-like exposure and 1.5% for child residential-like exposure for the evaluated data sets (Table 2-25). See Appendix B for model details.

2.5.2.2 Sandblast Area AOPC Groundwater

Excavation/Trench Worker

As presented in Table 2-22, the Excavation/Trench Worker RME exposure to contaminants in groundwater yielded cancer risk of 1 x 10^{-7} and noncancer health hazard of 0.7. Both are below ODEQ and USEPA risk thresholds. This pathway considered incidental ingestion and dermal contact to COPCs in groundwater and inhalation of VOCs, which volatilized from the groundwater into trench air. CTE calculations were not performed due the low RME results and because this is a minor exposure pathway.

2.5.2.3 Sandblast Area AOPC Soil Gas

The vapor intrusion pathway was considered for both current and potential future indoor exposures in an occupational setting. The approach included risk estimation based on modeled estimates of indoor air concentrations using soil gas data as well as a review of other site data and information.

2.5.2.3.1 Sandblast Area – Modeled Risk Estimates

Indoor Office Worker

The indoor office worker exposure to VOCs from soil gas was evaluated using multiple lines of evidence to account for the dynamic and highly variable vapor intrusion pathway. PCE and TCE were the two COPCs identified in soil gas. The USEPA JEM was used to derive AFs for each chemical for the various vapor intrusion exposure scenarios. The JEM input and output details are presented in Appendix B.

2.5.2.3.2 Sandblast Area – Current Existing Buildings Scenario

The current scenario used dimensions of the existing buildings and site-based soil type (i.e., sand) and detected COPC concentrations from the closest soil gas sampling locations (typically adjacent to the building).

As presented in Table 2-23, the indoor office worker at the Equipment Building (represented by data from soil gas location SB-14) has a RME risk of 3 x 10^{-8} and HI of 0.008, both of which are well below the ODEQ and USEPA risk thresholds. The CTE risk was 6 x 10^{-9}, with an HI of 0.008 (Table 2-24). The office building is noted as being a portable unit. The JEM does not account for buildings without a foundation which increases the uncertainties related to the derivation of the AFs for this receptor and are discussed in the uncertainty assessment section.

The indoor office worker at the Bradford Island Service Building (BISB) (represented by data from soil gas sample location SB-13) has a RME risk of 1 x 10^{-8} and a HI of 0.003, which are well below the ODEQ and USEPA risk thresholds (Table 2-23). The CTE risk was 3 x 10^{-9} and HI of 0.003 (Table 2-24). The BISB is a large L-shaped building having two distinct parts. One side is about 25 ft high with large open bay doors and is used as a paint and equipment shop. The other side is single story and houses the offices. Only the office side and its dimensions were used in deriving the attenuation factors.

In summary, risks and hazards were at acceptable levels for occupants of the current buildings.

2.5.2.3.3 Sandblast Area – Future Building Scenario

The future scenario used USEPA JEM conservative residential building dimension defaults, the most conservative soil type (sand), and the maximum detected concentrations of the COPCs in soil gas.

As presented in Table 2-23, the indoor office worker in a future building has a RME risk of 5 x 10^{-7} and HI of 0.1, which are below the ODEQ and USEPA risk thresholds. The CTE risk was 1 x 10^{-7} and HI was 0.14 (Table 2-24).

2.5.2.3.4 Sandblast Area – VOC Concentrations in All Media

In general, the highest concentrations of VOCs in all media are noted in samples taken from the vicinity of the Former Sandblast Building and the Current HMSA. This area also corresponds to the approximate location of a former aboveground storage tank (AST).

Soil Gas (See Figure 9-8 of the RI) had 5 sample locations (collected in 2009) within the Sandblast Area AOPC: two locations (SB-11 and SB-12) adjacent to the old Sandblast Building (no longer present), one location (SB-10) adjacent to the Current HMSA, one location (SB-14) adjacent to the Equipment Building, and one location (SB-13) adjacent to the BISB. PCE and TCE have been detected in all five samples with exceedances of screening levels at SB-12 and SB-10. The low number of soil gas samples limits the spatial analysis and shows fluctuating concentrations for PCE. The highest PCE concentration was reported as 34,000 $\mu g/m^3$ at SB-12, decreases to 800 $\mu g/m^3$ at SB-11 and 610 $\mu g/m^3$ at SB-10 to the south, increases to 1,800 $\mu g/m^3$ at SB-13 further southwest, and decreases to 730 $\mu g/m^3$ at SB-14 further south.

Surface Soil (See Figure 9-5j of the RI) had a relatively low number of PCE/TCE detections throughout the Sandblast Area AOPC. Two locations exceeding the SLV, HA4 and SBB18, are adjacent to the Current HMSA.

Deep Soil (See Figure 9-5k) sample locations appear to target the Erodible Unit Sampling Area and the Current HMSA. Although most samples had detections of PCE/TCE and some cis-DCE, none exceeded SLVs and were relatively low. The highest detections were locations (DP11 and DP12) near the Current HMSA.

Groundwater (See Figure 9-7b) data includes both monitoring well (MW) (collected in 2008 and 2009) and direct push samples (collected in 2004). Groundwater flows down northward towards the shore. There were extensive detections of PCE/TCE (and their degradation products) exceeding SLVs throughout almost all the sample locations. Concentrations were generally higher in direct-push samples than in monitoring well samples. The highest PCE/TCE detection location was at DP11 (2004), adjacent to the Current HMSA, and yet the nearby MW-11 location showed ND in years 2008 and 2009. The overall lateral trend shows decreasing concentrations moving away from the Current HMSA area, suggesting a historic source in groundwater near DP11.

There appears to be an association between soil (especially deep soil), groundwater, and soil gas data based on high detections at the Current HMSA and extending towards the former Sandblast Building. In all media, the highest concentrations were noted in this area with decreasing concentrations growing outward and away from the Current HMSA and former Sandblast Building.

Historical Site Activity

These VOC findings also align with historical activity in this area as described in the RI:

> The former HMSA was located approximately 200 feet to the south of the former sandblast building and is sometimes also referred to as the 'former drum storage area.'… Before the construction of the current HMSA, an approximately 300-gallon AST was formerly located in the vicinity. Waste paints were temporarily stored in this AST until the late 1990s at which time the tank was removed… Analytical chemistry results for the soil sample identified the presence of several VOCs. From these results, it has been

inferred that there was a historical release from the AST formerly located in the vicinity of the current HMSA. (Section 3.5.1.2 of the Final RI [URS 2012])

The historical record indicates VOC contamination due to spills from containers storing hazardous materials near the Current HMSA. The data also suggest that the locations of the soil gas samples are well situated to capture the highest concentrations of VOC contamination for vapor intrusion concerns. There is no data to imply that VOC concentrations may increase in the future; therefore, the low risks estimated for the indoor office worker, both current and future, are expected to decrease further. There are no soil or groundwater data in the vicinity of soil gas locations SB-13 and SB-14. However, these locations are situated at a distance from the inferred AST location, and soil gas concentrations at these two locations were below all screening levels.

In summary, the multiple lines of evidence suggest a localized historic source of VOCs in the vicinity of the Current HMSA. The source area and the associated plumes appear to be undergoing degradation, and vapor intrusion-related risks are at acceptable levels both for occupants of current buildings and for future buildings.

2.5.3 Pistol Range AOPC

Lead was the only COPC identified at the Pistol Range AOPC and only for the Hypothetical Fishing Platform User receptor.

The ALM predicted that a typical fetus of an adult receptor exposed to lead in soil at the site would have 0.033% of the chance of PbB exceeding 10 µg/dL (See Table 2-25 and Appendix B). The PbB prediction is well below USEPA’s target for women of child-bearing age to limit the risk to a typical developing fetus to no more than a 5% chance of exceeding the 10 µg/dL PbB level of concern (USEPA 2003b). Therefore, lead does not pose a threat to fetuses of adult receptors exposed to soil or sediment in the Pistol Range AOPC.

The IEUBK predicted that a typical child receptor exposed to lead in soil at the site would have an approximate 0.34% chance of PbBs exceeding 10 µg/dL (Table 2-25 and Appendix B). The PbB prediction is well below USEPA’s target to limit the risk to a typical child to no more than a 5% chance of exceeding the 10 µg/dL PbB level of concern (USEPA 1994). Therefore, lead does not pose a threat to child receptors exposed to soil in the Pistol Range AOPC.

2.5.4 Bulb Slope AOPC

Lead was the only COPC identified at the Bulb Slope AOPC and only for the Hypothetical Fishing Platform User receptor.

The ALM predicted that a typical fetus of an adult receptor exposed to lead in soil at the site would have 0.038% of the chance of PbB exceeding 10 µg/dL (See Table 2-25 and Appendix B). Therefore, lead does not pose a threat to fetuses of adult receptors exposed to soil in the Bulb Slope AOPC.

The IEUBK predicted that a typical child receptor exposed to lead in soil at the site would have an approximate 0.45% chance of PbBs exceeding 10 µg/dL (Table 2-25 and Appendix B). The PbB prediction is well below USEPA’s target to limit the risk to a typical child to no more than a 5% chance of exceeding the 10 µg/dL PbB level of concern (USEPA 1994). Therefore, lead does not pose a threat to child receptors exposed to soil in the Bulb Slope AOPC.

2.6 Uncertainty Assessment

Uncertainties are inherent in any risk-based approach to evaluation and decision making for potentially contaminated sites. The uncertainties may be general and systemic as well as specific to the site. The objective of the uncertainty assessment is to identify the sources of uncertainty in the RA process, understand their potential to contribute to either underestimation or overestimation of risk for the selected receptors and pathways, and describe how the uncertainty is addressed. By describing the nature and magnitude of the uncertainties, the findings and conclusions of the RA can be better understood and used as a tool for decision making.

The following discussion supplements the extensive uncertainty analysis performed in the RI (Appendix O, URS 2012). The sources of uncertainties discussed in this section will involve those related to the risk characterization presented in the BHHRA.

2.6.1 COPC Selection Process

COPCs for the BHHRA were selected using ODEQ's rigorous methodology (ODEQ 2010a), which included selection of all chemicals that exceeded their individual screening levels, as well as chemicals whose exceedances across multiple media exceeded their screening levels. Additionally, noncancer chemicals that were lower than their individual screening levels were also retained as COPCs if the sum of the noncancer exceedance ratio exceeded a value of 1. No consideration of whether chemicals could be related to site activities was applied. Chemicals without screening levels were also retained as COPCs. Degradation products of PCE and TCE were also retained as COPCs even though many of them were reported as not detected in the actual data.

Given this exhaustive and comprehensive COPC selection process, risks are more likely to be overestimated due to the inclusion of COPCs that were nondetect (e.g., degradation products) and COPCs that may not have been site related, which results in low potential for underestimation of risk.

2.6.2 Adequacy of the Analytical Data Used for Site Characterization

The quality of the analytical data used for site characterization was reviewed thoroughly in the RI (URS 2012) and was deemed to be acceptable and useable for RA purposes. The inclusion of total benzofluoranthenes from the earlier data introduced some uncertainty. Since these data represented unique locations not covered in later data, the total benzofluoranthenes data were retained for the BHHRA. Their toxicity was evaluated using the methodology described in Section 2.6.4.

2.6.3 Exposure Assessment

2.6.3.1 EPC for RME and CTE

The 95% UCL values for soil were used as the EPC for both RME and CTE scenarios for occupational exposures. This is consistent with USEPA recommendations (USEPA 1992b), but is more conservative than required by ODEQ guidance (2010a), which recommends the arithmetic mean to represent the CTE. The potential for overestimation of risk is increased by using the 95% UCL to represent both the RME and CTE.

2.6.3.2 Hypothetical Fishing Platform Exposure Assumptions

The exposure factor values assumed for the Hypothetical Fishing Platform receptor are likely to substantially overestimate risk. At this time, there is neither the access nor the usage of the Island for such long-term, high intensity use. Although this evaluation assumes unrestricted access to the Island, there are obstructions and barriers of terrain, vegetation, and industrial use that currently limit access to certain parts of the Island. Even if such uses were undertaken in the future, it is highly unlikely for any one receptor to spend 100% of their time (24 hours/day, 365 days/year, for 26 years) solely at any one AOPC area. The Bulb Slope AOPC, in particular, is a small area with steep slopes that affords very poor access. Overall, the exposure assumptions and risk estimates associated with the Hypothetical Fishing Platform User using current soil exposure concentrations should be interpreted only as a guide to assist in future decision making and not as a literal estimation of risks and potential adverse health effects.

2.6.3.3 Volatilization Factor Calculation for Outdoor Exposure from VOCs in Soil

The USEPA equation (2002b) for deriving an outdoor air concentration from VOC concentrations in soil is highly uncertain when deriving a VF for the BHHRA because of arithmetical uncertainties. Since this pathway was included in the RME calculation and yielded insignificant risk, this pathway was omitted in the risk calculation for the CTE because exposure to VOCs outdoors is a very minor pathway for all receptors. The effect of this uncertainty is minimal with a negligible underestimation of CTE risk.

2.6.3.4 Non-Detect COPCs (Degradation Products of PCE)

As reported in the RI (URS 2012), PCE was detected but its degradation products (i.e., TCE, DCE(s) and vinyl chloride) were not detected but included as COPCs to meet ODEQ recommendations. The potential risk contribution from the degradation compound COPCs were quantitatively evaluated by including them as COPCs for the main exposure pathways for the receptors of both Landfill and Sandblast Area AOPCs.

EPC Selection Process

The process of estimating an EPC for the degradation products considered key questions, which are listed below and addressed in the discussion that follows.

- What were the concentrations of the parent compound(s)?
    - If the parent compound was detected at a relatively high concentration which may have resulted in masking the detections of the degradation products; were there other samples further away with lower detections and therefore less likely to mask the degradation products in the sample?
- Were the degradation products detected in another media (i.e., groundwater or soil gas)?
- What were the MDLs (see Section 7.0 of the RI) for the degradation products and how do they compare to the screening levels? (see RI Appendix I, Tables I-12 to I-15)?
    - If MDLs are used, how will the EPC be derived (i.e., maximum or averaged)?
- Can the current or future concentrations of the degradation products be modeled?

The issue of a high PCE detection masking concentrations of degradation products in the same soil sample has occurred in a sample collected in the Landfill AOPC. The contamination profile of the Landfill AOPC is heterogeneous due to buried sources from past disposal practices; therefore, concentrations of contaminants in soil may be variable rather than show a gradient range of concentrations. At the Landfill AOPC, the analytical data for PCE from soil samples demonstrate this with only one high detection at 403,000 µg/kg (Sample 011015BIL04TPG [Table 5-2b of the Final RI]) and relatively low detections elsewhere (ND to 11.0 µg/kg). Subsequently, for the soil sample containing the high PCE concentration, none of the degradation products were detected (i.e., they were “U-qualified” as non-detect). They are listed with their respective MDLs (µg/kg) as follows:

- 1,1-DCE: 2300 U
- cis-1,2-DCE: 2300 U
- trans-1,2-DCE: 2300 U
- TCE: 2300 U
- Vinyl Chloride: 2300 U

It should be noted that the MDLs were elevated. The MDLs for other soil samples from the site were typically three orders of magnitude lower (i.e., 0.2300 µg/kg).

There were multiple detections of PCE in soil ranging from 0.605 µg/kg to 65.0 µg/kg (Appendix I Table I-1 of the Final RI [URS 2012]), but there were no corresponding detections of degradation products.

Amongst groundwater samples, there were multiple detections of PCE ranging from 0.23 µg/L to 8.78 µg/L) (Table I-1 of the RI), but none had corresponding detections of degradation product. There were two detections of vinyl chloride (0.531 and 0.507 µg/L) but these low detections were not co-located with PCE detections.

These findings show that there is no evidence of PCE degrading to its degradation products at detectable levels either in the soil or groundwater at the Landfill. Any risk calculated for these degradation products should be considered with high uncertainty and an overestimation of risk. Nevertheless, the lone high detection of PCE in soil resulted in elevated MDLs for the degradation product. The Landfill AOPC EPC concentrations were conservatively estimated at the maximum MDL of 2300 µg/kg for all PCE degradation products. The EPCs for degradation products in soil in the Sandblast Area AOPC were based on low MDLs.

PCE was identified as a soil COPC for the Construction Worker at the Landfill AOPC and for both Outdoor Maintenance Worker and Construction Worker at the Sandblast Area AOPC. The degradation products of PCE were added to the list of COPCs for these receptors, whether or not they were detected. The degradation products included TCE, 1,1-dichloroethene, cis-1-2 dichloroethene, trans-1,-2-dichloroethene, and vinyl chloride. More degradation products were detected in the Sandblast Area AOPC soils than in Landfill AOPC soils (Tables 9-1, 9-2 of the RI). The risk calculations are presented in Appendix A.

Landfill: Construction Worker

The RME cancer risk was 5×10^{-6}, and HI was 2 (Table A-3.5 of Appendix A). The degradation products of PCE contributed negligibly to cancer risk and slightly elevated the noncancer HI to 2, which would be considered a negligible increase over the threshold value of 1. The increase of the HI was primarily due to inhalation of TCE and the elevated MDL used for the EPC, which resulted in a HQ of 0.5.

Sandblast Area: Outdoor Maintenance Worker

The RME cancer risk was 2 x 10^{-5}, and HI was 0.1 (Table A-3.10 of Appendix A). The degradation products of PCE contributed negligibly to both the cancer risk and noncancer HI.

Sandblast Area: Construction Worker

The RME cancer risk was 2 x 10^{-6}, and HI was 1. (Table A-3.15 of Appendix A) The degradation products of PCE contributed negligibly to the cancer risk and the noncancer HI.

The inclusion of non-detected degradation products of PCE generally had a negligible effect on the calculated cancer risk and noncancer health hazard for all the receptors except for noncancer hazards for the Landfill Construction Worker. This was due to using the elevated MDL for the EPC for which inhalation of TCE contributed a HQ of 0.5. Other soil samples and groundwater data from the Landfill AOPC did not show the presence of degradation products; therefore, using the elevated MDL was likely overly conservative. In general, identifying the proper EPC to use for degradation products that were not detected is challenging since theoretically, the concentrations may increase over time, yet there are no established methods to derive future concentrations. Using the detection limits for the EPC showed that the uncertainty of excluding degradation products are expected to only negligibly underestimate risk.

2.6.3.5 Oral and Dermal Bioavailability of Arsenic and PAHs

This BHHRA assumes that the relative oral bioavailability of arsenic 60% in soil and 100% for PAHs. While the 60% value is consistent with USEPA's current default estimates (USEPA 2012a, 2012b), this represents an upper-bound value, and the actual bioavailability may be substantially lower since arsenic at the site is not associated with any particular source type and may be soil-related. The range of soils tested for bioavailability of arsenic included mining and smelter soils, volcanic soils, pesticide-treated soils, and soils with manufacturing and electrical waste (USEPA 2012a, 2012b). A total of 103 estimates based on swine, monkey, and rat bioassays were available. Relative to the bioavailability of arsenic in water, less than 5% of the values exceeded a relative bioavailability of 60%. USEPA selected 60% as a default value from the upper percentile range that would be unlikely to be exceeded or result in an underestimation of risk.

While USEPA does not currently endorse any oral bioavailability factors for PAHs, several studies have noted that the relative bioavailability of cPAHs in soil may range from as low as 0.1% to 29% (Turkall et al. 2014, Harris et al. 2013, Magee et al. 1996). Similarly, dermal penetration of PAHs is currently assumed to be 13% based on USEPA default assumptions (USEPA 2004c). However, studies point to a reasonable estimate of 0.02 for dermal penetration (Magee et al. 1996, MADEP 2013). Therefore, risk estimates for cPAHs and the RBCs for cPAHs are likely to include a high level of overestimation of risk.

2.6.4 Toxicity Assessment

Benzofluoranthenes, Total

Older soil data (collected in 2001 and 2004) reported benzofluoranthenes as total instead of individual chemicals. Due to the lack of chemical physical parameters and toxicity values for total benzofluoranthenes, the values for benzo(b)fluoranthene were used as a surrogate. The USEPA RSL tables list three benzofluoranthenes: benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene. They all share the same inhalation unit risk (IUR) but different SFo. The SFo for benzo(b)fluoranthene is the middle value. It should be noted that the most toxic benzo(j)fluoranthene has not been detected in Landfill soil. The uncertainty of using benzo(b)fluoranthene as a surrogate for total benzofluoranthenes in the risk screening in the RI intentionally overestimated risk. Use of a scaling factor of 60% of total benzofluoranthenes estimated as benzo(b)fluoranthene is based on a robust average of 30 samples and represents a more realistic and less uncertain method of treating the older data.

cPAHs were assumed to operate by a mutagenic mode of action, following current approaches suggested by ODEQ (2010a) and USEPA (2015a). This is likely to add to the potential for overestimation of risk for children since it is highly unlikely that exposure durations approaching residential levels would actually occur at the Island.

Chromium: Trivalent or Hexavalent Forms

As discussed in Section 2.4.5, the trivalent form of chromium was assumed for the RA for both the Landfill and Sandblast Area. Section 9 of the Final RI (URS 2012) notes the potential presence of nickel-chromium equipment coating that may have been sandblasted. Site conditions (i.e., high moisture and organic matter in soil and non-detect or very low dissolved chromium levels in groundwater) favor the occurrence of stable, insoluble trivalent chromium (Alloway 1990, Brookins 1988, ATSDR 2012a). Therefore, it is unlikely that any of the site chromium would be in the hexavalent form, and the potential for underestimation of risk is considered insignificant.

Petroleum Hydrocarbons

Consistent with USEPA’s CERCLA guidance, TPH chemicals were not included as COPCs, although they were included in the initial COPC screening tables in the Final RI and for the Hypothetical Fishing Platform User (Tables 2-1 to 2-4). This is not expected to significantly underestimate risk. The only TPH fraction that exceeded the residential SLV was residual range organics in landfill soils. The residual fraction is a highly immobile and non-volatile fraction whose primary constituents of health concern are PAHs. Both the cancer risks and noncancer hazards associated with PAHs have already been evaluated using PAH-specific data, and cPAHs have been identified as the dominant COCs in both Landfill and Sandblast Area soils. Therefore, it is unlikely that the exclusion of residual range organics would result in any significant underestimation of noncancer hazard at the Landfill.

Thallium: PPRTV Screening Level Values

Thallium was selected as a COPC in groundwater for incidental contact for construction/ excavation workers. It was reported at low levels in groundwater at a maximum concentration of 0.3 ug/l. There were no peer-reviewed toxicity values available from within the USEPA preferred hierarchy of sources for thallium. The PPRTV RfD_o for thallium is 1×10^{-5} mg/kg-day (USEPA 2015a). However, in the PPRTV Derivation Source Document, due to various critical limitations in the study, USEPA presents this RfD_o as a provisional screening value in Appendix A of the PPRTV document, with even more uncertainty than a PPRTV (USEPA 2012c) and does not endorse this value as part of the recommended hierarchy of values. Therefore, this screening level value should be used and interpreted with great caution. In the absence of reliable human toxicity data, the provisional screening value is based on a 1988 rat study with hair follicle atrophy as the critical effect. An uncertainty factor of 3,000 was applied. Even with the high degree of uncertainty and poor quality of the toxicity value, the noncancer hazard represented by thallium for the wader scenario was less than 1 and warranted no further consideration. Overall, the use of the PPRTV-screening value for thallium has a high potential to overestimate risk but is useful in eliminating thallium as a health concern at the site.

Vanadium

Vanadium was selected as a COPC for groundwater at the Sandblast AOPC with a maximum value of 0.22 ug/L. Elemental vanadium does not occur in nature, but vanadium may occur in six oxidation states in 65 different mineral ores and in association with fossil fuels (ATSDR 2012b). There were no peer-reviewed toxicity values available from within the USEPA preferred hierarchy of sources for vanadium compounds other than vanadium pentoxide. Values are provided in IRIS for vanadium pentoxide (V_2O_5) which is one of the more toxic forms of vanadium. The RfD_o for vanadium pentoxide is 9 x 10^{-3} mg/kg-day (USEPA 2015b) and the reference concentration (Rf_c) is 7 x 10^{-6} mg/m^3 (ORNL 2015). However, exposure to vanadium pentoxide for humans mostly occurs as ingestion through dietary pathways and inhalation of dust in occupational settings (ATSDR 2012b). Vanadium in environmental media is typically not present as vanadium pentoxide. Therefore, it is unlikely to be the form in which vanadium occurs in site sediments or the pathway by which exposure might occur. To evaluate vanadium without using the vanadium pentoxide values, the HHRA adopted the approach used in the USEPA RSLs (2015a). The RfD_o for vanadium pentoxide was adjusted by the molecular weight of vanadium only (56% of total molecular weight) and applied to the RfD_o , resulting in a vanadium-specific RfD_o of 5.04 x 10^{-3} mg/kg-day. The inhalation Rf_c for vanadium was selected as 1 x 10^{-4} mg/m^3 based on ATSDR (2012b), which is based on chronic exposure to pentoxide. Overall, the use of the modified oral toxicity values and pentoxide-based inhalation values for vanadium has the potential to overestimate risk but is useful in eliminating vanadium as a health concern at the site.

n-Isopropylbenzene

n-Isopropylbenzene was also selected as a COPC for groundwater in the Landfill AOPC with an EPC of 2 ug/L. There were no readily available toxicity values that corresponded with USEPA's recommended hierarchy of values for n-isopropylbenzene. Therefore, the screening-level PPRTV values with RfD_o of 0.1 mg/kg-day and inhalation Rf_c of 1 mg/m^3 were used (USEPA 2009c). Based on structural and metabolic similarities, the PPRTV-screening values for n-isopropylbenzene are based on ethylbenzene as a surrogate. The use of these values for quantitative risk assessment does not fall within USEPA's recommended hierarchy of sources and is accompanied by great uncertainty. Even with the high degree of uncertainty and poor quality of the toxicity value, the noncancer hazard represented by n-isopropylbenzene for the groundwater pathway was less than 1 and warranted no further consideration. Overall, the use of the PPRTV-screening value for n-isopropylbenzene has a high potential to overestimate risk but is useful in eliminating n-isopropylbenzene as a health concern at the site.

2.6.5 Risk and Hazard Estimates

The risk and hazard estimates are presented in the context of USEPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6} and a noncancer HI of 1. Individual chemicals with risks exceeding 1 x 10^{-6} or

HQ of 1 are noted as COPCs, as well as receptors and pathways with cumulative risks exceeding 1 x 10^{-6} or HI of 1.

Only the soil-related exposure pathway estimates exceeded the *de minimis* risk levels. Even these exceedances include several factors that are likely to overestimate risk. Risks were at acceptable levels for pathways related to groundwater and soil vapor.

Cumulative risks and hazards are also presented in the context of ODEQ's acceptable multi-carcinogen risk level of 1 x 10^{-5}. However, even if the cumulative multi-chemical risk level does not exceed 1 x 10^{-5}, individual chemicals are still identified as a COC if they exceed the individual risk level of 1 x 10^{-6} (i.e., the RME Construction Worker at both the Landfill and Sandblast Area AOPCs have cumulative cancer risks less than ODEQ's threshold of 1 x 10^{-5} but benzo(a)pyrene is identified as a COC at both AOPCs due to exceeding the individual risk level of 1 x 10^{-6}).

2.6.6 Landfill Heterogeneity

For approximately 40 years (early 1940s until the early 1980s), USACE managed, stored and disposed of waste materials at the landfill in excavated pits or existing depressions. By 1982, the surface of the Landfill AOPC had been capped with soil cover. In 1989, approximately 8-inches of additional soil cover was placed on the Landfill site by the USACE (Hibbs, personnel comm. 2001). Because the waste was buried in separate pits, rather than one continuous pit, the heterogeneity of the landfill composition makes contamination characterize difficult. Although sampling targeted areas known (via historical aerial review or previously exposed areas) or suspected (via electrical resistivity data and seismic refraction data) as having the greatest landfilling activity, risk may be underestimated due to the heterogeneous nature of the landfill.

2.7 Calculation of Site-Specific Risk-Based Concentrations

The COCs for the four Upland AOPCs are summarized below:

AOPC	Outdoor Maintenance Worker	Construction Worker	Excavation/ Trench Worker	Indoor Office Worker	Hypothetical Fishing Platform User
Landfill	cPAHs	Benzo(a)pyrene	None	None	Arsenic, PCBs, cPAHs
Sandblast Area	cPAHs	Benzo(a)pyrene	None	None	Arsenic, PCBs, cPAHs, DEHP
Pistol Range	NA	NA	NA	NA	None
Bulb Slope	NA	NA	NA	NA	None

To support the FS, RBCs were calculated for the COCs for each receptor, corresponding to a target cancer risk level of 1 x 10^{-6} (Table 2-27). The Reference Area UPL was also considered for inorganic chemicals (Table 1-9). The recommended RBC for each COC was selected as the higher of the RBC and UPL for inorganics. For organics, the risk-based value was selected as the recommended RBC.

The equation for calculating RBCs is as follows:

$$RBC = EPC \times \text{Target Risk} / \text{Calculated Risk}$$

where,

RBC = Risk Based Concentration
EPC = EPC for Chemical from BHHRA
Target Risk for individual PAHs and cumulative cPAHs = 1×10^{-6}
Calculated Risk = Chemical Specific from BHHRA

The RBC for arsenic for the Hypothetical Fishing Platform User is 0.68 mg/kg, while the Reference Area UPL is 5.4 mg/kg. Consistent with USEPA guidance that RBCs lower than ambient or background levels are not feasible for naturally occurring inorganics (USEPA 2002c, 2002d), the Reference Area UPL was selected as the recommended RBC for arsenic and was used to identify soil sampling locations where arsenic exceedances might occur.

The RBCs for Total PCBs (as Aroclors) and DEHP are based only on risk and did not take Reference Area concentrations into account.

The outdoor worker RBC for cPAHs was estimated at 0.3 mg/kg BaPeq. The RBC for the Construction Worker was 2 mg/kg BaPeq. The Outdoor worker RBC and the Construction worker RBC are higher than the Reference Area UPL (0.052 mg/kg), while the Hypothetical Fishing Platform User RBC (0.015 mg/kg) is less than the Reference Area UPL. Although the recommended cPAHs RBC for this receptor is the Reference Area UPL (Table 3-31), the exceedances shown in the figures discussed in Section 2.8 are based only on the risk-based value, in recognition of the fact that the naturally occurring background concept is not always applied to organic compounds. If ODEQ's acceptable risk level of 1×10^{-5} for COCs with a common and additive mode of action were taken into account, the RBCs for cPAHs may be adjusted upwards by a factor of 10.

2.8 Risk Interpretation

In this section, the results of the risk estimation, uncertainty assessment, and site-specific information are considered together to come up with a final assessment of risks. The RBCs for cPAHs, which are the primary COCs in Landfill and Sandblast AOPC soils, are highly influenced by certain conservative assumptions, including 100% oral bioavailability for all receptors, as well as residential-type exposures and mutagenic mode of action for Hypothetical Fishing Platform Users.

Figures 2-5 and 2-6 show all the sample locations at the Landfill and Sandblast AOPCs that exceeded the recommended occupational RBCs for the Outdoor Maintenance Worker (0.3 mg/kg BaPeq). Locations in deeper soils (3-10 ft bgs) which exceeded the Construction Worker RBC for cPAHs (2 mg/kg BaPeq) area also shown. Figures 2-7 and 2-8 show the locations where the RBCs for the Hypothetical Fishing Platform receptor were exceeded under current exposure conditions.

2.8.1 Landfill AOPC

cPAHs were identified as the only COC for occupational exposures (Section 2.7). A total of 30 locations (25 excluding composite sample locations) exceeded the occupational RBC for cPAHs at the Landfill in the 0-3 ft and 3-10 ft bgs depths (Figure 2-5). The locations were at the northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, far eastern portion of the Landfill, and one isolated spot northeast of the Pesticide/Herbicide Wash Area.

For the Hypothetical Fishing Platform User under current conditions, arsenic, Total PCBs, and cPAHs were identified as the COCs (Section 2.7). The RBCs for the Hypothetical Fishing Platform receptor were exceeded at 26 locations in the shallow soils at the Landfill, primarily for cPAHs (Figure 2-7). The exceeded locations for the Hypothetical Fishing Platform receptor (Figure 2-7) were almost identical with the exceeded locations for the occupational workers (Figure 2-5). Exceedances of the RBCs for arsenic and PCBs were co-located with the cPAH exceedances.

Arsenic exceedances were noted at five locations ranging, with four locations lower than approximately twice the Reference Area UPL (i.e., 12 mg/kg) (BIL11SS1, BIL22, BIL02USE, and BIL03USE) and one outlier location at 30.1 mg/kg (BIL05SS1). Overall, arsenic appears to be a relatively minor COC. Total PCBs were exceeded at only two locations (0.728 mg/kg at BIL04SS1 and 0.488 mg/kg at BIL02SS1). These are both estimated (J-qualified) values and are approximately two to three times higher than the RBC. Thus, the values represent a risk level of 3×10^{-6}, which is at the low end of the USEPA acceptable risk range. Considering the low frequency and magnitude of exceedance and the hypothetical and overly conservative nature of the Hypothetical Fishing Platform User scenario, risks related to PCBs may be considered to be very minor and represent an insignificant contribution.

Overall, risks related to exposure to shallow soils at the Landfill AOPC are primarily due to cPAHs for both occupational receptors and Hypothetical Fishing Platform Users. Arsenic and Total PCBs contribute very minor risks to the Hypothetical Fishing Platform User under current conditions. A subset of nine locations in deeper soil at the Gully Test Pit area and one location in the Mercury Vapor Lamp Test Pit Area also exceed Construction Worker RBCs for cPAHs. There are no unacceptable risks associated with groundwater at the Landfill.

2.8.2 Sandblast Area AOPC

cPAHs were identified as the only COC for occupational exposures to soil at the Sandblast Area AOPC (Section 2.7). A total of 16 locations exceeded the occupational RBCs at the Sandblast Area AOPC in the shallow and deeper soils (Figure 2-6). The locations are at the Erodible Unit, Current HMSA, Equipment Laydown Area, and the Former HMSA. All exceedances were in the shallow soils (0-3 ft bgs) with the exception of a single location (HA4, near the Current HMSA) that exceeded both the Outdoor Worker and Construction Worker RBC.

For the Hypothetical Fishing Platform User under current conditions, the COCs included arsenic, cPAHs, DEHP, and Total PCBs (Section 2.7). A total of 42 locations exceeded the Hypothetical Fishing Platform receptor RBCs (Figure 2-8). In comparing the figures for the occupational exceedances (Figure 2-6) with the Hypothetical Fishing Platform receptor exceedances (Figure 2-8), more locations exceeded for the Hypothetical Fishing Platform receptor including near the Catch Basin #1 and the Former HMSA. The organic COCs (PCBs, DEHP, and cPAHs) are generally co-located in their exceedances. Arsenic exceedances are sometimes co-located with the organic COCs and sometimes occur on their own. While cPAH and arsenic exceedances are dispersed throughout the Sandblast AOPC, DEHP and PCBs showed localized patterns of exceedance. DEHP exceedances were limited to two samples in the erodible unit (SB-EUA and SB-EUB). These samples represent composited samples from the area. DEHP exceeded the RBCs by approximately a factor of 1.6 (risk level 1.6×10^{-6}) at SB-EUA and a factor of 7 (risk level 7×10^{-6}) at SB-EUB, representing risk levels that fall within the USEPA acceptable risk range of 1×10^{-4} to 1×10^{-6}. PCB exceedances were limited to seven locations near the Equipment Laydown Area (LD-01, LD-02, LD-03, LD-05, LD-07, LD-10, and LD-11). The magnitude of exceedance ranged from approximately 1.7 times at LD-02 to approximately 9 times at LD-10. The risk levels associated with these exceedances also fall within the USEPA acceptable risk range.

Overall, risks related to exposure to shallow and deeper soils at the Sandblast Area AOPC are primarily due to cPAHs for both occupational receptors and Hypothetical Fishing Platform Users. Arsenic and Total PCBs contribute minor risks to the Hypothetical Fishing Platform User under current conditions. There are no unacceptable risks associated with groundwater or soil gas at the Sandblast Area AOPC.

Although all the locations are shown, not all the locations would need to be remediated to meet the risk target since an AOPC-wide statistical average exposure concentration is more realistic to actual receptor exposure.

2.8.3 ODEQ’s Acceptable Risk Level for Multi-Chemical Exposure

If ODEQ’s cumulative acceptable risk level of 1×10^{-5} were used as the basis for RBCs, the occupational RBC for cPAHs would be increased by a factor of 10 and would result in a value of 3 mg/kg BaPeq. The number of locations at both AOPCs where cPAHs exceed this RBC would be fewer than the number of locations that exceed the RBC based on 1×10^{-6} risk level (shown in orange on Figures 2-5 and 2-6).

At the Landfill AOPC, there were 16 locations that also exceeded the ODEQ multi-chemical cancer risk threshold of 1×10^{-5}. All of these locations were at and around the Gully Test Pit, Mercury Vapor-Lamp Test Pit, and Lead Hot Spot Test Pit #1 and at location BIL05SSI (Figure 2-5).

At the Sandblast Area AOPC, there were three locations that also exceeded the ODEQ multi-chemical cancer risk threshold of 1×10^{-5}. They were located in the northern Equipment Laydown Area and the Current HMSA (Figure 2-6).

It is apparent that cPAHs are a widespread COC in Landfill and Sandblast AOPC soils. As noted in the Uncertainty Assessment, the current risk estimates and RBCs assume that the oral bioavailability of cPAHs is 100% and the dermal absorption is 13%, based on current USEPA assumptions (USEPA 2015a). However, the actual oral bioavailability and dermal absorption of PAHs in soils are likely to be much lower (Magee et al. 1996, Turkall et al. 2014, Harris et al. 2013). Therefore, the risks are likely to be overestimated and the RBCs are likely to be overly stringent in this BHHRA. The point estimate of the oral-to-soil absorption adjustment factor (AAF) of 0.29 and the dermal absorption factor of 0.02 that have been suggested by Magee et al. (1996) have been incorporated into several approaches with regulatory approval. For example, Massachusetts Department of Environmental Protection uses these factors in developing numerical standards for soil under the Massachusetts Contingency Plan (MADEP 2015). The oral AAF of 0.29 has also been accepted by USEPA Region 5 in developing remedial goals for PAHs at a Superfund Site (AECOM 2009 for Solutia).

During the FS, if the human health-based RBCs for occupational and Hypothetical Fishing Platform User were modified by using the oral and dermal factors suggested above to develop alternative remedial action levels (RALs), it would result in RBCs approximately 3-fold higher that would still likely be protective of human health. Site-specific considerations for PAH bioavailability could also be explored if appropriate methods are available (ITRC 2015).

2.9 Conclusion and Recommendations

COCs are identified based on RME results exceeding the ODEQ cancer risk threshold of 1×10^{-6} cancer risk. Table 2-27 lists the RBCs and Reference Area UPLs (if available) for the COCs for the Landfill and Sandblast Area AOPCs that are recommended for further evaluation in the Upland OU FS.

Media evaluated for the Landfill AOPC and Sandblast Area AOPC included soil and groundwater. In addition, soil gas data were also evaluated at the Sandblast Area AOPC. Risk assessment findings were similar for both AOPCs. Exposure to shallow soil for the outdoor maintenance worker and to deeper soil for the construction worker showed RME and CTE cancer risks within the USEPA acceptable risk range of 1×10^{-6} to 1×10^{-4}. RME risks from exposure to deeper soils for construction workers were also within the USEPA acceptable risk range. RME risks related to trench worker exposure to groundwater were *de minimis* (less than 1×10^{-6}). At the Sandblast Area AOPC, RME and CTE risks related to soil gas were also *de minimis*.

At both the Landfill AOPC and the Sandblast Area AOPC, RME and CTE cancer risks exceeded the USEPA acceptable risk range for the Hypothetical Fishing Platform receptors from exposure to shallow soils under current conditions. Risks and noncancer hazards for nursing infants were generally close to or less than 1×10^{-6} for PCBs under current conditions.

At the Pistol Range and Bulb Slope AOPCs, which were evaluated only for the newly added Hypothetical Fishing Platform Users, lead concentrations were at acceptable levels under current conditions for exposure to soil and lagoon sediment at the Pistol Range and soil at the Bulb Slope.

At both the Landfill and Sandblast Area AOPCs, cPAHs were the primary COCs for occupational exposures in surface soil at the 0-3 ft bgs depth range. Benzo(a)pyrene (also a cPAH) was the only COC for deep soil at the 0-10 ft bgs depth range. Arsenic, PCBs, and DEHP (Sandblast Area AOPC only) were minor additional contributors to risk for Hypothetical Fishing Platform Users under current conditions.

3.0 BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents the findings of the BERA that was conducted for the Upland OU. The methodology followed for the BERA process is described in the Upland OU WP Update (URS 2014) and further details are provided in the RI/FS MP (URS 2007).

The purpose of this BERA is to further evaluate the CPECs identified for the four Upland OU AOPCs during the SLERA performed as part of the RI (URS 2012). The findings of this BERA will be used to identify CECs, receptors of concern, and pathways that should be retained for the Upland OU FS.

3.1 AOPCs, Media, and CPECs

All four AOPCs in the Upland OU were retained for evaluation in the BERA. Surface soil (0-1 ft bgs) and shallow soil (0-3 ft bgs) were identified as media of concern for terrestrial ecological receptors. The CPECs carried into the BERA include metals, total high-molecular-weight PAHs (HPAHs), tributyltin, organochlorine pesticides, VOCs, and SVOCs for the Landfill and Sandblast Area AOPCs (Tables 1-1 and 1-2), lead for the Pistol Range AOPC (Table 1-3), and lead and mercury for the Bulb Slope AOPC (Table 1-4). All of these CPECs were included in the Upland OU-wide evaluation in which wide-ranging receptors were assumed to forage in all four AOPCs combined (Table 1-5). Risk estimates were calculated for each CPEC for all receptors potential present at a given AOPC.

3.2 Receptors and Exposure Pathways

The following list of receptors and exposure pathways identified in the WP Update were included in the Upland BERA:

- Terrestrial plants and soil invertebrates exposed through direct contact with surface and shallow soil.
- Canada goose (*Branta canadensis*) exposed through incidental ingestion of surface and shallow soil, prey (100% plants), and water.
- American robin (*Turdus migratorius*) exposed through incidental ingestion of surface and shallow soil, prey (100% soil invertebrates), and water.
- American kestrel (*Falco sparverius*) exposed through incidental ingestion of surface and shallow soil, prey (100% small mammals), and water.
- Vagrant shrew (*Sorex vagrans*) exposed through incidental ingestion of surface and shallow soil, prey (100% soil invertebrates), and water.
- American mink exposed through incidental ingestion of surface soil, upland prey (15% small mammals), and water.

The assessment and measurement endpoints originally presented in the RI/FS MP (URS 2007), with the recent addition of the mink, are shown in Table 3-2 of the WP Update (Appendix C).

Based on the available data, surface soil is defined as 0 to 1 ft bgs for all AOPCs, except for the Pistol Range, for which surface soil is defined as 0 to 1.5 ft bgs based on the available depth interval data. Shallow soil is defined as 0 to 3 ft bgs, and this depth interval only applies to the Landfill and Sandblast Area AOPCs.

For the water ingestion pathway, highly mobile wildlife receptors (i.e., kestrel and mink) were assumed to ingest water from the river, while less mobile receptors (i.e., robin and shrew) and the Canada goose were assumed to ingest water that puddles in the Upland OU (via a simple equilibrium partitioning calculation). The soil to water equilibrium partitioning method was also used for the kestrel and mink for soil COIs lacking river surface water data. Ingestion of surface water from the river is a minor exposure pathway given the very low concentrations detected in surface water samples collected from the River OU during the RI (URS 2012) and because the water ingestion pathway typically provides a minor contribution to the overall dose for birds and mammals. Therefore, using RI surface water data from the River OU in the dose estimates for the kestrel and mink will not affect any risk management decisions in the FS for the Upland OU. This approach was used for purposes of dose calculation completeness and because measured data provide the most representative concentrations for this medium.

As described in detail in the WP Update, the mink is the identified receptor that could feasibly forage in the Upland OU as well as in the River OU. According to the studies reviewed during the development of the WP Update, it is likely that a mink would primarily be attracted to foraging resources in the River OU (e.g., crayfish and fish), but could sometimes supplement its aquatic prey diet with terrestrial prey from the Upland OU. For this reason, a dietary composition of 15% small mammals from the Upland OU was conservatively assumed as a first step in the evaluation for the mink, even though a lower proportion may actually be more realistic due to the presence of an immediately available permanent water source (i.e., the riverine habitat). The remaining 85% of the mink’s diet was assumed to be comprised of prey from the River OU (i.e., fish and crayfish), which was not evaluated in this Upland OU BERA (see separate River OU BERA report). An estimation of total risk for the mink that reflects the potential for adverse effects from exposure to both Upland and River OU media will be provided in the Upland FS or the River FS.

3.3 Exposure Assessment

The foodweb model for the Upland OU and the ecological CEMs for each AOPC are provided on Figures 3-1 through 3-5. These figures illustrate the most current understanding of potentially complete and significant ecological exposure pathways for the Upland OU, including those associated with transport to the River OU (not considered herein).

The SLERA conducted in the RI concluded that CPECs in Upland OU groundwater potentially discharging to the River OU did not pose a risk to aquatic receptors .Slope stability will be considered in the Upland OU FS as part of the evaluation of available remedial technologies. Therefore, Upland OU to River OU pathways are not included in this Upland OU BERA.

3.3.1 Exposure Factors

Tables 3-1 through 3-5 present the life history parameters for each terrestrial receptor evaluated in the Upland BERA that were input into the dose equation (see Section 3.3.3), which were presented in the approved Upland OU WP Update (URS 2014). For the animal receptors with small home ranges (i.e., shrew and robin), it is feasible for an individual to forage solely within one specific AOPC. Although the Canada goose has a potentially large home range, part of Bradford Island is managed as goose habitat, and therefore this receptor could spend most of its time on the Island. For the animal receptors with large home ranges (i.e., kestrel and mink), it was assumed that these receptors could forage at each individual AOPC (albeit unlikely) and within all four AOPCs combined. Receptor-specific area use factors were calculated as the AOPC (and/or combined AOPC) site size divided by the size of the home range.

The home range size of 1.85 kilometers for the mink that was originally developed in the RI/FS MP (URS 2007) for the River OU of Bradford Island is based on this receptor's inclination to forage along the riverbanks. The shape of mink home ranges depends on the type of habitat available. In riverine environments, home ranges are linear, whereas those in marsh habitats tend to be more circular (USEPA 1993). In addition, home ranges for adult males are generally larger than adult female home ranges, especially during the mating season. To be conservative, the smallest home range for an adult female in riverine habitat expressed as an area (7.8 hectare, or approximately 19 acres) was selected for use in the Upland BERA (USEPA 1993).

The study cited in USEPA (1993) from which this mink home range was derived (Mitchell 1961) is the same study presented in the document provided by Jeremy Buck of the USFWS during the Upland OU TAG meeting on April 14, 2014. The USFWS recommended that the information in this document be considered during the selection of a home range for the mink for the Upland OU BERA. The selected home range for the mink in the USFWS's document of 23 acres is slightly higher (less conservative) than the selected home range for this BERA. The home range for the mink of 19 acres was used to calculate AOPC-specific area use factors for the mink.

3.3.2 Exposure Point Concentrations

Soil. The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors in this BERA to provide more realistic, site-specific estimates of risk (Tables 1-1 through 1-5). There are no protected plant and invertebrate species in the Upland OU and the goal is estimating risk to these receptor groups at the community level (URS 2012).

Surface Water. For the water ingestion pathway, the kestrel and mink were assumed to ingest water from the river, and the robin, shrew, and Canada goose were assumed to ingest water that puddles in the Upland OU. The surface water EPCs for the kestrel and mink are the maximum detected concentration in river water of available data (Table 3-6). Otherwise, the surface water concentrations were derived based on surface soil concentrations and the simple equilibrium partitioning model, as described below.

For the robin, shrew, and goose, surface water concentrations were derived from the lower of the maximum detected concentration and 95% UCLs for surface soil through a simple equilibrium partitioning model (Tables 3-7a through 3-7e). Partitioning coefficients (K_d for inorganics and K_{oc} for organics) were applied to surface soil concentrations in the following equations. The fraction of organic carbon (foc) is a relevant parameter for the estimation of surface water concentrations of organic compounds and was assumed to be 1%:

Inorganics $$C_{surface\ water}\ (mg/L) = \frac{C_{soil}\ (mg/kg\ dry\ weight)}{K_d\ (L/kg)}$$

Organics $$C_{surface\ water}\ (mg/L) = \frac{C_{soil}\ (mg/kg\ dry\ weight)}{K_{oc}\ (L/kg) \times foc}$$

The K_d and K_{oc} values are presented in Tables 3-7a through 3-7e along with the estimated surface water concentrations. Dilution of porewater that enters surface water and mixes with shallower depths in the water column could result in lower EPCs for surface water; however, no dilution factors were applied to the estimated water (soil-porewater) concentrations.

3.3.3 Bioaccumulation Factors

A combination of regression-derived bioaccumulation factors (BAFs), median BAFs, and octanol-water partition coefficient ($logK_{ow}$)-based BAFs from the literature were used to predict tissue concentrations in the BERA. The regression-based approach is typically preferred because it provides a more site-specific prediction of a CPEC concentration in a certain dietary tissue type, as it incorporates the site soil EPCs.

Because most environmental data sets are log-normally distributed rather than normally distributed, a linear relationship between the soil and tissue concentrations is often revealed when a data set is transformed into lognormal values. Regression equations are usually presented in the following form:

$$\ln(y) = a + b \times \ln(x)$$

where,

y = chemical concentration in tissue (mg/kg dry weight)
x = chemical concentration in soil/sediment (mg/kg dry weight)
a = log-transformed y intercept
b = slope

In some instances, calculated regression equations do not reliably predict concentrations of chemicals that bioaccumulate (or bioconcentrate) in tissue. This type of unreliability can occur when the soil-tissue concentration relationship for a particular chemical is not linearized by log transformation, when the data set used to generate the regression equation is too limited, or when the chemical-specific lognormal $logK_{ow}$ is very high (e.g., steric hindrance) or very low (low persistence, readily metabolized) and does not fall within the $logK_{ow}$ range used in the model.

In the absence of empirically derived BAFs, equations to estimate BAFs for non-ionic organic compounds are typically based on the $logK_{ow}$ of the chemical and the organic carbon content of the soil. Caution is recommended when using this approach, as unrealistic BAFs can be generated for SVOCs and VOCs, e.g., phthalates that have high $logK_{ow}$ values.

The following hierarchy of sources was consulted for soil-to-plant, soil-to-soil invertebrate, and soil-to-small mammal BAFs:

- USEPA's Ecological Soil Screening Levels (Eco-SSLs) guidance document, Attachment 4-1 (2005a, last updated 2007).
- Oak Ridge National Laboratory (ORNL) publications (Sample et al. 1998a and 1998b, Bechtel-Jacobs 1998) and Risk Assessment Information System (RAIS) database.
- $LogK_{ow}$-based algorithms presented in Jager 1998 (soil invertebrate BAFs) and Travis and Arms 1988 (small mammal BAFs) converted to dry weight tissue concentrations (consistent with Eco-SSL and ORNL BAFs).
- USEPA's SLERA Protocol for Hazardous Waste Combustion Facilities, Peer Review Draft (1999); converted to dry weight tissue concentrations (consistent with Eco-SSL and ORNL BAFs).

Surrogate chemicals were used when appropriate for CPECs lacking BAFs in this hierarchy of sources. In addition, BAFs from the primary literature based on empirical data were used when available (i.e., Briggs et al. 1982 for di-n-butyl phthalate in plants).

Finally, a default BAF of 1.0 was applied for CPECs as a last resort, primarily for SVOCs and VOCs. This assumption is expected to overestimate the level of accumulation for CPECs lacking literature-based BAFs or reasonable surrogates.

The selected BAFs for each of the three dietary types are presented in Tables 3-8 through 3-10 by AOPC as follows:

- Tables 3-8a, b, c, and d for terrestrial plant BAFs for Landfill, Sandblast Area, Pistol Range, and Bulb Slope AOPCs, respectively.
- Tables 3-9a, b, c, and d for soil invertebrate BAFs for Landfill, Sandblast Area, Pistol Range, and Bulb Slope AOPCs, respectively.
- Tables 3-10a, b, c, d, and e for mammalian BAFs for Landfill AOPC, Sandblast Area AOPC, Pistol Range AOPC, Bulb Slope AOPC, and Combined-AOPCs, respectively.

3.3.4 Dose Estimation

For the birds and mammals, site-specific daily dose estimates were developed to estimate chemical intake from food resources, incidental soil ingestion, and water ingestion. The food chain transfer mechanisms via the ingestion pathway for each bird and mammal receptor group are summarized as follows:

- Soil → terrestrial plants → Canada goose
- Soil → soil invertebrates → American robin
- Soil → small mammals → American kestrel
- Soil → soil invertebrates → vagrant shrew
- Soil → small mammals → American mink

Site-specific daily dose estimates were calculated using the following general equation:

$$Dose_{total} = \frac{([IR_{food} \times C_{food}] + [IR_{soil} \times C_{soil}] + [IR_{water} \times C_{water}]) \times AUF}{BW}$$

where,

$Dose_{total}$	=	Estimated dose from ingestion (mg/kg BW per day dry weight [mg/kg-day])
IR_{food}	=	Ingestion rate of food (kg/day dry weight)
C_{food}	=	Concentration in dry weight of CPEC in food (mg/kg)
IR_{soil}	=	Ingestion rate of soil (kg/day)
C_{soil}	=	Concentration in dry weight of CPEC in soil (mg/kg)
IR_{water}	=	Ingestion rate of water (L/day)
C_{water}	=	Concentration of CPEC in surface water (mg/L)
AUF	=	Area use factor (unitless)
BW	=	Adult body weight (kg)

Exposure parameters for the bird and mammal receptors listed above were discussed in Section 3.3.1 and are presented in Tables 3-1 through 3-5. The methods used to estimate concentrations in food items are described in Section 3.3.3, and the resulting daily dose estimates for each receptor are presented in Tables 3-11a through 3-11e (Landfill), 3-12a through 3-12e (Sandblast Area), 3-13a through 3-13e (Pistol Range), 3-14a through 3-14e (Bulb Slope), and 3-15a and 3-15b for the kestrel and mink (Combined AOPCs).

3.4 Toxicity Values

Screening levels, or SLVs, are expressed as concentrations in media (i.e., mg of chemical/kg of soil). Although "screening levels" are typically associated with exposure via direct contact, and are commonly referred to as direct toxicity benchmarks, limited sources of generic media-based screening levels address both direct contact and dietary exposure for birds and mammals. In contrast, diet-based toxicity reference values (TRVs) protective of birds and mammals are expressed as a daily dose normalized to body weight (mg of chemical/kg of BW/day).

Both low SLVs/no observable adverse effect levels (NOAELs) and high SLVs/lowest observable adverse effect levels (LOAELs) were selected for each receptor group in order to develop a range of HQs for consideration by risk managers. An uncertainty factor of 5 was used to adjust chronic high SLVs/LOAELs to low SLVs/NOAELs and vice-versa, when necessary (ODEQ 2001). Additionally, in a few cases, chronic NOAEL and LOAEL TRVs were extrapolated from subchronic, acute, or lethal dose to 50% of test organisms (LD50) test results using uncertainty factors based on U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Technical Guide 254 - Standard Practice for Wildlife TRVs (USACHPPM 2000). The final selected SLVs and TRVs are described below.

3.4.1 Screening Levels for Terrestrial Plants and Soil Invertebrates

The following hierarchy of sources of terrestrial plant and soil invertebrate SLVs was consulted for the BERA:

- USEPA's Eco-SSLs (USEPA 2005-2008)

- ODEQ's Level II SLVs (ODEQ 2001)
- ORNL's RAIS database and ORNL guidance documents (Efroymson 1997a, 1997b)
- USEPA TRVs (USEPA 1999)

Lower-bound and upper-bound SLVs were selected for each receptor group and CPEC. The benchmarks are shortened to low and high SLVs in the text and tables. In the absence of SLVs from the hierarchy listed above, SLVs were drawn from other sources of the literature (Table 3-16). As shown in Table 3-16, the chromium SLVs for both plants and invertebrates were below the site-specific background UPL and, therefore, the chromium UPL was defaulted to as the SLV for these receptors.

3.4.2 Toxicity Reference Values for Birds and Mammals

The following hierarchy of sources of TRVs for birds and mammals were consulted for the BERA:

- USEPA's Eco-SSLs (USEPA 2005-2008)
- Final Portland Harbor RI/FS (Lower Willamette Group 2013)
- ORNL guidance (Sample et al. 1996)

Both low (NOAEL-based) and high (LOAEL-based) TRVs were selected for each receptor group and CPEC. In the absence of SLVs from the hierarchy listed above, TRVs were drawn from other sources of the literature (Table 3-17). As shown in Table 3-17, chemical surrogates were used when appropriate in the absence of CPEC-specific TRVs.

3.5 Risk Characterization

Risk characterization is the process of integrating the previous elements of the RA into quantitative or semi-quantitative estimates of risk. Risk characterization consists of risk estimation and uncertainty assessment. Risk estimation or the quantification of risk is then used as an integral component in remedial decision making and selection of potential remedies or actions. Uncertainty assessment describes the level of confidence in the risk estimation.

The two types of SLVs/TRVs listed in Section 3.4 were incorporated into the analysis: one based on a low SLV/NOAEL and a second based on an observed adverse effect in a test species (high SLV/LOAEL). For HQs based on the low SLV and NOAEL TRV that are less than 1, adverse effects are unlikely because of the inherent conservatism (protectiveness) built into the exposure and effects assessments. HQs based on the high SLV and LOAEL TRV (upper-bound risk estimates) that are greater than 1 indicate that exposure exceeds a known effect concentration for a test organism. In this case, potential risk management measures in the FS may be warranted for these receptors and exposure pathways.

For estimated exposures that exceeded the low SLV/NOAEL TRV (i.e., the low SLV/NOAEL TRV-based HQ is >1.0) but were less than the high SLV/LOAEL TRV (i.e., the high SLV/ LOAEL TRV-based HQ is <1.0), the associated complete exposure pathways were considered in greater detail to develop conclusions about the likelihood that a risk or hazard is present. For non-listed (common) terrestrial species known to be present on Bradford Island, more emphasis was placed on CPECs that have high SLV/LOAEL TRV-based HQs above 1. However, the range of HQs developed for each receptor and CPEC was presented in the risk characterization.

It is most appropriate to calculate HIs (i.e., a summation of HQs) for CPEC groups when multiple chemicals demonstrate similar modes of toxicity or affect the same target organ. The implications of HQs greater than or less than 1.0 discussed above were also applied to HIs. Due to a lack of data regarding additive effects associated with exposure to multiple chemicals for nonhuman receptors, professional judgment was used in the development of HIs. For the BERA, HIs were calculated based on the following chemical groupings (as cited in the RI/FS MP, URS 2007): inorganics (including butyltins), organochlorine pesticides, phthalates, HPAHs (evaluated as total HPAHs), and VOCs.

3.5.1 Summary of Hazard Quotients and Hazard Indices

This section summarizes the HQs and HIs for each AOPC and receptor and the combined AOPCs for the kestrel and mink. HIs were not calculated for the Pistol Range because only one CPEC (lead) was identified for this AOPC. The significance of CPECs with HQs greater 1.0 based on the low SLV/NOAEL or high SLV/LOAEL are discussed in the risk interpretation section relative to their potential to elicit adverse effects in the receptor populations for each AOPCs.

3.5.1.1 Landfill AOPC

Terrestrial Plants (Table 3-18a). In surface soil (0-1 ft bgs), chromium, mercury, chlordane (technical mixture and metabolites; hereafter simply referred to as “chlordane”), and Total HPAHs have HQs greater than 1.0 based on the low SLVs and high SLVs. In addition to these CPECs, copper, lead, and nickel also have HQs greater than 1.0 based on the low SLVs.

The same seven CPECs listed above for surface soil have low SLV-based HQs greater than one for shallow soil (0-3 ft bgs). Chromium, nickel, chlordane, and Total HPAHs have high SLV-based HQs greater than 1.0 for shallow soil.

For surface soil, the low SLV- and high SLV-based HIs for metals are 24 and 12, respectively. For shallow soil, the low SLV- and high SLV-based HIs for metals are 46 and 26, respectively. For pesticides for both surface and shallow soil, the low SLV- and high SLV-based HIs are 7.0 and 1.4.

Soil Invertebrates (Table 3-19a). In surface soil (0-1 ft bgs), chromium, mercury, and Total HPAHs have HQs greater than 1.0 based on the low SLVs and high SLVs. In addition to these CPECs, copper also has an HQ greater than 1.0 based on the low SLV.

The same four CPECs listed above for surface soil have low SLV-based HQs greater than 1.0 for shallow soil (0-3 ft bgs), with the addition of nickel. Chromium, mercury, and Total HPAHs have high SLV-based HQs greater than 1.0 for shallow soil.

For surface soil, the low SLV- and high SLV-based HIs for metals are 27 and 12, respectively. For shallow soil, the low SLV- and high SLV-based HIs for metals are 40 and 25, respectively. No soil invertebrate SLVs are available for the pesticides; therefore, these CPECs are addressed qualitatively in the uncertainty assessment.

Canada Goose (Table 3-11a). All LOAEL-based HQs are less than 1.0 for the goose. In surface soil, lead and mercury have HQs greater than 1.0 based on the NOAELs. In addition to these CPECs, chromium also has an NOAEL-based HQ greater than 1.0 for shallow soils.

For surface soil, the NOAEL- and LOAEL-based HIs for metals (including tributyltin) are 12 and 1.8, respectively. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 13 and 2.2, respectively. The remaining HIs are less than 1.0.

American Robin (Table 3-11b). In surface and shallow soil, chromium, copper, lead, mercury, nickel, and chlordane have HQs greater than 1.0 based on the NOAELs and LOAELs. In addition to these CPECs, DEHP also has an HQ greater than 1.0 based on the NOAEL in both surface and shallow soil.

For surface soil, the NOAEL- and LOAEL-based HIs for metals are 100 and 17, respectively. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 120 and 23, respectively. The NOAEL- based HIs for phthalates in surface and shallow soils are 2.0 and 1.4, respectively. The LOAEL-based HIs for phthalates are less than 1.0. The NOAEL- and LOAEL-based HIs for pesticides for both surface and shallow soils are 6.0 and 1.2, respectively.

American Kestrel (Table 3-11c). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the kestrel.

Vagrant Shrew (Table 3-11d). In surface soil, chromium, copper, lead, mercury, nickel, chlordane, and Total HPAHs have HQs greater than 1.0 based on the NOAELs and LOAELs. In addition to these CPECs, antimony also has an HQ greater than 1.0 based on the NOAEL.

The same CPECs listed above for surface soil also have HQs greater than 1.0 for shallow soil.

For surface soil, the NOAEL- and LOAEL-based HIs for metals are 69 and 25, respectively. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 120 and 47, respectively. All HIs for phthalates are less than 1.0. The NOAEL- and LOAEL-based HIs for pesticides for both surface and shallow soils are 3.2 and 1.6, respectively.

American Mink (Table 3-11e). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the mink.

3.5.1.2 Sandblast Area AOPC

Terrestrial Plants (Table 3-18b). In surface soil (0-1 ft bgs), chromium, nickel, and Total HPAHs have HQs greater than 1.0 based on the low SLVs and high SLVs. In addition to these CPECs, lead, and gamma-benzene hexachloride (BHC; lindane) also have HQs greater than 1.0 based on the low SLVs.

The same six CPECs listed above for surface soil have low SLV-based HQs greater than one for shallow soil (0-3 ft bgs), with the exception of gamma-BHC for which the HQ is less than 1.0. Chromium, nickel, and Total HPAHs have high SLV-based HQs greater than 1.0 for shallow soil.

Soil Invertebrates (Table 3-19b). In surface soil, chromium has HQs greater than 1.0 based on the low SLVs and high SLVs. In addition to chromium, mercury, nickel, and Total HPAHs also have HQs greater than 1.0 based on the low SLV.

In shallow soil, chromium has HQs greater than 1.0 based on the low SLVs and high SLVs, and the low SLV-based HQ for Total HPAHs is also greater than 1.0.

For surface soil, the low SLV- and high SLV-based HIs for metals are 29 and 26, respectively. For shallow soil, the low SLV- and high SLV-based HIs for metals are 23 and 21, respectively. No soil invertebrate SLVs are available for the pesticides; therefore, these CPECs are addressed qualitatively in the uncertainty assessment.

Canada Goose (Table 3-12a). All LOAEL-based HQs are less than 1.0 for the goose. In surface and shallow soil, chromium and lead have HQs greater than 1.0 based on the NOAELs.

For surface soil, the NOAEL- and LOAEL-based HIs for metals (including tributyltin) are 4.2 and 1.2, respectively. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 3.9 and 1.2, respectively.

American Robin (Table 3-12b). In surface soil, chromium, lead, nickel, and DEHP have HQs greater than 1.0 based on the NOAELs and LOAELs. In addition to these CPECs, cadmium, mercury, and endrin aldehyde also have HQs greater than 1.0 based on the NOAEL.

The same CPECs listed above for surface soil also have HQs greater than 1.0 for shallow soil.

For surface soil, the NOAEL- and LOAEL-based HIs for metals are 52 and 15, respectively, and the NOAEL-based HI for pesticides is 3.6. The LOAEL-based HI for pesticides is less than 1.0. In addition, the NOAEL- and LOAEL-based HIs for phthalates in surface soil are 16 and 1.6, respectively. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 46 and 14, respectively, and the NOAEL-based HI for pesticides is 3.1. The LOAEL-based HI for pesticides is less than 1.0. In addition, the NOAEL- and LOAEL-based HIs for phthalates in shallow soil are 13 and 1.3, respectively.

American Kestrel (Table 3-12c). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the kestrel.

Vagrant Shrew (Table 3-12d). In surface soil, antimony, chromium, lead, nickel, and Total HPAHs have HQs greater than 1.0 based on the NOAELs and LOAELs. In addition to these CPECs, cadmium, mercury, and DEHP also have HQs greater than 1.0 based on the NOAEL.

The same CPECs listed above for surface soil also have NOAEL-based HQs greater than 1.0 for shallow soil, with the exception of DEHP for which the NOAEL-based HQ is less than 1.0. Chromium, lead, nickel, and Total HPAHs in shallow soil also have LOAEL-based HQs greater than 1.0

For surface soil, the NOAEL- and LOAEL-based HIs for metals are 89 and 32, respectively. In addition, the NOAEL-based HI for phthalates is 1.1 for surface soil, but the LOAEL-based HI for phthalates is less than 1.0. For shallow soil, the NOAEL- and LOAEL-based HIs for metals are 70 and 25, respectively. All remaining HIs are less than 1.0.

American Mink (Table 3-12e). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the mink.

3.5.1.3 Pistol Range AOPC

Terrestrial Plants (Table 3-18c). Lead has a HQ of 3.0 based on the low SLV, and the high SLV-based HQ is less than 1.0.

Soil Invertebrates (Table 3-19c). The low SLV- and high SLV-based HQs for lead are less than 1.0 for soil invertebrates.

Canada Goose (Table 3-13a). Lead has a HQ of 1.2 based on the NOAEL, and the LOAEL-based HQ is less than 1.0.

American Robin (Table 3-13b). Lead has HQs of 9.2 and 4.6 based on the NOAEL and LOAEL, respectively.

American Kestrel (Table 3-13c). The NOAEL- and LOAEL-based HQs for lead are less than 1.0 for the kestrel.

Vagrant Shrew (Table 3-13d). Lead has HQs of 4.5 and 2.4 based on the NOAEL and LOAEL, respectively.

American Mink (Table 3-13e). The NOAEL- and LOAEL-based HQs for lead are less than 1.0 for the mink.

3.5.1.4 Bulb Slope AOPC

Terrestrial Plants (Table 3-18d). All high SLV-based HQs and the HI are less than 1.0 for the terrestrial plants. Lead and mercury have HQs of 2.6 and 2.4, respectively, based on the low SLVs. The low SLV-based HI is 5.0.

Soil Invertebrates (Table 3-19d). Mercury has HQs of 7.2 and 1.4 based on the low SLV and high SLV, respectively. The low SLV- and high SLV-based HIs are 7.2 and 1.4, respectively.

Canada Goose (Table 3-14a). All LOAEL-based HQs and the HI are less than 1.0 for the goose. Lead and mercury have HQs of 1.0 and 4.3, respectively, based on the NOAELs. The NOAEL-based HI is 5.3.

American Robin (Table 3-14b). All LOAEL-based HQs are less than 1.0 for the robin. Lead and mercury have HQs of 1.7 and 4.8, respectively, based on the NOAELs. The NOAEL- and LOAEL-based HIs are 6.5 and 1.3, respectively.

American Kestrel (Table 3-14c). All NOAEL- and LOAEL-based HQs and the HI are less than 1.0 for the kestrel.

Vagrant Shrew (Table 3-14d). All LOAEL-based HQs are less than 1.0 for the shrew. Mercury has a HQ of 2.6 based on the NOAEL. The NOAEL- and LOAEL-based HIs are 3.4 and 1.2, respectively.

American Mink (Table 3-14e). All NOAEL- and LOAEL-based HQs and the HI are less than 1.0 for the mink.

3.5.1.5 All Four AOPCs Combined

American Kestrel (Table 3-15a). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the kestrel.

American Mink (Table 3-15b). All NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the mink.

3.5.2 Uncertainty Assessment

Uncertainties are inherent in any risk-based approach to evaluation and decision making for potentially contaminated sites. The uncertainties may be general and systemic as well as specific to the site. The objective of the uncertainty assessment is to identify the sources of uncertainty in the RA process, understand their potential to contribute to either underestimation or overestimation of risk for the selected receptors and pathways and describe how the uncertainty is addressed. By describing the nature and magnitude of the uncertainties, the findings and conclusions of the RA can be better understood and used as a tool for decision making.

Some uncertainties are common to both the SLERA and the BERA. Those uncertainties inherent to both were previously described in Appendix O of the Final RI (URS 2012). These included:

- Data Adequacy and Data Quality (O.1.1.1)
- Exposure Point Concentrations (O.1.1.3)
- Selection and Use of SLVs (O.1.1.4 and O.3.1.6)
- Data Sensitivity (O.3.1.1)
- Calculation of Total HPAHs (O.3.1.4)
- Bioavailability, Absorption, and Metabolism of CPECs (O.3.1.8)

The following sections discuss uncertainties that apply specifically to the BERA.

3.5.2.1 Exposure Depth

The BERA assumed all receptors were exposed to surface soil (0-1 ft bgs), except for the Pistol Range where surface soil was defined as 0 to 1.5 ft. Shallow soil (0-3 ft bgs) exposure was also considered for the Landfill and Sandblast Areas. However, the most biologically active zone is represented by surface soil (e.g., bulk root zone for annual plants ingested by trophic receptors and depth at which earthworms are most active and preyed upon); therefore, risk estimates based on surface soil are likely to more realistically represent actual risk exposure potential for wildlife, with the exception of the burrowing shrew.

3.5.2.2 Selection of Toxicity Data

The studies upon which terrestrial plant SLVs were derived typically use crops as the test species, and sensitivity levels of undomesticated plant species are likely to be different from crops species. Measured endpoints for the phytotoxicity SLVs generally consist of growth or yield (biomass). Growth and yield are ecologically significant responses because they directly impact plant populations and the ability of the vegetation to support higher trophic levels. These phytotoxicity SLVs are conservative, and if a constituent is present in soil at a concentration greater than the SLV, yet there is a vegetative community present, then that chemical may not necessarily be phytotoxic to the plant species at the AOPCs. Furthermore, the types of plants found at the four AOPCs (ruderal vegetation and some remaining ornamental plants) are not considered sensitive species. Based on these considerations, the conservative SLVs used to assess risk to plants are likely to overestimate risk to the plant community.

Preferred wildlife TRVs were chronic NOAEL and/or LOAEL TRVs from the established hierarchy. If only a NOAEL or LOAEL TRV was provided from the preferred source, then, as recommended in ODEQ’s comments on the Level II Screening Assessment for the Landfill (ODEQ 2004), TRVs for CPECs that lack a NOAEL or LOAEL were generated by either multiplying or dividing the available TRV by a factor of five, depending on the desired TRV. TRVs extrapolated from these sources represent generally conservative values drawn from a review of the toxicological literature. For some CPECs, additional sources were consulted in order to obtain TRVs not provided for in the established hierarchy, and in some of these cases, uncertainty factors were used to calculate the final NOAEL and LOAEL TRVs for extrapolation of subchronic, acute, or LD50 test result to a chronic duration test result. The uncertainty factors used to adjust to chronic duration were based on USACHPPM Technical Guide 254 - Standard Practice for Wildlife TRVs (USACHPPM 2000). Although the use of these factors is standard practice in RAs, it is a source of uncertainty because linear adjustments to risk are unlikely for all CPECs and actual risk may be over- or under-predicted.

TRVs for avian and mammalian species were selected to assess risk to the selected representative receptors. However, these TRVs were not species-specific to the selected representative receptors, and species respond differently to exposures to toxicants. Responses to CPEC exposure by selected indicator species may be different from species for which toxicity data were reported. Direction and magnitude of this uncertainty are not measurable, although the choice of conservative TRVs was conducted in an attempt to skew the evaluation toward more protective conclusions.

3.5.2.3 Lack of Toxicity Data

Toxicity data were not available for a limited number of CEPCs. Those constituents for which toxicity data (SLVs) were not available for plants, soil invertebrates, or both are summarized below and identified in Table 3-16:

- Tributyltin
- Pesticides (limited to endosulfans and methoxyclor for plants and all 13 pesticides for soil invertebrates)
- SVOCs (limited to four SVOCs for plants, and all six SVOCs for soil invertebrates)
- Three VOCs

Those constituents for which toxicity data were not available for birds are summarized below and identified in Table 3-17:

- HPAHs
- Four SVOCs,
- Two VOCs

Unavailable toxicity data could cause underestimation of risk for those CPECs where surrogate toxicity data are not assigned. However, the presence of ruderal and ornamental plants in these AOPCs suggests that direct toxicity is not occurring in the plant species typically found in disturbed habitats.

The persistence of the pesticides in soil will be affected by microbial degradation and chemical degradation and are likely to decrease over time. Pesticide resistance by invertebrates is a well-established phenomenon, whereby individuals with higher resistance are the ones that have offspring and pass the resistance on to their offspring (Bellinger 1996). Due to this, it is unlikely that the residual pesticides detected in soil are highly toxic to the soil invertebrates present in the soil. Additionally, since the avian TRVs are very conservative (i.e., based on effects to eggs for receptors with known sensitivity), any future activities to address the risk to birds for chlordane will address the locations with the highest pesticide concentrations and thereby decrease the risk to soil invertebrate communities.

Although several SVOCs and VOCs lack plant/invertebrate and bird toxicity data, these CPECs volatilize, and the concentration of these CPECs in soil is expected to continue to decrease over time (it is likely the concentrations currently present are lower than the concentrations used in the BERA due to the age [collected in 2008] of the data). The assumption that these SVOCs and VOCs bioaccumulate in wildlife is based on the $\log K_{ow}$s, which are predicted values based on a model (not empirically derived) and many of which are only marginally above 3.5 (see J-6 in the Final RI, URS 2012). Whereas, the empirically modeled BAFs for these SVOCs and VOCs from plants are actually low (<0.5, see Table 3-8b). Since several SVOCs and VOCs with established toxicity were evaluated, continued volatilization, and considering the questionable bioaccumulation of these CPECs, the lack of toxicity data is unlikely to significantly impact the BERA findings or impact any risk management decisions in the Upland OU FS.

In the absence of reliable HPAH toxicity data for birds, the potential hazards to birds exposed to PAHs were addressed qualitatively in Section O.3.1.6 in the Final RI (URS 2012), and it was concluded that the lack of PAH TRVs for birds would not significantly impact the RA findings.

3.5.2.4 Selection of Mink as Terrestrial Large Mammal

According to Section 3.5 of the Level I Scoping Assessment that was performed for the Landfill (URS 2002), which included a thorough biological characterization of the Landfill and all habitats on the island, "large mammalian predators do not occur on the island." The only mammals on the island that are mentioned in the Scoping Assessment are small mammals (rodents) and feral cats: "Although the island harbors small mammals, feral cats, Canadian geese, and other bird species, the minimal amount of available habitat (~12 acres) makes it unsuitable for supporting viable populations of wildlife species with larger home ranges."

For this reason, large mammals were not included in the assessment endpoints described in the approved RI MP (URS 2007). However, as discussed in Section 3.2 and described in detail in the WP Update, mink were evaluated at the request of ODEQ to include a large terrestrial mammal (see Appendix P of Final RI [URS 2012]) and because mink are present in the area, are sensitive to environmental contaminants, and could feasibly access the island and forage there, exposure by this species through consumption of rodents was included in the BERA.

A dietary composition of 15% small mammals from the Upland OU was assumed in the BERA; however, this is a conservative estimate because small mammals are likely to comprise a lower proportion of the mink's actual diet based on the presence of an immediately available permanent water source (i.e., riverine habitat) and according to the studies reviewed during the development of the WP Update (i.e., it is likely that a mink would primarily be attracted to foraging resources, e.g., crayfish and fish) in the River OU.

3.5.2.5 Use of Input Exposure Parameters

A detailed explanation of the selection of the input exposure parameters selected for the BERA can be found in the RI MP (URS 2007) and the Upland OU Update to RA WP Technical Memorandum (URS 2014). Resources used to determine input exposure parameter values included USEPA's Wildlife Exposure Factors Handbook (USEPA 1993), Food Requirements of Wild Animals: Predictive Equations for Free-living Mammals, Reptiles, and Birds (Nagy 2001), Estimates of Soil Ingestion by Wildlife (Beyer et al. 1994), California Wildlife Biology, Exposure Factor, and Toxicity Database (Cal/ECOTOX, 2002), and California's Wildlife: Volume II, Mammals (Zeiner et al. 1990).

There can be variability in input rates among individuals within a species, between species, between soil types, and with the type and quantity of food items available. The direction and magnitude of the uncertainty associated with these variables is not measurable. For most receptors, a lower-end average body weight was paired with an upper-end average ingestion rate, resulting in exposure equations. These assumptions may overestimate or underestimate actual "real world" intake since lower-end body weights would be protective of small adult receptors, but may underestimate risk for young individuals and overestimate risk for larger adult individuals.

3.5.2.6 Dietary Item Assumptions

For the BERA, the terrestrial receptors that typically consume more than one type of food item (i.e., the American robin and the American kestrel) were conservatively assumed to consume only the food item that comprises the majority of their diet. However, this assumption of exclusive intake of a single prey item to estimate risk to a category of receptor (e.g., invertebrate birds) may over- or underestimate risk in those species that consume more than one type of dietary item.

3.5.2.7 Landfill Heterogeneity

For approximately 40 years (early 1940s until the early 1980s), the USACE managed, stored and disposed of waste materials at the landfill in excavated pits or existing depressions. By 1982, the surface of the Landfill AOPC had been capped with soil cover. In 1989, approximately 8-inches of additional soil cover was placed on the Landfill site by the USACE (Hibbs, personnel comm. 2001). Because the waste was buried in separate pits, rather than one continuous pit, the heterogeneity of the landfill composition makes contamination characterize difficult. Although sampling targeted areas known (via historical aerial review or previously exposed areas) or suspected (via electrical resistivity data and seismic refraction data) as having the greatest landfilling activity, risk may be underestimated due to the heterogeneous nature of the landfill.

3.5.3 Calculation of Site-Specific Risk-Based Concentrations

To aid in risk interpretation, site-specific RBCs were derived for each AOPC and wildlife receptor for the CECs with HQs greater than 1.0 based on LOAEL TRVs. All LOAEL-based HQs were less than 1.0 for the kestrel and mink; therefore, RBCs were only calculated for the robin and shrew. By selecting the most sensitive receptors to derive the RBCs, it is likely that the other receptor groups would also be protected. The following equation was used to calculate the RBCs for the robin and shrew:

$$\text{Site-Specific RBC} = \frac{TRV \times BW}{\left[\left(IR_{food} \times BAF\right) + IR_{\text{soil}}\right]}$$

where,

RBC = Site-specific risk-based concentration for soil (mg chemical per kg soil dry weight)

TRV	=	LOAEL-based TRV (mg chemical ingested per kg BW per day)
BW	=	Body weight (kg)
IR_{food}	=	Ingestion rate of food, as represented by soil invertebrate tissue (kg dry weight food per day)
BAF	=	Soil to terrestrial invertebrate bioaccumulation factor (kg soil per kg tissue)
IR_{soil}	=	Ingestion rate of soil (kg dry weight soil per day)

The exposure factors for the robin and shrew used in this equation are presented in Tables 3-2 and 3-4, respectively, and the LOAEL TRVs are presented in Table 3-17. Due to the low contribution of water ingestion to the overall dose for these receptors (less than 5%, but varies by CPEC), this pathway was not included in the RBC calculations. The final site-specific RBCs for each receptor are presented in Table 3-20. Additionally, Table 3-20 presents the high SLVs for plants and/or soil invertebrates per AOPC for the CECs with high-SLV based HQs greater than 1.0. In cases where LOAEL RBCs/high SLVs for metals are below the site-specific background UPLs (e.g., chromium and nickel), the UPL was selected as the default RBC.

3.5.4 Risk Interpretation

In this final phase of the risk characterization process, the quantitative and qualitative components of the BERA are evaluated to characterize the potential for ecological risk. The actual risk drivers at each AOPC and the extent of impacts for these CECs are identified to develop supportable recommendations for risk managers to review. The outcome of the risk characterization will constitute the basis of remedial decisions for the protection of ecological receptors and risk-driving receptors and exposure pathways.

For each AOPC, the CECs with exceedances of the lowest RBC (based on the high SLV/LOAEL TRVs) for any receptor group are plotted in Figures 3-6 through 3-9. The locations with exceedances of the lowest site-specific RBC for each CEC from Table 3-20 are identified with a data posting box that provides the concentrations of the CECs that exceed the RBCs at that particular location. For chromium at the Landfill and Sandblast Areas, the lowest RBC between the robin and shrew was selected for purposes of the mapping exercise because these two receptors drove risk for all other CECs, and the chromium SLVs for plants and invertebrates are below background; the background UPL was the default SLV for these two receptor groups. Sample locations without a data posting box indicate that CEC concentrations are below the RBCs at that particular location.

The spatial distribution of CEC concentrations relative to the RBCs was assessed through a review of this information on figures and the findings are described in the following subsections.

3.5.4.1 Landfill AOPC

The CECs identified for additional evaluation at the Landfill due to the potential for adverse effects to populations of invertivorous birds or mammals, represented by the robin and shrew, or community-level impacts to plants and invertebrates include the following: chromium, copper, lead, mercury, nickel, chlordane, and Total HPAHs. Figure 3-6 illustrates the locations with exceedances of the lowest site-specific RBC for each CEC and locations of the five subareas: Gully Test Pit, Lead Hotspot Test Pits #1 and #2, the Mercury Vapor Lamp Test Pit, and the Pesticide/Herbicide Wash Area.

Maximum concentrations of chromium, lead, and nickel were detected below 1 ft bgs inside northern boundary of the Gully Test Pit (BIL18), while the maximum concentrations of copper, mercury, most Total HPAHs, and chlordane were detected at the surface. Elevated detections of Total HPAHs also occur below the surface, as the mean and median Total HPAH concentrations are associated with the deeper depth interval (Table 1-1). The maximum concentration of Total HPAHs was detected within Lead Hot Spot Test Pit #1 (BIL04SSI).

The maximum concentration of chlordane, and the only detection above the RBC, was also detected within the northern boundary of the Gully Test Pit (BIL17). No pesticides were retained in the pesticide washing area (i.e., chlordane concentrations < LOAEL-based RBCs). The maximum concentration of mercury was detected in the center of Lead Hot Spot Test Pit #2 (BIL06SSI), and the maximum concentration of copper was detected outside of the eastern boundary of Lead Hot Spot Test Pit #1 (BIL05SSI).

In addition to the maximum detection, concentrations of chromium are elevated above the RBC in two more locations along northern boundary of the Gully Test Pit, and at one more location outside of the eastern boundary of Lead Hot Spot Test Pit #1. Lead concentrations are elevated at 21 locations in addition to the maximum detection. These samples are distributed evenly across the Landfill, with much higher concentrations present along northern boundary of the Gully Test Pit, within Lead Hot Spot Test Pit #1, and at one location northeast of the Pesticide/Herbicide Wash Area.

Concentrations of Total HPAHs are elevated at 16 locations in addition to the maximum detection. Similarly to lead, these samples are distributed evenly across the Landfill, with much higher concentrations within and around the Gully Test Pit and in a sample collected from the Mercury Vapor-Lamp Test Pit.

The Reference Area UPL is the default RBC for nickel (Table 3-20), and seven locations have concentrations above this RBC in addition to the maximum detection of nickel. Like most of the other CECs, the highest concentrations of nickel were detected along the northern boundary of the Gully Test Pit and within Lead Hot Spot Test Pit #1. Concentrations of copper were elevated above the RBC at three locations in addition to the maximum detection. One of these samples was collected from the Gully Test Pit, another from the Mercury Vapor-Lamp Test Pit (co-located with the maximum mercury detection), and the third just west of the Lead Hot Spot Test Pit #1.

Concentrations of mercury are elevated at seven locations in addition to the maximum detection. Unlike the other CECs discussed above, mercury concentrations are most elevated in the western portion of the Landfill where seven of the eight elevated locations are located within and just west of the Mercury Vapor-Lamp Test Pit. The remaining single elevated sample location is northeast of the Pesticide/Herbicide Wash Area.

In summary, the northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, is the most impacted area of this AOPC with co-occurrences of most CECs. In addition, the most impacted area of the Landfill for mercury is the Mercury Vapor-Lamp Test Pit and one isolated spot northeast of the Pesticide/Herbicide Wash Area. These areas of the Landfill should be further evaluated in the Upland OU FS.

3.5.4.2 Sandblast Area AOPC

The CECs identified for additional evaluation at the Sandblast Area due to the potential for adverse effects to populations of invertivorous birds or mammals, represented by the robin and shrew, or community-level impacts to plants and invertebrates include the following: antimony, chromium, lead, nickel, DEHP, and total HPAHs. Figure 3-7 illustrates the locations with exceedances of the lowest site-specific RBC for each CEC and the locations of the subareas: Equipment Laydown, Sandblast Grit Disposal Area, Current and Former HMSA, Catch Basins #1 through #4, and the Erodible Unit Sampling Area.

Maximum concentrations of most Total HPAHs were detected below 1 ft bgs, while the maximum concentrations of the remaining CECs were detected at the surface. Elevated detections of some Total HPAHs also occur at the surface. The maximum concentration of Total HPAHs was detected below the surface in a sample collected adjacent to the southwestern corner of the Current HMSA (SBB18) and within the approximate boundary of the Spent Sandblast Grit Disposal Area.

Concentrations of Total HPAHs are elevated at 11 locations in addition to the maximum detection. Most of these samples are located in the northeastern corner of the Sandblast Area within the Equipment Laydown Area, near the Former and Current HMSAs, and in a composite sample collected from the Erodible Unit Sampling Area.

The maximum concentrations of antimony and nickel were also detected within the Spent Sandblast Grit Disposal Area: antimony in a sample adjacent to the southeast corner of the Sandblast Building (SBB12) and nickel in a sample south of the Equipment Laydown Area (SBB23). The maximum concentration of chromium was detected on the northwestern boundary of the Spent Sandblast Grit Disposal Area (HA6), and the maximum concentration of lead was detected within the Equipment Laydown Area near the northern boundary of the Sandblast Area AOPC (HA3). The maximum concentration of DEHP, and the only detection above the RBC, was detected in a composite sample collected from the Erodible Unit Sampling Area (SB-EUB).

In addition to the maximum detection, concentrations of antimony are elevated above the RBC at two more locations (one near the Former and one near the Current HMSA), and at one more location northeast of the Sandblast Building. Chromium concentrations are elevated at 21 locations in addition to the maximum detection, with the highest concentrations present within the Spent Sandblast Grit Disposal Area, and in localized areas of the Erodible Unit Sampling Area, Catch Basin #1, and Former HMSA.

Lead and nickel concentrations are elevated in 51 sample locations and 36 sample locations, respectively, in addition to the maximum detections. These samples are distributed fairly evenly across the Sandblast Area, with much higher concentrations present within the Spent Sandblast Grit Disposal Area, around Catch Basin #1, within the Equipment Laydown Area, and in one sample from the Former HMSA. More elevated lead detections are prevalent within the Equipment Laydown Area than elevated nickel detections. The Reference Area UPL is the default RBC for nickel (Table 3-20).

In summary, most co-occurring exceedances of the RBCs occur within the Spent Sandblast Grit Disposal Area, which basically encompasses the Current HMSA, the northern boundary of the Former HMSA, and around Catch Basin #1. In addition, concentrations of chromium and nickel greater than background, lead, and HPAHs are elevated within the Equipment Laydown Area.

These areas of the Sandblast Area should be further evaluated in the Upland OU FS. Soil removal in these areas would likely reduce concentrations of the CECs identified and result in an AOPC-wide average concentration below the lowest site-specific RBCs.

For DEHP, the LOAEL-based HQs for all receptors, with the exception of the robin, are below 1.0, and the LOAEL-based HQs for the robin are low (1.6 for 0-1 ft bgs and 1.3 for 0-3 ft bgs). In addition, only one sample exceeds the RBC for the robin. For these reasons, no further evaluation is recommended for DEHP, with the exception of the potential erodibility issue that will be considered in the Upland FS or River FS.

3.5.4.3 Pistol Range AOPC

Lead was identified for additional evaluation at the Pistol Range due to the potential for adverse effects to populations of invertivorous birds or mammals, represented by the robin and shrew. Figure 3-8 illustrates the locations with exceedances of the lowest RBC for lead.

The highest concentrations of lead, including the maximum concentration that was detected below the surface (PFR50), were detected at and behind the approximate location of the backstop. Twenty additional locations have concentrations above the RBC in addition to the location with the maximum detection. In addition to the area surrounding the backstop, these locations also occur north and east of the approximate location of the Former Firing Shed. These areas of the Pistol Range should be further evaluated in the Upland OU FS. Limited soil removal in these areas would likely reduce concentrations of the CECs identified and result in an AOPC-wide average concentration below the lowest site-specific RBC.

3.5.4.4 Bulb Slope AOPC

Mercury was identified for additional evaluation at the Bulb Slope due to the potential for community-level impacts to soil invertebrates. Figure 3-9 illustrates the locations with exceedances of the mercury RBC for invertebrates.

The maximum concentration of mercury was detected in a sample collected from Pile #3, Bank #4, which is located near the southwestern boundary of the Bulb Slope, i.e., upgradient and away from the boundary closest to the Columbia River. The remaining two samples with exceedances of the RBC for soil invertebrates were also collected from the southern boundary of this AOPC. All three samples with elevated mercury are bound by samples with concentrations below the RBC collected downgradient of the slope, closest to the river.

The high SLV/LOAEL-based HQs for all receptors, with the exception of soil invertebrates, are below 1.0, and the high SLV-based HQ for invertebrates is low (1.4). The topography of the Bulb Slope is steep and the substrate consists of a mixture of soils, rock that may have been placed in some areas, and what appear to be natural rock outcrops, all of which are underlain by siltstone bedrock. The majority of the Bulb Slope AOPC is herbaceously vegetated and/or covered with organic debris.

For these reasons, no further upland evaluation is recommended for the Bulb Slope.

3.5.4.5 All Four AOPCs Combined

As all of the NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the wide-ranging receptors (kestrel and mink), no additional evaluation is needed for the combined AOPC exposure area.

3.6 Conclusions and Recommendations

Table 3-21 summarizes the AOPCs and CECs identified through the BERA that are recommended for further evaluation in the Upland OU FS. No further upland evaluation of the Bulb Slope is recommended based on the low risk estimates. Further evaluation in the FS is recommended for the three remaining AOPCs based on multiple exceedances of RBCs for one or more ecological receptor.

The site-specific RBCs were used in Section 3.5.4 to identify the areas within each AOPC that warrant specific attention in the Upland OU FS, which are summarizes as follows:

- Landfill – northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, and two locations within and northeast of the Pesticide/Herbicide Wash Area.
- Sandblast Area – Spent Sandblast Grit Disposal Area, northern boundary of the Former HMSA, Catch Basin #1, localized areas within the Erodible Unit Sampling Area, and Equipment Laydown Area (north and south of the northern roadway).
- Pistol Range – around the approximate location of the backstop, and north and east of the approximate location of the Former Firing Shed.

To protect ecological receptors, AOPC-wide average concentrations for each AOPC should be below the lowest site-specific RBCs. When the 95% UCL concentrations for the identified CECs are below the RBCs for each AOPC, acceptable levels of ecological risk will be achieved.

4.0 SUMMARY

This report presents the Upland OU BHHRA and BERA for the Bradford Island, Bonneville Dam Complex. The Portland District of the USACE has characterized and evaluated the contamination arising from historical practices at Bradford Island, a multipurpose facility located at RM 146.1 that consists of the First and Second Powerhouses, the old and new navigation locks, and a spillway with a capacity of 1.6 million cubic feet per second.

USACE and their contractors have performed numerous investigations since 1997, focusing on the Upland and River OUs. The Final RI (URS 2012) documented the investigation, identified source areas at Bradford Island, defined the nature and extent of the environmental contamination, and identified the COPCs for human health and CPECs in the media from the two OUs. Based on the screening level RAs for each of the AOPCs that were completed as part of the RI and the recent addition of the Hypothetical Platform Fisher receptor, site-specific BHHRAs and BERAs were conducted for all four AOPCs.

The Upland OU BHHRA and BERA build upon on the data and findings of the Final RI and will be attached as an appendix to the Upland OU FS. This RA document goes beyond the traditional assessment of the presence/absence and magnitude of baseline risk. To maximize use of these site datasets and develop an RA that is most beneficial to the Upland OU FS, site-specific RBCs were calculated for the chemicals recommended for further evaluation in the FS. Exceedances of these RBCs were illustrated for purposes of risk interpretation and to allow for general observations of the spatial distribution of potentially impacted areas.

Only upland exposure pathways were addressed in these baseline RAs. The Upland OU to River OU pathways (i.e., potential mass wasting, soil erosion) that were evaluated at a screening level in the Final RI (URS 2012) were not addressed, as these possible pathways will be considered in the Upland FS or River FS.

4.1 Baseline Human Health Risk Assessment

The Landfill and Sandblast Area AOPCs were evaluated in the BHHRA for occupational receptors exposed to soil, groundwater, and/or soil gas while engaged in outdoor maintenance, construction activities, or indoor office work (Sandblast Area AOPC only). All four AOPCs were evaluated for future Hypothetical Fishing Platform Users exposed to soil while engaged in associated camping activities under conditions representing current concentrations in soil.

Both RME and CTE scenarios were evaluated for most of the receptors, and ELCR and noncancer HI were evaluated with respect to whether they were:

1) less than the USEPA's risk level of 1×10^{-06} or HI of 1, whereby risk at or below this threshold has an insignificant contribution to risk (i.e., *de minimis*);
2) within USEPA's acceptable risk range of 1×10^{-4} to 1×10^{-6} for ELCR; or
3) exceeding the USEPA acceptable risk range, i.e., greater than 1×10^{-04}.

In addition, ODEQ's acceptable risk thresholds of 1×10^{-6} for individual carcinogens and 1×10^{-5} for multiple carcinogens were also considered. Due to this, individual chemicals associated with risk levels greater than 1×10^{-6} or noncancer HQ greater than 1 were identified as COCs, except for arsenic, for which background levels were also considered. Since the individual compounds that make up the cPAHs all act by the same mode of action, risks for PAHs were calculated by individual compound and also summed to present risks for cPAHs as a group. It is important to note that, since ELCRs are only expressions of likelihood of cancer incidence and HIs are estimated ratios to safe doses, exceedance of the ODEQ risk thresholds or USEPA acceptable risk range does not automatically mean that adverse effects may have occurred or will occur (e.g., does not automatically mean that the COC will be recommended for further evaluation in the FS).

As shown in Tables 1-1 to 1-8 and Tables 2-1 to 2-4, media and COPCs evaluated at the Landfill included metals (arsenic, chromium, lead), cPAHs, and CVOCs including PCE, TCE, and associated degradation products in soil and groundwater. Media and COPCs for the Sandblast Area included similar COPCs in soil, groundwater, and soil gas. The receptors evaluated included Outdoor Maintenance Worker (exposed to shallow soil of 0-3 ft bgs), Construction Worker (exposed to deeper soils of 0-10 ft bgs), Excavation/Trench Worker (incidental exposure to groundwater in a trench), and Indoor Worker exposed by vapor intrusion (Sandblast Area AOPC only). An additional Hypothetical Fishing Platform User consisting of adults and children who might camp on the island while utilizing fishing platforms on the Island in accordance with tribal treaty rights was also evaluated (exposed to shallow soils at 0-3 ft bgs) for the longer list of COPCs. Nursing infants who may be exposed by ingestion of maternal milk were also evaluated for PCBs, which are bioaccumulative COPCs.

Table 2-26 presents a summary of the risks and noncancer hazards for the media and receptors evaluated at all the AOPCs. For occupational receptors, estimated risks were either below ODEQ's threshold of 1×10^{-6} or within the USEPA acceptable risk range at both AOPCs for all exposure media. At both the Landfill and Sandblast Area AOPCs, RME exposure to surface and deeper soils resulted in risks that fell within the USEPA acceptable risk range for Outdoor Maintenance Workers and Construction Workers. Risks for Construction Workers were lower than ODEQ's acceptable risk level of 1×10^{-5} for multiple carcinogens. Incidental exposure to groundwater for Excavation/Trench Workers was *de minimis* (less than 1×10^{-6}) at both AOPCs. Risks related to vapor intrusion and indoor inhalation were also *de minimis* for both current and future Indoor Workers at the Sandblast Area AOPC. Only Outdoor Maintenance Workers at the Landfill AOPC had a CTE risk within the USEPA acceptable risk range and for all other receptors, CTE risks were insignificant contributors to risk.

For the Hypothetical Fishing Platform User, estimated risks exceeded the USEPA acceptable risk range under current conditions. Risks and noncancer hazards for nursing infants were close to or less than the ODEQ threshold of 1×10^{-6} for selected bioaccumulative COPCs.

Table 2-27 summarizes the COCs identified for further evaluation in the Upland OU FS in surface and shallow soils at the Landfill and Sandblast Area AOPCs. Within each AOPC, many of the COCs are spatially co-located.

No further upland evaluation or action is warranted to address lead at the Bulb Slope and Pistol Range and the sediments in the Pistol Range Lagoon. No further evaluation or action is warranted for groundwater at either the Bulb Slope or Pistol Range AOPC, or for soil gas at the Sandblast Area AOPC.

Areas that are recommended for further evaluation or potential risk management in the Upland OU FS based on exceedances of receptor-specific RBCs include:

- Landfill – northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, far eastern portion of the Landfill, and one isolated spot northeast of the Pesticide/Herbicide Wash Area (Figures 2-5, 2-7).
- Sandblast Area –the Erodible Unit, Current HMSA, Equipment Laydown Area, and the Former HMSA (Figures 2-6, 2-8).

To protect human receptors, the overall 95% UCL for each AOPC should fall below the relevant RBC. When this is achieved, acceptable levels of risk to human health will be achieved.

4.2 Baseline Ecological Risk Assessment

Surface and shallow soil at all four Upland OU AOPCs were evaluated in the BERA. The CPECs evaluated in the BERA include metals, total HPAHs, tributyltin, organochlorine pesticides, VOCs, and SVOCs for the Landfill and Sandblast Area, lead for the Pistol Range AOPC, and lead and mercury for the Bulb Slope AOPC (Tables 1-1 through 1-5). All of these CPECs were included in the Upland OU-wide evaluation in which wide-ranging receptors were assumed to forage in all four AOPCs combined. Risk estimates were calculated for each CPEC for all selected receptors (terrestrial plants, soil invertebrates, Canada goose, American robin, American kestrel, vagrant shrew, and American mink) potentially present at a given AOPC.

Both low SLVs/NOAELs and high SLVs/LOAELs were selected for each receptor in order to develop a range of HQs for consideration by risk managers. Table 3-21 summarizes the AOPCs and CECs identified in surface and/or shallow soil through the BERA that are recommended for further evaluation in the Upland OU FS.

No further upland evaluation of the Bulb Slope is recommended based on the low risk estimates. Further evaluation in the Upland OU FS is recommended for the three remaining AOPCs based on multiple exceedances of site-specific RBCs for one or more ecological receptor. All of the NOAEL- and LOAEL-based HQs and HIs are less than 1.0 for the wide-ranging receptors (kestrel and mink), and no additional evaluation is needed for these receptors on an individual AOPC basis or on a combined AOPC/Upland OU-wide basis.

Site-specific ecological RBCs were used to identify the areas within each AOPC that warrant specific attention in the Upland OU FS, which are summarized as follows:

- Landfill – northwestern section of the Landfill, primarily within and around the Gully Test Pit and Lead Hot Spot Test Pit #1, Mercury Vapor-Lamp Test Pit, and two locations within and northeast of the Pesticide/Herbicide Wash Area.
- Sandblast Area – Spent Sandblast Grit Disposal Area, northern boundary of the Former HMSA, Catch Basin #1, localized areas within the Erodible Unit Sampling Area, and Equipment Laydown Area (north and south of the northern roadway).
- Pistol Range – around the approximate location of the backstop, and north and east of the approximate location of the Former Firing Shed.

To protect ecological receptors, AOPC-wide average concentrations for each AOPC should be at or below the lowest site-specific RBCs. When the 95% UCL concentrations for the identified CECs are below the RBCs for each AOPC, acceptable levels of ecological risk will be achieved.

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TABLES

Table 1-1
Statistical Summary for Soil - Landfill AOPC

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	Metals	Total	Antimony	0-1 ft	mg/kg	20	4	2.80	3.35	4.20	0.815	1.21	1.36	95% KM (t) UCL
Soil	CPEC	Metals	Total	Antimony	0-3 ft	mg/kg	22	6	2.44	2.71	4.20	0.958	1.23	1.48	95% KM (t) UCL
Soil	COPC	Metals	Total	Arsenic	0-3 ft	mg/kg	23	23	5.30	3.70	30.1	-	-	10.5	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Chromium	0-1 ft	mg/kg	21	21	77.2	23.0	801	-	-	242	Use 95% Chebyshev (Mean, Sd) UCL
Soil	COPC/CPEC	Metals	Total	Chromium	0-3 ft	mg/kg	23	23	190	23.1	1,950	-	-	594	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Copper	0-1 ft	mg/kg	21	21	73.6	45.4	494	-	-	170	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Copper	0-3 ft	mg/kg	23	23	85.2	45.4	494	-	-	191	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Lead	0-1 ft	mg/kg	21	21	211	131	741	-	-	332	Use 95% Approximate Gamma UCL
Soil	COPC/CPEC	Metals	Total	Lead	0-3 ft	mg/kg	29	29	342	147	1,660	-	-	511	Use 95% Approximate Gamma UCL
Soil	CPEC	Metals	Total	Mercury	0-1 ft	mg/kg	23	18	0.524	0.160	4.15	0.427	0.851	1.57	97.5% KM (Chebyshev) UCL
Soil	COPC/CPEC	Metals	Total	Mercury	0-3 ft	mg/kg	25	20	0.478	0.126	4.15	0.397	0.823	1.45	97.5% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Nickel	0-1 ft	mg/kg	21	21	58.4	20.0	570	-	-	175	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Nickel	0-3 ft	mg/kg	23	23	148	20.2	1,610	-	-	472	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Butyltins	Total	Tributyltin	0-1 ft	ug/kg	7	3	59.7	9.01	165	28.5	55.7	-	-
Soil	CPEC	Butyltins	Total	Tributyltin	0-3 ft	ug/kg	9	4	48.6	12.2	165	24.5	49.8	60.1	95% KM (t) UCL
Soil	COPC	PCB Aroclors	Total	Total PCBs as Aroclors (NDs at MDL)	0-3 ft	ug/kg	29	24	174.7	103.9	996	153.7	215.9	409.9	97.5% KM (Chebyshev) UCL
Soil	COPC	Herbicides	Total	MCPP	0-3 ft	ug/kg	14	2	11800.00	11800.00	14000.00	10000.00	1410.0000	11200.00	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (technical)	0-1 ft	ug/kg	1	1	1,560	1,560	1,560	-	-	-	-
Soil	CPEC	Pesticides	Total	Heptachlor	0-1 ft	ug/kg	21	1	2.83	2.83	2.83	-	-	-	-
Soil	CPEC	Pesticides	Total	Chlordane (technical)	0-3 ft	ug/kg	3	3	573	92.7	1,560	-	-	-	-
Soil	CPEC	Pesticides	Total	Heptachlor	0-3 ft	ug/kg	23	2	2.95	2.95	3.07	2.84	0.0489	2.86	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-1 ft	ug/kg	27	24	2,010	425	21,000	1,800	4,030	9,680	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-3 ft	ug/kg	29	26	1,970	595	21,000	1,780	3,890	6,380	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-1 ft	ug/kg	26	3	52.6	67.2	68.7	28.1	15.6	36.6	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-3 ft	ug/kg	28	3	52.6	67.2	68.7	27.4	14.8	34.9	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Carbazole	0-1 ft	ug/kg	27	19	384	144	2,650	279	547	751	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Carbazole	0-3 ft	ug/kg	29	21	510	210	2,840	378	706	964	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-1 ft	ug/kg	27	11	160	67.7	810	84.0	159	152	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-3 ft	ug/kg	29	13	174	76.0	810	96.2	165	164	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-1 ft	ug/kg	26	4	496	84.5	1,800	98.5	342	232	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-3 ft	ug/kg	28	4	496	84.5	1,800	93.6	330	217	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)anthracene	0-1 ft	ug/kg	27	25	3,200	960	32,000	2,970	6,280	8,340	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(a)anthracene	0-3 ft	ug/kg	33	31	4,600	1,400	32,000	4,330	7,300	9,960	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)pyrene	0-1 ft	ug/kg	27	25	3,440	1,200	33,000	3,180	6,450	8,700	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(a)pyrene	0-3 ft	ug/kg	33	31	5,200	1,600	34,000	4,890	8,130	11,200	95% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	Benzo(a)pyrene	0-10 ft	ug/kg	44	42	5,890	3,240	34,000	5,620	7,740	10,800	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-1 ft	ug/kg	24	23	4,520	680	65,000	4,330	12,900	16,000	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-3 ft	ug/kg	28	27	5,210	1,200	65,000	5,030	12,100	15,200	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-1 ft	ug/kg	27	24	1,780	470	18,000	1,580	3,510	4,590	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-3 ft	ug/kg	33	30	2,740	830	18,000	2,490	4,320	5,820	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-1 ft	ug/kg	24	23	3,610	340	65000	3,460	12,900	30,200	99% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-3 ft	ug/kg	28	27	3,560	990	65000	3,440	11,900	26,300	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-1 ft	ug/kg	3	3	6,960	5,100	14,700	-	-	-	-
Soil	COPC/CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-3 ft	ug/kg	5	5	12,100	8,490	31,300	-	-	-	-
Soil	CPEC	SVOCs	Total	Chrysene	0-1 ft	ug/kg	27	26	3,230	1,250	32,000	3,110	6,180	8,400	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Chrysene	0-3 ft	ug/kg	33	32	4,930	1,620	35,300	4,780	8,050	11,000	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-1 ft	ug/kg	27	22	732	150	9,900	612	1,850	4,230	99% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-3 ft	ug/kg	33	28	854	345	9,900	739	1,710	2,060	95% KM (Chebyshev) UCL

Table 1-1
Statistical Summary for Soil - Landfill AOPC

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	SVOCs	Total	Fluoranthene	0-1 ft	ug/kg	27	25	5,740	1,300	54,000	5,320	10,800	14,500	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Fluoranthene	0-3 ft	ug/kg	33	31	8,240	2,700	54,000	7,750	12,600	17,500	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-1 ft	ug/kg	27	24	2,010	520	19,000	1,790	3,790	5,040	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-3 ft	ug/kg	33	30	3,230	800	20,000	2,940	5,000	6,800	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-1 ft	ug/kg	27	26	5,130	1,900	40,000	4,940	8,640	12,300	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-3 ft	ug/kg	33	32	8,470	2,720	67,100	8,220	13,700	18,800	95% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	cPAHs as BaPEQ (KM-capped, MDL-based)	0-3 ft	ug/kg	33	32	7,239	2,203	55,362	7,022	12,051	13,416	90% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	cPAHs as BaPEQ (KM-capped, MDL-based)	0-10 ft	ug/kg	44	43	8,086	4,558	55,362	7,905	11,200	13,030	90% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-1 ft	ug/kg	27	26	37,211	13,060	367,900	30,467	69,775	90,158	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-3 ft	ug/kg	33	32	47,894	16,735	367,900	43,348	75,465	101,525	95% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-1 ft	ug/kg	18	3	5,420	1,280	14,300	1,460	3,120	3,030	95% KM (t) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-3 ft	ug/kg	20	3	5,420	1,280	14,300	1,380	2,970	2,790	95% KM (t) UCL
Soil	COPC	VOCs	Total	Naphthalene	0-3 ft	ug/kg	20	3	3,140	542	8,360	899	1,710	3,830	97.5% KM (Chebyshev) UCL
Soil	COPC*	VOCs	Total	Tetrachloroethene (PCE)	0-10 ft	ug/kg	35	25	16,100	5.19	403,000	11,500	67,100	127,000	99% KM (Chebyshev) UCL

Notes

Only COPCs/CPECs identified in the Final RI Report (URS 2012) per relevant depth interval are shown; Table I-12 in Appendix I of the Final RI Report presents the summary statistics for the Landfill AOPC COIs for all media and depth intervals.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.
* = PCE and degradation products retained as COPCs.
BHHRA EPCs: 95% UCLs for soil data from 0-3 ft bgs depth interval were used as the EPCs for outdoor worker and fishing platform user scenarios; 95% UCLs for soil data from 0-10 ft bgs depth interval were used as EPCs for construction worker scenario.
BERA EPCs: The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors.

% = percent
AOPC = Area of Potential Concern
BaPEQ = benzo(a)pyrene equivalent(s)
BERA = baseline ecological risk assessment
bgs = below ground surface
BHHRA = baseline human health risk assessment
COI = chemical of interest
COPC = contaminant of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CPEC = contaminant of potential ecological concern
EPC = exposure point concentration
ft = foot or feet
HPAH = high molecular weight polycyclic aromatic hydrocarbon
KM = Kaplan-Meier
MDL = method detection limit
mg/kg = milligrams per kilogram
ND = non-detect
PCB = polychlorinated biphenyls
PCE = tetrachloroethene
RI = remedial investigation
SD = standard deviation
SVOC = semi-volatile organic carbon
UCL = upper confidence limit
ug/kg = micrograms per kilogram
VOC = volatile organic carbon

Source

URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

Table 1-2
Statistical Summary for Soil - Sandblast Area AOPC

													Statistics - ND censored at the MDL			
Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Sieve Size	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	Metals	Total	Antimony	0-1 ft	N/A	mg/kg	58	41	1.90	1.14	13.7	1.62	2.23	2.94	95% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Antimony	0-3 ft	N/A	mg/kg	75	55	1.57	1.07	13.7	1.38	2.02	2.42	95% KM (Chebyshev) UCL
Soil	COPC	Metals	Total	Arsenic	0-3 ft	N/A	mg/kg	75	74	7.24	5.02	80.9	7.15	11.4	9.71	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Cadmium	0-1 ft	N/A	mg/kg	58	53	1.82	1.04	17.3	1.66	2.65	3.20	95% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Cadmium	0-3 ft	N/A	mg/kg	75	67	1.58	0.963	17.3	1.42	2.38	2.63	95% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Chromium	0-1 ft	N/A	mg/kg	61	61	383	94.9	2,650	-	-	720	Use 95% Chebyshev (Mean, Sd) UCL
Soil	COPC/CPEC	Metals	Total	Chromium	0-3 ft	N/A	mg/kg	78	78	306	50.6	2,650	-	-	579	Use 95% Chebyshev (Mean, Sd) UCL
Soil	COPC	Metals	Total	Lead	0-1 ft	<250um	mg/kg	8	8	300	160	921	-	-	639	Use 95% Approximate Gamma UCL
Soil	COPC/CPEC	Metals	Total	Lead	0-1 ft	<2mm	mg/kg	8	8	233	133	768	-	-	551	Use 95% Approximate Gamma UCL
Soil	COPC/CPEC	Metals	Total	Lead	0-1 ft	N/A	mg/kg	61	61	362	272	3,260	-	-	465	Use 95% Approximate Gamma UCL
Soil	COPC	Metals	Total	Lead	0-3 ft	<250um	mg/kg	16	16	202	72.2	921	-	-	418	Use 95% Approximate Gamma UCL
Soil	COPC/CPEC	Metals	Total	Lead	0-3 ft	<2mm	mg/kg	16	16	148	34.9	768	-	-	303	Use 95% Approximate Gamma UCL
Soil	COPC/CPEC	Metals	Total	Lead	0-3 ft	N/A	mg/kg	78	78	309	139	3,260	-	-	529	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Mercury	0-1 ft	N/A	mg/kg	58	43	0.104	0.0440	0.723	0.0812	0.130	0.113	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Mercury	0-3 ft	N/A	mg/kg	75	58	0.0911	0.0433	0.723	0.0741	0.116	0.0976	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Nickel	0-1 ft	N/A	mg/kg	58	58	167	50.0	1,060	-	-	353	Use 95% H-UCL
Soil	COPC/CPEC	Metals	Total	Nickel	0-3 ft	N/A	mg/kg	75	75	135	33.3	1,060	-	-	251	Use 95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Butyltins	Total	Tributyltin	0-1 ft	N/A	ug/kg	47	16	186	29.8	1,860	64.3	278	481	99% KM (Chebyshev) UCL
Soil	CPEC	Butyltins	Total	Tributyltin	0-3 ft	N/A	ug/kg	62	16	186	29.8	1,860	49.2	243	248	97.5% KM (Chebyshev) UCL
Soil	COPC	PCB Aroclors	Total	Total PCBs as Aroclors (NDs at MDL)	0-3 ft	N/A	ug/kg	73	61	224	28.7	2,140	138.4	381	419	97.5% KM (Chebyshev) UCL
Soil	CPEC	Pesticides	Total	BHC (delta)	0-1 ft	N/A	ug/kg	31	2	1.55	1.55	3.03	0.176	0.530	1.54	99% KM (Chebyshev) UCL
Soil	CPEC	Pesticides	Total	BHC (delta)	0-3 ft	N/A	ug/kg	37	2	1.55	1.55	3.03	0.160	0.485	1.30	99% KM (Chebyshev) UCL
Soil	CPEC	Pesticides	Total	BHC (gamma) Lindane	0-1 ft	N/A	ug/kg	31	2	5.92	5.92	9.68	2.42	1.35	9.68	95% KM (BCA) UCL
Soil	CPEC	Pesticides	Total	BHC (gamma) Lindane	0-3 ft	N/A	ug/kg	37	3	4.02	2.17	9.68	0.520	1.58	1.06	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (alpha)	0-1 ft	N/A	ug/kg	19	3	1.01	0.860	1.50	0.718	0.195	0.815	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (alpha)	0-3 ft	N/A	ug/kg	25	3	1.01	0.860	1.50	0.703	0.171	0.776	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (gamma)	0-1 ft	N/A	ug/kg	19	6	43.7	29.8	97.0	19.0	26.0	30.3	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (gamma)	0-3 ft	N/A	ug/kg	25	10	27.4	10.6	97.0	11.3	25.2	20.4	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan I	0-1 ft	N/A	ug/kg	31	2	4.32	4.32	6.45	2.35	0.775	2.69	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan I	0-3 ft	N/A	ug/kg	37	5	2.21	2.00	6.45	0.447	1.13	0.809	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan II	0-1 ft	N/A	ug/kg	31	3	1.06	0.960	1.99	0.341	0.367	0.495	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan II	0-3 ft	N/A	ug/kg	37	3	1.06	0.960	1.99	0.322	0.333	0.447	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan Sulfate	0-1 ft	N/A	ug/kg	31	6	1.46	1.24	3.30	0.761	0.560	0.953	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan Sulfate	0-3 ft	N/A	ug/kg	37	6	1.46	1.24	3.30	0.729	0.515	0.889	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Aldehyde	0-1 ft	N/A	ug/kg	31	4	8.36	7.70	16.0	2.84	2.90	3.87	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Aldehyde	0-3 ft	N/A	ug/kg	37	5	7.06	4.40	16.0	2.60	2.70	3.44	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Ketone	0-1 ft	N/A	ug/kg	31	4	5.25	3.07	13.0	2.35	2.04	3.09	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Ketone	0-3 ft	N/A	ug/kg	37	4	5.25	3.07	13.0	2.26	1.87	2.88	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin	0-1 ft	N/A	ug/kg	31	3	11.7	15.0	17.0	3.84	3.20	5.04	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin	0-3 ft	N/A	ug/kg	37	4	9.28	9.00	17.0	2.88	3.15	3.89	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Heptachlor	0-1 ft	N/A	ug/kg	31	4	0.911	0.283	2.90	0.283	0.496	0.464	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Heptachlor	0-3 ft	N/A	ug/kg	37	4	0.911	0.283	2.90	0.265	0.453	0.415	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Methoxychlor	0-1 ft	N/A	ug/kg	31	2	1.10	1.10	1.20	1.02	0.0533	1.05	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Methoxychlor	0-3 ft	N/A	ug/kg	37	2	1.10	1.10	1.20	1.01	0.0447	1.04	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-1 ft	N/A	ug/kg	31	21	19,200	1,500	260,000	13,100	46,400	98,000	99% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-3 ft	N/A	ug/kg	40	29	15,400	1,040	260,000	11,200	41,200	77,100	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-1 ft	N/A	ug/kg	31	5	38.5	15.7	124	9.59	22.1	17.1	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-3 ft	N/A	ug/kg	39	6	37.4	23.7	124	9.14	20.2	15.2	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Carbazole	0-1 ft	N/A	ug/kg	31	20	141	68.5	530	91.8	144	144	95% KM (BCA) UCL

Table 1-2
Statistical Summary for Soil - Sandblast Area AOPC

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Sieve Size	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
													KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	SVOCs	Total	Carbazole	0-3 ft	N/A	ug/kg	39	24	118	35.0	530	73.7	133	112	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-1 ft	N/A	ug/kg	31	19	41.0	10.0	220	26.0	47.6	42.4	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-3 ft	N/A	ug/kg	40	24	58.1	8.90	485	35.5	85.3	122	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-1 ft	N/A	ug/kg	31	10	107	102	280	44.9	66.6	80.4	95% KM (Percentile Bootstrap) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-3 ft	N/A	ug/kg	39	14	82.0	49.0	280	36.5	61.1	54.3	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-octyl Phthalate	0-1 ft	N/A	ug/kg	31	5	49.4	31.0	127	17.6	22.1	25.1	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-octyl Phthalate	0-3 ft	N/A	ug/kg	39	6	45.0	27.0	127	16.6	19.9	22.5	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)anthracene	0-1 ft	N/A	ug/kg	31	29	787	190	6,440	736	1,270	1,750	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(a)anthracene	0-3 ft	N/A	ug/kg	40	35	1,070	183	12,300	935	2,160	2,450	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)pyrene	0-1 ft	N/A	ug/kg	31	30	771	180	6,470	746	1,280	1,760	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(a)pyrene	0-3 ft	N/A	ug/kg	40	36	1,030	155	11,700	926	2,090	2,390	95% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	Benzo(a)pyrene	0-10 ft	N/A	ug/kg	43	37	1,000	151	11,700	862	2,030	3,980	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-1 ft	N/A	ug/kg	13	13	1,350	1,100	4,100	-	-	1,950	Use 95% Student's-t UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-3 ft	N/A	ug/kg	18	17	1,050	640	4,100	991	1,150	2,210	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-1 ft	N/A	ug/kg	31	26	534	180	3,830	449	774	1,070	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-3 ft	N/A	ug/kg	40	33	555	120	3,830	459	843	1,050	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-1 ft	N/A	ug/kg	13	13	469	360	1,400	-	-	676	Use 95% Student's-t UCL
Soil	CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-3 ft	N/A	ug/kg	18	17	365	220	1,400	345	396	764	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-1 ft	N/A	ug/kg	18	17	1,100	74.2	12,100	1,040	2,780	7,760	99% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-3 ft	N/A	ug/kg	22	20	1,900	105	16,300	1,730	4,090	10,600	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Chrysene	0-1 ft	N/A	ug/kg	31	30	904	222	7,590	875	1,500	2,070	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Chrysene	0-3 ft	N/A	ug/kg	40	37	1,120	129	12,000	1,030	2,230	4,590	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-1 ft	N/A	ug/kg	31	20	232	113	1,430	150	280	244	95% KM (BCA) UCL
Soil	COPC/CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-3 ft	N/A	ug/kg	40	26	235	93.2	1,430	153	295	238	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Fluoranthene	0-1 ft	N/A	ug/kg	31	30	1,710	284	20,700	1,660	3,740	4,640	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Fluoranthene	0-3 ft	N/A	ug/kg	40	37	2,290	216	28,600	2,120	5,420	10,800	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-1 ft	N/A	ug/kg	31	28	530	155	3,910	479	811	1,130	95% KM (Chebyshev) UCL
Soil	COPC/CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-3 ft	N/A	ug/kg	40	35	575	97.8	4,170	503	944	1,160	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-1 ft	N/A	ug/kg	31	30	1,710	338	21,900	1,660	3,920	4,780	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-3 ft	N/A	ug/kg	40	38	2,350	184	32,000	2,230	5,950	11,700	99% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	cPAHs as BaPEQ (KM-capped, MDL-based)	0-3 ft	N/A	ug/kg	40	38	1,441	192	16,103	1,369	2,988	2,805	90% KM (Chebyshev) UCL
Soil	COPC	SVOCs	Total	cPAHs as BaPEQ (KM-capped, MDL-based)	0-10 ft	N/A	ug/kg	43	39	1,405	173	16,103	1,274	2,903	2,620	90% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-1 ft	N/A	ug/kg	31	30	7765	738	72270	7516	13891	18577	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-3 ft	N/A	ug/kg	40	38	9430	926	105200	8959	19945	40758	99% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-1 ft	N/A	ug/kg	37	15	0.246	0.230	0.523	0.195	0.0993	0.230	95% KM (t) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-3 ft	N/A	ug/kg	46	21	1,250	0.230	14,300	572	2,690	4,620	99% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	4-Isopropyltoluene	0-1 ft	N/A	ug/kg	37	14	1.63	0.415	12.0	0.749	1.98	1.33	95% KM (t) UCL
Soil	CPEC	VOCs	Total	4-Isopropyltoluene	0-3 ft	N/A	ug/kg	46	17	10.9	0.900	161	4.25	23.7	20.1	95% KM (Chebyshev) UCL
Soil	COPC*	VOCs	Total	cis-1,2-Dichloroethene	0-3 ft	N/A	ug/kg	46	2	66.0	66.0	120	14.4	15.9	-	-
Soil	COPC*	VOCs	Total	cis-1,2-Dichloroethene	0-10 ft	N/A	ug/kg	49	4	48.8	35.2	120	8.61	18.0	13.6	95% KM (t) UCL
Soil	CPEC	VOCs	Total	n-Propylbenzene	0-1 ft	N/A	ug/kg	37	1	0.150	0.150	0.150	-	-	-	-
Soil	CPEC	VOCs	Total	n-Propylbenzene	0-3 ft	N/A	ug/kg	46	3	40.8	0.409	122	2.87	18.0	35.5	99% KM (Chebyshev) UCL
Soil	COPC*	VOCs	Total	Tetrachloroethene (PCE)	0-3 ft	N/A	ug/kg	46	5	85,900	5.84	420,000	9,340	61,200	26,300	95% KM (t) UCL
Soil	COPC*	VOCs	Total	Tetrachloroethene (PCE)	0-10 ft	N/A	ug/kg	49	8	53,700	10.1	420,000	8,760	59,400	99,000	99% KM (Chebyshev) UCL
Soil	COPC*	VOCs	Total	Trichloroethene (TCE)	0-1 ft	N/A	ug/kg	37	4	0.0912	0.0661	0.171	0.0678	0.0216	0.0766	95% KM (t) UCL
Soil	COPC*	VOCs	Total	Trichloroethene (TCE)	0-3 ft	N/A	ug/kg	46	7	1,330	0.171	6,080	202	993	1,780	99% KM (Chebyshev) UCL

Table 1-2
Statistical Summary for Soil - Sandblast Area AOPC

Notes
Only COPCs/CPECs identified in the Final RI Report (URS 2012) per relevant depth interval are shown; Table I-13 in Appendix I of the Final RI Report presents the summary statistics for the Sandblast Area AOPC COIs for all media and depth intervals.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.
* = PCE and degradation products retained as COPCs.
BHHRA EPCs: 95% UCLs for soil data from 0-3 ft bgs depth interval were used as the EPCs for outdoor worker and fishing platform user scenarios; 95% UCLs for soil data from 0-10 ft bgs depth interval were used as EPCs for construction worker scenario.
BERA EPCs: BERA EPCs: The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors.

% = percent
AOPC = Area of Potential Concern
BaPEQ = benzo(a)pyrene equivalent(s)
BERA = baseline ecological risk assessment
bgs = below ground surface
BHC = benzene hexachloride
BHHRA = baseline human health risk assessment
COI = chemical of interest
COPC = contaminant of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CPEC = contaminant of potential ecological concern
EPC = exposure point concentration
ft = foot or feet
HPAH = high molecular weight polycyclic aromatic hydrocarbon
KM = Kaplan-Meier
MDL = method detection limit
mg/kg = milligrams per kilogram
N/A = not applicable
ND = non-detect
PCB = polychlorinated biphenyls
PCE = tetrachloroethene
RI = remedial investigation
SD = standard deviation
SVOC = semi-volatile organic carbon
UCL = upper confidence limit
ug/kg = micrograms per kilogram
VOC = volatile organic carbon

Source
URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

Table 1-3
Statistical Summary for Soil and Lagoon Sediment - Pistol Range AOPC

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	COPC/CPEC	Metals	Total	Lead	0-1.5 ft	mg/kg	63	63	208	60	1,110	-	-	365	Use 95% Chebyshev (Mean, Sd) UCL
Lagoon Sediment	COPC	Metals	Total	Lead	N/A	mg/kg	5	5	27	28	33	-	-	-	-

Notes

Only COPCs/CPECs identified in the Final RI Report (URS 2012) are shown; Table I-14 in Appendix I of the Final RI Report presents the summary statistics for the Pistol Range AOPC COIs for all media.

BHHRA EPCs: 95% UCLs were used as the EPCs for fishing platform user scenario.

BERA EPCs: The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors.

% = percent
BERA = baseline ecological risk assessment
BHHRA = baseline human health risk assessment
COPC = contaminant of potential concern
CPEC = contaminant of potential ecological concern
EPC = exposure point concentration
ft = foot or feet
KM = Kaplan-Meier
MDL = method detection limit
mg/kg = milligrams per kilogram
N/A = not applicable
ND = non-detect
RI = remedial investigation
SD = standard deviation
UCL = upper confidence limit

Source

URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

Table 1-4
Statistical Summary for Soil - Bulb Slope AOPC

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	COPC/CPEC	Metals	Total	Lead	0-1 ft	mg/kg	12	12	222	199	597	-	-	307	Use 95% Student's-t UCL
Soil	CPEC	Metals	Total	Mercury	0-1 ft	mg/kg	12	12	0.404	0.280	1.54	-	-	0.720	Use 95% Approximate Gamma UCL

Notes

Only COPCs/CPECs identified in the Final RI Report (URS 2012) are shown; Table I-15 im Appendix I of the Final RI Report presents the summary statistics for the Bulb Slope AOPC COIs.
BHHRA EPCs: 95% UCLs were used as the EPCs for fishing platform user scenario.
BERA EPCs: The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors.

% = percent
BERA = baseline ecological risk assessment
BHHRA = baseline human health risk assessment
COPC = contaminant of potential concern
CPEC = contaminant of potential ecological concern
EPC = exposure point concentration
ft = foot or feet
KM = Kaplan-Meier
MDL = method detection limit
ND = non-detect
mg/kg = milligrams per kilogram
RI = remedial investigation
SD = standard deviation
UCL = upper confidence limit

Source

URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

Table 1-5
Statistical Summary for Soil - Combined AOPCs

												Statistics - ND censored at the MDL			
Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	Metals	Total	Antimony	0-1 ft	mg/kg	83	45	1.98	1.28	13.7	1.39	2.02	1.80	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Antimony	0-3 ft	mg/kg	102	61	1.65	1.10	13.7	1.26	1.86	1.64	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Cadmium	0-1 ft	mg/kg	79	68	1.62	0.963	17.3	1.41	2.33	1.97	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Cadmium	0-3 ft	mg/kg	98	84	1.48	0.924	17.3	1.28	2.14	1.67	95% KM (BCA) UCL
Soil	CPEC	Metals	Total	Chromium	0-1 ft	mg/kg	82	82	305	49.8	2,650	-	-	567	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Chromium	0-3 ft	mg/kg	101	101	279	35.7	2,650	-	-	510	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Copper	0-1 ft	mg/kg	93	93	62.8	43.8	494	-	-	95.0	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Copper	0-3 ft	mg/kg	112	112	64.0	45.7	494	-	-	93.6	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Lead	0-1 ft	mg/kg	157	157	270	128	3,260	-	-	398	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Lead	0-3 ft	mg/kg	182	182	274	119	3,260	-	-	396	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Mercury	0-1 ft	mg/kg	107	73	0.257	0.0940	4.15	0.183	0.459	0.378	95% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Mercury	0-3 ft	mg/kg	126	90	0.219	0.0686	4.15	0.163	0.426	0.330	95% KM (Chebyshev) UCL
Soil	CPEC	Metals	Total	Nickel	0-1 ft	mg/kg	89	89	125	26.3	1,060	-	-	227	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Metals	Total	Nickel	0-3 ft	mg/kg	108	108	128	26.2	1,610	-	-	234	95% Chebyshev (Mean, Sd) UCL
Soil	CPEC	Butyltins	Total	Tributyltin	0-1 ft	ug/kg	54	19	166	23.6	1,860	59.4	260	422	99% KM (Chebyshev) UCL
Soil	CPEC	Butyltins	Total	Tributyltin	0-3 ft	ug/kg	71	20	158	19.5	1,860	45.8	228	219	97.5% KM (Chebyshev) UCL
Soil	CPEC	Pesticides	Total	BHC (delta)	0-1 ft	ug/kg	52	2	1.55	1.55	3.03	0.136	0.409	-	-
Soil	CPEC	Pesticides	Total	BHC (delta)	0-3 ft	ug/kg	60	2	1.55	1.55	3.03	0.128	0.381	-	-
Soil	CPEC	Pesticides	Total	BHC (gamma) Lindane	0-1 ft	ug/kg	52	2	5.92	5.92	9.68	2.32	1.04	-	-
Soil	CPEC	Pesticides	Total	BHC (gamma) Lindane	0-3 ft	ug/kg	60	3	4.02	2.17	9.68	0.395	1.25	-	-
Soil	CPEC	Pesticides	Total	Chlordane (alpha)	0-1 ft	ug/kg	39	4	1.76	1.18	4.00	0.805	0.589	1.01	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (alpha)	0-3 ft	ug/kg	45	4	1.76	1.18	4.00	0.781	0.544	0.952	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (gamma)	0-1 ft	ug/kg	39	6	43.7	29.8	97.0	13.2	19.0	18.8	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (gamma)	0-3 ft	ug/kg	45	10	27.4	10.6	97.0	6.62	19.5	11.8	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Chlordane (technical)	0-1 ft	ug/kg	13	1	1,560	1,560	1,560	-	-	-	-
Soil	CPEC	Pesticides	Total	Chlordane (technical)	0-3 ft	ug/kg	15	3	573	92.7	1,560	167	372	902	97.5% KM (Chebyshev) UCL
Soil	CPEC	Pesticides	Total	Endosulfan I	0-1 ft	ug/kg	52	2	4.32	4.32	6.45	2.28	0.595	-	-
Soil	CPEC	Pesticides	Total	Endosulfan I	0-3 ft	ug/kg	60	5	2.21	2.00	6.45	0.328	0.890	0.547	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan II	0-1 ft	ug/kg	52	4	3.01	1.48	8.84	0.502	1.22	0.844	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan II	0-3 ft	ug/kg	60	4	3.01	1.48	8.84	0.463	1.14	0.756	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan Sulfate	0-1 ft	ug/kg	52	7	2.11	1.70	5.97	0.842	0.887	1.08	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endosulfan Sulfate	0-3 ft	ug/kg	60	7	2.11	1.70	5.97	0.800	0.825	1.01	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Aldehyde	0-1 ft	ug/kg	52	4	8.36	7.70	16.0	2.52	2.28	3.14	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Aldehyde	0-3 ft	ug/kg	60	5	7.06	4.40	16.0	2.34	2.16	2.86	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Ketone	0-1 ft	ug/kg	51	4	5.25	3.07	13.0	2.16	1.61	2.61	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin Ketone	0-3 ft	ug/kg	59	4	5.25	3.07	13.0	2.12	1.49	2.50	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin	0-1 ft	ug/kg	52	3	11.7	15.0	17.0	3.50	2.51	4.21	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Endrin	0-3 ft	ug/kg	60	4	9.28	9.00	17.0	2.58	2.50	3.21	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Heptachlor	0-1 ft	ug/kg	52	5	1.30	0.380	2.90	0.297	0.526	0.437	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Heptachlor	0-3 ft	ug/kg	60	6	1.59	1.60	3.07	0.330	0.610	0.477	95% KM (t) UCL
Soil	CPEC	Pesticides	Total	Methoxychlor	0-1 ft	ug/kg	52	2	1.10	1.10	1.20	1.02	0.0533	-	-
Soil	CPEC	Pesticides	Total	Methoxychlor	0-3 ft	ug/kg	60	2	1.10	1.10	1.20	1.01	0.0447	-	-
Soil	CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-1 ft	ug/kg	58	45	10,000	895	260,000	7,820	34,500	36,400	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Bis(2-ethylhexyl) Phthalate	0-3 ft	ug/kg	69	55	9,040	825	260,000	7,220	31,800	31,300	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-1 ft	ug/kg	57	8	43.8	30.8	124	11.3	22.2	17.2	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Butyl Benzyl Phthalate	0-3 ft	ug/kg	67	9	42.5	31.7	124	10.4	20.5	15.4	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Carbazole	0-1 ft	ug/kg	58	39	259	91.0	2,650	178	399	272	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Carbazole	0-3 ft	ug/kg	68	45	301	78.0	2,840	202	496	312	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-1 ft	ug/kg	58	30	84.6	40.2	810	48.2	119	77.1	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Dibenzofuran	0-3 ft	ug/kg	69	37	98.8	42.4	810	56.6	130	83.4	95% KM (BCA) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-1 ft	ug/kg	57	14	218	86.4	1,800	68.3	238	124	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-butyl Phthalate	0-3 ft	ug/kg	67	18	174	61.0	1,800	58.0	221	105	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-octyl Phthalate	0-1 ft	ug/kg	57	5	49.4	31.0	127	15.8	18.6	21.0	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Di-n-octyl Phthalate	0-3 ft	ug/kg	67	6	45.0	27.0	127	15.2	16.9	19.4	95% KM (t) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)anthracene	0-1 ft	ug/kg	58	54	1,900	428	32,000	1,770	4,520	4,390	95% KM (Chebyshev) UCL

Table 1-5
Statistical Summary for Soil - Combined AOPCs

Medium	Retention Reason	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil	CPEC	SVOCs	Total	Benzo(a)anthracene	0-3 ft	ug/kg	73	66	2,730	530	32,000	2,470	5,430	5,260	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)pyrene	0-1 ft	ug/kg	58	55	1,980	435	33,000	1,880	4,660	4,570	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(a)pyrene	0-3 ft	ug/kg	73	67	2,960	450	34,000	2,720	6,020	7,150	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-1 ft	ug/kg	37	36	3,380	835	65,000	3,280	10,500	20,700	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(b)fluoranthene	0-3 ft	ug/kg	46	44	3,600	835	65,000	3,450	9,690	9,750	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-1 ft	ug/kg	58	50	1,130	280	18,000	976	2,520	2,440	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(g,h,i)perylene	0-3 ft	ug/kg	73	63	1,590	290	18,000	1,380	3,140	3,690	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-1 ft	ug/kg	37	36	2,480	350	65,000	2,410	10,500	19,800	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzo(k)fluoranthene	0-3 ft	ug/kg	46	44	2,330	350	65,000	2,230	9,420	11,000	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-1 ft	ug/kg	21	20	1,980	155	14,700	1,880	3,950	10,700	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Benzofluoranthenes, Total	0-3 ft	ug/kg	27	25	3,950	212	31,300	3,650	7,120	17,600	99% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Chrysene	0-1 ft	ug/kg	58	56	1,980	520	32,000	1,920	4,500	4,510	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Chrysene	0-3 ft	ug/kg	73	69	2,880	620	35,300	2,730	5,960	5,790	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-1 ft	ug/kg	58	42	494	140	9,900	363	1,300	1,120	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Dibenz(a,h)anthracene	0-3 ft	ug/kg	73	54	556	155	9,900	416	1,210	1,040	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Fluoranthene	0-1 ft	ug/kg	58	55	3,540	795	54,000	3,360	8,060	8,020	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Fluoranthene	0-3 ft	ug/kg	73	68	5,000	816	54,000	4,660	9,770	11,900	97.5% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-1 ft	ug/kg	58	52	1,210	285	19,000	1,090	2,730	2,670	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-3 ft	ug/kg	73	65	1,800	300	20,000	1,600	3,640	3,480	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-1 ft	ug/kg	58	56	3,300	810	40,000	3,190	6,750	7,090	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Pyrene	0-3 ft	ug/kg	73	70	5,150	897	67,100	4,940	10,600	10,400	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-1 ft	ug/kg	58	55.9999999	22,488	4,976	367,900	18,198	50,007	47,078	95% KM (Chebyshev) UCL
Soil	CPEC	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-3 ft	ug/kg	73	70	28,142	5,626	367,900	24,503	55,546	53,046	95% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-1 ft	ug/kg	55	18	903	0.240	14300	296	1,920	2,940	99% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	1,2,4-Trimethylbenzene	0-3 ft	ug/kg	66	24	1,770	0.240	14,300	645	2,830	2,860	97.5% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	4-Isopropyltoluene	0-1 ft	ug/kg	55	14	1.63	0.415	12.0	0.596	1.71	1.02	95% KM (t) UCL
Soil	CPEC	VOCs	Total	4-Isopropyltoluene	0-3 ft	ug/kg	66	17	10.9	0.900	161	3.14	20.3	14.7	95% KM (Chebyshev) UCL
Soil	CPEC	VOCs	Total	n-Propylbenzene	0-1 ft	ug/kg	55	1	0.150	0.150	0.150	-	-	-	-
Soil	CPEC	VOCs	Total	n-Propylbenzene	0-3 ft	ug/kg	66	3	40.8	0.409	122	2.12	15.4	-	-

Notes

Only CPECs identified in the Final RI Report (URS 2012), per relevant depth interval, are shown; Table I-16 in Appendix I of the Final RI Report presents the summary statistics for the COIs in the combined dataset of all Four AOPCs Combined.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.
BERA EPCs: The lower of the maximum detected concentrations and 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors.

% = percent
AOPC = Area of Potential Concern
BERA = baseline ecological risk assessment
BHC = benzene hexachloride
COI = chemical of interest
CPEC = contaminant of potential ecological concern
EPC = exposure point concentration
ft = foot or feet
HPAH = high molecular weight polycyclic aromatic hydrocarbon
KM = Kaplan-Meier
MDL = method detection limit
mg/kg = milligrams per kilogram
ND = non-detect
RI = remedial investigation
SD = standard deviation
UCL = upper confidence limit
ug/kg = micrograms per kilogram
VOC = volatile organic carbon

Source

URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

Table 1-6
Statistical Summary for Soil Gas - Sandblast Area AOPC

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Sieve Size	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
Soil Gas	VOCs	Total	cis-1,2-Dichloroethene	N/A	N/A	ug/m^3	5	5	115	69.0	330	-	-	-	-
Soil Gas	VOCs	Total	Tetrachloroethene (PCE)	N/A	N/A	ug/m^3	5	5	7,590	800	34,000	-	-	-	-
Soil Gas	VOCs	Total	Trichloroethene (TCE)	N/A	N/A	ug/m^3	5	5	214	41.0	610	-	-	-	-
Degradation Products of PCE/ TCE			1,1-dichloroethene	N/A	N/A	ug/m^3	Not Detected Above the Method Detection Limit (MDL) MDL used as theoretical concentration					-	-	-	-
			tran-1,2-dichloroethene	N/A	N/A	ug/m^3						-	-	-	-
			vinyl chloride	N/A	N/A	ug/m^3						-	-	-	-

Notes
Only those analytes with at least 2 detected results are shown on this table.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.

% = percent
KM = Kaplan-Meier
MDL = method detection limit
N/A = not applicable
ND = non-detect
SD = standard deviation
ug/m^3 = micrograms per cubic meters
UCL = upper confidence limit
VOC = volatile organic carbon

Table 1-7
Statistical Summary for Groundwater - Landfill AOPC

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
											KM-Mean	KM-SD	Final 95% UCL	UCL Type
Groundwater	Metals	Total	Antimony	N/A	ug/L	19	8	1.53	1.07	3.89	1.49	1.15	2.23	95% KM (t) UCL
Groundwater	Metals	Total	Iron	N/A	ug/L	53	50	11,600	3,590	42,900	10,900	13,200	29,100	99% KM (Chebyshev) UCL
Groundwater	Metals	Total	Mercury	N/A	ug/L	24	4	0.148	0.115	0.330	0.0496	0.0676	0.0769	95% KM (t) UCL
Groundwater	Metals	Total	Thallium	N/A	ug/L	19	9	0.202	0.197	0.323	0.202	0.0582	0.238	95% KM (t) UCL
Groundwater	Metals	Total	Zinc	N/A	ug/L	19	15	416	23.7	2,660	329	736	2,070	99% KM (Chebyshev) UCL
Groundwater	Metals	Dissolved	Iron	N/A	ug/L	36	25	14,100	18,800	35,400	9,800	12,600	31,000	99% KM (Chebyshev) UCL
Groundwater	SVOCs	Total	Di-n-octyl Phthalate	N/A	ug/L	23	3	5.07	5.29	7.08	3.59	1.45	4.61	95% KM (t) UCL
Groundwater	SVOCs	Total	Naphthalene	N/A	ug/L	23	3	0.0993	0.101	0.157	0.0598	0.0393	0.0873	95% KM (t) UCL
Groundwater	VOCs	Total	1,2,4-Trimethylbenzene	N/A	ug/L	22	2	3.10	3.10	5.20	1.19	0.875	-	-
Groundwater	VOCs	Total	Acetone	N/A	ug/L	22	4	13.2	14.6	15.4	9.27	2.22	10.2	95% KM (t) UCL
Groundwater	VOCs	Total	Chloroform	N/A	ug/L	56	8	1.59	1.19	3.70	0.320	0.739	0.498	95% KM (t) UCL
Groundwater	VOCs	Total	Isopropylbenzene	N/A	ug/L	22	2	3.90	3.90	4.60	3.26	0.292	3.42	95% KM (t) UCL
Groundwater	VOCs	Total	n-Propylbenzene	N/A	ug/L	22	2	1.60	1.60	2.00	1.24	0.167	1.32	95% KM (t) UCL
Groundwater	VOCs	Total	Tetrachloroethene (PCE)	N/A	ug/L	56	13	4.18	4.80	8.78	1.15	2.08	2.80	95% KM (Percentile Bootstrap) UCL
Groundwater	VOCs	Total	Vinyl Chloride	N/A	ug/L	56	16	0.404	0.335	0.955	0.257	0.189	0.307	95% KM (t) UCL

Notes
Only those analytes with at least two detected results are shown on this table.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.
The potentially mass wasting soil subset is comprised of the following samples: BIL01USE through BIL09USE, BIL13SSI, and L-01 through L-04.

% = percent
KM = Kaplan-Meier
MDL = method detection limit
N/A = not applicable
ND = non-detect
SD = standard deviation
SVOC = semi-volatile organic carbon
ug/L = micrograms per liter
UCL = upper confidence limit
VOC = volatile organic carbon

Table 1-8
Statistical Summary for Groundwater - Sandblast Area AOPC

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Sieve Size	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	Statistics - ND censored at the MDL			
												KM-Mean	KM-SD	Final 95% UCL	UCL Type
DP Groundwater	Metals	Total	Vanadium	N/A	N/A	ug/L	10	10	20.3	7.32	77.6	-	-	47.0	95% Approximate Gamma UCL
DP Groundwater	Metals	Dissolved	Vanadium	N/A	N/A	ug/L	10	6	1.35	1.24	2.61	1.24	0.648	1.74	95% KM (t) UCL
DP Groundwater	VOCs	Total	1,1,1-Trichloroethane (TCA)	N/A	N/A	ug/L	10	7	0.467	0.127	2.22	0.348	0.638	1.71	97.5% KM (Chebyshev) UCL
DP Groundwater	VOCs	Total	1,1-Dichloroethane	N/A	N/A	ug/L	10	5	0.604	0.173	2.52	0.330	0.730	0.876	95% KM (BCA) UCL
DP Groundwater	VOCs	Total	1,1-Dichloroethene	N/A	N/A	ug/L	10	2	0.614	0.614	1.16	0.173	0.331	1.64	99% KM (Chebyshev) UCL
DP Groundwater	VOCs	Total	1,2,4-Trimethylbenzene	N/A	N/A	ug/L	10	3	0.0406	0.0415	0.0485	0.0344	0.00555	0.0383	95% KM (t) UCL
DP Groundwater	VOCs	Total	2,2-Dichloropropane	N/A	N/A	ug/L	10	3	0.142	0.130	0.179	0.125	0.0186	0.138	95% KM (t) UCL
DP Groundwater	VOCs	Total	Acetone	N/A	N/A	ug/L	10	3	2.23	1.59	3.88	1.52	0.793	2.09	95% KM (t) UCL
DP Groundwater	VOCs	Total	Benzene	N/A	N/A	ug/L	10	6	0.0744	0.0600	0.137	0.0664	0.0247	0.0821	95% KM (t) UCL
DP Groundwater	VOCs	Total	Chloroform	N/A	N/A	ug/L	10	2	0.132	0.132	0.174	0.0990	0.0250	0.119	95% KM (t) UCL
DP Groundwater	VOCs	Total	cis-1,2-Dichloroethene	N/A	N/A	ug/L	10	9	57.3	4.54	341	51.6	106	206	95% KM (Chebyshev) UCL
DP Groundwater	VOCs	Total	Ethylbenzene	N/A	N/A	ug/L	10	4	0.0402	0.0402	0.0447	0.0377	0.00307	0.0399	95% KM (t) UCL
DP Groundwater	VOCs	Total	m,p-Xylenes	N/A	N/A	ug/L	10	4	0.119	0.132	0.132	0.0971	0.0226	0.112	95% KM (t) UCL
DP Groundwater	VOCs	Total	Naphthalene	N/A	N/A	ug/L	10	2	0.0406	0.0406	0.0452	0.0375	0.00347	0.0411	95% KM (t) UCL
DP Groundwater	VOCs	Total	o-Xylene	N/A	N/A	ug/L	10	4	0.0507	0.0495	0.0735	0.0385	0.0139	0.0478	95% KM (t) UCL
DP Groundwater	VOCs	Total	Tetrachloroethene (PCE)	N/A	N/A	ug/L	10	10	7.80	1.45	54.5	-	-	27.6	95% Adjusted Gamma UCL
DP Groundwater	VOCs	Total	Toluene	N/A	N/A	ug/L	10	6	0.205	0.199	0.299	0.189	0.0787	0.249	95% KM (t) UCL
DP Groundwater	VOCs	Total	trans-1,2-Dichloroethene	N/A	N/A	ug/L	10	3	0.995	1.09	1.80	0.365	0.563	0.765	95% KM (t) UCL
DP Groundwater	VOCs	Total	Trichloroethene (TCE)	N/A	N/A	ug/L	10	9	5.83	0.597	43.7	5.26	12.8	48.1	99% KM (Chebyshev) UCL
DP Groundwater	VOCs	Total	Vinyl Chloride	N/A	N/A	ug/L	10	2	0.372	0.372	0.611	0.180	0.144	-	-

Notes
Only those analytes with at least two detected results are shown on this table.
If not all samples were detected results (i.e., detection rate = <100%), the mean and standard deviation were estimated by the Kaplan-Meier method.
The erodible soil subset is comprised of the following samples: SB-EUA, SB-EUB, SB-EUA-02, SB-EUA-04, SB-EUA-06, SB-EUA-08, SB-EUB-02, SB-EUB-03, SB-EUB-12, SB-EUB-15, and SB-04.

% = percent
DP = Direct Push
KM = Kaplan-Meier
MDL = method detection limit
N/A = not applicable
ND = non-detect
SD = standard deviation
SVOC = semi-volatile organic carbon
ug/L = micrograms per liter
UCL = upper confidence limit
VOC = volatile organic carbon

Table 1-9
Statistical Summary for Reference Area Samples

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	UPL Distribution	UPL 95% UPL
Soil	Metals	Total	Aluminum	0-1 ft	mg/kg	14	14	22,700	22,000	33,200	Normal	31400
Soil	Metals	Total	Antimony	0-1 ft	mg/kg	14	14	0.128	0.130	0.180	Normal	0.176
Soil	Metals	Total	Arsenic	0-1 ft	mg/kg	14	14	3.10	3.22	5.18	Normal	5.40
Soil	Metals	Total	Barium	0-1 ft	mg/kg	14	14	110	105	182	Normal	169
Soil	Metals	Total	Beryllium	0-1 ft	mg/kg	14	14	0.491	0.498	0.629	Normal	0.659
Soil	Metals	Total	Cadmium	0-1 ft	mg/kg	14	14	0.162	0.156	0.340	Gamma	0.271
Soil	Metals	Total	Chromium	0-1 ft	mg/kg	14	14	21.8	21.8	27.3	Normal	28.1
Soil	Metals	Total	Cobalt	0-1 ft	mg/kg	14	14	16.5	17.4	19.9	Non-parametric	19.9
Soil	Metals	Total	Copper	0-1 ft	mg/kg	14	14	39.0	36.6	58.2	Normal	56.7
Soil	Metals	Total	Lead	0-1 ft	mg/kg	14	14	17.7	16.4	26.5	Normal	25.5
Soil	Metals	Total	Manganese	0-1 ft	mg/kg	14	14	627	624	920	Normal	885
Soil	Metals	Total	Mercury	0-1 ft	mg/kg	14	14	0.0494	0.0480	0.0680	Normal	0.0660
Soil	Metals	Total	Nickel	0-1 ft	mg/kg	14	14	18.7	19.2	26.1	Normal	26.5
Soil	Metals	Total	Selenium	0-1 ft	mg/kg	14	0	-	-	-	Non-parametric	0.500
Soil	Metals	Total	Silver	0-1 ft	mg/kg	14	12	0.0635	0.0483	0.187	Non-parametric	0.187
Soil	Metals	Total	Thallium	0-1 ft	mg/kg	14	8	0.158	0.150	0.203	Non-parametric	0.203
Soil	Metals	Total	Vanadium	0-1 ft	mg/kg	14	14	78.8	80.2	99.3	Normal	104
Soil	Metals	Total	Zinc	0-1 ft	mg/kg	14	14	58.8	57.6	68.5	Normal	71.7
Soil	SVOCs	Total	Acenaphthene	0-1 ft	ug/kg	14	9	1.75	1.60	3.40	Non-parametric	3.40
Soil	SVOCs	Total	Acenaphthylene	0-1 ft	ug/kg	14	1	-	-	1.60	Non-parametric	1.60
Soil	SVOCs	Total	Anthracene	0-1 ft	ug/kg	14	12	2.47	2.05	4.90	Non-parametric	4.90
Soil	SVOCs	Total	Fluorene	0-1 ft	ug/kg	14	1	-	-	3.20	Non-parametric	3.20
Soil	SVOCs	Total	Naphthalene	0-1 ft	ug/kg	14	6	1.70	1.65	2.20	Gamma	29.4
Soil	SVOCs	Total	Phenanthrene	0-1 ft	ug/kg	14	14	13.2	12.0	34.0	Non-parametric	2.20
Soil	SVOCs	Total	Total LPAHs (KM, capped; NDs at MDL)	0-1 ft	ug/kg	14	14	21.2	19.8	49.3	Non-parametric	49.3
Soil	SVOCs	Total	Benzo(a)anthracene	0-1 ft	ug/kg	14	14	14.0	12.5	34.0	Gamma	28.7
Soil	SVOCs	Total	Benzo(a)pyrene	0-1 ft	ug/kg	14	14	18.2	16.0	45.0	Gamma	37.0
Soil	SVOCs	Total	Benzo(b)fluoranthene	0-1 ft	ug/kg	14	14	23.4	21.0	55.0	Gamma	46.4
Soil	SVOCs	Total	Benzo(g,h,i)perylene	0-1 ft	ug/kg	14	14	13.7	12.5	32.0	Gamma	26.5
Soil	SVOCs	Total	Benzo(k)fluoranthene	0-1 ft	ug/kg	14	14	8.00	7.45	19.0	Gamma	16.2
Soil	SVOCs	Total	Chrysene	0-1 ft	ug/kg	14	14	18.3	16.0	45.0	Gamma	37.4
Soil	SVOCs	Total	Dibenz(a,h)anthracene	0-1 ft	ug/kg	14	7	4.36	4.30	6.90	Non-parametric	6.90
Soil	SVOCs	Total	Fluoranthene	0-1 ft	ug/kg	14	14	27.0	24.0	66.0	Gamma	55.1
Soil	SVOCs	Total	Indeno(1,2,3-cd)pyrene	0-1 ft	ug/kg	14	14	14.1	12.0	34.0	Gamma	27.0
Soil	SVOCs	Total	Pyrene	0-1 ft	ug/kg	14	14	26.8	25.0	64.0	Gamma	53.3
Soil	SVOCs	Total	cPAHs as BaPEQ (KM-capped, MDL-based)	0-1 ft	ug/kg	14	14	26.0	22.7	64.8	95% UPL (t)	51.6
Soil	SVOCs	Total	Total HPAHs (KM, capped; NDs at MDL)	0-1 ft	ug/kg	14	14	167	147	401	Non-parametric	401
Groundwater	Metals	Total	Aluminum	N/A	ug/L	4	4	110	111	210	-	-
Groundwater	Metals	Total	Antimony	N/A	ug/L	4	4	0.0515	0.0505	0.0800	-	-
Groundwater	Metals	Total	Arsenic	N/A	ug/L	4	3	1.50	1.60	1.68	-	-

Table 1-9
Statistical Summary for Reference Area Samples

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	UPL Distribution	UPL 95% UPL
Groundwater	Metals	Total	Barium	N/A	ug/L	4	4	20.8	19.6	26.5	-	-
Groundwater	Metals	Total	Beryllium	N/A	ug/L	4	1	0.0100	0.0100	0.0100	-	-
Groundwater	Metals	Total	Cadmium	N/A	ug/L	4	1	0.0490	0.0490	0.0490	-	-
Groundwater	Metals	Total	Calcium	N/A	ug/L	4	4	30,000	30,000	31,000	-	-
Groundwater	Metals	Total	Chromium	N/A	ug/L	4	3	1.44	0.210	3.98	-	-
Groundwater	Metals	Total	Cobalt	N/A	ug/L	4	4	0.215	0.233	0.323	-	-
Groundwater	Metals	Total	Copper	N/A	ug/L	4	3	0.502	0.260	1.12	-	-
Groundwater	Metals	Total	Iron	N/A	ug/L	4	2	284	284	451	-	-
Groundwater	Metals	Total	Lead	N/A	ug/L	4	3	0.160	0.130	0.248	-	-
Groundwater	Metals	Total	Magnesium	N/A	ug/L	4	4	7,950	7,920	8,320	-	-
Groundwater	Metals	Total	Manganese	N/A	ug/L	4	4	229	226	258	-	-
Groundwater	Metals	Total	Mercury	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Total	Nickel	N/A	ug/L	4	3	2.75	1.07	6.62	-	-
Groundwater	Metals	Total	Potassium	N/A	ug/L	4	4	4,850	4,870	4,960	-	-
Groundwater	Metals	Total	Selenium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Total	Silver	N/A	ug/L	4	1	0.00900	0.00900	0.00900	-	-
Groundwater	Metals	Total	Sodium	N/A	ug/L	4	4	5,210	5,140	5,620	-	-
Groundwater	Metals	Total	Thallium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Total	Vanadium	N/A	ug/L	4	3	0.682	0.320	1.55	-	-
Groundwater	Metals	Total	Zinc	N/A	ug/L	4	4	4.61	4.20	8.28	-	-
Groundwater	Metals	Dissolved	Aluminum	N/A	ug/L	4	4	2.30	2.30	2.60	-	-
Groundwater	Metals	Dissolved	Antimony	N/A	ug/L	4	2	0.0320	0.0320	0.0500	-	-
Groundwater	Metals	Dissolved	Arsenic	N/A	ug/L	4	4	1.37	1.39	1.55	-	-
Groundwater	Metals	Dissolved	Barium	N/A	ug/L	4	4	18.7	18.4	22.8	-	-
Groundwater	Metals	Dissolved	Beryllium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Dissolved	Cadmium	N/A	ug/L	4	2	0.0368	0.0368	0.0425	-	-
Groundwater	Metals	Dissolved	Calcium	N/A	ug/L	4	4	29,700	29,800	30,100	-	-
Groundwater	Metals	Dissolved	Chromium	N/A	ug/L	4	4	0.163	0.150	0.290	-	-
Groundwater	Metals	Dissolved	Cobalt	N/A	ug/L	4	3	0.103	0.109	0.139	-	-
Groundwater	Metals	Dissolved	Copper	N/A	ug/L	4	3	0.163	0.0950	0.315	-	-
Groundwater	Metals	Dissolved	Iron	N/A	ug/L	4	3	15.1	10.7	24.8	-	-
Groundwater	Metals	Dissolved	Lead	N/A	ug/L	4	2	0.0140	0.0140	0.0220	-	-
Groundwater	Metals	Dissolved	Magnesium	N/A	ug/L	4	4	7,690	7,660	8,080	-	-
Groundwater	Metals	Dissolved	Manganese	N/A	ug/L	4	4	207	208	228	-	-
Groundwater	Metals	Dissolved	Mercury	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Dissolved	Nickel	N/A	ug/L	4	3	1.05	1.07	1.41	-	-
Groundwater	Metals	Dissolved	Potassium	N/A	ug/L	4	4	4,780	4,780	4,880	-	-
Groundwater	Metals	Dissolved	Selenium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Dissolved	Silver	N/A	ug/L	4	1	0.117	0.117	0.117	-	-
Groundwater	Metals	Dissolved	Sodium	N/A	ug/L	4	3	4,890	4,880	4,980	-	-

Table 1-9
Statistical Summary for Reference Area Samples

Medium	Analyte Group	Total/ Dissolved	Analyte	Depth Category	Unit	Number of Samples	Number of Detections	Mean of Detects	Median of Detects	Maximum Detected Value	UPL Distribution	UPL 95% UPL
Groundwater	Metals	Dissolved	Thallium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Dissolved	Vanadium	N/A	ug/L	4	0	-	-	-	-	-
Groundwater	Metals	Dissolved	Zinc	N/A	ug/L	4	3	1.86	1.30	3.14	-	-
Groundwater	Butyltins	Total	Dibutyltin	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	Butyltins	Total	Monobutyltin	N/A	ug/L	1	1	0.0345	0.0345	0.0345	-	-
Groundwater	NWTPH-Dx	Total	Diesel Range Organics	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	NWTPH-Dx	Total	Residual Range Organics	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	NWTPH-Gx	Total	Gasoline Range Organics	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	SVOCs	Total	1,4-Dichlorobenzene	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	SVOCs	Total	4-Nitrophenol	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	SVOCs	Total	Benzo(b)fluoranthene	N/A	ug/L	1	1	0.0250	0.0250	0.0250	-	-
Groundwater	SVOCs	Total	Benzo(k)fluoranthene	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	SVOCs	Total	Phenanthrene	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	SVOCs	Total	Phenol	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	VOCs	Total	Chloroform	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	VOCs	Total	Tetrachloroethene (PCE)	N/A	ug/L	1	0	-	-	-	-	-
Groundwater	VOCs	Total	Vinyl Chloride	N/A	ug/L	1	0	-	-	-	-	-

Notes
For soil, analytes with less than 100% detection rate, but at least one detection, the maximum detected value was assessed as the non-parametric UPL.
For soil, analytes with no detections (0% detection rate), the maximum MDL is shown as the non-paramentric UPL.
UPLs were not calculated when less than 8 samples were available (i.e., no groundwater UPLs).

- = not available/applicable
BaPEQ = benzo(a)pyrene equivalent(s)
cPAH = carcinogenic polycyclic aromatic hydrocarbon
ft = foot or feet
HPAH = high molecular weight polycyclic aromatic hydrocarbon
KM = Kaplan-Meier
LPAH = low molecular weight polycyclic aromatic hydrocarbon
MDL = method detection limit
mg/kg = milligrams per kilogram
ND = non-detect
NWTPH-Dx = northwest total petroleum hydrocarbon-diesel-extended
NWTPH-Gx =northwest total petroleum hydrocarbon-gasoline-extended
SVOC = semi-volatile organic carbon
ug/kg = micrograms per kilogram
ug/L = micrograms per liter
UPL = upper prediction limit
VOC = volatile organic carbon

Table 2-1

Hypothetical Fishing Platform User: COPC Selection - Landfill AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
INORGANICS (mg/kg)							
Antimony	n	27%	1.48	30		0.050	No
Arsenic	c	100%	10.5	0.64		**16**	Yes (Csoil > SLV)
Cadmium	c	74%	1.17	67		0.017	No
Chromium	c	100%	594	0.288	**	**2,065**	Yes (Csoil > SLV)
Lead	n	100%	511	384		**1.3**	Yes (Pb Special Case)
Mercury	n	80%	1.45	9		0.16	Yes (NC>0.1)
Silver	n	39%	0.450	374		0.0012	No
Zinc	n	100%	417	22,057		0.019	No
BUTYLTINS (ug/kg)							
Dibutyltin	n	22%	20.1	15,344		0.0013	No
Monobutyltin	n	22%	38.0	15,344	bo	0.0025	No
Tributyltin	n	44%	60.1	15,344		0.0039	No
PESTICIDES (ug/kg)							
4,4'-DDT	c	30%	11.8	1,822		0.0065	No
Chlordane (technical)	c	100%	1,560	1,726		0.90	No
Heptachlor	c	9%	2.86	115		0.025	No
PCBs (ug/kg)							
Aroclor 1248	c	7%	364	230		**1.6**	No (see Total PCB)
Aroclor 1254	c	38%	31.1	230		0.14	No
Aroclor 1260	c	83%	190	230		0.83	No
Total PCBs (Aroclors)	c	55%	410	230		**1.8**	Yes (Csoil > SLV)
HERBICIDES (ug/kg)							
2,4,5-T	n	14%	70.3	594,580		0.00012	No
Dichloroprop	n	14%	174	469,910	br	0.00037	No
MCPP	n	14%	11,200	59,458		0.19	Yes (NC>0.1)
VOCs (ug/kg)							
1,2,4-Trimethylbenzene	n	15%	2,790	55,622		0.050	No
1,3,5-Trimethylbenzene	n	15%	1,110	748,020		0.0015	No
Naphthalene	c	15%	3,830	3,644		**1.1**	Yes (Csoil > SLV)
Tetrachloroethene (PCE)	c	58%	16.5	23,016		7.2E-04	No
Toluene	n	42%	1.64	4,699,100		3.5E-07	No
SVOCs (ug/kg)							
Benzoic Acid	n	36%	218	239,750,000		9.09E-07	No
Bis(2-ethylhexyl) Phthalate	c	90%	6,380	36,442		0.18	No
Butyl Benzyl Phthalate	c	11%	34.9	268,520		0.00013	No
Carbazole	c	72%	964	69,048		0.014	No
Dibenzofuran	n	45%	164	69,048	bs	0.0024	No

Table 2-1

Hypothetical Fishing Platform User: COPC Selection - Landfill AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
Diethyl Phthalate	n	18%	38.9	46,991,000		8.3E-07	No
Di-n-butyl Phthalate	n	14%	217	5,945,800		3.6E-05	No
Pentachlorophenol	c	7%	98.8	949		0.10	No
PAHs (ug/kg)							
2-Methylnaphthalene	n	31%	199	220,570		0.00090	No
Acenaphthene	n	76%	913	3,356,500		0.00027	No
Acenaphthylene	n	39%	34.9	3,644	g	0.00958	No
Anthracene	n	88%	1,930	16,303,000		0.00012	No
Benzo(a)anthracene	c	94%	9,960	144		**69**	Yes (Csoil > SLV)
Benzo(a)pyrene	c	94%	11,200	14		**779**	Yes (Csoil > SLV)
Benzo(b)fluoranthene	c	96%	15,200	144		**106**	Yes (Csoil > SLV)
Benzo(g,h,i)perylene	c	91%	5,820	1,439	b	**4.0**	Yes (Csoil > SLV)
Benzo(k)fluoranthene	c	96%	26,300	1,439		**18**	Yes (Csoil > SLV)
Benzofluoranthenes, Total	c	100%	31,300	144	bx	**218**	Yes (Csoil > SLV)
Chrysene	c	97%	11,000	14,385		0.76	No
Dibenz(a,h)anthracene	c	85%	2,060	14		**143**	Yes (Csoil > SLV)
Fluoranthene	n	94%	17,500	2,205,700		0.0079	No
Fluorene	n	67%	324	2,205,700		1.5E-04	No
Indeno(1,2,3-cd)pyrene	c	91%	6,800	144		**47**	Yes (Csoil > SLV)
Naphthalene	c	52%	157	3,644		0.043	No
Phenanthrene	n	97%	5,780	16,303,000	bt	0.00035	No
Pyrene	n	97%	18,800	1,630,300		0.012	No
TPH (mg/kg)							
Diesel Range Organics	n	95%	1,000	1,100	x3	0.91	No***
Gasoline Range Organics	n	27%	157	1,200	x3	0.13	No***
Residual Range Organics	n	95%	9,450	2,800	x3	**3.4**	No***

Table 2-2
Hypothetical Fishing Platform User: COPC Selection - Sandblast Area AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
INORGANICS (mg/kg)							
Antimony	n	73%	2.42	30		0.081	No
Arsenic	c	99%	9.71	0.64		**15**	Yes (Csoil > SLV)
Cadmium	c	89%	2.63	67		0.039	No
Chromium	c	100%	579	0.288	**	**2013**	Yes (Csoil > SLV)
Lead - sieved <250um, 0-3 ft bgs	n	100%	418	400		1.0	Yes (Pb Special Case)
Lead - sieved <2mm, 0-3 ft bgs	n	100%	303	400		0.76	Yes (Pb Special Case)
Lead - unsieved, 0-3 ft bgs	n	100%	529	400		**1.3**	Yes (Pb Special Case)
Lead - sieved <250um, 0-1 ft bgs	n	100%	921	400		**2.3**	Yes (Pb Special Case)
Lead - sieved <2mm, 0-1 ft bgs	n	100%	768	400		**1.9**	Yes (Pb Special Case)
Lead - unsieved, 0-1 ft bgs	n	100%	3,260	400		**8.2**	Yes (Pb Special Case)
Nickel	c	100%	251	1,439		**0.17**	Yes (NC > 0.1)
Selenium	n	57%	0.479	374		0.0013	No
Silver	n	96%	0.152	374		0.00041	No
Zinc	n	100%	237	22,057		0.011	No
BUTYLTINS (ug/kg)							
Dibutyltin	n	29%	26.6	15,344		0.0017	No
Monobutyltin	n	36%	8.62	15,344	bo	0.00056	No
Tributyltin	n	26%	248	15,344		0.016	No
PESTICIDES (ug/kg)							
4,4'-DDD	c	5.4%	0.721	2,110		0.00034	No
4,4'-DDE	c	19%	0.567	1,534		0.00037	No
4,4'-DDT	c	60%	79.4	1,822		0.044	No
BHC (delta)	n	5.4%	1.30	82	c	0.016	No
BHC (gamma) Lindane	c	8%	1.06	537		0.0020	No
Chlordane (alpha)	c	12%	0.776	1,726	d	0.00045	No
Chlordane (gamma)	c	40%	20.4	1,726	d	0.012	No
Dieldrin	c	5.4%	0.483	32		0.015	No
Endosulfan I	n	14%	0.809	354,830	f	2.3E-06	No
Endosulfan II	n	8%	0.447	354,830	f	1.3E-06	No
Endosulfan Sulfate	n	16%	0.889	354,830	f	2.5E-06	No
Endrin	n	11%	3.89	17,262		0.00023	No
Endrin Aldehyde	n	14%	3.44	17,262	t	0.00020	No
Endrin Ketone	n	11%	2.88	17,262	t	0.00017	No
Heptachlor	c	11%	0.415	115		0.0036	No
Methoxychlor	n	5.4%	1.04	297,290		3.5E-06	No
PCBs (ug/kg)							
Aroclor 1254	c	14%	136	230		0.59	No
Aroclor 1260	c	84%	167	230		0.73	No
Total PCBs (Aroclors)	c	84%	419	230		**1.8**	Yes (Csoil > SLV)

Table 2-2
Hypothetical Fishing Platform User: COPC Selection - Sandblast Area AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
VOCs (ug/kg)							
1,2,4-Trimethylbenzene	n	46%	4,620	55,622		0.083	No
1,3,5-Trimethylbenzene	n	17%	1,630	748,020		0.0022	No
2-Butanone (MEK)	n	41%	13.3	25,893,000		5.1E-07	No
2-Hexanone	n	7%	5.12	191,800		2.7E-05	No
4-Isopropyltoluene	n	37%	20.1	1,822,100		1.1E-05	No
4-Methyl-2-pentanone (MIBK)	n	20%	0.525	5,082,700		1.0E-07	No
Acetone	n	50%	122	58,499,000		2.1E-06	No
Benzene	c	37%	0.463	1,151		0.00040	No
Bromomethane	n	17%	1.11	6,521		0.00017	No
Carbon Disulfide	n	52%	1.12	738,430		1.5E-06	No
Chloroform	c	7%	5.70	307		0.019	No
cis-1,2-Dichloroethene	n	4%	120	153,440		0.00078	No
Dichlorodifluoromethane	n	9%	6.74	83,433		8.1E-05	No
Dichloromethane (Methylene Chloride)	c	37%	56.0	54,663		1.0E-03	No
Ethylbenzene	c	22%	4.69	5,562		8.4E-04	No
m,p-Xylenes	n	24%	1,820	527,450	x2	3.5E-03	No
Naphthalene	c	24%	1.94	3,644		5.3E-04	No
n-Propylbenzene	n	7%	35.5	3,164,700		1.1E-05	No
o-Xylene	n	11%	200	623,350	x1	3.2E-04	No
Tetrachloroethene (PCE)	c	11%	26,300	23,016		**1.1**	Yes (Csoil > SLV)
Toluene	n	57%	9,360	4,699,100		0.0020	No
trans-1,2-Dichloroethene	n	2%	2.28	1,534,400		1.5E-06	No
Trichloroethene (TCE)	c	15%	1,780	901		**2.0**	Yes (Csoil > SLV)
SVOCs (ug/kg)							
Benzoic Acid	n	31%	132	239,750,000		5.5E-07	No
Bis(2-ethylhexyl)Phthalate	c	73%	77,100	36,442		**2.12**	Yes (Csoil > SLV)
Butyl Benzyl Phthalate	c	15%	15.2	268,520		5.7E-05	No
Carbazole	c	62%	112	69,048	bs	0.0016	No
Dibenzofuran	n	60%	122	69,048		0.0018	No
Dimethyl Phthalate	n	8%	31.0	36,442	l	0.00085	No
Di-n-butyl Phthalate	n	36%	54.3	5,945,800		9.1E-06	No
Di-n-octyl Phthalate	n	15%	22.5	36,442	l	0.00062	No
Pentachlorophenol	c	5.1%	13.3	949		0.014	No
Phenol	n	13%	35.0	17,262,000		2.0E-06	No
PAHs (ug/kg)							
2-Methylnaphthalene	n	45%	23.9	220,570		0.00011	No
Acenaphthene	n	78%	652	3,356,500		0.00019	No
Acenaphthylene	n	40%	29.6	3,644	g	0.0081	No
Anthracene	n	88%	772	16,303,000		0.000047	No

Table 2-2
Hypothetical Fishing Platform User: COPC Selection - Sandblast Area AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
Benzo(a)anthracene	c	88%	2,450	144		**17**	Yes (Csoil > SLV)
Benzo(a)pyrene	c	90%	2,390	14		**166**	Yes (Csoil > SLV)
Benzo(b)fluoranthene	c	94%	2,210	144		**15**	Yes (Csoil > SLV)
Benzo(g,h,i)perylene	c	83%	1,050	14	b	**72.99**	Yes (Csoil > SLV)
Benzo(k)fluoranthene	c	94%	764	1,439		0.53	No
Benzofluoranthenes, Total	c	91%	10,600	144	bx	**74**	Yes (Csoil > SLV)
Chrysene	c	93%	4,590	14,385		0.32	No
Dibenz(a,h)anthracene	c	65%	238	14		**17**	Yes (Csoil > SLV)
Fluoranthene	n	93%	10,800	2,205,700		0.0049	No
Fluorene	n	70%	227	2,205,700		0.00010	No
Indeno(1,2,3-cd)pyrene	c	88%	1,160	144		**8.1**	Yes (Csoil > SLV)
Naphthalene	c	60%	81.4	3,644		0.022	No
Phenanthrene	n	95%	2,910	16,303,000	bt	0.00018	No
Pyrene	n	95%	11,700	1,630,300		0.0072	No
TPH (mg/kg)							
Diesel Range Organics	n	85%	266	1,100	x3	0.24	No***
Gasoline Range Organics	n	23%	1,030	1,200	x3	0.86	No***
Residual Range Organics	n	89%	577	2,800	x3	0.21	No***

Table 2-3

Hypothetical Fishing Platform User: COPC Selection - Pistol Range AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
SURFACE SOIL (0-1.5 ft bgs): INORGANICS (mg/kg)							
Lead	n	100%	365	400		0.91	Yes (Pb Special Case)
Nickel	n	100%	25.9	1438.5		0.018	No
Zinc	n	100%	148	22057		0.0067	No
SEDIMENT: INORGANICS (mg/kg)							
Copper	n	100%	25.4	3100		0.008	No
Lead	n	100%	33.0	400		0.083	Yes (Pb Special Case)
Nickel	c	100%	15.4	820		0.019	No
Zinc	n	100%	174	23000		0.0076	No

Table 2-4
Hypothetical Fishing Platform User: COPC Selection - Bulb Slope AOPC

Chemicals of Interest	note	Detection Rate	Lower of the Maximum and 95% UCL	Modified* Residential RSLs (USEPA) SLV	note	Screen Result $\frac{C_{soil}}{SLV_{RSL}}$	COPC: Yes / No (Selection Rationale)
INORGANICS (mg/kg)							
Lead	n	100%	307	400		0.77	Yes (Pb Special Case)
Mercury	n	100%	0.720	9		0.080	No
PCBs (ug/kg)							
Aroclor 1260	c	67%	108	230		0.47	No
Total PCBs (Aroclors)	c	67%	104	230		0.45	No
TPH (mg/kg)							
Diesel Range Organics	n	100%	102	1,100		0.093	No
Residual Range Organics	n	100%	232	2,800		0.083	No

Table 2-5
Hypothetical Fishing Platform User: Summary of COPCs in Soil

COPCs For Fishing Platform Scenario			
Landfill AOPC	**Sandblast Area AOPC**	**Pistol Range AOPC**	**Bulb Slope AOPC**
INORGANICS	**INORGANICS**	**SURFACE SOIL INORGANICS**	**INORGANICS**
Arsenic	Arsenic	Lead	Lead
Chromium	Chromium		
Lead	Lead	**SEDIMENT INORGANICS**	
Mercury	Nickel	Lead	
PCBs	**PCBs**		
Total PCBs (Aroclors)	Total PCBs (Aroclors)		
VOCs	**VOCs**		
Naphthalene	Tetrachloroethene (PCE)		
Pesticides	Trichloroethene (TCE)		
MCPP	**SVOCs**		
PAHs	Bis(2-ethylhexyl)Phthalate		
Benzo(a)anthracene	**PAHs**		
Benzo(a)pyrene	Benzo(a)anthracene		
Benzo(b)fluoranthene	Benzo(a)pyrene		
Benzo(g,h,i)perylene	Benzo(b)fluoranthene		
Benzo(k)fluoranthene	Benzo(g,h,i)perylene		
Benzofluoranthenes, Total	Benzofluoranthenes, Total		
Dibenz(a,h)anthracene	Dibenz(a,h)anthracene		
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene		

Notes
AOPC = area of potential concern
COPCs = chemicals of potential concern
PAHs = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyl
SVOCs = semi-volatile organic compounds
VOCs = volatile organic compounds

Table 2-6
Nursing Infant Pathway: Soil Screening

Analyte (a)	Exposure Point Concentrations in Soil (mg/kg) (b)						Residential (Hypothetical Fishing Platform User)			Commercial (Occupational Exposure)		
	Landfill AOPC		Sandblast Area AOPC		Bulb Slope AOPC		Residential RSL (mg/kg)	ODEQ IRAF (c)	Modified Nursing Infant RSL (Noncancer) mg/kg	Commercial/Industrial RSL (mg/kg)	DEQ IRAF (c)	Modified Nursing Infant RSL (Noncancer) mg/kg
	0-3 ft bgs	0-10 ft bgs	0-3 ft bgs	0-10 ft bgs	0-3 ft bgs	0-10 ft bgs	Noncancer	Residential Noncancer		Noncancer	Non-Residential Noncancer	
Total PCBs (As Aroclors)	0.4	0.28	0.419	0.419	0.10	--	1.2	4	0.3	15	25	0.6
DDx	0.012	0.01	0.08	0.079	--	--	37	0.3	123	520	2	260

Notes

Shading represents a soil concentration exceeding a modified RSL.

RSLs are modified using the following equation: RSL / IRAF = modified Nursing Infant RSL.

-- = not applicable

AOPC = area of potential concern

DDD = dichloro-diphenyl-dichloroethane

DDE = dichloro-diphenyl-dichloroethylene

DDT = dichloro-diphenyl-trichloroethane

DDx = sum of DDD, DDE, and DDT

EPC = exposure point concentration

ft bgs = feet below ground surface

mg/kg = milligram per kilogram

ODEQ IRAF = Oregon Department of Environmental Quality Infant Risk Adjustment Factor

PCBs = polychlorinated biphenyls

RI = Remedial Investigation

RSL= regional screening levels (USEPA 2015)

UCL = upper confidence limit

(a) - ODEQ (2010) lists bioaccumulative compounds IRAFs, of which PCBs and DDx (DDT, DDE, DDD) are relevant for this report. Only noncancer is presented as it is the endpoint that may result in higher health hazard to the nursing infant than the mother. These analytes were not detected in the Pistol Range AOPC and therefore not evaluated. See Section 2.1.

(b) - Soil concentrations are lower of maximum and 95% UCLs (EPCs). See Appendix M of the RI (URS 2012)

(c) - From Table D-3, ODEQ (2010)

Sources

ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.

URS. 2012. Upland and River Operable Units Remedial Investigation Report. June.

USEPA. 2015. Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites. RSL Table Update. May.

Table 2-7a
Occupational Worker: Exposure Factors

Reasonable Maximum Exposure (RME)

Exposure Factors	Abbreviations	Units	Indoor Worker (IW)	Outdoor Maintenance Worker (OW)	Construction Worker (CW)	Excavation / Trench Worker	References
Averaging Time, Carcinogens	ATc	yrs	70	70	70	70	USEPA 2015
Averaging Time, Noncarcinogens, adult	ATnc,a	yrs	25	25	1	1	USEPA 2015
Body Weight, adult	BW_{adult}	kg	80	80	80	80	USEPA 2015
Exposure Duration	ED_w	yrs	25	25	1	1	USEPA 2015
Exposure Frequency	EF_w	days/yr	250	225	250	9 (a)	USEPA 2015
Exposure Time	ET_w	hours/day	8	8	8	4 (b)	USEPA 2015
Event Frequency (contact with groundwater)	EV_w	events/day	NA	NA	NA	2 (b)	Professional Judgement
Event Time (contact with groundwater)	t_{event}	hr/event	NA	NA	NA	2 (b)	Professional Judgement
Soil Ingestion Rate	$IR_{soil,w}$	mg/day	NA	100	330	NA	USEPA 2015
Particulate Emission Factor (non-VOCs), Salem, Oregon	PEF	m^3/kg	NA	$1.36 \times 10^{+09}$	$1.0 \times 10^{+06}$	NA	USEPA 2015; DTSC 2014
Soil Adherence Factor	AF_w	mg/cm^2-event	NA	0.12	0.3	0.3	USEPA 2015
Exposed Body Surface Area (soil)	SAs	cm^2	NA	3527	3527	3300 (ODEQ 2010)	USEPA 2015
Exposed Body Surface Area (groundwater/seep)	SA_w	cm^2	NA	NA	NA	5700	USEPA 2015
Duration of event	t_{event}	hr/event	NA	NA	NA	2 (b)	Professional Judgement
Conversion Factor - dermal	CF_d	kg/mg	NA	1.0×10^{-06}	1.0×10^{-06}	1.0×10^{-06}	NA
Conversion Factor - inhalation	CF_i	m^2/cm^2	0.0001	0.0001	0.0001	0.0001	NA
Conversion Factor - ingestion	CF_o	kg/mg	NA	1.0×10^{-06}	1.0×10^{-06}	1.0×10^{-06}	NA
Inverse of the mean concentration at the center of a 0.5-acre square source in Salem, Oregon (Site Specific)	Q/C	g/m^2-s per kg/m^3	73.4	73.4	73.4	73.4	USEPA 2002
Relative Bioavailability Percentage	$RBA_{arsenic}$	%	NA	60	60	60	USEPA 2012

Central Tendency Exposure (CTE)

Exposure Factors	Variable	Units	Indoor Worker (IW)	Outdoor Maintenance Worker (OW)	Construction Worker (CW)	References
Averaging Time, Carcinogens	ATc	yrs	70	70	70	ODEQ 2010, 2013
Averaging Time, Noncarcinogens, adult	ATnc,a	yrs	6	6	0.5	ODEQ 2010, 2013
Body Weight, adult	BW_{adult}	kg	80	80	80	ODEQ 2010, 2013
Exposure Duration	ED_w	yrs	6	6	0.5	ODEQ 2010, 2013
Exposure Frequency	EF_w	days/yr	250	225 (RME)	250	ODEQ 2010, 2013
Exposure Time	ET_w	hours/day	8 (RME)	8 (RME)	8 (RME)	ODEQ 2010, 2013
Event Frequency (contact with groundwater)	EV_w	events/day	NA	NA	NA	NA
Event Time (contact with groundwater)	t_{event}	hr/event	NA	NA	NA	NA
Soil Ingestion Rate	$IR_{soil,w}$	mg/day	NA	50	100	ODEQ 2010, 2013
Particulate Emission Factor (non-VOCs), Salem, Oregon	PEF	m^3/kg	NA	$1.36 \times 10^{+09}$	$1.0 \times 10^{+06}$	USEPA 2015; DTSC 2014
Soil Adherence Factor	AF_w	mg/cm^2-event	NA	0.02	0.1	ODEQ 2010, 2013
Exposed Body Surface Area (soil)	SAs	cm^2	NA	3300	3300	ODEQ 2010, 2013
Exposed Body Surface Area (groundwater/seep)	SA_w	cm^2	NA	NA	5700	ODEQ 2010, 2013
Duration of event	t_{event}	hr/event	NA	NA	NA	ODEQ 2010, 2013
Conversion Factor - dermal	CF_d	kg/mg	NA	NA	NA	NA
Conversion Factor - inhalation	CF_i	m^2/cm^2	0.0001	NA	NA	NA
Conversion Factor - ingestion	CF_o	kg/mg	NA	NA	NA	NA
Inverse of the mean concentration at the center of a 0.5-acre square source in Salem, Oregon (Site Specific [USEPA 2002])	Q/C	g/m^2-s per kg/m^3	73.4	73.4	73.4	USEPA 2002
Relative Bioavailability Percentage	$RBA_{arsenic}$	%	NA	60	60	USEPA 2012

Table 2-7a
Occupational Worker: Exposure Factors

Notes
% = percent
cm^2 = square centimeter
CTE = central tendency exposure
DTSC = California Department of Toxic Substances Control
g = gram
hr = hour
kg = kilogram
m^2 = square meter
m^3 = cubic meter
mg = milligram
NA = Not Applicable
RME = reasonable maximum exposure
VOC = volatile organic chemical
yr = year

(RME) CTE value was not available (or higher than the RME) and therefore the RME value was used.
a = The value of 9 days per year was based on standard residential excavation site from ODEQ (2010).
b = Assumes that direct soil contact or groundwater contact activities occur twice a day (morning, afternoon) for a total of 4 hours per day.

Sources
DTSC, 2014. Human Health Risk Assessment (HHRA) Note 2. Available at https://www.dtsc.ca.gov/assessingrisk/humanrisk2.cfm
USEPA. 2002. Supplemental Guidance for Developing Soil Screening levels for Superfund Sites. OSWER 9355.4-24. Solid Waste and Emergency Response. December.
USEPA. 2012. Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil. OSER 9200.1-113.
USEPA. 2015. Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites. RSL Table Update. May.
ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.
ODEQ. 2013. Risk-Based Concentrations for Individual Chemicals - Exposure Factors.

Table 2-7b
Hypothetical Fishing platform User: RME & CTE Exposure Factors

Definitions	Variable	Units	RME[a,b]		CTE[a,c]	
			USEPA 2015		ODEQ 2010	
			Tribal Fisher (Adult)	Tribal Fisher (Child)	Tribal Fisher (Adult)	Tribal Fisher (Child)
Averaging Time, Carcinogens	ATc	yrs	70	70	70	70
Averaging Time, Noncarcinogens, adult	ATnc,a	yrs	20	6	3	6
Body Weight, adult	BW_{adult}	kg	80	15	80 (d)	15
Exposure Duration	ED_w	yrs	20	6	3	6
Exposure Frequency	EF_w	days/yr	365 (b)	365 (b)	152 (c)	152 (c)
Soil Ingestion Rate	$IR_{soil,w}$	mg/day	100	200	50	100
Particulate Emission Factor (non-VOCs), Salem, Oregon	PEF	m^3/kg	1.360E+09	1.360E+09	1.360E+09	1.360E+09
Soil Adherence Factor	AF_w	mg/cm^2-event	0.07	0.2	0.01	0.04
Exposed Body Surface Area (soil)	SAs	cm^2	6032	2373	6032	2373 (e)
Conversion Factor - dermal	CF_d	kg/mg	1.0E-06	1.0E-06	1.0E-06	1.0E-06
Conversion Factor - inhalation	CF_i	m^2/cm^2	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Conversion Factor - ingestion	CF_o	kg/mg	1.0E-06	1.0E-06	1.0E-06	1.0E-06
Inverse of the mean concentration at the center of a 0.5-acre square source in Salem, Oregon (Site Specific [USEPA 2002])	Q/C	g/m^2-s per kg/m^3	7.34E+01	7.34E+01	7.34E+01	7.34E+01
Relative Bioavailability Percentage	$RBA_{arsenic}$	%	60	60	60	60

Notes
% = percent
cm^2 = square centimeter
CTE = central tendency exposure
g = gram
HHRA = human health risk assessment
hr = hour
kg = kilogram
m^2 = square meter
m^3 = cubic meter
mg = milligram
NA = Not Applicable
OU = operable unit
RME = reasonable maximum exposure
VOC = volatile organic chemical
yr = year

Table 2-7b
Hypothetical Fishing platform User: RME & CTE Exposure Factors

(a) This scenario is based on assumed exposure to surface soils only. No exposure to groundwater or soil vapor from the Upland OU. Exposures through fish consumption, swimming, and wading in sediments are covered in River OU HHRA and not included here.
(b) Project specific = For RME, assume year-round usage and residential exposure assumptions, per direction from USACE (E-mail from Mike Gross NWP sent June 24,
(c) Based on estimated frequency of subsistence fishing 3 days a week for 12 months (see email from Michael Gross, USACE, sent June 24, 2014 8:45 am)
(d) USEPA 2015 updated value. Updates to ODEQ (2010) are expected in the near future.
(e) Due to the ODEQ 2010 CTE value being higher than USEPA 2015 RME values, the USEPA 2015 value was used. Updates to ODEQ (2010) are expected in the near

Sources

ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.
USEPA. 2015. Regional Screening (RSL) User's Guide. Available at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/usersguide.htm (Accessed July 14,

Table 2-8
Toxicity Values Used in the HHRA

	Noncancer Health-Hazard Values				Cancer-Risk Values						Dermal			
	Reference Dose - Oral		Reference Concentration		Oral Slope Factor		Inhalation Unit Risk		Oral Absorption Factor		Reference Dose	Slope Factor	Dermal Absorption Factor	
Analyte	RfDo (mg/kg-d)	Reference	RfC ($\mu g/m^3$)	Reference	SFo $(mg/kg\text{-}d)^{-1}$	Reference	URF_i $(\mu g/m^3)^{-1}$	Reference	OAF (dimensionless)	Reference	RfDd \a (mg/kg-d)	SF_D \b $(mg/kg\text{-}d)^{-1}$	ABS_d (dimensionless)	Reference
Inorganic Constituents														
Arsenic	3.00E-04	IRIS	1.50E-02	CalEPA	1.50E+00	IRIS	4.30E-03	IRIS	1.00E+00	USEPA 2004 (RAGS Part E)	3.00E-04	1.50E+00	3.00E-02	RSL 2013-05
Lead\c	NV	--	NV	--	NV	--	NV	--	NV	--	--	--	NV	--
Chromium (iii)	1.50E+00	IRIS	NV	--	NV	--	NV	--	0.00E+00	USEPA 2004 (RAGS Part E)	0.00E+00	--	1.00E-02	DTSC 1994
Antimony	4.00E-04	IRIS	NV	--	NV	--	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	4.00E-04	--	1.30E-01	DTSC 1994
Iron	7.00E-01	PPRTV	NV	--	NV	--	1.10E-03	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	7.00E-01	--	1.30E-01	RSL 2013-05
Mercury	1.60E-04	CalEPA	3.00E-01	IRIS	NV	--	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	1.60E-04	--	1.30E-01	DTSC 1994
Nickel	2.00E-02	IRIS	9.00E-02	ATSDR	NV	--	2.60E-04	CalEPA	4.00E-02	USEPA 2004 (RAGS Part E)	--	8.00E-04	1.00E-02	DTSC 1994
Thallium	1.00E-05	Screening PPRTV	NV	--	NV	--	1.20E-03	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-05	--	1.30E-01	DTSC 1994
Zinc	3.00E-01	IRIS	NV	--	NV	--	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	3.00E-01	--	1.30E-01	DTSC 1994
Vanadium	5.00E-03	MW-adjusted from vanadium pentoxide; (USEPA RSL table)	1.00E-01	ATSDR	NV	--	NV	--	2.60E-02	USEPA 2004 (RAGS Part E)	1.30E-04	--	1.00E-02	DTSC 1994
Polychlorinated Biphenyls (PCBs) - Mixtures														
Total PCBs	2.00E-05	IRIS	NV	--	2.00E+00	PCB mixture (CAS# 1336-36-3), IRIS high-risk upper estimate	5.70E-04	PCB mixture (CAS# 1336-36-3), IRIS upper-bound slope factor, high risk and persistence, converted to IUR	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E+00	2.00E-05	1.40E-01	RSL 2013-05
Polycyclic Aromatic Hydroc														
Benzo[a]anthracene	NV	--	NV	--	7.30E-01	Environmental Criteria and Assessment Office (USEPA RSL table)	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E-01	1.30E-01	RSL 2013-05
Benzo[a]pyrene	NV	--	NV	--	7.30E+00	IRIS	1.10E-03	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E+00	1.30E-01	RSL 2013-05
Benzo[b]fluoranthene	NV	--	NV	--	7.30E-01	Environmental Criteria and Assessment Office (USEPA RSL table)	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E-01	1.30E-01	RSL 2013-05
Benzo[g,h,i]perylene	3.00E-02	pyrene surrogate (IRIS)	NV	--	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	--	3.00E-02	1.30E-01	USEPA 2004 (RAGS Part E)
Benzo[k]fluoranthene	NV	--	NV	--	7.30E-02	Environmental Criteria and Assessment Office (USEPA RSL table)	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E-02	1.30E-01	RSL 2013-05
Dibenz[a,h]anthracene	NV	--	NV	--	7.30E+00	Environmental Criteria and Assessment Office (USEPA RSL table)	1.20E-03	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E+00	1.30E-01	RSL 2013-05
Indeno[1,2,3-cd]pyrene	NV	--	NV	--	7.30E-01	Environmental Criteria and Assessment Office (USEPA RSL table)	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E-01	1.30E-01	RSL 2013-05
Benzofluoranthenes, total	NV	--	NV	--	7.30E-01	Environmental Criteria and Assessment Office (USEPA RSL table)	1.10E-04	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	7.30E-01	1.30E-01	RSL 2013-05
Volatile Organic Compound														
Acetone	9.00E-01	IRIS	3.10E+04	ATSDR	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	9.00E-01	--	0.00E+00	USEPA 2004 (RAGS Part E)
Benzene	4.00E-03	IRIS	3.00E+01	IRIS	5.50E-02	IRIS	7.80E-06	IRIS	1.00E+00	USEPA 2004 (RAGS Part E)	4.00E-03	5.50E-02	0.00E+00	USEPA 2004 (RAGS Part E)
1,1-Dichloroethane	2.00E-01	PPRTV	NV	--	5.70E-03	OEHHA	1.60E-06	OEHHA	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E-01	5.70E-03	0.00E+00	USEPA 2004 (RAGS Part E)
1,2-Dichloropropane	9.00E-02	ATSDR	4.00E+00	IRIS	3.60E-02	OEHHA	1.00E-05	OEHHA	1.00E+00	USEPA 2004 (RAGS Part E)	9.00E-02	3.60E-02	0.00E+00	USEPA 2004 (RAGS Part E)
Ethylbenzene	1.00E-01	IRIS	1.00E+03	IRIS	1.10E-02	OEHHA	2.50E-06	OEHHA	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-01	1.10E-02	0.00E+00	USEPA 2004 (RAGS Part E)
Toluene	8.00E-02	IRIS	5.00E+03	IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	8.00E-02	--	0.00E+00	USEPA 2004 (RAGS Part E)
1,1,1-Trichloroethane	2.00E+00	IRIS	5.00E+03	IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E+00	--	0.00E+00	USEPA 2004 (RAGS Part E)
Xylenes	2.00E-01	IRIS	1.00E+02	IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E-01	--	0.00E+00	USEPA 2004 (RAGS Part E)
o-xylene	2.00E-01	Xylenes surrogate; IRIS	1.00E+02	mixed xylenes surrogate; IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E-01	--	0.00E+00	USEPA 2004 (RAGS Part E)
Chloroform	1.00E-02	IRIS	9.80E+01	ATSDR	3.10E-02	CalEPA	2.30E-05	IRIS	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-02	3.10E-02	0.00E+00	USEPA 2004 (RAGS Part E)
Isopropylbenzene	1.00E-01	IRIS	4.00E+02	IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-01	--	0.00E+00	USEPA 2004 (RAGS Part E)
n-propylbenzene	1.00E-01	Screening PPRTV	1.00E+03	Screening PPRTV	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-01	--	0.00E+00	USEPA 2004 (RAGS Part E)
1,2,4-trimethylbenzene	NV	--	7.00E+00	PPRTV	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	--	--	0.00E+00	USEPA 2004 (RAGS Part E)
Tetrachloroethene	6.00E-03	IRIS	4.00E+01	IRIS	2.10E-03	IRIS	2.60E-07	IRIS	1.00E+00	USEPA 2004 (RAGS Part E)	6.00E-03	2.10E-03	0.00E+00	USEPA 2004 (RAGS Part E)
Naphthalene	2.00E-02	IRIS	3.00E+00	IRIS	NV	--	3.40E-05	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	--	2.00E-02	0.00E+00	USEPA 2004 (RAGS Part E)
1,1-Dichloroethene	5.00E-02	IRIS	2.00E+02	IRIS	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	5.00E-02	--	0.00E+00	USEPA 2004 (RAGS Part E)
cis-1,2-Dichloroethene	2.00E-03	IRIS	NV	--	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E-03	--	0.00E+00	USEPA 2004 (RAGS Part E)

Table 2-8
Toxicity Values Used in the HHRA

	Noncancer Health-Hazard Values				Cancer-Risk Values						Dermal			
	Reference Dose - Oral		Reference Concentration		Oral Slope Factor		Inhalation Unit Risk		Oral Absorption Factor		Reference Dose	Slope Factor	Dermal Absorption Factor	
Analyte	RfDo (mg/kg-d)	Reference	RfC ($\mu g/m^3$)	Reference	SFo $(mg/kg\text{-}d)^{-1}$	Reference	URF_i $(\mu g/m^3)^{-1}$	Reference	OAF (dimensionless)	Reference	RfDd [a] (mg/kg-d)	SF_D [b] $(mg/kg\text{-}d)^{-1}$	ABS_d (dimensionless)	Reference
trans-1,2-Dichloroethene	2.00E-02	IRIS	6.00E+01	PPRTV	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	2.00E-02	--	0.00E+00	USEPA 2004 (RAGS Part E)
Trichloroethene	5.00E-04	IRIS	2.00E+00	IRIS	4.60E-02	IRIS; adult approximation, no age-adjustment	4.10E-06	IRIS; adult approximation, no age-adjustment	1.00E+00	USEPA 2004 (RAGS Part E)	5.00E-04	4.60E-02	0.00E+00	USEPA 2004 (RAGS Part E)
Vinyl Chloride	3.00E-03	IRIS	1.00E+02	IRIS	7.20E-01	IRIS; continuous lifetime exposure during adulthood	4.40E-06	IRIS; continuous lifetime exposure during adulthood	1.00E+00	USEPA 2004 (RAGS Part E)	3.00E-03	7.20E-01	0.00E+00	USEPA 2004 (RAGS Part E)
Pesticides														
MCPP	1.00E-03	IRIS	NV	--	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	--	1.00E-03	1.00E-01	RSL 2013-05
Semivolatile Organic Compounds (SVOCs)														
Bis(2-ethylhexyl) Phthalate	2.00E-02	IRIS	NV	--	1.40E-02	IRIS	2.40E-06	CalEPA	1.00E+00	USEPA 2004 (RAGS Part E)	1.40E-02	2.00E-02	1.00E-01	RSL 2013-05
Phthalates														
Di-n-octyl phthalate	1.00E-02	PPRTV	NV	--	NV	--	NV	--	1.00E+00	USEPA 2004 (RAGS Part E)	1.00E-02	--	1.00E-01	RSL 2013-05

Notes

[a] Reference dose adjusted for oral absorption: RfDd = RfDo × OAF (USEPA 2004. RAGS Part E. EPA/540/R/99/005).

[b] Slope factor adjusted for oral absorption: SFd = SFo ÷ OAF (USEPA 2004. RAGS Part E. EPA/540/R/99/005).

[c] Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = quantitative toxicity values are not available
µg/m3 = microgram per cubic meter
ABS = dermal absorption factor
HHRA = human health risk assessment
IUR = inhalation unit risk
mg/kg-d = milligram per kilogram day
MW = molecular weight
NV = No Value
OAF = oral absorption factor
PCB = polychlorinated biphenyl
RfC = reference concentration
RfDo = oral reference dose
RSL = Regional Screening Level
SFo = oral slope factor
SVOC = semivolatile organic compound
URF = unit risk factor
VOC = volatile organic chemical

Sources

ATSDR = Agency for Toxic Substances and Disease Registry, Minimal Risk Level (MRL). Available at http://www.atsdr.cdc.gov/mrls/.
DTSC 1994 = CalEPA Department of Toxic Substances and Control Preliminary Endangerment Assessment (PEA) Guidance Manual January 1994.
HEAST = USEPA Health Effects Assessment Summary Tables, FY 1997 Update (EPA-540-R-97-036).
IRIS = USEPA Integrated Risk Information System. Available at: http://www.epa.gov/iris/.
CalEPA = California Environmental Protection Agency Office of Environmental Health hazard Assessment (OEHHA) Toxicity Database (Website). Available at: http://oehha.ca.gov/tcdb/index.asp.
PPRTV = Provisional Peer-Reviewed Reference Toxicity Value, as cited in USEPA's RSL tables. Available at: http://www.epa.gov/region09/superfund/prg/.
RSL 2013-05 = USEPA Regional Screening Level May 2013.
USEPA 2004 = Risk Assessment Guidance for Superfund: Human Health Evaluation Manual. Part E: Supplemental Guidance for Dermal Evaluation. Final. PB99-963312. July.

Table 2-9
Outdoor Maintenance Worker: RME Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Arsenic	1.05E+01	**2.60E-06**	1.46E-09	3.30E-07	**2.9E-06**	5%	1.62E-02	6.35E-05	2.05E-03	1.8E-02	93%
Chromium (III)	5.94E+02	--	--	--			3.05E-04	--	9.93E-04	1.3E-03	7%
Lead[1]	5.11E+02	--	--	--			--	--	--		
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	9.96E+00	**2.00E-06**	5.91E-11	**1.10E-06**	**3.1E-06**	5%	--	--	--		
Benzo[a]pyrene	1.12E+01	**2.25E-05**	6.65E-10	**1.24E-05**	**3.5E-05**	58%	--	--	--		
Benzo[b]fluoranthene	1.52E+01	**3.05E-06**	9.02E-11	**1.68E-06**	**4.7E-06**	8%	--	--	--		
Dibenz[a,h]anthracene	2.06E+00	**4.14E-06**	1.33E-10	**2.28E-06**	**6.4E-06**	11%	--	--	--		
Indeno[1,2,3-cd]pyrene	6.80E+00	**1.37E-06**	4.04E-11	7.52E-07	**2.1E-06**	4%	--	--	--		
Benzofluoranthenes, total	1.88E+01	**3.77E-06**	1.11E-10	**2.08E-06**	**5.8E-06**	10%	--	--	--		
				cPAHs Cancer Risk	**5.1E-05**						
				Cumulative Risk:	**6.0E-05**				**Cumulative Hazard:**	2.0E-02	

Notes
EPCs from Table 1-1.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

% = percent
"--" = data not available or not calculated
AOPC = area of potential concern
cPAH = carcinogenic PAHs
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
RME = reasonable maximum exposure

Table 2-10
Outdoor Maintenance Worker: CTE Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Arsenic	1.05E+01	3.12E-07	3.51E-10	1.24E-08	3.2E-07	6%	8.09E-03	6.35E-05	3.20E-04	8.5E-03	96%
Chromium (III)	5.94E+02	--	--	--			1.53E-04	--	1.55E-04	3.1E-04	4%
Lead[1]	5.11E+02	--	--	--			--	--	--		
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	9.96E+00	2.40E-07	1.42E-11	4.12E-08	2.8E-07	5%	--	--	--		
Benzo[a]pyrene	1.12E+01	**2.70E-06**	1.60E-10	4.63E-07	**3.2E-06**	57%	--	--	--		
Benzo[b]fluoranthene	1.52E+01	3.66E-07	2.17E-11	6.29E-08	4.3E-07	8%	--	--	--		
Dibenz[a,h]anthracene	2.06E+00	4.97E-07	3.20E-11	8.52E-08	5.8E-07	11%	--	--	--		
Indeno[1,2,3-cd]pyrene	6.80E+00	1.64E-07	9.69E-12	2.81E-08	1.9E-07	3%	--	--	--		
Benzofluoranthenes, total	1.91E+01	4.60E-07	2.72E-11	7.90E-08	5.4E-07	10%	--	--	--		
				cPAHs Cancer Risk	**5.2E-06**						
				Cumulative Risk:	**5.5E-06**				**Cumulative Hazard:**	8.8E-03	

Notes
EPCs from Table 1-1.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7b.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
CTE = central tendency exposure
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbons

Table 2-11
Construction Worker: RME Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	1.27E+02	1.1E-08	1.8E-07	0.0E+00	1.9E-07	4%	6.0E-02	1.2E+00	0.0E+00	1.2E+00	100%
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	1.08E+01	**3.2E-06**	3.9E-08	**1.3E-06**	**4.5E-06**	96%	--	--	--		
				Cumulative Risk:	4.7E-06				**Cumulative Hazard:**	**1.2E+00**	

Notes
EPCs from Table 1-1.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

% = percent
"--" = data not available or not calculated
AOPC = area of potential concern
EPC = exposure point concentration
mg/kg = milligrams per kilogram
RME = reasonable maximum exposure

Table 2-12
Construction Worker: CTE Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	1.27E+02	1.63E-09	--	0.00E+00	1.6E-09	< 1%	1.81E-02	--	0.00E+00	1.8E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	1.08E+01	4.82E-07	1.94E-08	2.07E-07	7.1E-07	100%	--	--	--		
				Cumulative Risk:	7.1E-07				**Cumulative Hazard:**	1.8E-02	

Notes
The VF equation is not adequate for exposure durations of less than 1 year; therefore, the inhalation of VOCs in soil is not evaluated.
EPCs from Table 1-1.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
CTE = central tendency exposure
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAHs = polycyclic aromatic hydrocarbons
VF = volatilization factor
VOCs = volatile organic chemicals

Table 2-13
Hypothetical Fishing Platform User: RME Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Mutagen?	Cancer-Risk Estimate Ingestion	Cancer-Risk Estimate Inhalation	Cancer-Risk Estimate Dermal	Cancer-Risk Estimate Multi-Pathway	% of Cumulative	Noncancer Hazard Estimate (Child) Ingestion	Noncancer Hazard Estimate (Child) Inhalation	Noncancer Hazard Estimate (Child) Dermal	Noncancer Hazard Estimate (Child) Multi-Pathway
Inorganic Constituents											
Arsenic	10.5	0	**1.42E-05**	7.40E-09	**1.20E-06**	**1.5E-05**	1%	2.80E-01	3.09E-04	1.99E-02	3.0E-01
Chromium (III)	594	0	--	--	--			5.28E-03	--	9.64E-03	1.5E-02
Lead[1]	0	0	--	--	--			--	--	--	--
Mercury	1.45	0	--	--	--			1.21E-01	1.47E-01	2.87E-03	2.7E-01
Polychlorinated Biphenyls (PCBs) - Mixtures											
Total PCBs	0.41	0	**1.23E-06**	6.38E-11	4.84E-07	**1.7E-06**	< 1%	2.73E-01	--	9.08E-02	3.6E-01
Volatile Organic Compounds (VOCs)											
Naphthalene	3.83	0	--	**9.10E-06**	--	**9.1E-06**	< 1%	2.55E-03	2.40E-01	7.88E-04	2.4E-01
Pesticides											
MCPP	11.2	0	--	--	--			1.49E-01	--	3.54E-02	1.8E-01
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	9.96	M	**4.95E-05**	8.29E-10	**1.65E-05**	**6.6E-05**	5%	--	--	--	--
Benzo[a]pyrene	11.2	M	**5.57E-04**	9.32E-09	**1.86E-04**	**7.4E-04**	59%	--	--	--	--
Benzo[b]fluoranthene	15.2	M	**7.56E-05**	1.26E-09	**2.52E-05**	**1.0E-04**	8%	--	--	--	--
Benzo[g,h,i]perylene	5.82	0	--	--	--			2.59E-03	--	7.98E-04	3.4E-03
Benzo[k]fluoranthene	26.3	M	**1.31E-05**	2.19E-09	**4.36E-06**	**1.7E-05**	1%	--	--	--	--
Benzofluoranthenes, Total	18.78	M	**9.34E-05**	1.56E-09	**3.12E-05**	**1.2E-04**	10%	--	--	--	--
Dibenz[a,h]anthracene	2.06	M	**1.02E-04**	1.87E-09	**3.42E-05**	**1.4E-04**	11%	--	--	--	--
Indeno[1,2,3-cd]pyrene	6.8	M	**3.38E-05**	5.66E-10	**1.13E-05**	**4.5E-05**	4%	--	--	--	--
					cPAH Risk:	**1.2E-03**					
					Cumulative Risk:	**1.3E-03**				**Hazard Index (Child):**	1.4
					Nursing Infant Risk:	*1.0E-06*				***Nursing Infant Hazard:***	***1.5***

Notes
Cancer risks are presented for time-integrated adult+child exposure. Noncancer hazards are presented separately for exposure during adulthood and exposure during childhood.
Nursing infant's risks and hazards are presented as a function of Mother's risks and hazards, assuming an infant exposure duration of 1 year.
EPCs from Table 1-1.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7b.
Italics = Nursing Infant cancer risk and noncancer hazard based on ODEQ (2010) approach.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

% = percent
"--" = data not available or not calculated
AOPC = area of potential concern
cPAH = carcinogenic PAH
EPC = exposure point concentration
M= mutagenic compound
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
RME = reasonable maximum exposure

Table 2-14
Hypothetical Fishing Platform User: CTE Summary – Landfill AOPC

Analyte	Soil EPC (mg/kg)	Mutagen?	Cancer-Risk Estimate: Ingestion	Cancer-Risk Estimate: Inhalation	Cancer-Risk Estimate: Dermal	Cancer-Risk Estimate: Multi-Pathway	% of Cumulative	Noncancer Hazard Estimate (Child): Ingestion	Noncancer Hazard Estimate (Child): Inhalation	Noncancer Hazard Estimate (Child): Dermal	Noncancer Hazard Estimate (Child): Multi-Pathway	Noncancer Hazard Estimate (Adult): Ingestion	Noncancer Hazard Estimate (Adult): Inhalation	Noncancer Hazard Estimate (Adult): Dermal	Noncancer Hazard Estimate (Adult): Multi-Pathway
Inorganic Constituents															
Arsenic	10.5	0	**2.35E-06**	1.07E-09	6.79E-08	**2.4E-06**	1%	5.83E-02	1.29E-04	1.66E-03	6.0E-02	5.47E-03	1.29E-04	1.98E-04	5.8E-03
Chromium (III)	594	0	--	--	--			1.10E-03	--	8.03E-04	1.9E-03	1.03E-04	--	9.56E-05	2.0E-04
Lead[1]	0	0	--	--	--			--	--	--	--	--	--	--	--
Mercury	1.45	0	--	--	--			2.52E-02	1.05E-01	2.39E-04	1.3E-01	2.36E-03	1.05E-01	2.85E-05	1.1E-01
Polychlorinated Biphenyls (PCBs) - Mixtures															
Total PCBs	0.41	0	2.04E-07	9.20E-12	2.75E-08	2.3E-07	< 1%	5.69E-02	--	7.56E-03	6.4E-02	5.34E-03	--	9.01E-04	6.2E-03
Volatile Organic Compounds (VOCs)															
Naphthalene	3.83	0	--	**2.24E-06**	--	**2.2E-06**	1%	5.32E-04	1.71E-01	6.56E-05	1.7E-01	4.98E-05	1.71E-01	7.82E-06	1.7E-01
Pesticides															
MCPP	11.2	0	--	--	--			3.11E-02	--	2.95E-03	3.4E-02	2.92E-03	--	3.52E-04	3.3E-03
Polycyclic Aromatic Hydrocarbons (PAHs)															
Benzo[a]anthracene	9.96	M	**1.03E-05**	3.45E-10	**1.31E-06**	**1.2E-05**	5%	--	--	--	--	--	--	--	--
Benzo[a]pyrene	11.2	M	**1.16E-04**	3.88E-09	**1.47E-05**	**1.3E-04**	59%	--	--	--	--	--	--	--	--
Benzo[b]fluoranthene	15.2	M	**1.57E-05**	5.27E-10	**2.00E-06**	**1.8E-05**	8%	--	--	--	--	--	--	--	--
Benzo[g,h,i]perylene	5.82	0	--	--	--			5.39E-04	--	6.65E-05	6.1E-04	5.05E-05	--	7.92E-06	5.8E-05
Benzo[k]fluoranthene	26.3	M	**2.72E-06**	9.11E-10	3.45E-07	**3.1E-06**	1%	--	--	--	--	--	--	--	--
Benzofluoranthenes, Total	18.78	M	**1.94E-05**	6.51E-10	**2.47E-06**	**2.2E-05**	10%	--	--	--	--	--	--	--	--
Dibenz[a,h]anthracene	2.06	M	**2.13E-05**	7.79E-10	**2.71E-06**	**2.4E-05**	11%	--	--	--	--	--	--	--	--
Indeno[1,2,3-cd]pyrene	6.8	M	**7.04E-06**	2.36E-10	8.93E-07	**7.9E-06**	4%	--	--	--	--	--	--	--	--
					cPAH Risk:	**2.2E-04**									
					Cumulative Risk:	**2.2E-04**				**Hazard Index (Child):**	0.46			**Hazard Index (Adult):**	0.29
					Nursing Infant Risk:	*1.4E-07*				***Nursing Infant Hazard:***	*0.26*				

Notes

Cancer risks are presented for time-integrated adult+child exposure. Noncancer hazards are presented separately for exposure during adulthood and exposure during childhood.

Nursing infant's risks and hazards are presented as a function of Mother's risks and hazards, assuming an infant exposure duration of 1 year.

EPCs from Table 1-1.

Toxicity values from Table 2-8.

Exposure Factors from Table 2-7b.

Italics = Nursing Infant cancer risk and noncancer hazard based on ODEQ (2010) approach.

Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

% = percent
"--" = data not available or not calculated
AOPC = area of potential concern
cPAH = carcinogenic PAH
CTE = central tendency exposure
EPC = exposure point concentration
M= mutagenic compound
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
VOC = volatile organic chemical

Source

ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.

Table 2-15
Excavation/Trench Worker, Exposure to Groundwater: RME Summary – Landfill AOPC

Analyte	Water EPC (µg/L)	Cancer-Risk Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Antimony	2.23E-01	--	--	--			3.44E-06	--	2.61E-05	3.0E-05	< 1%
Iron	2.91E+04	--	--	--			2.56E-04	--	2.92E-04	5.5E-04	2%
Mercury	7.69E-02	--	--	--			2.96E-06	--	3.38E-06	6.3E-06	< 1%
Thallium	2.38E-01	--	--	--			1.47E-04	--	1.67E-04	3.1E-04	< 1%
Zinc	2.07E+03	--	--	--			4.25E-05	--	2.91E-05	7.2E-05	< 1%
Phthalates											
di-n-octyl phthalate	4.61E+00	--	--	--			2.84E-06	--	--	2.8E-06	< 1%
Volatile Organic Compounds											
Acetone	1.54E+01	--	--	--			1.05E-07	8.41E-06	7.64E-08	8.6E-06	< 1%
Chloroform	3.70E+00	1.01E-11	4.67E-08	1.15E-10	4.7E-08	92%	2.28E-06	1.45E-03	2.61E-05	1.5E-03	4%
Isopropylbenzene	4.60E+00	--	--	--			2.84E-07	4.51E-04	3.95E-05	4.9E-04	1%
Tetrachloroethene	8.78E+00	1.62E-12	1.01E-09	1.12E-10	1.1E-09	2%	9.02E-06	6.79E-03	6.22E-04	7.4E-03	20%
Vinyl Chloride	9.55E-01	6.06E-11	2.05E-09	6.97E-10	2.8E-09	6%	1.96E-06	3.26E-04	2.26E-05	3.5E-04	< 1%
n-propylbenzene	2.00E+00	--	--	--			1.23E-07	6.96E-05	1.80E-05	8.8E-05	< 1%
1,2,4-trimethylbenzene	5.20E+00	--	--	--			--	2.55E-02	--	2.6E-02	70%
				Cumulative Risk:	5.1E-08				**Cumulative Hazard:**	3.6E-02	

Notes
EPCs from Table 1-7.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
EPC = exposure point concentration
RME = reasonable maximum exposure
ug/L = micrograms per liter
VOC = volatile organic chemical

Table 2-16
Outdoor Maintenance Worker – RME Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Arsenic	9.71E+00	**2.40E-06**	1.35E-09	3.05E-07	**2.7E-06**	21%	1.50E-02	5.87E-05	1.90E-03	1.7E-02	25%
Chromium (III)	5.79E+02	--	--	--			2.97E-04	--	9.68E-04	1.3E-03	2%
Lead[1]	0.00E+00	--	--	--			--	--	--		
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	2.39E+00	**4.80E-06**	1.42E-10	**2.64E-06**	**7.4E-06**	57%	--	--	--		
Benzofluoranthenes Total	6.36E+00	**1.28E-06**	3.78E-11	7.03E-07	**2.0E-06**	15%	--	--	--		
Dibenz[a,h]anthracene	2.38E-01	4.78E-07	1.54E-11	2.63E-07	7.4E-07	6%	--	--	--		
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	2.73E+01	1.58E-08	1.71E-07	0.00E+00	1.9E-07	1%	3.51E-03	4.60E-02	0.00E+00	5.0E-02	73%
		--	--	--			--	--	--		
				cPAHs Cancer Risk	**1.0E-05**	78%	--	--	--		
				Cumulative Risk:	**1.3E-05**			**Cumulative Hazard:**		6.8E-02	

Notes
EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = data not available or not calculated
%= percent
AOPC = area of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
RME = reasonable maximum exposure
VOC = volatile organic chemical

Table 2-17
Outdoor Maintenance Worker – CTE Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Arsenic	9.71E+00	2.89E-07	3.24E-10	1.14E-08	3.0E-07	24%	7.48E-03	5.87E-05	2.96E-04	7.8E-03	96%
Chromium (III)	5.79E+02	--	--	--			1.49E-04	--	1.51E-04	3.0E-04	4%
Lead[1]	4.18E+02	--	--	--			--	--	--		
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	2.39E+00	5.76E-07	3.40E-11	9.89E-08	6.8E-07	53%	--	--	--		
Benzofluoranthenes Total	7.84E+00	1.89E-07	1.12E-11	3.24E-08	2.2E-07	18%	--	--	--		
Dibenz[a,h]anthracene	2.38E-01	5.74E-08	3.70E-12	9.85E-09	6.7E-08	5%	--	--	--		
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	2.73E+01	--	--	0.00E+00			--	--	0.00E+00		
			cPAHs Cancer Risk		1E-06	76%	--	--	--		
				Cumulative Risk:	1.3E-06				**Cumulative Hazard:**	8.1E-03	

Notes

EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CTE = central tendency exposure
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
VOC = volatile organic chemical

Table 2-18
Construction Worker – RME Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	9.90E+01	8.39E-09	1.38E-07	0.00E+00	1.5E-07	8%	4.66E-02	9.27E-01	0.00E+00	9.7E-01	100%
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	3.98E+00	**1.17E-06**	1.43E-08	4.89E-07	**1.7E-06**	92%	--	--	--		
				Cumulative Risk:	1.8E-06			**Cumulative Hazard:**		0.97	

Notes

EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
RfD_o = oral reference dose
RME = reasonable maximum exposure
VOC = volatile organic chemical

Table 2-19
Construction Worker – CTE Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Cancer-Risk Estimate Ingestion	Cancer-Risk Estimate Inhalation	Cancer-Risk Estimate Dermal	Cancer-Risk Estimate Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Noncancer-Hazard Estimate Inhalation	Noncancer-Hazard Estimate Dermal	Noncancer-Hazard Estimate Multi-Pathway	% of Cumulative
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	9.90E+01	1.27E-09	--	0.00E+00	1.3E-09	< 1%	1.41E-02	--	0.00E+00	1.4E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]pyrene	3.98E+00	1.78E-07	7.14E-09	7.62E-08	2.6E-07	100%	--	--	--		
				Cumulative Risk:	2.6E-07				**Cumulative Hazard:**	1.4E-02	

Notes
The VF equation does not adequately assess VOCs from soil for exposure durations less than 1 year; therefore, this pathway in soil is not evaluated.
EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
CTE = central tendency exposure
EPC = exposure point concentration
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
RfD_o = oral reference dose
VF = volatilization factor
VOC = volatile organic chemical

Table 2-20
Hypothetical Fishing Platform User: RME Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Mutagen?	Cancer-Risk Estimate: Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer Hazard Estimate (Child): Ingestion	Inhalation	Dermal	Multi-Pathway	Noncancer Hazard Estimate (Adult): Ingestion	Inhalation	Dermal	Multi-Pathway
Inorganic Constituents															
Arsenic	9.71	0	**1.31E-05**	6.84E-09	**1.11E-06**	**1.4E-05**	5%	2.59E-01	2.86E-04	1.84E-02	2.8E-01	2.43E-02	2.86E-04	3.07E-03	2.8E-02
Chromium (III)	579	0	--	--	--			5.15E-03	--	9.39E-03	1.5E-02	4.83E-04	--	1.57E-03	2.0E-03
Lead[1]	418	0	--	--	--			--	--	--	--	--	--	--	--
Nickel	251	0	--	1.78E-08	--	1.8E-08	< 1%	1.67E-01	2.05E-03	9.93E-02	2.7E-01	1.57E-02	2.05E-03	1.66E-02	3.4E-02
Polychlorinated Biphenyls (PCBs) - Mixtures															
Total PCBs	0.419	0	**1.26E-06**	6.52E-11	4.95E-07	**1.8E-06**	< 1%	2.79E-01	--	9.28E-02	3.7E-01	2.62E-02	--	1.55E-02	4.2E-02
Volatile Organic Compounds (VOCs)															
Tetrachloroethene	26.3	0	8.28E-08	**1.83E-06**	0.00E+00	**1.9E-06**	< 1%	5.84E-02	4.75E-01	0.00E+00	5.3E-01	5.48E-03	4.75E-01	0.00E+00	4.8E-01
Trichloroethene	1.78	0	1.23E-07	**1.12E-06**	0.00E+00	**1.2E-06**	< 1%	4.75E-02	3.69E-01	0.00E+00	4.2E-01	4.45E-03	3.69E-01	0.00E+00	3.7E-01
Semivolatile Organic Compounds (SVOCs)															
DEHP	77.1	0	**1.62E-06**	5.05E-11	4.56E-07	**2.1E-06**	< 1%	5.14E-02	--	1.22E-02	6.4E-02	4.82E-03	--	2.03E-03	6.9E-03
Polycyclic Aromatic Hydrocarbons (PAHs)															
Benzo[a]anthracene	2.45	M	**1.22E-05**	2.04E-10	**4.06E-06**	**1.6E-05**	6%	--	--	--	--	--	--	--	--
Benzo[a]pyrene	2.39	M	**1.19E-04**	1.99E-09	**3.96E-05**	**1.6E-04**	57%	--	--	--	--	--	--	--	--
Benzo[b]fluoranthene	2.21	M	**1.10E-05**	1.84E-10	**3.67E-06**	**1.5E-05**	5%	--	--	--	--	--	--	--	--
Benzo[g,h,i]perylene	1.05	0	--	--	--			4.67E-04	--	1.44E-04	6.1E-04	4.38E-05	--	2.40E-05	6.8E-05
Benzofluoranthenes, Total	6.36	M	**3.16E-05**	5.29E-10	**1.06E-05**	**4.2E-05**	15%	--	--	--	--	--	--	--	--
Dibenz[a,h]anthracene	0.238	M	**1.18E-05**	2.16E-10	**3.95E-06**	**1.6E-05**	6%	--	--	--	--	--	--	--	--
Indeno[1,2,3-cd]pyrene	1.16	M	**5.77E-06**	9.65E-11	**1.92E-06**	**7.7E-06**	3%	--	--	--	--	--	--	--	--
					cPAH Risk:	**2.5E-04**									
					Cumulative Risk:	**2.8E-04**				**Hazard Index (Child):**	**1.9**			**Hazard Index (Adult):**	0.97
					Nursing Infant Risk:	*1.1E-06*				***Nursing Infant Hazard:***	***1.5***				

Notes

Cancer risks are presented for time-integrated adult+child exposure. Noncancer hazards are presented separately for exposure during adulthood and exposure during childhood.
Nursing infant's risks and hazards are presented as a function of Mother's risks and hazards, assuming an infant exposure duration of 1 year.
EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7b.
Italics = Nursing Infant cancer risk and noncancer hazard based on ODEQ (2010) approach.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = data not available or not calculated
% = percent
0 = non-mutagenic
AOPC = area of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
DEHP = bis(2-ethylhexyl)phthalate
EPC = exposure point concentration
M = mutagenic compound
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
RME = reasonable maximum exposure
SVOC = semivolatile organic compound
VOC = volatile organic compound

Table 2-20
Hypothetical Fishing Platform User: RME Summary - Sandblast Area AOPC

Source

ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.

Table 2-21
Hypothetical Fishing Platform User: CTE Summary - Sandblast Area AOPC

Analyte	Soil EPC (mg/kg)	Mutagen?	Cancer-Risk Estimate: Ingestion	Cancer-Risk Estimate: Inhalation	Cancer-Risk Estimate: Dermal	Cancer-Risk Estimate: Multi-Pathway	% of Cumulative	Noncancer Hazard Estimate (Child): Ingestion	Noncancer Hazard Estimate (Child): Inhalation	Noncancer Hazard Estimate (Child): Dermal	Noncancer Hazard Estimate (Child): Multi-Pathway	Noncancer Hazard Estimate (Adult): Ingestion	Noncancer Hazard Estimate (Adult): Inhalation	Noncancer Hazard Estimate (Adult): Dermal	Noncancer Hazard Estimate (Adult): Multi-Pathway
Inorganic Constituents															
Arsenic	9.71		**2.18E-06**	9.86E-10	6.27E-08	**2.2E-06**	5%	5.39E-02	1.19E-04	1.54E-03	5.6E-02	5.05E-03	1.19E-04	1.83E-04	5.4E-03
Chromium (III)	579		--	--	--			1.07E-03	--	7.82E-04	1.9E-03	1.00E-04	--	9.32E-05	1.9E-04
Lead[1]	418		--	--	--			--	--	--	--	--	--	--	--
Nickel	251		--	2.57E-09	--	2.6E-09	< 1%	3.48E-02	8.54E-04	8.27E-03	4.4E-02	3.27E-03	8.54E-04	9.85E-04	5.1E-03
Polychlorinated Biphenyls (PCBs) - Mixtures															
Total PCBs	0.419		2.09E-07	9.40E-12	2.81E-08	2.4E-07	< 1%	5.82E-02	--	7.73E-03	6.6E-02	5.45E-03	--	9.21E-04	6.4E-03
Volatile Organic Compounds (VOCs)															
Tetrachloroethene	26.3		1.38E-08	2.45E-07	0.00E+00	2.6E-07	< 1%	1.22E-02	1.83E-01	0.00E+00	2.0E-01	1.14E-03	1.83E-01	0.00E+00	1.8E-01
Trichloroethene	1.78		2.04E-08	2.77E-07	0.00E+00	3.0E-07	< 1%	9.88E-03	2.63E-01	0.00E+00	2.7E-01	9.27E-04	2.63E-01	0.00E+00	2.6E-01
Semivolatile Organic Compounds (SVOCs)															
DEHP	77.1		2.69E-07	7.28E-12	2.58E-08	2.9E-07	< 1%	1.07E-02	--	1.02E-03	1.2E-02	1.00E-03	--	1.21E-04	1.1E-03
Polycyclic Aromatic Hydrocarbons (PAHs)															
Benzo[a]anthracene	2.45	M	**2.54E-06**	8.49E-11	3.22E-07	**2.9E-06**	6%	--	--	--	--	--	--	--	--
Benzo[a]pyrene	2.39	M	**2.47E-05**	8.28E-10	**3.14E-06**	**2.8E-05**	58%	--	--	--	--	--	--	--	--
Benzo[b]fluoranthene	2.21	M	**2.29E-06**	7.66E-11	2.90E-07	**2.6E-06**	5%	--	--	--	--	--	--	--	--
Benzo[g,h,i]perylene	1.05		--	--	--			9.72E-05	--	1.20E-05	1.1E-04	9.11E-06	--	1.43E-06	1.1E-05
Benzofluoranthenes, Total	6.36	M	**6.58E-06**	2.20E-10	8.35E-07	**7.4E-06**	15%	--	--	--	--	--	--	--	--
Dibenz[a,h]anthracene	0.238	M	**2.46E-06**	9.00E-11	3.13E-07	**2.8E-06**	6%	--	--	--	--	--	--	--	--
Indeno[1,2,3-cd]pyrene	1.16	M	**1.20E-06**	4.02E-11	1.52E-07	**1.4E-06**	3%	--	--	--	--	--	--	--	--
					cPAH Risk:	**4.5E-05**									
					Cumulative Risk:	**4.8E-05**				**Hazard Index (Child):**	0.65			**Hazard Index (Adult):**	0.47
					Nursing Infant Risk:	*1.4E-07*				***Nursing Infant Hazard:***	*0.26*				

Notes
Cancer risks are presented for time-integrated adult+child exposure. Noncancer hazards are presented separately for exposure during adulthood and exposure during childhood.
Nursing infant's risks and hazards are presented as a function of Mother's risks and hazards, assuming an infant exposure duration of 1 year.
EPCs from Table 1-2.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7b.
Italics = Nursing Infant cancer risk and noncancer hazard based on ODEQ (2010) approach.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.
(1) Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B.

"--" = data not available or not calculated
% = percent
0 = non-mutagenic
AOPC = area of potential concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CTE = central tendency exposure
DEHP = bis(2-ethylhexyl)phthalate
EPC = exposure point concentration
M = mutagenic compound
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
SVOC = semivolatile organic compound
VOC = volatile organic compound

Source
ODEQ. 2010. Human Health Risk Assessment Guidance. Final. October.

Table 2-22
Excavation/Trench Worker, Exposure to Groundwater: RME Summary - Sandblast Area AOPC

Analyte	Water EPC ($\mu g/L$)	Cancer-Risk Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative	Noncancer-Hazard Estimate Ingestion	Inhalation	Dermal	Multi-Pathway	% of Cumulative
Inorganic Constituents											
Vanadium	2.23E-01	--	--	--			2.75E-07	--	1.21E-05	1.2E-05	< 1%
Volatile Organic Compounds (VOCs)											
Acetone	3.88E+00	--	--	--			2.66E-08	2.12E-06	1.93E-08	2.2E-06	< 1%
Benzene	1.37E-01	6.64E-13	5.86E-10	1.40E-11	6.0E-10	< 1%	2.11E-07	1.75E-04	4.45E-06	1.8E-04	< 1%
Carbon disulfide	2.55E-01	--	--	--			1.57E-08	1.43E-05	2.55E-07	1.5E-05	< 1%
Chloroform	1.74E-01	4.75E-13	1.77E-09	5.43E-12	1.8E-09	2%	1.07E-07	5.49E-05	1.23E-06	5.6E-05	< 1%
1,1-Dichloroethane	5.00E+00	2.51E-12	3.90E-09	2.62E-11	3.9E-09	4%	1.54E-07	--	1.61E-06	1.8E-06	< 1%
1,1-Dichloroethene	1.16E+00	--	--	--			1.43E-07	2.02E-04	2.53E-06	2.0E-04	< 1%
cis-1,2-Dichloroethene	6.60E+02	--	--	--			2.03E-03	--	2.40E-02	2.6E-02	4%
trans-1,2-Dichloroethene	1.80E+00	--	--	--			5.55E-07	1.04E-03	9.24E-06	1.0E-03	< 1%
1,2-Dichloropropane	1.79E-01	5.67E-13	8.09E-10	6.95E-12	8.2E-10	< 1%	1.23E-08	1.42E-03	1.50E-07	1.4E-03	< 1%
Ethylbenzene	4.47E-02	4.33E-14	5.28E-11	3.17E-12	5.6E-11	< 1%	2.76E-09	1.48E-06	2.02E-07	1.7E-06	< 1%
Tetrachloroethene	5.45E+01	1.01E-11	5.38E-09	6.95E-10	6.1E-09	6%	5.60E-05	3.62E-02	3.86E-03	4.0E-02	5%
Toluene	6.40E-01	--	--	--			4.93E-08	4.54E-06	2.21E-06	6.8E-06	< 1%
1,1,1-Trichloroethane	2.22E+00	--	--	--			6.84E-09	1.32E-05	1.53E-07	1.3E-05	< 1%
Trichloroethene	4.37E+01	1.77E-10	7.62E-08	3.61E-09	8.0E-08	74%	5.39E-04	6.51E-01	1.10E-02	6.6E-01	90%
Vinyl Chloride	4.10E+00	2.60E-10	1.12E-08	2.99E-09	1.4E-08	13%	8.42E-06	1.78E-03	9.70E-05	1.9E-03	< 1%
Xylenes	1.32E-01	--	--	--			4.07E-09	4.35E-05	3.03E-07	4.4E-05	< 1%
1,2,4-trimethylbenzene	4.85E-02	--	--	--			--	2.15E-04	--	2.1E-04	< 1%
o-xylene	7.35E-02	--	--	--			2.27E-09	2.42E-05	1.59E-07	2.4E-05	< 1%
Naphthalene	4.52E-02	--	5.96E-10	--	6.0E-10	< 1%	1.39E-08	4.09E-04	1.08E-06	4.1E-04	< 1%
				Cumulative Risk:	1.1E-07				**Cumulative Hazard:**	0.73	

Notes
EPCs from Table 1-8.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

RME = reasonable maximum exposure
"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
EPC = exposure point concentration
ug/L = micrograms per liter
VOC = volatile organic chemical

Table 2-23
Indoor Worker, Exposure to Indoor Air: RME Summary - Sandblast Area AOPC

Definition	Variable	Value	
Attenuation Factor	α	chemical-specific	dimensionless
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	25	yrs
COPC Concentration in indoor air	$C_{indoor\ air}$	chemical-specific	$\mu g/m^3$
COPC Concentration in soil gas	$C_{soil\ gas}$	chemical-specific	$\mu g/m^3$
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	250	days/yr
Exposure Time, worker	ET_w	8	hours/day
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$

Risk and Hazard Equations

Cancer Risk:

$$Risk = IUR \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_{nc,w} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Where:

$$C_{indoor\ air} = C_{soil\ gas} \times \alpha$$

Analyte	$C_{soil\ gas}$ ($\mu g/m^3$)	α (dimensionless)	$C_{indoor\ air}$ ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Hypothetical Future Scenario: Volatile Organic Compounds (VOCs)									
tetrachloroethene	3.40E+04	5.06E-04	1.72E+01	2.60E-07	3.65E-07	77%	4.00E+01	9.82E-02	73%
trichloroethene	6.10E+02	5.24E-04	3.20E-01	4.10E-06	1.07E-07	23%	2.00E+00	3.65E-02	27%
Current Scenario BISB: Volatile Organic Compounds (VOCs)									
tetrachloroethene	1.80E+03	2.34E-04	4.21E-01	2.60E-07	8.94E-09	2%	4.00E+01	2.41E-03	2%
trichloroethene	2.70E+01	2.38E-04	6.43E-03	4.10E-06	2.15E-09	< 1%	2.00E+00	7.34E-04	< 1%
Current Scenario Equipment Building: Volatile Organic Compounds (VOCs)									
tetrachloroethene	7.30E+02	8.88E-04	6.48E-01	2.60E-07	1.37E-08	3%	4.00E+01	3.70E-03	3%
trichloroethene	4.10E+01	9.41E-04	3.86E-02	4.10E-06	1.29E-08	3%	2.00E+00	4.40E-03	3%

Hypothetical Future Scenario: Totals

	Cancer Risk	Hazard Index
Pathway Sums:	4.7E-07	1.3E-01

Current Scenario BISB: Totals

	Cancer Risk	Hazard Index
Pathway Sums:	1.1E-08	3.1E-03

Table 2-23
Indoor Worker, Exposure to Indoor Air: RME Summary - Sandblast Area AOPC

Definition	Variable	Value	Units
Attenuation Factor	α	chemical-specific	dimensionless
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	25	yrs
COPC Concentration in indoor air	$C_{indoor\ air}$	chemical-specific	$\mu g/m^3$
COPC Concentration in soil gas	$C_{soil\ gas}$	chemical-specific	$\mu g/m^3$
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	250	days/yr
Exposure Time, worker	ET_w	8	hours/day
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$

Risk and Hazard Equations

Cancer Risk:

$$Risk = IUR \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_{nc,w} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Where:

$$C_{indoor\ air} = C_{soil\ gas} \times \alpha$$

Analyte	$C_{soil\ gas}$ $(\mu g/m^3)$	α (dimensionless)	$C_{indoor\ air}$ $(\mu g/m^3)$	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC $(\mu g/m^3)$	Hazard Quotient (dimensionless)	% of Total
Current Scenario Equipment Building: Totals									
				Pathway Sums:	Cancer Risk 2.7E-08			Hazard Index 8.1E-03	

Notes
EPCs from Table 1-6.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

α = Attenuation factor — See Appendix B for USEPA model.
"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
BISB = existing building on site
EPC = exposure point concentration
ug/m^3 = micrograms per cubic meter
RME = reasonable maximum exposure
VOCs = volatile organic compounds

Table 2-24
Indoor Worker, Exposure to Indoor Air: CTE Summary - Sandblast Area AOPC

Definition	Variable	Value	
Attenuation Factor	α	chemical-specific	dimensionless
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	6	yrs
COPC Concentration in indoor air	$C_{indoor\ air}$	chemical-specific	$\mu g/m^3$
COPC Concentration in soil gas	$C_{soil\ gas}$	chemical-specific	$\mu g/m^3$
Exposure Duration, worker	ED_w	6	yrs
Exposure Frequency, worker	EF_w	250	days/yr
Exposure Time, worker	ET_w	8	hours/day
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$

Risk and Hazard Equations

Cancer Risk:

$$Risk = IUR \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_{nc,w} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$

Where:

$$C_{indoor\ air} = C_{soil\ gas} \times \alpha$$

Analyte	$C_{soil\ gas}$ ($\mu g/m^3$)	α (dimensionless)	$C_{indoor\ air}$ ($\mu g/m^3$)	IUR ($\mu g/m^3$)$^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Hypothetical Future Scenario: Volatile Organic Compounds (VOCs)									
tetrachloroethene	3.40E+04	5.06E-04	1.72E+01	2.60E-07	8.76E-08	77%	4.00E+01	9.82E-02	73%
trichloroethene	6.10E+02	5.24E-04	3.20E-01	4.10E-06	2.56E-08	23%	2.00E+00	3.65E-02	27%
Current Scenario BISB: Volatile Organic Compounds (VOCs)									
tetrachloroethene	1.80E+03	2.34E-04	4.21E-01	2.60E-07	2.14E-09	2%	4.00E+01	2.41E-03	2%
trichloroethene	2.70E+01	2.38E-04	6.43E-03	4.10E-06	5.16E-10	< 1%	2.00E+00	7.34E-04	< 1%
Current Scenario Equipment Building: Volatile Organic Compounds (VOCs)									
tetrachloroethene	7.30E+02	8.88E-04	6.48E-01	2.60E-07	3.30E-09	3%	4.00E+01	3.70E-03	3%
trichloroethene	4.10E+01	9.41E-04	3.86E-02	4.10E-06	3.10E-09	3%	2.00E+00	4.40E-03	3%

Hypothetical Future Scenario: Volatile Organic Compounds (VOCs)

	Cancer Risk	Hazard Index
Pathway Sums:	1E-07	1.3E-01

Current Scenario BISB: Volatile Organic Compounds (VOCs)

	Cancer Risk	Hazard Index
Pathway Sums:	3E-09	3.1E-03

Table 2-24
Indoor Worker, Exposure to Indoor Air: CTE Summary - Sandblast Area AOPC

Definition	Variable	Value		Risk and Hazard Equations
Attenuation Factor	α	chemical-specific	dimensionless	Cancer Risk:
Averaging Time, carcinogens	AT_c	70	yrs	$$Risk = IUR \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	6	yrs	
COPC Concentration in indoor air	$C_{indoor\ air}$	chemical-specific	µg/m^3	Noncancer Hazard:
COPC Concentration in soil gas	$C_{soil\ gas}$	chemical-specific	µg/m^3	$$Hazard = \frac{1}{RfC} \times \left[C_{indoor\ air} \times \left(\frac{ED_w \times EF_w \times ET_w}{AT_{nc,w} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right) \right]$$
Exposure Duration, worker	ED_w	6	yrs	
Exposure Frequency, worker	EF_w	250	days/yr	Where:
Exposure Time, worker	ET_w	8	hours/day	
Inhalation Reference Concentration	RfC	chemical-specific	µg/m^3	$$C_{indoor\ air} = C_{soil\ gas} \times \alpha$$
Inhalation Unit-Risk Factor	IUR	chemical-specific	(µg/m^3)$^{-1}$	

Analyte	**$C_{soil\ gas}$** ($\mu g/m^3$)	**α** (*dimensionless*)	**$C_{indoor\ air}$** ($\mu g/m^3$)	**IUR** ($\mu g/m^3$)$^{-1}$	**Cancer Risk** (*dimensionless*)	**% of Total**	**RfC** ($\mu g/m^3$)	**Hazard Quotient** (*dimensionless*)	**% of Total**
Current Scenario Equipment Building: Volatile Organic Compounds (VOCs)									
				Pathway Sums:	Cancer Risk 6.4E-09			Hazard Index 8.1E-03	

Notes
EPCs from Table 1-6.
Toxicity values from Table 2-8.
Exposure Factors from Table 2-7a.
Bolded values indicate a risk estimate > 1E-06 or a hazard estimate >1.

α = Attenuation factor — See Appendix B for EPA model
"--" = data not available or not calculated
% = percent
AOPC = area of potential concern
BISB = existing building on site
CTE = central tendency exposure
EPC = exposure point concentration
ug/m^3 = micrograms per cubic meter
VOCs = volatile organic compounds
BISB = building on site

Table 2-25
Summary of Lead Models Results

AOPC	Medium	EPC (mg/kg)	Receptor	Probability [a]	Probability Exceeds 5% [b]
Landfill	Unsieved soil (0-1 ft bgs)	211	Occupational	0.013%	No
			Fetus of Adult Resident	0.034%	No
			Child Resident	0.36%	No
	Unsieved soil (0-3 ft bgs)	342	Occupational	0.032%	No
Sandblast	Soil - sieved <250 um (0-1 ft bgs)	300	Occupational	0.025%	No
			Fetus of Adult Resident	0.075%	No
			Child Resident	1.52%	No
	Soil - sieved <250 um (0-3 ft bgs)	202	Occupational	0.013%	No
Pistol Range	Unsieved soil	208	Fetus of Adult Resident	0.033%	No
			Child Resident	0.34%	No
Pistol Range	Unsieved sediment	27.1	Fetus of Adult Resident	0.0033%	No
			Child Resident	<0.075%	No
Bulb Slope	Unsieved soil	222	Fetus of Adult Resident	0.038%	No
			Child Resident	0.45%	No

Notes

Model details are available in Appendix B.

(a) Probability that the receptor would have a PbB exceeding the 10 µg/dL level of concern.

(b) USEPA's target is to limit the risk to a typical child or fetus of an adult exposed at a site to no more than a 5% chance of exceeding the 10 µg/dL PbB of concern (USEPA 1994, 2003).

PbB was also evaluated for probability of exceeding the CDC recommended level of concern of 5 ug/dl, and all results were less than 5% (CDC 2012, USEPA 2010).

% = percent
µg/dL = micrograms of lead per deciliter of blood
AOPC = area of potential concern
bgs = below ground surface
EPC = exposure point concentration
ft = foot
mg/kg = milligrams per kilogram
PbB = blood lead level
um = micrometers

Sources

CDC. 2012. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. January.

USEPA. 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Washington, DC: Office of Emergency and Remedial Response. July. OSWER Directive #9355.4-12. July.

USEPA. 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil [EPA-540-R-03-001, OSWER Dir #9285.7-54. January.

USEPA. 2010. Integrated Exposure Uptake Biokinetic Model for Lead in Children, IEUBK win v1.1 Build 11, Software Program. Developed by U.S. EPA. February.

Table 2-26
Summary of Upland OU Cancer Risk and Noncancer Health Hazard

AOPC	Receptor (a)	Exposure Media	Reasonable Maximum Exposure (RME) Cancer Risk ELCR	RME Adult Noncancer	RME Child Noncancer	Central Tendency Exposure (CTE) Cancer Risk ELCR	CTE Adult Noncancer	CTE Child Noncancer
Landfill	**Outdoor Maintenance Worker**	**Surface Soil (0-3 ft bgs)**	**6E-05**	0.020	NA	**6E-06**	0.0088	NA
	Construction Worker	**Deep Soil (0-10 ft bgs)**	**5E-06**	1.2	NA	7E-07	0.018	NA
	Excavation / Trench Worker	**Groundwater**	5E-08	0.036	NA	--	--	NA
	Hypothetical Fishing Platform User	**Surface Soil (0-3 ft bgs)**	**1E-03**	0.49	1.4	**2E-04**	0.14	0.31
	Nursing Infant: Hypothetical Fishing Platform User	**Surface Soil (0-3 ft bgs)**	1E-06	NA	**1.5**	1E-07	NA	0.26
Sandblast Area	**Outdoor Maintenance Worker**	**Surface Soil (0-3 ft bgs)**	**1E-05**	0.068	NA	1E-06	0.0081	NA
	Construction Worker	**Deep Soil (0-10 ft bgs)**	**2E-06**	0.97	NA	3E-07	0.014	NA
	Excavation / Trench Worker	**Groundwater**	1E-07	0.73	NA	--	--	NA
	Future: Indoor Worker	**Indoor Air**	5E-07	0.13	NA	1E-07	0.13	NA
	Current: BISB Indoor Worker	**Indoor Air**	1E-08	0.0031	NA	3E-09	0.0031	NA
	urrent: Equipment Building Indoor Worke	**Indoor Air**	3E-08	0.0081	NA	6E-09	0.0081	NA
	Hypothetical Fishing Platform User	**Surface Soil (0-3 ft bgs)**	**3E-04**	0.97	**1.9**	**5E-05**	0.47	0.65
	Nursing Infant: Hypothetical Fishing Platform User	**Surface Soil (0-3 ft bgs)**	1E-06	NA	**1.5**	1E-07	NA	0.26

Table 2-26
Summary of Upland OU Cancer Risk and Noncancer Health Hazard

Notes

benzofluoranthenes, total = uses benzo(b)fluoranthene for surrogate toxicity values and chemical properties.

(a) The Nursing Infant pathway screened out for the occupational receptors. See Section 2.1.

Cancer risks are presented for time-integrated child + adult exposure.

Noncancer health hazards are presented separately for exposure during adulthood and exposure during childhood.

Nursing infant risks and hazards are presented as a function of mother's risks, assuming a 1-year exposure duration

Bold font indicates greater than the ODEQ risk threshold for cancer risk ($1x10^{-6}$) and/or noncancer HI (1).

-- = not available / not calculated
AOPC = area of potential concern
BISB = Bradford Island Service Building (Located near Sandblast AOPC)
CTE = central tendency exposure
ELCR = excess lifetime cancer risk
ft bgs = foot/feet below ground surface
HI = hazard index
NA = not applicable
OU = operable unit
RME = reasonable maximum exposure

Table 2-27
Summary of Upland OU Human Health COCs for Further Evaluation in the FS

AOPC	Receptor	Chemical of Concern (COC)	Calculated Soil RBC (mg/kg)	Reference Area UPL (mg/kg)
Landfill	Outdoor Maintenance Worker	cPAHs [b]	0.3 [a]	0.052
	Construction Worker	cPAHs [b]	2.0	0.052
	Hypothetical Fishing Platform User	Arsenic	0.68	5.5
		Total PCBs	0.24	--
		cPAHs [b]	0.015	0.052
Sandblast Area	Outdoor Maintenance Worker	cPAHs [b]	0.3 [a]	0.037 [a]
	Hypothetical Fishing Platform User	Arsenic	0.68	5.5
		Total PCBs	0.24	--
		Bis(2-ethylhexyl)phthalate (DEHP)	37	--
		cPAHs [b]	0.015	0.052

Notes

(a) Based on the toxicity value for benzo(a)pyrene and expressed as benzo(a)pyrene equivalents (BaPeq).

(b) RBC for cPAH is based on RME and target cancer risk of 1E-06. If ODEQ's acceptable risk level of 1E-05 was used, the RBCs would increase to: Outdoor Maintenance Worker – 3 mg/kg, Construction Worker – 20 mg/kg, and Hypothetical Fishing Platform User – 0.15 mg/kg.

In Section 2.5, arsenic was tentatively identified as a COC for occupational receptors. The calculated risk-based value was 2 mg/kg, which is lower than the Reference Area UPL of 5.4 mg/kg. Arsenic was included in the exceedance Figure 2-3 and Figure 2-4 based on concentrations exceeding the Reference UPL value of 5.4 mg/kg.

Table 2-27
Summary of Upland OU Human Health COCs for Further Evaluation in the FS

-- = not available
AOPC = area of potential concern
COC = constituent of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
DEHP = Bis(2-ethylhexyl)phthalate
mg/kg = milligram per kilogram
PCB = polychlorinated biphenyl
RBC = risk-based concentration
RME = reasonable maximum exposure
UPL = upper prediction limit

Table 3-1
Exposure Assumptions and Dose Equations for the Canada Goose (*Branta canadensis*)

Equation:

$$D = \frac{AUF \times [(C_{F1} \times P_{F1} \times IR_F) + (C_S \times IR_S) + (C_W \times IR_W)]}{BW}$$

Where:

D = Chemical dose (mg/kg-bw/day)

C_{F1} = C_S x plant BAF, where C_S is the chemical concentration

C_W = C_S/Kd (inorganics) and $C_S/(foc * K_{oc})$ (organics), foc assumed 0.01

IR_F = 0.638 x BW in grams ^0.685 *0.001 [a]

IR_S = 0.082 x IR_F

IR_W = 0.059 x BW^0.67

Parameter	Definition	Value	Units	Source [b]
C_{F1}	Chemical concentration in food item 1 (plants)	food chain model	mg/kg dry	Food concentrations were estimated on a dry weight basis using uptake models using concentrations at the AOPC or by multiplying concentrations in soil at the site by BAFs for plants.
C_S	Surface: 95% UCL in surface soil (0-1 feet) Shallow: 95% UCL in shallow soil (0-3 feet)	chemical-specific	mg/kg dry	Upland OU analytical data.
C_W	Concentration in upland water	chemical-specific	mg/L	Upland OU calculated puddled water (via equilibrium partitioning calculation).
HR	Home Range	2,430	acres	USEPA 1993
AUF	Area Use Factor - All AOPCs	1	unitless	Assumed present 100% of the time. Bradford Island is managed as Canada goose habitat.
P_{F1}	Proportion of food item 1 - plants	1	unitless	Diet assumed 100% plants.
IR_F	Ingestion Rate - plants	0.15	kg dry/day	Nagy 2001 for all birds.
IRs	Incidental Ingestion Rate - soil	0.013	kg dry/day	Based on 8.2% of total food ingestion rate (Beyer et al. 1994).
IR_W	Ingestion Rate - water	0.12	L/day	USEPA 1993
BW	Body weight	3.0	kg	Since no breeding female available, average of adult female data used (USEPA 1993).

Table 3-1
Exposure Assumptions and Dose Equations for the Canada Goose (*Branta canadensis*)

Notes:
a) Allometric relationships with gram body weight.
b) See Table 3-3 of Technical Memorandum, Update to Risk Assessment Work Plan, Upland OU (URS 2014).

% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
foc = fraction of organic carbon
Kd = soil-water partition coefficient (cm^3/g)
kg = kilograms
kg dry/day = kilograms per day in dry weight
K_{oc} = organic carbon partition coefficient (L/kg)
L/day = liters per day
mg/kg-day = milligrams per kilogram per day
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
OU = operational unit
UCL = upper confidence limit
USEPA = U.S. Environmental Protection Agency

References:

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage* . 58:375-382.
Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B 71, 21R-31R.
URS. 2014. Update to Risk Assessment Work Plan for the Upland OU. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. April.
U.S. Environmental Protection Agency (USEPA). 1993. “Wildlife Exposure Factors Handbook.” December. 1993.

Table 3-2
Exposure Assumptions and Dose Equations for the American Robin (*Turdus migratorius*)

Equation:

$$D = \frac{AUF \times [(C_{F1} \times P_{F1} \times IR_F) + (C_S \times IR_S) + (C_W \times IR_W)]}{BW}$$

Where:

D = Chemical dose (mg/kg-bw/day)

C_{F1} = C_S x invertebrate BAF, where C_S is the chemical concentration

C_W = C_S/Kd (inorganics) and $C_S/(foc * K_{oc})$ (organics), foc assumed 0.01

IR_F = 0.638 x BW in grams ^0.685 *0.001 [a]

IR_S = 0.104 x IR_F

IR_W= 0.059 x BW^0.67

Parameter	Definition	Value	Units	Source [b]
C_{F1}	Chemical concentration in food item 1 (invertebrates)	food chain model	mg/kg dry	Food concentrations were estimated on a dry weight basis using uptake models using concentrations at the site or by multiplying concentrations in soil at the site by BAFs for soil invertebrates.
C_S	Surface: 95% UCL in surface soil (0-1 feet) Shallow: 95% UCL in shallow soil (0-3 feet)	chemical-specific	mg/kg dry	Upland OU analytical data.
C_W	Concentration in upland water	chemical-specific	mg/L	Upland OU calculated puddled water (via equilibrium partitioning calculation).
HR	Home Range	0.37	acres	USEPA 1993
AUF	Landfill AOPC (1.36 acres)	1	unitless	Area of site divided by area of HR (1 = 100% site use).
	Sandblast Area AOPC (3.10 acres)	1	unitless	Area of site divided by area of HR (1 = 100% site use).
	Pistol Range AOPC (0.26 acres)	0.26	unitless	Area of site divided by area of HR.
	Bulb Slope AOPC (0.054 acres)	0.15	unitless	Area of site divided by area of HR.
P_{F1}	Proportion of food item 1 - invertebrates	1	unitless	Diet assumed 100% invertebrates.
IR_F	Ingestion Rate - invertebrates	0.013	kg dry/day	Nagy 2001 for all birds.
IR_S	Incidental Ingestion Rate - soil	0.0013	kg dry/day	Based on 10.4% of total food ingestion for woodcock (Beyer et al. 1994).
IR_W	Ingestion Rate - water	0.011	L/day	USEPA 1993
BW	Body weight	0.0773	kg	USEPA 1993

Table 3-2
Exposure Assumptions and Dose Equations for the American Robin (*Turdus migratorius*)

Notes:

a) Allometric relationships with gram body weight.

b) See Table 3-3 of Technical Memorandum, Update to Risk Assessment Work Plan, Upland OU (URS 2014).

% = percent
AOPC = area of potential concern
AUF = area use factor
BAF = bioaccumulation factor
foc = fraction of organic carbon
Kd = soil-water partition coefficient (cm^3/g)
kg = kilograms
kg dry/day = kilograms per day in dry weight
K_{oc} = organic carbon partition coefficient (L/kg)
L/day = liters per day
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/kg dry = milligrams per kilogram in dry weight
mg/L = milligrams per liter
OU = operational unit
UCL = upper confidence limit
USEPA = U.S. Environmental Protection Agency

References:

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage* . 58:375-382.

Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B 71, 21R-31R.

URS. 2014. Update to Risk Assessment Work Plan for the Upland OU. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. April.

U.S. Environmental Protection Agency (USEPA). 1993. “Wildlife Exposure Factors Handbook.” December. 1993.

Table 3-3
Exposure Assumptions and Dose Equations for the American Kestrel (*Falco sparverius*)

Equation:

$$D = \frac{AUF \times [(C_{F1} \times P_{F1} \times IR_F) + (C_S \times IR_S) + (C_W \times IR_W)]}{BW}$$

Where:

$D =$ Chemical dose (mg/kg-bw/day)

$C_{F1} = C_S$ x small mammal BAF, where C_S is the chemical concentration

$IR_F =$ 0.638 x BW in grams ^0.685 *0.001 [a]

$IR_S = 0.02 \times IR_F$

$IR_W = 0.059 \times BW^{0.67}$

Parameter	Definition	Value	Units	Source [b]
C_{F1}	Chemical concentration in food	food chain model	mg/kg dry	Food concentrations were estimated on a dry weight basis using uptake models using concentrations at the site or by multiplying concentrations in soil at the site by BAFs for small mammals.
C_S	Surface: 95% UCL in surface soil (0-1 feet) Shallow: 95% UCL in shallow soil (0-3 feet)	chemical-specific	mg/kg dry	Upland OU analytical data.
Cw	Concentration in upland water	chemical-specific	mg/L	River OU analytical data.
HR	Home Range	270	acres	Cal/ECOTOX 2002
AUF	Landfill AOPC (1.36 acres)	0.0050	unitless	Area of site divided by area of HR.
	Sandblast Area AOPC (3.10 acres)	0.0115	unitless	Area of site divided by area of HR (1 = 100% site use).
	Pistol Range AOPC (0.26 acres)	0.00020	unitless	Area of site divided by area of HR.
	Bulb Slope AOPC (0.054 acres)	0.00096	unitless	Area of site divided by area of HR.
	Combined AOPCs (4.77 acres)	0.0177	unitless	Area of site divided by area of HR.
P_{F1}	Proportion of food item 1 - small mammal	1	unitless	100% small mammal diet.
IR_F	Food ingestion rate - small mammal	0.017	kg dry /day	Nagy 2001 for all birds.
IR_S	Incidental Ingestion Rate - soil	0.00033	kg dry/day	Default 2% of total food ingestion rate (Beyer et al. 1994).
IR_W	Ingestion Rate - water	0.014	L/day	USEPA 1993
BW	Body weight	0.116	kg	USEPA 1993

Table 3-3
Exposure Assumptions and Dose Equations for the American Kestrel (*Falco sparverius*)

Notes:

a) Allometric relationships with gram body weight.

b) See Table 3-3 of Technical Memorandum, Update to Risk Assessment Work Plan, Upland OU (URS 2014).

% = percent
AOPC = area of potential concern
AUF = area use factor
BAF = bioaccumulation factor
kg = kilograms
kg dry/day = kilograms per day in dry weight
L/day = liters per day
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/kg dry = milligrams per kilogram in dry weight
mg/L = milligrams per liter
OU = operational unit
UCL = upper confidence limit
USEPA = U.S. Environmental Protection Agency

References:

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage* . 58:375-382.

California Wildlife Biology, Exposure Factor, and Toxicity Database (Cal/ECOTOX). 2002. Created by the California Office of Environmental Health Hazard Assessment and the University of California at Davis.

Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B

URS. 2014. Update to Risk Assessment Work Plan for the Upland OU. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. April.

U.S. Environmental Protection Agency (USEPA). 1993. “Wildlife Exposure Factors Handbook.” December. 1993.

Table 3-4
Exposure Assumptions and Dose Equations for the Vagrant Shrew (*Sorex vagrans*)

Equation:

$$D = \frac{AUF \times [(C_{F1} \times P_{F1} \times IR_F) + (C_S \times IR_S) + (C_W \times IR_W)]}{BW}$$

Where:

D = Chemical dose (mg/kg-bw/day)

C_{F1} = C_S x invertebrate BAF, where C_S is the chemical concentration

C_W = C_S/Kd (inorganics) and $C_S/(foc * K_{oc})$ (organics), foc assumed 0.01

IR_F = 0.323 x BW in grams ^0.744 *0.001 [a]

IR_S = 0.04 x IR_F

IR_W = 0.099 x BW^0.9

Parameter	Definition	Value	Units	Source [b]
C_{F1}	Chemical concentration in food	food chain model	mg/kg dry	Food concentrations were estimated on a dry weight basis using uptake models using concentrations at the site or by multiplying concentrations in soil at the site by BAFs for soil invertebrates.
C_S	Surface: 95% UCL in surface soil (0-1 feet) Shallow: 95% UCL in shallow soil (0-3 feet)	chemical specific	mg/kg dry	Upland OU analytical data.
C_W	Concentration in upland water	chemical-specific	mg/L	Upland OU calculated puddled water (via equilibrium partitioning calculation).
HR	Home Range	0.26	acres	Zeiner et al. 1990
AUF	Landfill AOPC (1.36 acres)	1	unitless	Area of site divided by area of HR (1 = 100% site use).
	Sandblast Area AOPC (3.10 acres)	1	unitless	Area of site divided by area of HR (1 = 100% site use)
	Pistol Range AOPC (0.26 acres)	1	unitless	Area of site divided by area of HR.
	Bulb Slope AOPC (0.054 acres)	0.21	unitless	Area of site divided by area of HR.
P_{F1}	Proportion of food item 1 - invertebrates	1	unitless	Diet assumed 100% invertebrates.
IR_F	Food ingestion rate - invertebrates	0.0014	kg dry /day	Nagy 2001 for all mammals.
IR_S	Incidental Ingestion Rate - soil	0.000055	kg dry /day	Based on 4% of total food ingestion rate (double white-footed mouse; Beyer et al. 1994).
IR_W	Ingestion Rate - water	0.0011	L/day	USEPA 1993
BW	Body weight	0.007	kg	USEPA 1993

Table 3-4
Exposure Assumptions and Dose Equations for the Vagrant Shrew (*Sorex vagrans*)

Notes:

a) Allometric relationships with gram body weight.

b) See Table 3-3 of Technical Memorandum, Update to Risk Assessment Work Plan, Upland OU (URS 2014).

% = percent
AOPC = area of potential concern
AUF = area use factor
BAF = bioaccumulation factor
kg = kilograms
kg dry/day = kilograms per day in dry weight
L/day = liters per day
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/kg dry = milligrams per kilogram in dry weight
mg/L = milligrams per liter
OU = operational unit
UCL = upper confidence limit
USEPA = U.S. Environmental Protection Agency

References:

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage* . 58:375-382.

Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B

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U.S. Environmental Protection Agency (USEPA). 1993. “Wildlife Exposure Factors Handbook.” December. 1993.

Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White. 1990. “California’s Wildlife: Volume II, Mammals.” CWHR System. State of California, the Resource Agency, CDFG. Sacramento, California.

Table 3-5
Exposure Assumptions and Dose Equations For the American Mink (*Neovison vison*)

Equation:

$$D = \frac{AUF \times [(C_{F1} \times P_{F1} \times IR_F) + (C_S \times IR_S) + (C_W \times IR_W)]}{BW}$$

Where:

D = Chemical dose (mg/kg-bw/day)

C_{F1} = C_S x small mammal BAF, where C_S is the chemical concentration

IR_F = 0.323 x BW in grams ^0.744 *0.001 [a]

IR_S = 0.094 x IR_F

IR_W = 0.099 x BW^0.9

Parameter	Definition	Value	Units	Source [b]
C_{F1}	Chemical concentration in food	food chain model	mg/kg dry	Food concentrations were estimated on a dry weight basis using uptake models using concentrations at the site or by multiplying concentrations in soil at the site by BAFs for small mammals.
C_S	Surface: 95% UCL in surface soil (0-1 feet) Shallow: 95% UCL in shallow soil (0-3 feet)	chemical specific	mg/kg dry	Analytical data.
C_W	Concentration in upland water	chemical-specific	mg/L	River OU analytical data.
HR	Home Range	19	acres	USEPA 1993
AUF	Landfill AOPC (1.36 acres)	0.072	unitless	Area of site divided by area of HR.
	Sandblast Area AOPC (3.10 acres)	0.163	unitless	Area of site divided by area of HR.
	Pistol Range AOPC (0.26 acres)	0.014	unitless	Area of site divided by area of HR.
	Bulb Slope AOPC (0.054 acres)	0.0028	unitless	Area of site divided by area of HR.
	Combined AOPCs (4.77 acres)	0.251	unitless	Area of site divided by area of HR.
P_{F1}	Proportion of food item 1 - small mammal	0.15	unitless	15% small mammal diet.
IR_F	Food ingestion rate - small mammal	0.054	kg dry /day	Nagy 2001 for all mammals.
IR_S	Incidental Ingestion Rate - soil	0.0051	kg dry /day	Based on 9.4% of total food ingestion rate for raccoon (Beyer et al. 1994).
IR_W	Ingestion Rate - water	0.097	L/day	USEPA 1993
BW	Body weight	0.974	kg	USEPA 1993

Table 3-5
Exposure Assumptions and Dose Equations For the American Mink (*Neovison vison*)

Notes:

a) Allometric relationships with gram body weight.

b) See Table 3-3 of Technical Memorandum, Update to Risk Assessment Work Plan, Upland OU (URS 2014).

% = percent
AOPC = area of potential concern
AUF = area use factor
BAF = bioaccumulation factor
kg = kilograms
kg dry/day = kilograms per day in dry weight
L/day = liters per day
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/kg dry = milligrams per kilogram in dry weight
mg/L = milligrams per liter
OU = operational unit
UCL = upper confidence limit
USEPA = U.S. Environmental Protection Agency

References:

Beyer, W.N., E. E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage* . 58:375-382.

Nagy, K.A. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B 71, 21R-31R.

URS. 2014. Update to Risk Assessment Work Plan for the Upland OU. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. April.

U.S. Environmental Protection Agency (USEPA). 1993. “Wildlife Exposure Factors Handbook.” December. 1993

Table 3-6
Statistical Summary for Random Forebay Surface Water Samples

Medium	Analyte Group	Preparation Fraction	Analyte	Basis	Number of Samples	Number of Detections	Mean of Detects (ug/L)	Median of Detects (ug/L)	Maximum Detected Value (ug/L)	EPC (mg/L)
Surface Water	Metals	Dissolved	Cadmium	Wet	5	2	0.00900	0.00900	0.0100	1.00E-05
Surface Water	Metals	Dissolved	Copper	Wet	5	5	0.470	0.460	0.520	5.20E-04
Surface Water	Metals	Dissolved	Lead	Wet	5	3	0.0240	0.0220	0.0360	3.60E-05
Surface Water	SVOCs	C+F	Benzo(a)anthracene	Wet	5	3	0.0536	-	0.0600	6.00E-07
Surface Water	SVOCs	C+F	Benzo(b)fluoranthene	Wet	5	2	0.0902	-	0.0917	9.17E-07
Surface Water	SVOCs	C+F	Chrysene	Wet	5	5	0.139	0.136	0.171	1.71E-06
Surface Water	SVOCs	C+F	Fluoranthene	Wet	5	5	0.706	0.674	0.784	7.84E-06

Notes
C+F = column plus filter
EPC = exposure point concentration
mg/L = milligrams per liter
SVOC = semi-volatile organic carbon
ug/L = micrograms per liter
Wet = Wet Weight

Table 3-7a
Estimated Surface Water Concentrations – Landfill AOPC

Analyte	95% UCL in Surface Soil (0-1 feet) (mg/kg dw)	Kd (cm^3/g) [a]	K_{oc} (L/kg) [a]	Water Concentration (mg/L) [b]
Inorganics				
Antimony	1.36	45	--	0.0302
Chromium	242	1,800,000	--	1.34E-04
Copper	170	35	--	4.86
Lead	332	900	--	0.37
Mercury	1.57	52	--	0.0302
Nickel	175	65	--	2.69
Butyltins				
Tributyltin	0.165	--	12,100	0.00136
Pesticides				
Chlordane (technical)	1.56	--	33,800	0.00462
Heptachlor	0.00283	--	41,300	6.85E-06
HPAHs				
Benzo(a)anthracene	8.34	--	177,000	0.00471
Benzo(a)pyrene	8.70	--	587,000	0.00148
Benzo(b)fluoranthene	16.0	--	599,000	0.00267
Benzo(g,h,i)perylene	4.59	--	1,950,000	2.35E-04
Benzo(k)fluoranthene	30.2	--	587,000	0.00514
Benzofluoranthenes, Total [c]	14.7	--	587,000	0.00250
Chrysene	8.40	--	181,000	0.00464
Dibenz(a,h)anthracene	4.23	--	1,910,000	2.21E-04
Fluoranthene	14.5	--	55,500	0.0261
Indeno(1,2,3-cd)pyrene	5.04	--	3,470,000	1.45E-04
Pyrene	12.3	--	54,300	0.0227
Total HPAHs [d]	90.2	--	437,607	0.0206
SVOCs				
Bis(2-ethylhexyl) Phthalate	9.68	--	120,000	0.00807
Butyl Benzyl Phthalate	0.0366	--	7,160	5.11E-04
Carbazole	0.751	--	9,160	0.00820
Dibenzofuran	0.152	--	9,160	0.00166
Di-n-butyl Phthalate	0.232	--	1,160	0.0200
VOCs				
1,2,4-Trimethylbenzene	3.03	--	614	0.493

Notes:
a) ORNL RAIS Database Chemical Parameters.
b) COC concentrations in water, used for the goose, robin, and shrew dose calculations, were calculated using equilibrium partitioning calculations:
Concentration in water (inorganics) = Concentration soil/ Kd
Concentration in water (organics) = Concentration soil/ (foc * K_{oc}), where foc assumed = 0.01
c) Benzo(k)fluoranthene Koc used as surrogate.
d) Geometric mean Koc of individual HPAHs used for Total HPAH.
-- = no data
% = percent
AOPC = area of potential concern
cm^3 = cubic centimeter
COC = chemical of concern
dw = dry weight
g = gram
HPAHs = high molecular weight polycyclic aromatic hydrocarbons

foc = fraction of organic carbon
Kd = soil-water partition coefficient (cm^3/g)
kg = kilogram
K_{oc} = organic carbon partition coefficient (L/kg)
L = liter
mg = milligrams
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-7b
Estimated Surface Water Concentrations – Sandblast Area AOPC

Analyte	95% UCL in Surface Soil (0-1 feet) (mg/kg dw)	Kd (cm^3/g) [a]	K_{oc} (L/kg) [a]	Water Concentration (mg/L) [b]
Inorganics				
Antimony	2.94	45	--	0.0653
Cadmium	3.20	75	--	0.0427
Chromium	720	1,800,000	--	4.00E-04
Lead	465	900	--	0.517
Mercury	0.113	52	--	0.00217
Nickel	353	65	--	5.43
Butyltins				
Tributyltin	0.481	--	12,100	0.00398
Pesticides				
BHC (delta)	0.00154	--	2,810	5.48E-05
BHC (gamma) Lindane	0.00968	--	2,810	3.44E-04
Chlordane (alpha)	0.000815	--	67,500	1.21E-06
Chlordane (gamma)	0.0303	--	67,500	4.49E-05
Endosulfan I	0.00269	--	6,760	3.98E-05
Endosulfan II	0.000495	--	6,760	7.32E-06
Endosulfan Sulfate	0.000953	--	9,850	9.68E-06
Endrin Aldehyde	0.00387	--	3,270	1.18E-04
Endrin Ketone	0.00309	--	9,720	3.18E-05
Endrin	0.00504	--	20,100	2.51E-05
Heptachlor	0.000464	--	41,300	1.12E-06
Methoxychlor	0.00105	--	41,300	2.54E-06
HPAHs				
Benzo(a)anthracene	1.75	--	177,000	9.89E-04
Benzo(a)pyrene	1.76	--	587,000	3.00E-04
Benzo(b)fluoranthene	1.95	--	599,000	3.26E-04
Benzo(g,h,i)perylene	1.07	--	1,950,000	5.49E-05
Benzo(k)fluoranthene	0.676	--	587,000	1.15E-04
Benzofluoranthenes, Total [c]	7.76	--	587,000	0.00132
Chrysene	2.07	--	181,000	0.00114
Dibenz(a,h)anthracene	0.244	--	1,910,000	1.28E-05
Fluoranthene	4.64	--	55,500	0.00836
Indeno(1,2,3-cd)pyrene	1.13	--	3,470,000	3.26E-05
Pyrene	4.78	--	54,300	0.00880
Total HPAHs [d]	18.6	--	437,607	0.00425
SVOCs				
Bis(2-ethylhexyl) Phthalate	98.0	--	120,000	0.0817
Butyl Benzyl Phthalate	0.0171	--	7,160	2.39E-04
Carbazole	0.144	--	9,160	0.00157
Dibenzofuran	0.0424	--	9,160	4.63E-04
Di-n-butyl Phthalate	0.0804	--	1,160	0.00693
Di-n-octyl Phthalate	0.0251	--	141,000	1.78E-05

Table 3-7b
Estimated Surface Water Concentrations – Sandblast Area AOPC

Analyte	95% UCL in Surface Soil (0-1 feet) (mg/kg dw)	Kd (cm^3/g) [a]	K_{oc} (L/kg) [a]	Water Concentration (mg/L) [b]
VOCs				
1,2,4-Trimethylbenzene	0.000230	--	614	3.75E-05
4-Isopropyltoluene	0.00133	--	1,120	1.19E-04
n-Propylbenzene	0.000150	--	813	1.85E-05

Notes:

a) ORNL RAIS Database Chemical Parameters.

b) COC concentrations in water, used for the goose, robin, and shrew dose calculations, were calculated using equilibrium partitioning calculations:

Concentration in water (inorganics) = Concentration soil/ Kd

Concentration in water (organics) = Concentration soil/ (foc * K_{oc}), where foc assumed = 0.01

c) Benzo(k)fluoranthene Koc used as surrogate.

d) Geometric mean Koc of individual HPAHs used for Total HPAH.

-- = no data

% = percent

AOPC = area of potential concern

BHC = benzene hexachloride

cm^3 = cubic centimeter

COC = chemical of concern

dw = dry weight

g = gram

HPAHs = high molecular weight polycyclic aromatic hydrocarbons

foc = fraction of organic carbon

Kd = soil-water partition coefficient (cm^3/g)

kg = kilogram

K_{oc} = organic carbon partition coefficient (L/kg)

L = liter

mg = milligrams

SVOC = semivolatile organic compound

UCL = upper confidence limit

VOC = volatile organic compound

Table 3-7c
Estimated Surface Water Concentrations – Pistol Range AOPC

CPEC	95% UCL in Surface Soil (0-1.5 feet) (mg/kg dw)	Kd (cm^3/g) [a]	K_{oc} (L/kg) [a]	Water Concentration (kg/L) [b]
Inorganics				
Lead	365	900	--	0.406

Notes:
a) ORNL RAIS Database Chemical Parameters.
b) COC concentrations in water, used for the goose, robin, and shrew dose calculations, were calculated using equilibrium partitioning calculations:
Concentration in water (inorganics) = Concentration soil/ Kd

-- = no data
% = percent
AOPC = area of potential concern
cm^3 = cubic centimeter
COC = chemical of concern
CPEC = chemical of potential ecological concern
dw = dry weight
g = gram
Kd = soil-water partition coefficient (cm^3/g)
kg = kilogram
K_{oc} = organic carbon partition coefficient (L/kg)
L = liter
mg = milligrams
UCL = upper confidence limit

Table 3-7d
Estimated Surface Water Concentrations – Bulb Slope AOPC

CPEC	95% UCL in Surface Soil (0-1 feet) (mg/kg dw)	Kd (cm^3/g) [a]	K_{oc} (L/kg) [a]	Water Concentration (kg/L) [b]
Inorganics				
Lead	307	900	--	0.341
Mercury	0.720	52	--	0.0138

Notes:
a) ORNL RAIS Database Chemical Parameters.
b) COC concentrations in water, used for the goose, robin, and shrew dose calculations, were calculated using equilibrium partitioning calculations:
Concentration in water (inorganics) = Concentration soil/ Kd

-- = no data
% = percent
AOPC = area of potential concern
cm^3 = cubic centimeter
CPEC = chemical of potential ecological concern
dw = dry weight
g = gram
Kd = soil-water partition coefficient (cm^3/g)
kg = kilogram
K_{oc} = organic carbon partition coefficient (L/kg)
L = liter
mg = milligrams
UCL = upper confidence limit

Table 3-8a
Soil to Plant Tissue Bioaccumulation Factors - Landfill AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	1.36	1.48	0.0387	0.0385	EcoSSL regression (USEPA 2005)	0.938	-3.233
Chromium	--	--	0.0410	0.0410	EcoSSL (USEPA 2005)	--	--
Copper	170	191	0.0868	0.0809	EcoSSL regression (USEPA 2005)	0.394	0.668
Lead	332	511	0.0207	0.0171	EcoSSL regression (USEPA 2005)	0.561	-1.328
Mercury	--	--	0.650	0.650	Bechtel-Jacobs, 1998 median (ORNL)	--	--
Nickel	175	472	0.0295	0.0229	EcoSSL regression (USEPA 2005)	0.748	-2.223
Butyltins							
Tributyltin	--	--	2.04	2.04	McKone, T. E. 1994 (ORNL RAIS)	--	--
Pesticides							
Chlordane (technical)	--	--	0.00950	0.00950	McKone 1994 (ORNL RAIS)	--	--
Heptachlor	--	--	0.0112	0.0112	McKone 1994 (ORNL RAIS)	--	--
HPAHs							
Benzo(a)anthracene	8.34	10.0	0.0282	0.0262	EcoSSL regression (USEPA 2005)	0.5944	-2.7078
Benzo(a)pyrene	8.70	11.2	0.121	0.120	EcoSSL regression (USEPA 2005)	0.9750	-2.0615
Benzo(b)fluoranthene	--	--	0.310	0.310	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	4.59	5.82	0.521	0.544	EcoSSL regression (USEPA 2005)	1.1829	-0.9313
Benzo(k)fluoranthene	30.2	26.3	0.0716	0.0730	EcoSSL regression (USEPA 2005)	0.8595	-2.1579
Benzofluoranthenes, Total	--	--	0.31	0.31	Benzofluoranthene surrogate [d]	--	--
Chrysene	8.40	11.0	0.0281	0.0252	EcoSSL regression (USEPA 2005)	0.5944	-2.7078
Dibenzo(a,h)anthracene	--	--	0.130	0.130	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	0.500	0.500	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	0.110	0.110	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	0.720	0.720	EcoSSL (USEPA 2005)	--	--
Total HPAHs	90.2	102	0.143	0.143	EcoSSL regression (USEPA 2005)	0.9469	-1.7026
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	0.00150	0.00150	McKone 1994 (ORNL RAIS)	--	--
Butyl Benzyl Phthalate	--	--	0.0695	0.0695	McKone 1994 (ORNL RAIS)	--	--
Carbazole	--	--	0.268	0.268	McKone 1994 (ORNL RAIS)	--	--
Dibenzofuran	--	--	0.157	0.157	McKone 1994 (ORNL RAIS)	--	--
Di-n-butyl Phthalate	--	--	0.236	0.236	Briggs et al. 1982	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	0.302	0.302	McKone 1994 (ORNL RAIS)	--	--

Table 3-8a
Soil to Plant Tissue Bioaccumulation Factors - Landfill AOPC

Notes:

a) Used for Canada goose dose calculations.
b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.
c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).
d) Most conservative (higher) BAF between the benzo(b)- and benzo(k)fluoranthenes.

-- = No Data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound

References:

Bechtel-Jacobs, 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants, Oak Ridge National Laboratory (ORNL), Oak Ridge TN. 116 pp BJC/OR-13.

Briggs, G., R. Bromilow, and A. Evans. 1982. Relationships Between Lipophilicity and Root Uptake and Translocation of Non-Ionized Chemicals by Barley. Pestic. Sci. 13: 495-504. Equation: ((10^(0.77*logKow-1.52)+0.82)/(Koc*0.05))/0.222, where logKow = 4.50 and Koc = 33900 for di-n-butyl phthalate.

McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463. From ORNL Risk Assessment Information System (RAIS) Database (soil-to-dry plant uptake).

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-8b
Soil to Plant Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	2.94	2.42	0.0369	0.0373	EcoSSL regression (USEPA 2005)	0.938	-3.233
Cadmium	3.20	2.63	0.367	0.401	EcoSSL regression (USEPA 2005)	0.546	-0.475
Chromium	--	--	0.0410	0.0410	EcoSSL (USEPA 2005)	--	--
Lead	465	529	0.0179	0.0169	EcoSSL regression (USEPA 2005)	0.561	-1.328
Mercury	--	--	0.650	0.650	Bechtel-Jacobs 1998 median (ORNL)	--	--
Nickel	353	251	0.0247	0.0269	EcoSSL regression (USEPA 2005)	0.748	-2.223
Butyltins							
Tributyltin	--	--	2.04	2.04	McKone 1994 (ORNL RAIS)	--	--
Pesticides							
BHC (delta)	--	--	0.153	0.153	McKone 1994 (ORNL RAIS)	--	--
BHC (gamma) Lindane	--	--	0.268	0.268	McKone 1994 (ORNL RAIS)	--	--
Chlordane (alpha)	--	--	0.0112	0.0112	McKone 1994 (ORNL RAIS)	--	--
Chlordane (gamma)	--	--	0.00950	0.00950	McKone 1994 (ORNL RAIS)	--	--
Endosulfan I	--	--	0.231	0.231	McKone 1994 (ORNL RAIS)	--	--
Endosulfan II	--	--	0.231	0.231	McKone 1994 (ORNL RAIS)	--	--
Endosulfan Sulfate	--	--	0.290	0.290	McKone 1994 (ORNL RAIS)	--	--
Endrin Aldehyde	--	--	0.0633	0.0633	McKone 1994 (ORNL RAIS)	--	--
Endrin Ketone	--	--	0.0491	0.0491	McKone 1994 (ORNL RAIS)	--	--
Endrin	--	--	0.0371	0.0371	McKone 1994 (ORNL RAIS)	--	--
Heptachlor	--	--	0.0112	0.0112	McKone 1994 (ORNL RAIS)	--	--
Methoxychlor	--	--	0.0436	0.0436	McKone 1994 (ORNL RAIS)	--	--
HPAHs							
Benzo(a)anthracene	1.75	2.45	0.0531	0.046	EcoSSL regression (USEPA 2005)	0.5944	-2.7078
Benzo(a)pyrene	1.76	2.39	0.125	0.125	EcoSSL regression (USEPA 2005)	0.9750	-2.0615
Benzo(b)fluoranthene	--	--	0.310	0.310	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	1.07	1.05	0.399	0.398	EcoSSL regression (USEPA 2005)	1.1829	-0.9313
Benzo(k)fluoranthene	0.676	0.764	0.122	0.120	EcoSSL regression (USEPA 2005)	0.8595	-2.1579
Benzofluoranthenes, Total	--	--	0.310	0.310	Benzofluoranthene surrogate [d]	--	--
Chrysene	2.07	4.59	0.0496	0.0359	EcoSSL regression (USEPA 2005)	0.5944	-2.7078
Dibenzo(a,h)anthracene	--	--	0.13	0.13	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	0.50	0.50	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	0.11	0.11	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	0.72	0.72	EcoSSL (USEPA 2005)	--	--
Total HPAHs	18.6	40.8	0.156	0.150	EcoSSL regression (USEPA 2005)	0.9469	-1.7026

Table 3-8b
Soil to Plant Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	0.00150	0.00150	McKone 1994 (ORNL RAIS)	--	--
Butyl Benzyl Phthalate	--	--	0.0695	0.0695	McKone 1994 (ORNL RAIS)	--	--
Carbazole	--	--	0.268	0.268	McKone 1994 (ORNL RAIS)	--	--
Dibenzofuran	--	--	0.157	0.157	McKone 1994 (ORNL RAIS)	--	--
Di-n-butyl Phthalate	--	--	0.236	0.236	Briggs et al. 1982	--	--
Di-n-octyl Phthalate	--	--	0.000772	0.000772	McKone 1994 (ORNL RAIS)	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	0.302	0.302	McKone 1994 (ORNL RAIS)	--	--
4-Isopropyltoluene	--	--	0.161	0.161	McKone 1994 (ORNL RAIS)	--	--
n-Propylbenzene	--	--	0.279	0.279	McKone 1994 (ORNL RAIS)	--	--

Notes:

a) Used for Canada goose dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

d) Most conservative (higher) BAF between the benzo(b)- and benzo(k)fluoranthenes.

-- = No Data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound
HPAHs = high molecular weight polycyclic aromatic hydrocarbons

References:

Bechtel-Jacobs, 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants, Oak Ridge National Laboratory (ORNL), Oak Ridge TN. 116 pp BJC/OR-13.

Briggs, G., R. Bromilow, and A. Evans. 1982. Relationships Between Lipophilicity and Root Uptake and Translocation of Non-Ionized Chemicals by Barley. Pestic. Sci. 13: 495-504. Equation: ((10^(0.77*logKow-1.52)+0.82)/(Koc*0.05))/0.222, where logKow = 4.50 and Koc = 33900 for di-n-butyl phthalate.

McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463. From ORNL Risk Assessment Information System (RAIS) Database (soil-to-dry plant uptake).

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-8c
Soil to Plant Tissue Bioaccumulation Factors – Pistol Range AOPC

CPEC	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Surface Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	365	0.0199	EcoSSL regression (USEPA 2005)	0.561	-1.328

Notes:

a) Used for Canada goose dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
UCL = upper confidence limit

References:

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-8d
Soil to Plant Tissue Bioaccumulation Factors – Bulb Slope AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Surface Soil BAF Plant (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	307	0.0214	EcoSSL regression (USEPA 2005)	0.561	-1.328
Mercury	--	0.650	Bechtel-Jacobs 1998 median (ORNL)	--	--

Notes:

a) Used for Canada goose dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

-- = No Data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
UCL = upper confidence limit

References:

Bechtel-Jacobs, 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants, Oak Ridge National Laboratory (ORNL), Oak Ridge TN. 116 pp BJC/OR-13.

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-9a
Soil to Soil Invertebrate Tissue Bioaccumulation Factors - Landfill AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	--	--	1.0	1.0	EcoSSL (USEPA 2005)	--	--
Chromium	--	--	0.306	0.306	EcoSSL (USEPA 2005)	--	--
Copper	--	--	0.515	0.515	EcoSSL (USEPA 2005)	--	--
Lead	332	511	0.262	0.241	EcoSSL regression (USEPA 2005)	0.807	-0.218
Mercury	--	--	1.69	1.69	Sample et al. 1998b (ORNL)	--	--
Nickel	--	--	1.06	1.06	Sample et al. 1998b (ORNL)	--	--
Butyltins							
Tributyltin	--	--	0.0424	0.0424	Jager 1998 (logKow algorithm)	--	--
Pesticides							
Chlordane (technical)	--	--	47.7	47.7	Jager 1998 (logKow algorithm)	--	--
Heptachlor	--	--	8.75	8.75	USEPA 1999 (converted to dw [d])	--	--
HPAHs							
Benzo(a)anthracene	--	--	1.59	1.59	EcoSSL (USEPA 2005)	--	--
Benzo(a)pyrene	--	--	1.33	1.33	EcoSSL (USEPA 2005)	--	--
Benzo(b)fluoranthene	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	--	--	2.94	2.94	EcoSSL (USEPA 2005)	--	--
Benzo(k)fluoranthene	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Benzofluoranthenes, Total	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Chrysene	--	--	2.29	2.29	EcoSSL (USEPA 2005)	--	--
Dibenz(a,h)anthracene	--	--	2.31	2.31	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	3.04	3.04	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	2.86	2.86	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	1.75	1.75	EcoSSL (USEPA 2005)	--	--
Total HPAHs	--	--	2.6	2.6	EcoSSL (USEPA 2005)	--	--
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	1	1	Conservative Default Value	--	--
Butyl Benzyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Carbazole	--	--	1	1	Conservative Default Value	--	--
Dibenzofuran	--	--	1	1	Conservative Default Value	--	--

Table 3-9a
Soil to Soil Invertebrate Tissue Bioaccumulation Factors - Landfill AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Di-n-butyl Phthalate	--	--	1	1	Conservative Default Value	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	1	1	Conservative Default Value	--	--

Notes:

a) Used for the American robin and vagrant shrew dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

d) BAF (dry weight) = BAF (wet weight) / 0.16 (assuming earthworm contains 16% dry solids, USEPA 1993)

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor in kilograms of soil per kilograms of tissue.
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound

References:

Jager, T. 1998. Mechanistic approach for estimating bioconcentration of organic chemicals in earthworms. Environ. Toxicol. Chem. 17:2080-2090. BAF for non-ionic organic compounds = Kww (L/kg worm dw) / Kd (L/kg soil dw), where Kww = (10^(0.87 * log Kow - 2.0))/0.16; and Kd = foc (0.01) * Kow

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998b. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp, ES/ER/TM-220. Median BAF.

Table 3-9a
Soil to Soil Invertebrate Tissue Bioaccumulation Factors - Landfill AOPC

USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Office of Solid Waste & Emergency Response. August. EPA530-D-99-001.

USEPA. 1993. “Wildlife Exposure Factors Handbook.” December. 1993.

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-9b
Soil to Soil Invertebrate Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	--	--	1.0	1.0	EcoSSL (USEPA 2005)	--	--
Cadmium	3.20	2.63	6.52	6.79	EcoSSL regression (USEPA 2005)	0.795	2.114
Chromium	--	--	0.306	0.306	EcoSSL (USEPA 2005)	--	--
Lead	465	529	0.246	0.240	EcoSSL regression (USEPA 2005)	0.807	-0.218
Mercury	--	--	1.69	1.69	Sample et al. 1998 (ORNL)	--	--
Nickel	--	--	1.06	1.06	Sample et al. 1998 (ORNL)	--	--
Butyltins							
Tributyltin	--	--	0.0424	0.0424	Jager 1998 (logKow algorithm)	--	--
Pesticides							
BHC (delta)	--	--	8.89	8.89	Jager 1998 (logKow algorithm)	--	--
BHC (gamma) Lindane	--	--	3.83	3.83	Jager 1998 (logKow algorithm)	--	--
Chlordane (alpha)	--	--	18.8	18.8	Jager 1998 (logKow algorithm)	--	--
Chlordane (gamma)	--	--	23.9	23.9	Jager 1998 (logKow algorithm)	--	--
Endosulfan I	--	--	1.99	1.99	Jager 1998 (logKow algorithm)	--	--
Endosulfan II	--	--	1.99	1.99	Jager 1998 (logKow algorithm)	--	--
Endosulfan Sulfate	--	--	0.970	0.970	Jager 1998 (logKow algorithm)	--	--
Endrin Aldehyde	--	--	28.7	28.7	Jager 1998 (logKow algorithm)	--	--
Endrin Ketone	--	--	14.1	14.1	Jager 1998 (logKow algorithm)	--	--
Endrin	--	--	10.4	10.4	Jager 1998 (logKow algorithm)	--	--
Heptachlor	--	--	30.7	30.7	USEPA 1999 (converted to dw [d])	--	--
Methoxychlor	--	--	3.98	3.98	Jager 1998 (logKow algorithm)	--	--
HPAHs							
Benzo(a)anthracene	--	--	1.59	1.59	EcoSSL (USEPA 2005)	--	--
Benzo(a)pyrene	--	--	1.33	1.33	EcoSSL (USEPA 2005)	--	--
Benzo(b)fluoranthene	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	--	--	2.94	2.94	EcoSSL (USEPA 2005)	--	--
Benzo(k)fluoranthene	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Benzofluoranthenes, Total	--	--	2.60	2.60	EcoSSL (USEPA 2005)	--	--
Chrysene	--	--	2.29	2.29	EcoSSL (USEPA 2005)	--	--
Dibenz(a,h)anthracene	--	--	2.31	2.31	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	3.04	3.04	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	2.86	2.86	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	1.75	1.75	EcoSSL (USEPA 2005)	--	--
Total HPAHs	--	--	2.6	2.6	EcoSSL (USEPA 2005)	--	--

Table 3-9b
Soil to Soil Invertebrate Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Invertebrate (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	1	1	Conservative Default Value	--	--
Butyl Benzyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Carbazole	--	--	1	1	Conservative Default Value	--	--
Dibenzofuran	--	--	1	1	Conservative Default Value	--	--
Di-n-butyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Di-n-octyl Phthalate	--	--	1	1	Conservative Default Value	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	1	1	Conservative Default Value	--	--
4-Isopropyltoluene	--	--	1	1	Conservative Default Value	--	--
n-Propylbenzene	--	--	1	1	Conservative Default Value	--	--

Notes:

a) Used for the American robin and vagrant shrew dose calculations.
b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.
c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).
d) BAF (dry weight) = BAF (wet weight) / 0.16 (assuming earthworm contains 16% dry solids, USEPA 1993)

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor in kilograms of soil per kilograms of tissue.
BHC = benzene hexachloride
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-9b
Soil to Soil Invertebrate Tissue Bioaccumulation Factors – Sandblast Area AOPC

References:

Jager, T. 1998. Mechanistic approach for estimating bioconcentration of organic chemicals in earthworms. Environ. Toxicol. Chem. 17:2080-2090. BAF for non-ionic organic compounds = Kww (L/kg worm dw) / Kd (L/kg soil dw), where Kww = (10^(0.87 * log Kow - 2.0))/0.16; and Kd = foc (0.01) * Koc
LogKow and Koc values taken from ORNL RAIS Database Chemical Parameters (2014).

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp, ES/ER/TM-220. Median BAF.

USEPA. 1993. "Wildlife Exposure Factors Handbook." December. 1993.

USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Office of Solid Waste & Emergency Response. August. EPA530-D-99-001.

USEPA. 2005. "Guidance for Developing Ecological Soil Screening Levels." Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-9c
Soil to Soil Invertebrate Tissue Bioaccumulation Factors – Pistol Range AOPC

CPEC	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	365	0.258	EcoSSL regression (USEPA 2005)	0.807	-0.218

Notes:
a) Used for the American robin and vagrant shrew dose calculations.
b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other
c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor in kilograms of soil per kilograms of tissue.
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
UCL = upper confidence limit

References:

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-9d
Soil to Soil Invertebrate Tissue Bioaccumulation Factors – Bulb Slope AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Surface Soil BAF Invertebrate (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	307	0.266	EcoSSL regression (USEPA, 2005)	0.807	-0.218
Mercury	--	1.69	Sample et al. 1998b (ORNL)	--	--

Notes:

a) Used for the american robin and vagrant shrew dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor in kilograms of soil per kilograms of tissue.
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
UCL = upper confidence limit

References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II, and T.L. Ashwood. 1998b. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp, ES/ER/TM-220. Median BAF.

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-10a
Soil to Mammal Tissue Bioaccumulation Factors - Landfill AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Shallow Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	--	--	0.050	0.050	EcoSSL (USEPA 2005)	--	--
Chromium	242	594	0.0539	0.0424	EcoSSL regression (USEPA 2005)	0.7338	-1.4599
Copper	170	191	0.0952	0.0861	EcoSSL regression (USEPA 2005)	0.1444	2.042
Lead	332	511	0.0423	0.0333	EcoSSL regression (USEPA 2005)	0.4422	0.0761
Mercury	--	--	0.0543	0.0543	Sample et al. 1998 (ORNL)	--	--
Nickel	175	472	0.0495	0.0292	EcoSSL regression (USEPA 2005)	0.4658	-0.2462
Butyltins							
Tributyltin	--	--	0.0000124	0.0000124	Travis and Arms 1988 [d]	--	--
Pesticides							
Chlordane (technical)	--	--	0.130	0.130	Travis and Arms 1988 [d]	--	--
Heptachlor	--	--	0.0232	0.0232	Travis and Arms 1988 [d]	--	--
HPAHs [e]							
Benz(a)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(a)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(b)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(k)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzofluoranthenes, Total	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Chrysene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Dibenz(a,h)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Total HPAHs	--	--	0	0	EcoSSL (USEPA 2005)	--	--
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	1	1	Conservative Default Value	--	--
Butyl Benzyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Carbazole	--	--	1	1	Conservative Default Value	--	--
Dibenzofuran	--	--	1	1	Conservative Default Value	--	--
Di-n-butyl Phthalate	--	--	1	1	Conservative Default Value	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	1	1	Conservative Default Value	--	--

Table 3-10a
Soil to Mammal Tissue Bioaccumulation Factors - Landfill AOPC

Notes:

a) Used for the American kestrel and American mink dose calculations.
b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.
c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).
d) Converted to dry weight: BAF (dry weight) = BAF (wet weight) / 0.32 (assuming mammals contains 32% dry solids, USEPA 1993)
e) The recommended BAF for PAHs is zero because of the rapid metabolism of these compounds after ingestion by birds and mammals.

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
SVOC = semivolatile organic compound
UCL = 95% upper confidence limit
VOC = volatile organic compound

References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G W. Suter II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, TN. Median BAF.

Travis, C.C., and A.D. Arms, 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science & Technology. 22: 271-274. Based on biotransfer equation for mammals: logBa = -7.6 + logKow. LogKow values taken from ORNL RAIS Database Chemical Parameters (2014).

USEPA. 1993. "Wildlife Exposure Factors Handbook." December. 1993.

USEPA. 2005. "Guidance for Developing Ecological Soil Screening Levels." Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-10b
Soil to Mammal Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Mammal (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	--	--	0.050	0.050	EcoSSL (USEPA 2005)	--	--
Cadmium	3.20	2.63	0.154	0.171	EcoSSL regression (USEPA 2005)	0.4723	-1.2571
Chromium	720	579	0.0403	0.0427	EcoSSL regression (USEPA 2005)	0.7338	-1.4599
Lead	465	529	0.0351	0.0327	EcoSSL regression (USEPA 2005)	0.4422	0.0761
Mercury	--	--	0.0543	0.0543	Sample et al. 1998 (ORNL)	--	--
Nickel	353	251	0.0340	0.0408	EcoSSL regression (USEPA 2005)	0.4658	-0.2462
Butyltins							
Tributyltin	--	--	0.0000124	0.0000124	Travis and Arms 1988 [d]	--	--
Pesticides							
BHC (delta)	--	--	0.00108	0.00108	Travis and Arms 1988 [d]	--	--
BHC (gamma) Lindane	--	--	0.000412	0.000412	Travis and Arms 1988 [d]	--	--
Chlordane (alpha)	--	--	0.0988	0.0988	Travis and Arms 1988 [d]	--	--
Chlordane (gamma)	--	--	0.130	0.130	Travis and Arms 1988 [d]	--	--
Chlordane (technical)	--	--	0.113	0.113	Travis and Arms 1988 [d]	--	--
Endosulfan I	--	--	0.000531	0.000531	Travis and Arms 1988 [d]	--	--
Endosulfan II	--	--	0.000531	0.000531	Travis and Arms 1988 [d]	--	--
Endosulfan Sulfate	--	--	0.000359	0.000359	Travis and Arms 1988 [d]	--	--
Endrin Aldehyde	--	--	0.00495	0.00495	Travis and Arms 1988 [d]	--	--
Endrin Ketone	--	--	0.00767	0.00767	Travis and Arms 1988 [d]	--	--
Endrin	--	--	0.0124	0.0124	Travis and Arms 1988 [d]	--	--
Heptachlor	--	--	0.0988	0.0988	Travis and Arms 1988 [d]	--	--
Methoxychlor	--	--	0.00944	0.00944	Travis and Arms 1988 [d]	--	--
HPAHs [e]							
Benz(a)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(a)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--

Table 3-10b
Soil to Mammal Tissue Bioaccumulation Factors – Sandblast Area AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/ kg dw soil) [a]	Shallow Soil BAF Mammal (kg dw tissue/ kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Benzo(b)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(k)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzofluoranthenes, Total	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Chrysene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Dibenz(a,h)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Total HPAHs	--	--	0	0	EcoSSL (USEPA 2005)	--	--
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	1	1	Conservative Default Value	--	--
Butyl Benzyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Carbazole	--	--	1	1	Conservative Default Value	--	--
Dibenzofuran	--	--	1	1	Conservative Default Value	--	--
Di-n-butyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Di-n-octyl Phthalate	--	--	1	1	Conservative Default Value	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	1	1	Conservative Default Value	--	--
4-Isopropyltoluene	--	--	1	1	Conservative Default Value	--	--
n-Propylbenzene	--	--	1	1	Conservative Default Value	--	--

Notes:

a) Used for the American kestrel and American mink dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

d) Converted to dry weight: BAF (dry weight) = BAF (wet weight) / 0.32(assuming mammals contains 32% dry solids, USEPA 1993)

e) The recommended BAF for PAHs is zero because of the rapid metabolism of these compounds after ingestion by birds and mammals.

Table 3-10b
Soil to Mammal Tissue Bioaccumulation Factors – Sandblast Area AOPC

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
BHC = benzene hexachloride
CPEC = chemical of potential ecological concern
dw = dry weight
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = 95% upper confidence limit
VOC = volatile organic compound

References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G W. Suter II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, TN. Median BAF.

Travis, C.C., and A.D. Arms, 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science & Technology. 22: 271-274. Based on biotransfer equation for mammals: logBa = -7.6 + logKow. LogKow values taken from ORNL RAIS Database Chemical Parameters (2014).

USEPA. 1993. "Wildlife Exposure Factors Handbook." December. 1993.

USEPA. 2005. "Guidance for Developing Ecological Soil Screening Levels." Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-10c
Soil to Mammal Tissue Bioaccumulation Factors – Pistol Range AOPC

CPEC	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	365	0.0402	EcoSSL regression (USEPA 2005)	0.4422	0.0761

Notes:

a) Used for the American kestrel and American mink dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

The recommended BAF for PAHs is zero because of the rapid metabolism of these compounds after ingestion by birds and mammals.

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
UCL = 95% upper confidence limit

References:

USEPA. 2005. "Guidance for Developing Ecological Soil Screening Levels." Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-10d
Soil to Mammal Tissue Bioaccumulation Factors – Bulb Slope AOPC

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics					
Lead	307	0.0442	EcoSSL regression (USEPA 2005)	0.4422	0.0761
Mercury	--	0.0543	Sample et al. 1998a (ORNL)	--	--

Notes:
a) Used for the american kestrel and american mink dose calculations.
b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.
c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
kg = kilogram
mg/kg = milligrams per kilogram
UCL = 95% upper confidence limit

References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G W. Suter II, and T.L. Ashwood. 1998a. Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, TN. Median BAF.

USEPA. 2005. "Guidance for Developing Ecological Soil Screening Levels." Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-10e
Soil to Mammal Tissue Bioaccumulation Factors – Combined AOPCs

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Shallow Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Inorganics							
Antimony	--	--	0.050	0.050	EcoSSL (USEPA 2005)	--	--
Cadmium	1.97	1.67	0.199	0.217	EcoSSL regression (USEPA 2005)	0.4723	-1.2571
Chromium	567	510	0.0430	0.0442	EcoSSL regression (USEPA 2005)	0.7338	-1.4599
Copper	95.0	93.6	0.157	0.159	EcoSSL regression (USEPA 2005)	0.1444	2.042
Lead	398	396	0.0383	0.0384	EcoSSL regression (USEPA 2005)	0.4422	0.0761
Mercury	--	--	0.0543	0.0543	Sample et al. 1998a (ORNL)	--	--
Nickel	227	234	0.0431	0.0424	EcoSSL regression (USEPA 2005)	0.4658	-0.2462
Butyltins							
Tributyltin	--	--	0.0424	0.0424	Travis and Arms 1988 [d]	--	--
Pesticides							
BHC (delta)	--	--	8.89	8.89	Travis and Arms 1988 [d]	--	--
BHC (gamma) Lindane	--	--	3.83	3.83	Travis and Arms 1988 [d]	--	--
Chlordane (alpha)	--	--	18.8	18.8	Travis and Arms 1988 [d]	--	--
Chlordane (gamma)	--	--	23.9	23.9	Travis and Arms 1988 [d]	--	--
Chlordane (technical)	--	--	47.7	47.7	Travis and Arms 1988 [d]	--	--
Endosulfan I	--	--	1.99	1.99	Travis and Arms 1988 [d]	--	--
Endosulfan II	--	--	1.99	1.99	Travis and Arms 1988 [d]	--	--
Endosulfan Sulfate	--	--	0.970	0.970	Travis and Arms 1988 [d]	--	--
Endrin Aldehyde	--	--	28.7	28.7	Travis and Arms 1988 [d]	--	--
Endrin Ketone	--	--	14.1	14.1	Travis and Arms 1988 [d]	--	--
Endrin	--	--	10.4	10.4	Travis and Arms 1988 [d]	--	--
Heptachlor	--	--	8.75	8.75	Travis and Arms 1988 [d]	--	--
Methoxychlor	--	--	3.98	3.98	Travis and Arms 1988 [d]	--	--
HPAHs [e]							
Benz(a)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--

Table 3-10e
Soil to Mammal Tissue Bioaccumulation Factors – Combined AOPCs

CPEC	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	95% UCL in Shallow Soil (0-3 ft bgs) (mg/kg dw)	Surface Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Shallow Soil BAF Mammal (kg dw tissue/kg dw soil) [a]	Source [b]	Regression Slope [c]	Regression Intercept [c]
Benzo(a)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(b)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(g,h,i)perylene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzo(k)fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Benzofluoranthenes, Total	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Chrysene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Dibenz(a,h)anthracene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Fluoranthene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Indeno(1,2,3-cd)pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Pyrene	--	--	0	0	EcoSSL (USEPA 2005)	--	--
Total HPAHs	--	--	0	0	EcoSSL (USEPA 2005)	--	--
SVOCs							
Bis(2-ethylhexyl) Phthalate	--	--	1	1	Conservative Default Value	--	--
Butyl Benzyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Carbazole	--	--	1	1	Conservative Default Value	--	--
Dibenzofuran	--	--	1	1	Conservative Default Value	--	--
Di-n-butyl Phthalate	--	--	1	1	Conservative Default Value	--	--
Di-n-octyl Phthalate	--	--	1	1	Conservative Default Value	--	--
VOCs							
1,2,4-Trimethylbenzene	--	--	1	1	Conservative Default Value	--	--
4-Isopropyltoluene	--	--	1	1	Conservative Default Value	--	--
n-Propylbenzene	--	--	1	1	Conservative Default Value	--	--

Notes:

a) Used for the American kestrel and American mink dose calculations.

b) Hierarchy of sources: USEPA Eco-SSL Attachment 4-1, ORNL RAIS database, other.

c) Regression Formula: *ln* (tissue concentration) = *Y*- intercept + slope * (*ln* [soil concentration]).

d) Converted to dry weight: BAF (dry weight) = BAF (wet weight) / 0.32 (assuming mammals contains 32% dry solids, USEPA 1993)

e) The recommended BAF for PAHs is zero because of the rapid metabolism of these compounds after ingestion by birds and mammals.

Table 3-10e
Soil to Mammal Tissue Bioaccumulation Factors – Combined AOPCs

-- = no data
% = percent
AOPC = area of potential concern
BAF = bioaccumulation factor
BHC = benzene hexachloride
CPEC = chemical of potential ecological concern
dw = dry weight
ft bgs = feet below ground surface
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
kg = kilogram
mg/kg = milligrams per kilogram
SVOC = semivolatile organic compound
UCL = 95% upper confidence limit
VOC = volatile organic compound

References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G W. Suter II, and T.L. Ashwood. 1998a. Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, TN. Median BAF.

Travis, C.C., and A.D. Arms, 1988. Bioconcentration of Organics in Beef, Milk, and Vegetation. Environmental Science & Technology. 22: 271-274. Based on biotransfer equation for mammals: logBa = -7.6 + logKow. LogKow values taken from ORNL RAIS Database Chemical Parameters (2014).

USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Washington, D.C.

USEPA. 2005. “Guidance for Developing Ecological Soil Screening Levels.” Attachment 4-1. Office of Solid Waste and Emergency Response, Washington, DC. Office of Solid Waste and Emergency Response Directive 9285.7-55. November. Last Updated 2007.

Table 3-11a
Calculation of Dose and Hazard Quotient for the Canada Goose - Landfill AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF plant (kg tissue/kg soil) [a]	Shallow Soil BAF plant (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Plants	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	1.36	1.48	0.0302	0.0387	0.0385	0.013	0.15	0.12	1	1	3.0	0.010	0.010	NA	NA	No TRV	No TRV	No TRV	No TRV
Chromium III	242	594	0.000134	0.0410	0.0410	0.013	0.15	0.12	1	1	3.0	1.5	3.7	2.66	14.5	5.7E-01	1.1E-01	**1.4E+00**	2.6E-01
Copper	170	191	4.86	0.0868	0.0809	0.013	0.15	0.12	1	1	3.0	1.7	1.8	4.05	12.1	4.1E-01	1.4E-01	4.4E-01	1.5E-01
Lead	332	511	0.369	0.0207	0.0171	0.013	0.15	0.12	1	1	3.0	1.8	2.6	1.63	3.26	**1.1E+00**	5.4E-01	**1.6E+00**	8.0E-01
Mercury	1.57	1.45	0.0302	0.650	0.650	0.013	0.15	0.12	1	1	3.0	0.060	0.056	0.0064	0.064	**9.4E+00**	9.4E-01	**8.7E+00**	8.7E-01
Nickel	175	472	2.69	0.0295	0.0229	0.013	0.15	0.12	1	1	3.0	1.1	2.6	6.71	26.8	1.7E-01	4.1E-02	3.9E-01	9.9E-02
Butyltins																			
Tributyltin	0.165	0.0601	0.00136	2.04	2.04	0.013	0.15	0.12	1	1	3.0	0.018	0.0066	6.8	16.9	2.6E-03	1.1E-03	9.7E-04	3.9E-04
Pesticides																			
Chlordane (technical)	1.56	1.56	0.00462	0.00950	0.00950	0.013	0.15	0.12	1	1	3.0	0.0075	0.0075	2.14	10.7	3.5E-03	7.0E-04	3.5E-03	7.0E-04
Heptachlor	0.00283	0.00286	0.00000685	0.0112	0.0112	0.013	0.15	0.12	1	1	3.0	0.000014	0.000014	0.013	0.065	1.1E-03	2.1E-04	1.1E-03	2.1E-04
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	9.68	6.38	0.00807	0.00150	0.00150	0.013	0.15	0.12	1	1	3.0	0.042	0.028	1.1	11	3.8E-02	3.8E-03	2.5E-02	2.5E-03
Butyl Benzyl Phthalate [b]	0.0366	0.0349	0.000511	0.0695	0.0695	0.013	0.15	0.12	1	1	3.0	0.00031	0.00029	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole [b]	0.751	0.964	0.00820	0.268	0.268	0.013	0.15	0.12	1	1	3.0	0.014	0.018	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran [b]	0.152	0.164	0.00166	0.157	0.157	0.013	0.15	0.12	1	1	3.0	0.0019	0.0021	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.232	0.217	0.0200	0.236	0.236	0.013	0.15	0.12	1	1	3.0	0.0046	0.0044	0.11	1.1	4.2E-02	4.2E-03	4.0E-02	4.0E-03
VOCs																			
1,2,4-Trimethylbenzene [b]	3.03	2.79	0.493	0.302	0.302	0.013	0.15	0.12	1	1	3.0	0.080	0.075	NA	NA	No TRV	No TRV	No TRV	No TRV

Metals + Butyltin HI	**1.2E+01**	**1.8E+00**	**1.3E+01**	**2.2E+00**
Pesticides HI	4.6E-03	9.1E-04	4.6E-03	9.2E-04
Phthalate HI	8.0E-02	8.0E-03	6.5E-02	6.5E-03

Notes:
a) Sources listed on Table 3-8a for plant BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7a.
d) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

% = percent
-- = not calculated
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-11b
Calculation of Dose and Hazard Quotient for the American Robin - Landfill AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Shallow Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	1.36	1.48	0.0302	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.25	0.3	NA	NA	No TRV	No TRV	No TRV	No TRV
Chromium III	242	594	0.000134	0.306	0.306	0.0013	0.013	0.011	1	1.00	0.0773	16	40	2.66	14.5	**6.1E+00**	**1.1E+00**	**1.5E+01**	**2.7E+00**
Copper	170	191	4.86	0.515	0.515	0.0013	0.013	0.011	1	1.00	0.0773	18	20	4.05	12.1	**4.4E+00**	**1.5E+00**	**4.9E+00**	**1.6E+00**
Lead	332	511	0.369	0.262	0.241	0.0013	0.013	0.011	1	1.00	0.0773	20	29	1.63	3.26	**1.2E+01**	**6.1E+00**	**1.8E+01**	**8.8E+00**
Mercury	1.57	1.45	0.0302	1.69	1.69	0.0013	0.013	0.011	1	1.00	0.0773	0.46	0.43	0.0064	0.064	**7.2E+01**	**7.2E+00**	**6.7E+01**	**6.7E+00**
Nickel	175	472	2.69	1.06	1.06	0.0013	0.013	0.011	1	1.00	0.0773	33	89	6.71	26.8	**5.0E+00**	**1.2E+00**	**1.3E+01**	**3.3E+00**
Butyltins																			
Tributyltin	0.165	0.0601	0.00136	0.042	0.042	0.0013	0.013	0.011	1	1.00	0.0773	0.0041	0.0016	6.80	16.9	6.0E-04	2.4E-04	2.4E-04	9.6E-05
Pesticides																			
Chlordane (technical)	1.56	1.56	0.00462	47.7	47.7	0.0013	0.013	0.011	1	1.00	0.0773	12	12	2.14	10.7	**5.7E+00**	**1.1E+00**	**5.7E+00**	**1.1E+00**
Heptachlor	0.00283	0.00286	0.00000685	8.75	8.75	0.0013	0.013	0.011	1	1.00	0.0773	0.0041	0.0041	0.013	0.065	3.1E-01	6.3E-02	3.2E-01	6.3E-02
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	9.68	6.38	0.00807	1	1	0.0013	0.013	0.011	1	1.00	0.0773	1.7	1.1	1.1	11	**1.6E+00**	1.6E-01	**1.0E+00**	1.0E-01
Butyl Benzyl Phthalate [b]	0.0366	0.0349	0.000511	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.0066	0.0063	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole [b]	0.751	0.964	0.00820	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.14	0.17	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran [b]	0.152	0.164	0.00166	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.027	0.030	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.232	0.217	0.0200	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.044	0.042	0.11	1.1	4.0E-01	4.0E-02	3.8E-01	3.8E-02
VOCs																			
1,2,4-Trimethylbenzene [b]	3.03	2.79	0.493	1	1	0.0013	0.013	0.011	1	1.00	0.0773	0.61	0.57	NA	NA	No TRV	No TRV	No TRV	No TRV

Metals + Butyltin HI	**1.0E+02**	**1.7E+01**	**1.2E+02**	**2.3E+01**
Pesticides HI	**6.0E+00**	**1.2E+00**	**6.0E+00**	**1.2E+00**
Phthalate HI	**2.0E+00**	2.0E-01	**1.4E+00**	1.4E-01

Notes:
a) Sources listed on Table 3-9a for invertebrate BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7a.
d) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

-- = not calculated
%= percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-11c
Calculation of Dose and Hazard Quotient for the American Kestrel - Landfill AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients[b]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Shallow Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	1.36	1.48	0.0302	0.0500	0.0500	0.00033	0.017	0.014	1	0.00504	0.116	0.000087	0.000093	NA	NA	No TRV	No TRV	No TRV	No TRV
Chromium III	242	594	0.000134	0.0539	0.0424	0.00033	0.017	0.014	1	0.00504	0.116	0.013	0.027	2.66	14.5	4.8E-03	8.9E-04	1.0E-02	1.8E-03
Copper	170	191	0.000520	0.0952	0.0861	0.00033	0.017	0.014	1	0.00504	0.116	0.014	0.015	4.05	12.1	3.5E-03	1.2E-03	3.6E-03	1.2E-03
Lead	332	511	0.0000360	0.0423	0.0333	0.00033	0.017	0.014	1	0.00504	0.116	0.015	0.020	1.63	3.26	9.1E-03	4.6E-03	1.2E-02	6.0E-03
Mercury	1.57	1.45	0.0302	0.0543	0.0543	0.00033	0.017	0.014	1	0.00504	0.116	0.00010	0.000096	0.0064	0.064	1.6E-02	1.6E-03	1.5E-02	1.5E-03
Nickel	175	472	2.69	0.0495	0.0292	0.00033	0.017	0.014	1	0.00504	0.116	0.010	0.018	6.71	26.8	1.5E-03	3.9E-04	2.7E-03	6.8E-04
Butyltins																			
Tributyltin	0.165	0.0601	0.00136	0.000012	0.000012	0.00033	0.017	0.014	1	0.00504	0.116	0.0000032	0.0000017	6.8	16.9	4.7E-07	1.9E-07	2.5E-07	1.0E-07
Pesticides																			
Chlordane (technical)	1.56	1.56	0.00462	0.130	0.130	0.00033	0.017	0.014	1	0.00504	0.116	0.00017	0.00017	2.14	10.7	8.0E-05	1.6E-05	8.0E-05	1.6E-05
Heptachlor	0.00283	0.00286	0.00000685	0.0232	0.0232	0.00033	0.017	0.014	1	0.00504	0.116	0.000000092	0.000000093	0.013	0.065	7.1E-06	1.4E-06	7.1E-06	1.4E-06
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	9.68	6.38	0.00807	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.0071	0.0047	1.1	11	6.5E-03	6.5E-04	4.3E-03	4.3E-04
Butyl Benzyl Phthalate[b]	0.0366	0.0349	0.000511	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.000027	0.000026	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole[b]	0.751	0.964	0.00820	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.00056	0.00071	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran[b]	0.152	0.164	0.00166	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.00011	0.00012	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.232	0.217	0.0200	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.00018	0.00017	0.11	1.1	1.7E-03	1.7E-04	1.6E-03	1.6E-04
VOCs																			
1,2,4-Trimethylbenzene[b]	3.03	2.79	0.493	1	1	0.00033	0.017	0.014	1	0.00504	0.116	0.0025	0.0023	NA	NA	No TRV	No TRV	No TRV	No TRV

Metals + Butyltin HI	3.5E-02	8.6E-03	4.3E-02	1.1E-02
Pesticides HI	8.7E-05	1.7E-05	8.7E-05	1.7E-05
Phthalate HI	8.1E-03	8.1E-04	5.8E-03	5.8E-04

Notes:

a) Sources listed on Table 3-10a for mammal BAFs.

b) These chemicals do not have established TRVs, but will be evaluated qualitatively.

c) Copper and lead (dissolved) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7a.

d) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).

Bold indicates hazard quotient greater than 1.0.

-- = not calculated
% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-11d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew - Landfill AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Shallow Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony	1.36	1.48	0.0302	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.28	0.31	0.059	0.59	**4.8E+00**	4.8E-01	**5.2E+00**	5.2E-01
Chromium III	242	594	0.000134	0.306	0.306	0.0000550	0.00137	0.00114	1	1.00	0.007	16	40	2.40	12.0	**6.8E+00**	**1.4E+00**	**1.7E+01**	**3.4E+00**
Copper	170	191	4.86	0.515	0.515	0.0000550	0.00137	0.00114	1	1.00	0.007	19	22	5.60	9.34	**3.4E+00**	**2.1E+00**	**3.9E+00**	**2.3E+00**
Lead	332	511	0.369	0.262	0.241	0.0000550	0.00137	0.00114	1	1.00	0.007	20	28	4.70	8.90	**4.2E+00**	**2.2E+00**	**6.0E+00**	**3.2E+00**
Mercury	1.57	1.45	0.0302	1.69	1.69	0.0000550	0.00137	0.00114	1	1.00	0.007	0.54	0.50	0.02	0.07	**2.7E+01**	**7.7E+00**	**2.5E+01**	**7.1E+00**
Nickel	175	472	2.69	1.06	1.06	0.0000550	0.00137	0.00114	1	1.00	0.007	38	102	1.70	3.40	**2.2E+01**	**1.1E+01**	**6.0E+01**	**3.0E+01**
Butyltins																			
Tributyltin	0.165	0.0601	0.00136	0.042	0.042	0.0000550	0.00137	0.00114	1	1.00	0.007	0.0029	0.0012	23.4	35	1.2E-04	8.3E-05	5.1E-05	3.4E-05
Pesticides																			
Chlordane (technical)	1.56	1.56	0.00462	47.7	47.7	0.0000550	0.00137	0.00114	1	1.00	0.007	15	15	4.6	9.2	**3.2E+00**	**1.6E+00**	**3.2E+00**	**1.6E+00**
Heptachlor	0.00283	0.00286	0.00000685	8.75	8.75	0.0000550	0.00137	0.00114	1	1.00	0.007	0.0049	0.0049	0.1	1	4.9E-02	4.9E-03	4.9E-02	4.9E-03
HPAHs																			
Benzo(a)anthracene	8.34	10.0	0.00471	1.59	1.59	0.0000550	0.00137	0.00114	1	1.00	0.007	2.7	3.2	***	***	**4.3E+00**	8.7E-01	**5.2E+00**	**1.0E+00**
Benzo(a)pyrene	8.70	11.2	0.00148	1.33	1.33	0.0000550	0.00137	0.00114	1	1.00	0.007	2.3	3.0	***	***	**3.8E+00**	7.6E-01	**4.9E+00**	9.8E-01
Benzo(b)fluoranthene	16.0	15.2	0.00267	2.60	2.60	0.0000550	0.00137	0.00114	1	1.00	0.007	8.3	7.9	***	***	**1.3E+01**	**2.7E+00**	**1.3E+01**	**2.6E+00**
Benzo(g,h,i)perylene	4.59	58.2	0.000235	2.94	2.94	0.0000550	0.00137	0.00114	1	1.00	0.007	2.7	34	***	***	**4.4E+00**	8.7E-01	**5.5E+01**	**1.1E+01**
Benzo(k)fluoranthene	30.2	26.3	0.00514	2.60	2.60	0.0000550	0.00137	0.00114	1	1.00	0.007	16	14	***	***	**2.5E+01**	**5.1E+00**	**2.2E+01**	**4.4E+00**
Benzofluoranthenes, Total	14.7	31.3	0.00250	2.60	2.60	0.0000550	0.00137	0.00114	1	1.00	0.007	7.6	16	***	***	**1.2E+01**	**2.5E+00**	**2.6E+01**	**5.3E+00**
Chrysene	8.40	11.0	0.00464	2.29	2.29	0.0000550	0.00137	0.00114	1	1.00	0.007	3.8	5	***	***	**6.2E+00**	**1.3E+00**	**8.2E+00**	**1.6E+00**
Dibenz(a,h)anthracene	4.23	20.6	0.000221	2.31	2.31	0.0000550	0.00137	0.00114	1	1.00	0.007	2.0	10	***	***	**3.2E+00**	6.4E-01	**1.5E+01**	**3.1E+00**
Fluoranthene	14.5	17.5	0.0261	3.04	3.04	0.0000550	0.00137	0.00114	1	1.00	0.007	8.8	11	***	***	**1.4E+01**	**2.9E+00**	**1.7E+01**	**3.4E+00**
Indeno(1,2,3-cd)pyrene	5.04	68.0	0.000145	2.86	2.86	0.0000550	0.00137	0.00114	1	1.00	0.007	2.9	39	***	***	**4.7E+00**	9.3E-01	**6.3E+01**	**1.3E+01**
Pyrene	12.3	18.8	0.0227	1.75	1.75	0.0000550	0.00137	0.00114	1	1.00	0.007	4.3	6.6	***	***	**7.0E+00**	**1.4E+00**	**1.1E+01**	**2.2E+00**
Total HPAHs	90.2	102	0.0206	2.60	2.60	0.0000550	0.00137	0.00114	1	1.00	0.007	47	53	0.615	3.07	**7.6E+01**	**1.5E+01**	**8.6E+01**	**1.7E+01**
SVOCs																			
Bis(2-ethylhexyl) Phthalate	9.68	6.38	0.00807	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	2.0	1.3	18.3	183	1.1E-01	1.1E-02	7.1E-02	7.1E-03
Butyl Benzyl Phthalate	0.0366	0.0349	0.000511	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.0076	0.0072	159	470	4.8E-05	1.6E-05	4.5E-05	1.5E-05
Carbazole	0.751	0.964	0.00820	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.15	0.20	5	50	3.1E-02	3.1E-03	4.0E-02	4.0E-03
Dibenzofuran	0.152	0.164	0.00166	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.031	0.034	6	30	5.2E-03	1.0E-03	5.6E-03	1.1E-03
Di-n-butyl Phthalate	0.232	0.217	0.0200	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.051	0.048	550	1,833	9.2E-05	2.8E-05	8.6E-05	2.6E-05
VOCs																			
1,2,4-Trimethylbenzene	3.03	2.79	0.493	1	1	0.0000550	0.00137	0.00114	1	1.00	0.007	0.7	0.6	13	65	5.4E-02	1.1E-02	5.0E-02	1.0E-02

Metals + Butyltin HI	**6.9E+01**	**2.5E+01**	**1.2E+02**	**4.7E+01**
Pesticides HI	**3.2E+00**	**1.6E+00**	**3.2E+00**	**1.6E+00**
Phthalate HI	1.1E-01	1.1E-02	7.1E-02	7.2E-03

Notes:
a) Sources listed on Table 3-9a for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7a.
c) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.
*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

Table 3-11d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew - Landfill AOPC

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest oberserved adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no oberserved adverse effect level
PF = portion of food item
SLV = screening level value
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-11e
Calculation of Dose and Hazard Quotient for the American Mink - Landfill AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Shallow Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony	1.36	1.48	0.0302	0.0500	0.0500	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00076	0.00081	0.059	0.59	1.3E-02	1.3E-03	1.4E-02	1.4E-03
Chromium III	242	594	0.000134	0.0539	0.0424	0.0051	0.054	0.097	0.15	0.07158	0.974	0.10	0.24	2.40	12.0	4.1E-02	8.2E-03	9.9E-02	2.0E-02
Copper	170	191	0.000520	0.0952	0.0861	0.0051	0.054	0.097	0.15	0.07158	0.974	0.073	0.081	5.60	9.34	1.3E-02	7.8E-03	1.4E-02	8.7E-03
Lead	332	511	0.0000360	0.0423	0.0333	0.0051	0.054	0.097	0.15	0.07158	0.974	0.13	0.20	4.70	8.90	2.8E-02	1.5E-02	4.3E-02	2.3E-02
Mercury	1.57	1.45	0.0302	0.0543	0.0543	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00085	0.00080	0.02	0.07	4.3E-02	1.2E-02	4.0E-02	1.1E-02
Nickel	175	472	2.69	0.0495	0.0292	0.0051	0.054	0.097	0.15	0.07158	0.974	0.090	0.20	1.70	3.40	5.3E-02	2.6E-02	1.2E-01	6.0E-02
Butyltins																			
Tributyltin	0.165	0.0601	0.00136	0.0000124	0.0000124	0.0051	0.054	0.097	0.15	0.07158	0.974	0.000071	0.000032	23.4	35	3.0E-06	2.0E-06	1.4E-06	9.2E-07
Pesticides																			
Chlordane (technical)	1.56	1.56	0.00462	0.130	0.130	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00074	0.00074	4.6	9.2	1.6E-04	8.0E-05	1.6E-04	8.0E-05
Heptachlor	0.00283	0.00286	0.00000685	0.0232	0.0232	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0000011	0.0000012	0.1	1	1.1E-05	1.1E-06	1.2E-05	1.2E-06
HPAHs																			
Benzo(a)anthracene	8.34	10.0	0.00000060	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0031	0.0037	***	***	5.1E-03	1.0E-03	6.0E-03	1.2E-03
Benzo(a)pyrene	8.70	11.2	0.00148	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0033	0.0042	***	***	5.3E-03	1.1E-03	6.8E-03	1.4E-03
Benzo(b)fluoranthene	16.0	15.2	0.00000092	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0060	0.0057	***	***	9.7E-03	1.9E-03	9.2E-03	1.8E-03
Benzo(g,h,i)perylene	4.59	58.2	0.000235	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0017	0.022	***	***	2.8E-03	5.6E-04	3.5E-02	7.1E-03
Benzo(k)fluoranthene	30.2	26.3	0.00514	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.011	0.010	***	***	1.8E-02	3.7E-03	1.6E-02	3.2E-03
Benzofluoranthenes, Total	14.7	31.3	0.00250	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0055	0.012	***	***	9.0E-03	1.8E-03	1.9E-02	3.8E-03
Chrysene	8.40	11.0	0.00000171	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0031	0.0041	***	***	5.1E-03	1.0E-03	6.7E-03	1.3E-03
Dibenz(a,h)anthracene	4.23	20.6	0.000221	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0016	0.0077	***	***	2.6E-03	5.1E-04	1.3E-02	2.5E-03
Fluoranthene	14.5	17.5	0.00000784	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0054	0.0065	***	***	8.8E-03	1.8E-03	1.1E-02	2.1E-03
Indeno(1,2,3-cd)pyrene	5.04	68.0	0.000145	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0019	0.025	***	***	3.1E-03	6.1E-04	4.1E-02	8.3E-03
Pyrene	12.3	18.8	0.0227	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0048	0.0072	***	***	7.7E-03	1.5E-03	1.2E-02	2.3E-03
Total HPAHs	90.2	102	0.0206	0	0	0.0051	0.054	0.097	0.15	0.07158	0.974	0.034	0.038	0.615	3.07	5.5E-02	1.1E-02	6.2E-02	1.2E-02
SVOCs																			
Bis(2-ethylhexyl) Phthalate	9.68	6.38	0.00807	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0094	0.0062	18.3	183	5.2E-04	5.2E-05	3.4E-04	3.4E-05
Butyl Benzyl Phthalate	0.0366	0.0349	0.000511	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.000039	0.000037	159	470	2.5E-07	8.3E-08	2.4E-07	8.0E-08
Carbazole	0.751	0.964	0.00820	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00079	0.00099	5	50	1.6E-04	1.6E-05	2.0E-04	2.0E-05
Dibenzofuran	0.152	0.164	0.00166	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00016	0.00017	6	30	2.7E-05	5.3E-06	2.8E-05	5.7E-06
Di-n-butyl Phthalate	0.232	0.217	0.0200	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.00037	0.00035	550	1,833	6.7E-07	2.0E-07	6.4E-07	1.9E-07
VOCs																			
1,2,4-Trimethylbenzene	3.03	2.79	0.493	1	1	0.0051	0.054	0.097	0.15	0.07158	0.974	0.0064	0.0062	13	65	5.0E-04	9.9E-05	4.8E-04	9.6E-05

Metals + Butyltin HI	1.9E-01	7.1E-02	3.3E-01	1.2E-01
Pesticides HI	1.7E-04	8.1E-05	1.7E-04	8.1E-05
Phthalate HI	5.2E-04	5.2E-05	3.4E-04	3.4E-05

Notes:
a) Sources listed on Table 3-10a for mammal BAFs.
b) Copper & lead (dissolved), benzo(a)anthracene, benzo(b)fluoranthene, chrysene, and fluoranthene (C+F) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7a.
c) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.
*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

Table 3-11e
Calculation of Dose and Hazard Quotient for the American Mink - Landfill AOPC

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SLV = screening level value
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-12a
Calculation of Dose and Hazard Quotient for the Canada Goose – Sandblast Area AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF plant (kg tissue/kg soil) [a]	Shallow Soil BAF plant (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Plants	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	2.94	2.42	0.0653	0.0369	0.0373	0.013	0.15	0.12	1	1	3.0	0.021	0.017	NA	NA	No TRV	No TRV	No TRV	No TRV
Cadmium	3.20	2.63	0.0427	0.367	0.401	0.013	0.15	0.12	1	1	3.0	0.075	0.067	1.47	5.88	5.1E-02	1.3E-02	4.5E-02	1.1E-02
Chromium III	720	579	0.000400	0.0410	0.0410	0.013	0.15	0.12	1	1	3.0	4.5	3.6	2.66	14.5	**1.7E+00**	3.1E-01	**1.4E+00**	2.5E-01
Lead	465	529	0.517	0.0179	0.0169	0.013	0.15	0.12	1	1	3.0	2.4	2.7	1.63	3.26	**1.5E+00**	7.4E-01	**1.7E+00**	8.3E-01
Mercury	0.113	0.098	0.00217	0.650	0.650	0.013	0.15	0.12	1	1	3.0	0.0043	0.0037	0.0064	0.064	6.8E-01	6.8E-02	5.9E-01	5.9E-02
Nickel	353	251	5.43	0.0247	0.0269	0.013	0.15	0.12	1	1	3.0	2.2	1.6	6.71	26.8	3.2E-01	8.0E-02	2.4E-01	6.1E-02
Butyltins																			
Tributyltin	0.481	0.248	0.00398	2.04	2.04	0.013	0.15	0.12	1	1	3.0	0.052	0.027	6.8	16.9	7.7E-03	3.1E-03	4.0E-03	1.6E-03
Pesticides																			
BHC (delta)	0.00154	0.00130	5.48E-05	0.153	0.153	0.013	0.15	0.12	1	1	3.0	0.000021	0.000018	2	20	1.0E-05	1.0E-06	9.0E-06	9.0E-07
BHC (gamma) Lindane	0.00968	0.00106	0.000344	0.268	0.268	0.013	0.15	0.12	1	1	3.0	0.00019	0.000033	2	20	9.4E-05	9.4E-06	1.7E-05	1.7E-06
Chlordane (alpha)	0.000815	0.000776	1.21E-06	0.011	0.011	0.013	0.15	0.12	1	1	3.0	0.0000039	0.0000038	2.14	10.7	1.8E-06	3.7E-07	1.8E-06	3.5E-07
Chlordane (gamma)	0.0303	0.0204	4.49E-05	0.010	0.010	0.013	0.15	0.12	1	1	3.0	0.00014	0.00010	2.14	10.7	6.7E-05	1.3E-05	4.6E-05	9.1E-06
Endosulfan I	0.00269	0.000809	3.98E-05	0.231	0.231	0.013	0.15	0.12	1	1	3.0	0.000045	0.000015	10	50	4.5E-06	9.0E-07	1.5E-06	2.9E-07
Endosulfan II	0.000495	0.000447	7.32E-06	0.231	0.231	0.013	0.15	0.12	1	1	3.0	0.0000082	0.0000075	10	50	8.2E-07	1.6E-07	7.5E-07	1.5E-07
Endosulfan Sulfate	0.000953	0.000889	9.68E-06	0.290	0.290	0.013	0.15	0.12	1	1	3.0	0.000019	0.000017	10	50	1.9E-06	3.7E-07	1.7E-06	3.5E-07
Endrin Aldehyde	0.00387	0.00344	0.000118	0.063	0.063	0.013	0.15	0.12	1	1	3.0	0.000034	0.000030	0.01	0.1	3.4E-03	3.4E-04	3.0E-03	3.0E-04
Endrin Ketone	0.00309	0.00288	3.18E-05	0.049	0.049	0.013	0.15	0.12	1	1	3.0	0.000022	0.000021	0.01	0.1	2.2E-03	2.2E-04	2.1E-03	2.1E-04
Endrin	0.00504	0.00389	2.51E-05	0.037	0.037	0.013	0.15	0.12	1	1	3.0	0.000032	0.000025	0.01	0.1	3.2E-03	3.2E-04	2.5E-03	2.5E-04
Heptachlor	0.000464	0.000415	1.12E-06	0.011	0.011	0.013	0.15	0.12	1	1	3.0	0.0000023	0.0000020	0.013	0.065	1.7E-04	3.5E-05	1.6E-04	3.1E-05
Methoxychlor	0.00105	0.00104	2.54E-06	0.044	0.044	0.013	0.15	0.12	1	1	3.0	0.0000069	0.0000068	125	625	5.5E-08	1.1E-08	5.4E-08	1.1E-08
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	98.0	77.1	0.0817	0.00150	0.00150	0.013	0.15	0.12	1	1	3.0	0.42	0.33	1.1	11	3.8E-01	3.8E-02	3.0E-01	3.0E-02
Butyl Benzyl Phthalate [b]	0.0171	0.0152	0.000239	0.0695	0.0695	0.013	0.15	0.12	1	1	3.0	0.00014	0.00013	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole [b]	0.144	0.112	0.00157	0.268	0.268	0.013	0.15	0.12	1	1	3.0	0.0026	0.0021	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran [b]	0.0424	0.122	0.000463	0.157	0.157	0.013	0.15	0.12	1	1	3.0	0.00054	0.0015	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.0804	0.0543	0.00693	0.236	0.236	0.013	0.15	0.12	1	1	3.0	0.0016	0.0012	0.11	1.1	1.4E-02	1.4E-03	1.1E-02	1.1E-03
Di-n-octyl Phthalate [b]	0.0251	0.0225	0.0000178	0.000772	0.000772	0.013	0.15	0.12	1	1	3.0	0.00011	0.00010	NA	NA	No TRV	No TRV	No TRV	No TRV
VOCs																			
1,2,4-Trimethylbenzene [b]	0.000230	4.62	0.0000375	0.302	0.302	0.013	0.15	0.12	1	1	3.0	0.0000061	0.091	NA	NA	No TRV	No TRV	No TRV	No TRV
4-Isopropyltoluene	0.00133	0.0201	0.000119	0.161	0.161	0.013	0.15	0.12	1	1	3.0	0.000021	0.00026	3.16	15.8	6.8E-06	1.4E-06	8.1E-05	1.6E-05
n-Propylbenzene [b]	0.000150	0.0355	0.0000185	0.279	0.279	0.013	0.15	0.12	1	1	3.0	0.0000035	0.00066	NA	NA	No TRV	No TRV	No TRV	No TRV

	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Metals + Butyltin HI	**4.2E+00**	**1.2E+00**	**3.9E+00**	**1.2E+00**
Pesticides HI	9.1E-03	9.4E-04	7.8E-03	8.0E-04
Phthalate HI	4.0E-01	4.0E-02	3.1E-01	3.1E-02

Notes:
a) Sources listed on Table 3-8b for plant BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7b.
d) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

Table 3-12a
Calculation of Dose and Hazard Quotient for the Canada Goose – Sandblast Area AOPC

-- = not calculated
% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
CPEC = chemical of potential ecological concern
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-12b
Calculation of Dose and Hazard Quotient for the American Robin – Sandblast Area AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Shallow Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	2.94	2.42	0.0653	1	1	0.0013	0.013	0.011	1	1	0.0773	0.54	0.44	NA	NA	No TRV	No TRV	No TRV	No TRV
Cadmium	3.20	2.63	0.0427	6.52	6.79	0.0013	0.013	0.011	1	1	0.0773	3.4	2.9	1.47	5.88	**2.3E+00**	5.9E-01	**2.0E+00**	5.0E-01
Chromium III	720	579	0.000400	0.306	0.306	0.0013	0.013	0.011	1	1	0.0773	48	39	2.66	14.5	**1.8E+01**	**3.3E+00**	**1.4E+01**	**2.7E+00**
Lead	465	529	0.517	0.246	0.240	0.0013	0.013	0.011	1	1	0.0773	26	30	1.63	3.26	**1.6E+01**	**8.1E+00**	**1.8E+01**	**9.1E+00**
Mercury	0.113	0.098	0.00217	1.69	1.69	0.0013	0.013	0.011	1	1	0.0773	0.033	0.029	0.0064	0.064	**5.2E+00**	5.2E-01	**4.5E+00**	4.5E-01
Nickel	353	251	5.43	1.06	1.06	0.0013	0.013	0.011	1	1	0.0773	67	48	6.71	26.8	**1.0E+01**	**2.5E+00**	**7.2E+00**	**1.8E+00**
Butyltins																			
Tributyltin	0.481	0.248	0.00398	0.0424	0.0424	0.0013	0.013	0.011	1	1	0.0773	0.012	0.0064	6.80	16.9	1.8E-03	7.1E-04	9.5E-04	3.8E-04
Pesticides																			
BHC (delta)	0.00154	0.00130	5.48E-05	8.89	8.89	0.0013	0.013	0.011	1	1	0.0773	0.0023	0.0019	2	20	1.1E-03	1.1E-04	9.5E-04	9.5E-05
BHC (gamma) Lindane	0.00968	0.00106	0.000344	3.83	3.83	0.0013	0.013	0.011	1	1	0.0773	0.0062	0.00072	2	20	3.1E-03	3.1E-04	3.6E-04	3.6E-05
Chlordane (alpha)	0.000815	0.000776	1.21E-06	18.8	18.8	0.0013	0.013	0.011	1	1	0.0773	0.0025	0.0024	2.14	10.7	1.2E-03	2.3E-04	1.1E-03	2.2E-04
Chlordane (gamma)	0.0303	0.0204	4.49E-05	23.9	23.9	0.0013	0.013	0.011	1	1	0.0773	0.12	0.079	2.14	10.7	5.5E-02	1.1E-02	3.7E-02	7.4E-03
Endosulfan I	0.00269	0.000809	3.98E-05	1.99	1.99	0.0013	0.013	0.011	1	1	0.0773	0.00092	0.00028	10	50	9.2E-05	1.8E-05	2.8E-05	5.6E-06
Endosulfan II	0.000495	0.000447	7.32E-06	1.99	1.99	0.0013	0.013	0.011	1	1	0.0773	0.00017	0.00015	10	50	1.7E-05	3.4E-06	1.5E-05	3.1E-06
Endosulfan Sulfate	0.000953	0.000889	9.68E-06	0.970	0.970	0.0013	0.013	0.011	1	1	0.0773	0.00017	0.00016	10	50	1.7E-05	3.3E-06	1.6E-05	3.1E-06
Endrin Aldehyde	0.00387	0.00344	0.000118	28.7	28.7	0.0013	0.013	0.011	1	1	0.0773	0.018	0.016	0.01	0.1	**1.8E+00**	1.8E-01	**1.6E+00**	1.6E-01
Endrin Ketone	0.00309	0.00288	3.18E-05	14.1	14.1	0.0013	0.013	0.011	1	1	0.0773	0.0071	0.0066	0.01	0.1	7.1E-01	7.1E-02	6.6E-01	6.6E-02
Endrin	0.00504	0.00389	2.51E-05	10.4	10.4	0.0013	0.013	0.011	1	1	0.0773	0.0086	0.0066	0.01	0.1	8.6E-01	8.6E-02	6.6E-01	6.6E-02
Heptachlor	0.000464	0.000415	1.12E-06	30.7	30.7	0.0013	0.013	0.011	1	1	0.0773	0.0023	0.0021	0.013	0.065	1.8E-01	3.6E-02	1.6E-01	3.2E-02
Methoxychlor	0.00105	0.00104	2.54E-06	3.98	3.98	0.0013	0.013	0.011	1	1	0.0773	0.00070	0.00069	125	625	5.6E-06	1.1E-06	5.5E-06	1.1E-06
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	98.0	77.1	0.0817	1	1	0.0013	0.013	0.011	1	1	0.0773	18	14	1.1	11	**1.6E+01**	**1.6E+00**	**1.3E+01**	**1.3E+00**
Butyl Benzyl Phthalate [b]	0.0171	0.0152	0.000239	1	1	0.0013	0.013	0.011	1	1	0.0773	0.0031	0.0028	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole [b]	0.144	0.112	0.00157	1	1	0.0013	0.013	0.011	1	1	0.0773	0.026	0.020	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran [b]	0.0424	0.122	0.000463	1	1	0.0013	0.013	0.011	1	1	0.0773	0.0077	0.022	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.0804	0.0543	0.00693	1	1	0.0013	0.013	0.011	1	1	0.0773	0.015	0.011	0.11	1.1	1.4E-01	1.4E-02	9.7E-02	9.7E-03
Di-n-octyl Phthalate [b]	0.0251	0.0225	0.0000178	1	1	0.0013	0.013	0.011	1	1	0.0773	0.0045	0.0040	NA	NA	No TRV	No TRV	No TRV	No TRV
VOCs																			
1,2,4-Trimethylbenzene [b]	0.000230	4.62	0.0000375	1	1	0.0013	0.013	0.011	1	1	0.0773	0.000046	0.83	NA	NA	No TRV	No TRV	No TRV	No TRV
4-Isopropyltoluene	0.00133	0.0201	0.000119	1	1	0.0013	0.013	0.011	1	1	0.0773	0.00025	0.0036	3	15.8	8.1E-05	1.6E-05	1.1E-03	2.3E-04
n-Propylbenzene [b]	0.000150	0.0355	0.0000185	1	1	0.0013	0.013	0.011	1	1	0.0773	0.000029	0.0064	NA	NA	No TRV	No TRV	No TRV	No TRV

Metals + Butyltin HI	**5.2E+01**	**1.5E+01**	**4.6E+01**	**1.4E+01**
Pesticides HI	**3.6E+00**	3.9E-01	**3.1E+00**	3.3E-01
Phthalate HI	**1.6E+01**	**1.6E+00**	**1.3E+01**	**1.3E+00**

Notes:
a) Sources listed on Table 3-9b for invertebrate BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7b.
d) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

Table 3-12b
Calculation of Dose and Hazard Quotient for the American Robin – Sandblast Area AOPC

-- = not calculated
%= percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-12c
Calculation of Dose and Hazard Quotient for the American Kestrel – Sandblast Area AOPC

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L)[c]	Surface Soil BAF mammals (kg tissue/kg soil)[a]	Shallow Soil BAF mammals (kg tissue/kg soil)[a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony[b]	2.94	2.42	0.0653	0.050	0.050	0.00033	0.017	0.014	1	0.01148	0.116	0.00043	0.00037	NA	NA	No TRV	No TRV	No TRV	No TRV
Cadmium	3.20	2.63	0.0000100	0.154	0.171	0.00033	0.017	0.014	1	0.01148	0.116	0.00091	0.0008	1.47	5.88	6.2E-04	1.6E-04	5.6E-04	1.4E-04
Chromium III	720	579	0.000400	0.0403	0.0427	0.00033	0.017	0.014	1	0.0115	0.116	0.071	0.060	2.66	14.5	2.7E-02	4.9E-03	2.2E-02	4.1E-03
Lead	465	529	0.0000360	0.0351	0.0327	0.00033	0.017	0.014	1	0.0115	0.116	0.042	0.046	1.63	3.26	2.6E-02	1.3E-02	2.8E-02	1.4E-02
Mercury	0.113	0.098	0.00217	0.0543	0.0543	0.00033	0.017	0.014	1	0.0115	0.116	0.000017	0.000015	0.0064	0.064	2.6E-03	2.6E-04	2.3E-03	2.3E-04
Nickel	353	251	5.43	0.0340	0.0408	0.00033	0.017	0.014	1	0.0115	0.116	0.039	0.033	6.71	26.8	5.8E-03	1.4E-03	4.8E-03	1.2E-03
Butyltins																			
Tributyltin	0.481	0.248	0.00398	0.0000124	0.0000124	0.00033	0.017	0.014	1	0.0115	0.116	0.000021	0.000014	6.8	16.9	3.1E-06	1.3E-06	2.0E-06	8.1E-07
Pesticides																			
BHC (delta)	0.00154	0.00130	5.48E-05	0.00108	0.00108	0.00033	0.017	0.014	1	0.0115	0.116	0.00000013	0.00000012	2	20	6.4E-08	6.4E-09	6.0E-08	6.0E-09
BHC (gamma) Lindane	0.00968	0.00106	0.000344	0.000412	0.000412	0.00033	0.017	0.014	1	0.0115	0.116	0.00000080	0.00000051	2	20	4.0E-07	4.0E-08	2.6E-07	2.6E-08
Chlordane (alpha)	0.000815	0.000776	1.21E-06	0.0988	0.0988	0.00033	0.017	0.014	1	0.0115	0.116	0.00000016	0.00000015	2.14	10.7	7.5E-08	1.5E-08	7.1E-08	1.4E-08
Chlordane (gamma)	0.0303	0.0204	4.49E-05	0.130	0.130	0.00033	0.017	0.014	1	0.0115	0.116	0.0000075	0.0000051	2.14	10.7	3.5E-06	7.0E-07	2.4E-06	4.8E-07
Endosulfan I	0.00269	0.000809	3.98E-05	0.000531	0.000531	0.00033	0.017	0.014	1	0.0115	0.116	0.00000015	0.000000082	10	50	1.5E-08	2.9E-09	8.2E-09	1.6E-09
Endosulfan II	0.000495	0.000447	7.32E-06	0.000531	0.000531	0.00033	0.017	0.014	1	0.0115	0.116	0.000000027	0.000000025	10	50	2.7E-09	5.4E-10	2.5E-09	5.0E-10
Endosulfan Sulfate	0.000953	0.000889	9.68E-06	0.000359	0.000359	0.00033	0.017	0.014	1	0.0115	0.116	0.000000045	0.000000043	10	50	4.5E-09	9.0E-10	4.3E-09	8.6E-10
Endrin Aldehyde	0.00387	0.00344	0.000118	0.00495	0.00495	0.00033	0.017	0.014	1	0.0115	0.116	0.00000032	0.00000030	0.01	0.1	3.2E-05	3.2E-06	3.0E-05	3.0E-06
Endrin Ketone	0.00309	0.00288	3.18E-05	0.00767	0.00767	0.00033	0.017	0.014	1	0.0115	0.116	0.00000018	0.00000017	0.01	0.1	1.8E-05	1.8E-06	1.7E-05	1.7E-06
Endrin	0.00504	0.00389	2.51E-05	0.0124	0.0124	0.00033	0.017	0.014	1	0.0115	0.116	0.00000030	0.00000024	0.01	0.1	3.0E-05	3.0E-06	2.4E-05	2.4E-06
Heptachlor	0.000464	0.000415	1.12E-06	0.0988	0.0988	0.00033	0.017	0.014	1	0.0115	0.116	0.000000092	0.000000082	0.013	0.065	7.1E-06	1.4E-06	6.3E-06	1.3E-06
Methoxychlor	0.00105	0.00104	2.54E-06	0.00944	0.00944	0.00033	0.017	0.014	1	0.0115	0.116	0.000000054	0.000000054	125	625	4.3E-10	8.7E-11	4.3E-10	8.6E-11
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	98.0	77.1	0.0817	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.16	0.13	1.1	11	1.5E-01	1.5E-02	1.2E-01	1.2E-02
Butyl Benzyl Phthalate[b]	0.0171	0.0152	0.000239	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.000029	0.000026	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole[b]	0.144	0.112	0.00157	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.00024	0.00019	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran[b]	0.0424	0.122	0.000463	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.000072	0.00020	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.0804	0.0543	0.00693	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.00014	0.000100	0.11	1.1	1.3E-03	1.3E-04	9.1E-04	9.1E-05
Di-n-octyl Phthalate[b]	0.0251	0.0225	0.0000178	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.0000	0.0000	NA	NA	No TRV	No TRV	No TRV	No TRV
VOCs																			
1,2,4-Trimethylbenzene[b]	0.000230	4.62	0.0000375	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.00000044	0.0077	NA	NA	No TRV	No TRV	No TRV	No TRV
4-Isopropyltoluene	0.00133	0.0201	0.000119	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.0000024	0.000034	3	15.8	7.6E-07	1.5E-07	1.1E-05	2.1E-06
n-Propylbenzene[b]	0.000150	0.0355	0.0000185	1	1	0.00033	0.017	0.014	1	0.0115	0.116	0.00000028	0.000059	NA	NA	No TRV	No TRV	No TRV	No TRV

	Surface Soil NOAEL HQ	Surface Soil LOAEL HQ	Shallow Soil NOAEL HQ	Shallow Soil LOAEL HQ
Metals + Butyltin HI	6.2E-02	2.0E-02	5.8E-02	2.0E-02
Pesticides HI	9.2E-05	1.0E-05	8.1E-05	9.0E-06
Phthalate HI	1.5E-01	1.5E-02	1.2E-01	1.2E-02

Notes:
a) Sources listed on Table 3-10b for mammal BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Cadmium and lead (dissolved) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7b.
d) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

Table 3-12c
Calculation of Dose and Hazard Quotient for the American Kestrel – Sandblast Area AOPC

-- = not calculated
% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-12d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew – Sandblast Area AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Shallow Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony	2.94	2.42	0.0653	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.61	0.50	0.059	0.59	**1.0E+01**	**1.0E+00**	**8.6E+00**	8.6E-01
Cadmium	3.20	2.63	0.0427	6.52	6.79	0.0000550	0.00137	0.00114	1	1	0.007	4.1	3.5	0.770	7.70	**5.4E+00**	5.4E-01	**4.6E+00**	4.6E-01
Chromium III	720	579	0.000400	0.306	0.306	0.0000550	0.00137	0.00114	1	1	0.007	49	39	2.40	12.0	**2.0E+01**	**4.1E+00**	**1.6E+01**	**3.3E+00**
Lead	465	529	0.517	0.246	0.240	0.0000550	0.00137	0.00114	1	1	0.007	26	29	4.70	8.90	**5.6E+00**	**2.9E+00**	**6.2E+00**	**3.3E+00**
Mercury	0.113	0.098	0.00217	1.69	1.69	0.0000550	0.00137	0.00114	1	1	0.007	0.039	0.033	0.02	0.07	**1.9E+00**	5.5E-01	**1.7E+00**	4.8E-01
Nickel	353	251	5.43	1.06	1.06	0.0000550	0.00137	0.00114	1	1	0.007	77	55	1.70	3.40	**4.5E+01**	**2.3E+01**	**3.2E+01**	**1.6E+01**
Butyltins																			
Tributyltin	0.481	0.248	0.00398	0.0424	0.0424	0.0000550	0.00137	0.00114	1	1	0.007	0.0084	0.0047	23.4	35	3.6E-04	2.4E-04	2.0E-04	1.3E-04
Pesticides																			
BHC (delta)	0.00154	0.00130	5.48E-05	8.89	8.89	0.0000550	0.00137	0.00114	1	1	0.007	0.0027	0.0023	8	40	3.4E-04	6.8E-05	2.9E-04	5.7E-05
BHC (gamma) Lindane	0.00968	0.00106	0.000344	3.83	3.83	0.0000550	0.00137	0.00114	1	1	0.007	0.0074	0.00086	8	40	9.3E-04	1.9E-04	1.1E-04	2.2E-05
Chlordane (alpha)	0.000815	0.000776	1.21E-06	18.8	18.8	0.0000550	0.00137	0.00114	1	1	0.007	0.0030	0.0029	4.6	9.2	6.5E-04	3.3E-04	6.2E-04	3.1E-04
Chlordane (gamma)	0.0303	0.0204	4.49E-05	23.9	23.9	0.0000550	0.00137	0.00114	1	1	0.007	0.142	0.096	4.6	9.2	3.1E-02	1.5E-02	2.1E-02	1.0E-02
Endosulfan I	0.00269	0.000809	3.98E-05	1.99	1.99	0.0000550	0.00137	0.00114	1	1	0.007	0.0011	0.00033	0.15	0.75	7.2E-03	1.4E-03	2.2E-03	4.4E-04
Endosulfan II	0.000495	0.000447	7.32E-06	1.99	1.99	0.0000550	0.00137	0.00114	1	1	0.007	0.0002	0.0002	0.15	0.75	1.3E-03	2.6E-04	1.2E-03	2.4E-04
Endosulfan Sulfate	0.000953	0.000889	9.68E-06	0.970	0.970	0.0000550	0.00137	0.00114	1	1	0.007	0.00019	0.00018	0.15	0.75	1.3E-03	2.5E-04	1.2E-03	2.4E-04
Endrin Aldehyde	0.00387	0.00344	0.000118	28.7	28.7	0.0000550	0.00137	0.00114	1	1	0.007	0.022	0.019	0.092	0.92	2.4E-01	2.4E-02	2.1E-01	2.1E-02
Endrin Ketone	0.00309	0.00288	3.18E-05	14.1	14.1	0.0000550	0.00137	0.00114	1	1	0.007	0.009	0.008	0.092	0.92	9.3E-02	9.3E-03	8.7E-02	8.7E-03
Endrin	0.00504	0.00389	2.51E-05	10.4	10.4	0.0000550	0.00137	0.00114	1	1	0.007	0.010	0.008	0.092	0.92	1.1E-01	1.1E-02	8.7E-02	8.7E-03
Heptachlor	0.000464	0.000415	1.12E-06	30.7	30.7	0.0000550	0.00137	0.00114	1	1	0.007	0.00280	0.00250	0.1	1	2.8E-02	2.8E-03	2.5E-02	2.5E-03
Methoxychlor	0.00105	0.00104	2.54E-06	3.98	3.98	0.0000550	0.00137	0.00114	1	1	0.007	0.00083	0.00082	4	8	2.1E-04	1.0E-04	2.1E-04	1.0E-04
HPAHs																			
Benzo(a)anthracene	1.75	2.45	0.000989	1.59	1.59	0.0000550	0.00137	0.00114	1	1	0.007	0.56	0.78	***	***	9.1E-01	1.8E-01	**1.3E+00**	2.6E-01
Benzo(a)pyrene	1.76	2.39	0.000300	1.33	1.33	0.0000550	0.00137	0.00114	1	1	0.007	0.47	0.64	***	***	7.7E-01	1.5E-01	**1.0E+00**	2.1E-01
Benzo(b)fluoranthene	1.95	2.21	0.000326	2.60	2.60	0.0000550	0.00137	0.00114	1	1	0.007	1.0	1.1	***	***	**1.6E+00**	3.3E-01	**1.9E+00**	3.7E-01
Benzo(g,h,i)perylene	1.07	1.05	5.49E-05	2.94	2.94	0.0000550	0.00137	0.00114	1	1	0.007	0.63	0.61	***	***	**1.0E+00**	2.0E-01	1.0E+00	2.0E-01
Benzo(k)fluoranthene	0.676	0.764	0.000115	2.60	2.60	0.0000550	0.00137	0.00114	1	1	0.007	0.35	0.40	***	***	5.7E-01	1.1E-01	6.4E-01	1.3E-01
Benzofluoranthenes, Total	7.76	10.6	0.00132	2.60	2.60	0.0000550	0.00137	0.00114	1	1	0.007	4.0	5.5	***	***	**6.5E+00**	**1.3E+00**	**8.9E+00**	**1.8E+00**
Chrysene	2.07	4.59	0.00114	2.29	2.29	0.0000550	0.00137	0.00114	1	1	0.007	0.95	2.1	***	***	**1.5E+00**	3.1E-01	**3.4E+00**	6.8E-01
Dibenz(a,h)anthracene	0.244	0.238	1.28E-05	2.31	2.31	0.0000550	0.00137	0.00114	1	1	0.007	0.11	0.11	***	***	1.8E-01	3.7E-02	1.8E-01	3.6E-02
Fluoranthene	4.64	10.8	0.00836	3.04	3.04	0.0000550	0.00137	0.00114	1	1	0.007	2.8	6.5	***	***	**4.6E+00**	9.1E-01	**1.1E+01**	**2.1E+00**
Indeno(1,2,3-cd)pyrene	1.13	1.16	3.26E-05	2.86	2.86	0.0000550	0.00137	0.00114	1	1	0.007	0.64	0.66	***	***	**1.0E+00**	2.1E-01	**1.1E+00**	2.2E-01
Pyrene	4.78	11.7	0.00880	1.75	1.75	0.0000550	0.00137	0.00114	1	1	0.007	1.7	4.1	***	***	**2.7E+00**	5.5E-01	**6.7E+00**	**1.3E+00**
Total HPAHs	18.6	40.8	0.00425	2.60	2.60	0.0000550	0.00137	0.00114	1	1	0.007	9.6	21	0.615	3.07	**1.6E+01**	**3.1E+00**	**3.4E+01**	**6.9E+00**
SVOCs																			
Bis(2-ethylhexyl) Phthalate	98.0	77.1	0.0817	1	1	0.0000550	0.00137	0.00114	1	1	0.007	20	16	18.3	183	**1.1E+00**	1.1E-01	8.6E-01	8.6E-02
Butyl Benzyl Phthalate	0.0171	0.0152	0.000239	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.004	0.003	159	470	2.2E-05	7.5E-06	2.0E-05	6.7E-06
Carbazole	0.144	0.112	0.00157	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.030	0.023	5	50	5.9E-03	5.9E-04	4.6E-03	4.6E-04
Dibenzofuran	0.0424	0.122	0.000463	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.0087	0.025	6	30	1.5E-03	2.9E-04	4.2E-03	8.3E-04
Di-n-butyl Phthalate	0.0804	0.0543	0.00693	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.018	0.012	550	1,833	3.2E-05	9.6E-06	2.2E-05	6.7E-06
Di-n-octyl Phthalate	0.0251	0.0225	0.0000178	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.0051	0.0046	7,500	37,500	6.8E-07	1.4E-07	6.1E-07	1.2E-07
VOCs																			
1,2,4-Trimethylbenzene	0.000230	4.62	0.0000375	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.000053	0.94	13	65	4.1E-06	8.2E-07	7.3E-02	1.5E-02

Table 3-12d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew – Sandblast Area AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Shallow Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
4-Isopropyltoluene	0.00133	0.0201	0.000119	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.00029	0.0041	47.5	237.5	6.1E-06	1.2E-06	8.7E-05	1.7E-05
n-Propylbenzene	0.000150	0.0355	0.0000185	1	1	0.0000550	0.00137	0.00114	1	1	0.007	0.000034	0.0072	60.4	302	5.6E-07	1.1E-07	1.2E-04	2.4E-05

Metals + Butyltin HI	**8.9E+01**	**3.2E+01**	**7.0E+01**	**2.5E+01**
Pesticides HI	5.1E-01	6.5E-02	4.4E-01	5.3E-02
Phthalate HI	**1.1E+00**	1.1E-01	8.6E-01	8.6E-02
VOCs HI	1.1E-05	2.2E-06	7.3E-02	1.5E-02

Notes:
a) Sources listed on Table 3-9b for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7b.
c) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.
*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
EcoSSL = ecological soil screening level
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest oberserved adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no oberserved adverse effect level
PF = portion of food item
SLV =screening level value
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-12e
Calculation of Dose and Hazard Quotient for the American Mink– Sandblast Area AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/ kg soil) [a]	Shallow Soil BAF mammals (kg tissue/ kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony[b]	2.94	2.42	0.0653	0.050	0.050	0.0051	0.054	0.097	0.15	0.163158	0.974	0.0038	0.0033	0.059	0.59	6.4E-02	6.4E-03	5.6E-02	5.6E-03
Cadmium	3.20	2.63	0.0000100	0.1540	0.1708	0.0051	0.054	0.097	0.15	0.163158	0.974	0.0034	0.0028	0.770	7.70	4.4E-03	4.4E-04	3.7E-03	3.7E-04
Chromium III	720	579	0.000400	0.0403	0.0427	0.0051	0.054	0.097	0.15	0.163158	0.974	0.65	0.53	2.40	12.0	2.7E-01	5.4E-02	2.2E-01	4.4E-02
Lead	465	529	0.0000360	0.0351	0.0327	0.0051	0.054	0.097	0.15	0.163158	0.974	0.42	0.47	4.70	8.90	8.9E-02	4.7E-02	1.0E-01	5.3E-02
Mercury	0.113	0.098	0.00217	0.0543	0.0543	0.0051	0.054	0.097	0.15	0.163158	0.974	0.00014	0.00013	0.02	0.07	7.0E-03	2.0E-03	6.3E-03	1.8E-03
Nickel	353	251	5.43	0.0340	0.0408	0.0051	0.054	0.097	0.15	0.163158	0.974	0.40	0.32	1.70	3.40	2.4E-01	1.2E-01	1.9E-01	9.3E-02
Butyltins																			
Tributyltin	0.481	0.248	0.00398	0.00001	0.00001	0.0051	0.054	0.097	0.15	0.163158	0.974	0.00047	0.00028	23.4	35	2.0E-05	1.4E-05	1.2E-05	7.9E-06
Pesticides																			
BHC (delta)	0.00154	0.00130	5.48E-05	0.00108	0.00108	0.0051	0.054	0.097	0.15	0.163158	0.974	0.0000022	0.0000020	8	40	2.8E-07	5.5E-08	2.5E-07	5.0E-08
BHC (gamma) Lindane	0.00968	0.00106	0.000344	0.000412	0.000412	0.0051	0.054	0.097	0.15	0.163158	0.974	0.000014	0.0000065	8	40	1.7E-06	3.5E-07	8.1E-07	1.6E-07
Chlordane (alpha)	0.000815	0.000776	1.21E-06	0.0988	0.0988	0.0051	0.054	0.097	0.15	0.163158	0.974	0.00000082	0.00000078	4.6	9.2	1.8E-07	8.9E-08	1.7E-07	8.5E-08
Chlordane (gamma)	0.0303	0.0204	4.49E-05	0.1303	0.1303	0.0051	0.054	0.097	0.15	0.163158	0.974	0.000032	0.000022	4.6	9.2	6.9E-06	3.5E-06	4.7E-06	2.4E-06
Endosulfan I	0.00269	0.000809	3.98E-05	0.000531	0.000531	0.0051	0.054	0.097	0.15	0.163158	0.974	0.0000029	0.0000013	0.15	0.75	2.0E-05	3.9E-06	8.9E-06	1.8E-06
Endosulfan II	0.000495	0.000447	7.32E-06	0.0005	0.0005	0.0051	0.054	0.097	0.15	0.163158	0.974	0.00000054	0.00000050	0.15	0.75	3.6E-06	7.2E-07	3.3E-06	6.7E-07
Endosulfan Sulfate	0.000953	0.000889	9.68E-06	0.000359	0.000359	0.0051	0.054	0.097	0.15	0.163158	0.974	0.0000010	0.00000091	0.15	0.75	6.5E-06	1.3E-06	6.1E-06	1.2E-06
Endrin Aldehyde	0.00387	0.00344	0.000118	0.005	0.005	0.0051	0.054	0.097	0.15	0.163	0.974	0.0000052	0.0000049	0.092	0.92	5.7E-05	5.7E-06	5.3E-05	5.3E-06
Endrin Ketone	0.00309	0.00288	3.18E-05	0.0077	0.0077	0.0051	0.054	0.097	0.15	0.163	0.974	0.0000032	0.0000030	0.092	0.92	3.5E-05	3.5E-06	3.3E-05	3.3E-06
Endrin	0.00504	0.00389	2.51E-05	0.0124	0.0124	0.0051	0.054	0.097	0.15	0.163	0.974	0.0000048	0.0000038	0.092	0.92	5.2E-05	5.2E-06	4.1E-05	4.1E-06
Heptachlor	0.000464	0.000415	1.12E-06	0.0988	0.0988	0.0051	0.054	0.097	0.15	0.163	0.974	0.00000048	0.00000043	0.1	1	4.8E-06	4.8E-07	4.3E-06	4.3E-07
Methoxychlor	0.00105	0.00104	2.54E-06	0.00944	0.00944	0.0051	0.054	0.097	0.15	0.163	0.974	0.00000095	0.00000094	4	8	2.4E-07	1.2E-07	2.3E-07	1.2E-07
HPAHs																			
Benzo(a)anthracene	1.75	2.45	0.00000060	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0015	0.0021	***	***	2.4E-03	4.9E-04	3.4E-03	6.8E-04
Benzo(a)pyrene	1.76	2.39	0.000300	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0015	0.0020	***	***	2.4E-03	4.9E-04	3.3E-03	6.6E-04
Benzo(b)fluoranthene	1.95	2.21	0.00000092	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0017	0.0019	***	***	2.7E-03	5.4E-04	3.1E-03	6.1E-04
Benzo(g,h,i)perylene	1.07	1.05	5.49E-05	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.00091	0.00089	***	***	1.5E-03	3.0E-04	1.5E-03	2.9E-04
Benzo(k)fluoranthene	0.676	0.764	0.000115	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.00058	0.00065	***	***	9.4E-04	1.9E-04	1.1E-03	2.1E-04
Benzofluoranthenes, Total	7.76	10.6	0.00132	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0066	0.0090	***	***	1.1E-02	2.2E-03	1.5E-02	2.9E-03
Chrysene	2.07	4.59	0.0000017	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0018	0.0039	***	***	2.9E-03	5.7E-04	6.4E-03	1.3E-03
Dibenz(a,h)anthracene	0.244	0.238	1.28E-05	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.00021	0.00020	***	***	3.4E-04	6.8E-05	3.3E-04	6.6E-05
Fluoranthene	4.64	10.8	0.0000078	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0039	0.0092	***	***	6.4E-03	1.3E-03	1.5E-02	3.0E-03
Indeno(1,2,3-cd)pyrene	1.13	1.16	3.26E-05	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0010	0.0010	***	***	1.6E-03	3.1E-04	1.6E-03	3.2E-04
Pyrene	4.78	11.7	0.00880	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.0042	0.010	***	***	6.8E-03	1.4E-03	1.6E-02	3.3E-03
Total HPAHs	18.6	40.8	0.00425	0	0	0.0051	0.054	0.097	0.15	0.163	0.974	0.016	0.035	0.615	3.07	2.6E-02	5.2E-03	5.7E-02	1.1E-02
SVOCs																			
Bis(2-ethylhexyl) Phthalate	98.0	77.1	0.0817	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.22	0.17	18.3	183	1.2E-02	1.2E-03	9.4E-03	9.4E-04
Butyl Benzyl Phthalate	0.0171	0.0152	0.000239	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.000042	0.000037	159	470	2.6E-07	8.9E-08	2.4E-07	8.0E-08
Carbazole	0.144	0.112	0.00157	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.00034	0.00027	5	50	6.9E-05	6.9E-06	5.5E-05	5.5E-06
Dibenzofuran	0.0424	0.122	0.000463	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.00010	0.00028	6	30	1.7E-05	3.4E-06	4.6E-05	9.2E-06
Di-n-butyl Phthalate	0.0804	0.0543	0.00693	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.00029	0.00023	550	1,833	5.3E-07	1.6E-07	4.2E-07	1.3E-07
Di-n-octyl Phthalate	0.0251	0.0225	0.0000178	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.00006	0.00005	7,500	37,500	7.4E-09	1.5E-09	6.7E-09	1.3E-09
VOCs																			
1,2,4-Trimethylbenzene	0.000230	4.62	0.0000375	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.0000011	0.010	13	65	8.6E-08	1.7E-08	7.8E-04	1.6E-04

Table 3-12e
Calculation of Dose and Hazard Quotient for the American Mink– Sandblast Area AOPC

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L)[b]	Surface Soil BAF mammals (kg tissue/ kg soil)[a]	Shallow Soil BAF mammals (kg tissue/ kg soil)[a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
4-Isopropyltoluene	0.00133	0.0201	0.000119	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.0000049	0.000046	47.5	237.5	1.0E-07	2.0E-08	9.8E-07	2.0E-07
n-Propylbenzene	0.000150	0.0355	0.0000185	1	1	0.0051	0.054	0.097	0.15	0.163	0.974	0.00000063	0.000079	60.4	302	1.0E-08	2.1E-09	1.3E-06	2.6E-07

	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Metals + Butyltin HI	6.7E-01	2.3E-01	5.7E-01	2.0E-01
Pesticides HI	1.9E-04	2.5E-05	1.6E-04	2.0E-05
Phthalate HI	1.2E-02	1.2E-03	9.4E-03	9.4E-04
VOCs HI	2.0E-07	4.0E-08	7.9E-04	1.6E-04

Notes:

a) Sources listed on Table 3-10b for mammal BAFs.

b) Cadmium & lead (dissolved), benzo(a)anthracene, benzo(b)fluoranthene, chrysene, and fluoranthene (C+F) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7l

c) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).

Bold indicates hazard quotient greater than 1.0.

*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SLV = screening level value
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-13a
Calculation of Dose and Hazard Quotient for the Canada Goose – Pistol Range AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF plant (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Plants	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1.5 ft bgs) NOAEL HQ	Surface Soil (0-1.5 ft bgs) LOAEL HQ
Inorganics														
Lead	365	0.406	0.0199	0.013	0.15	0.12	1	1	3.0	1.9	1.63	3.26	**1.2E+00**	5.9E-01

Notes:
a) Sources listed on Table 3-8c for plant BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7c.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-13b
Calculation of Dose and Hazard Quotient for the American Robin – Pistol Range AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Inverte-brates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1.5 ft bgs) NOAEL HQ	Surface Soil (0-1.5 ft bgs) LOAEL HQ
Inorganics														
Lead	365	0.406	0.258	0.0013	0.013	0.011	1	0.703	0.0773	15	1.63	3.26	**9.3E+00**	**4.6E+00**

Notes:
a) Sources listed on Table 3-9c for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7c.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-13c
Calculation of Dose and Hazard Quotient for the American Kestrel – Pistol Range AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1.5 ft bgs) NOAEL HQ	Surface Soil (0-1.5 ft bgs) LOAEL HQ
Inorganics														
Lead	365	0.0360	0.0402	0.00033	0.017	0.014	1	0.00096	0.116	0.0030	1.63	3.26	1.9E-03	9.3E-04

Notes:
a) Sources listed on Table 3-10c for mammal BAFs.
b) Lead (dissolved) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-13d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew – Pistol Range AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Concentration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Invertebrates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1.5 ft bgs) NOAEL HQ	Surface Soil (0-1.5 ft bgs) LOAEL HQ
Inorganics														
Lead	365	0.406	0.258	0.000055	0.0014	0.0011	1	1	0.007	21	4.70	8.90	**4.5E+00**	**2.4E+00**

Notes:
a) Sources listed on Table 3-9c for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7c.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest oberserved adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no oberserved adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-13e
Calculation of Dose and Hazard Quotient for the American Mink – Pistol Range AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Concentration in Water (mg/L)[b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1.5 ft bgs) NOAEL HQ	Surface Soil (0-1.5 ft bgs) LOAEL HQ
Inorganics														
Lead	365	0.0360	0.0402	0.0051	0.054	0.097	0.15	0.0137	0.974	0.028	4.70	8.90	5.9E-03	3.1E-03

Notes:
a) Sources listed on Table 3-10c for mammal BAFs.
b) Lead (dissolved) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-14a
Calculation of Dose and Hazard Quotient for the Canada Goose – Bulb Slope AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF plant (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Plants	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ
Inorganics														
Lead	307	0.341	0.0214	0.013	0.15	0.12	1	1	3.0	2	1.63	3.26	**1.0E+00**	5.0E-01
Mercury	0.720	0.0138	0.650	0.013	0.15	0.12	1	1	3.0	0.0276	0.0064	0.064	**4.3E+00**	4.3E-01
												HI	**5.3E+00**	9.3E-01

Notes:
a) Sources listed on Table 3-8d for plant BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7d.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentrations
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-14b
Calculation of Dose and Hazard Quotient for the American Robin – Bulb Slope AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Concentration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Invertebrates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ
Inorganics														
Lead	307	0.341	0.266	0.0013	0.013	0.011	1	0.146	0.0773	3	1.63	3.26	**1.7E+00**	8.3E-01
Mercury	0.720	0.0138	1.69	0.0013	0.013	0.011	1	0.146	0.0773	0.0309	0.0064	0.064	**4.8E+00**	4.8E-01
												HI	**6.5E+00**	**1.3E+00**

Notes:
a) Sources listed on Table 3-9d for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7d.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentrations
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-14c
Calculation of Dose and Hazard Quotient for the American Kestrel – Bulb Slope AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ
Inorganics														
Lead	307	0.0360	0.0442	0.00033	0.017	0.014	1	0.0002	0.116	0.00	1.63	3.26	3.5E-04	1.7E-04
Mercury	0.720	0.0138	0.0543	0.00033	0.017	0.014	1	0.0002	0.116	0.0000019	0.0064	0.064	2.9E-04	2.9E-05
												HI	6.4E-04	2.0E-04

Notes:
a) Sources listed on Table 3-10d for mammal BAFs.
b) Lead (dissolved) maximum detected concentration in River OU Forebay surface water; see Table 3-6.
Mercury concentration in water calculated using an equilibrium partitioning equation due to lack of River OU analytical data; see Table 3-7d.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentrations
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-14d
Calculation of Dose and Hazard Quotient for the Vagrant Shrew – Bulb Slope AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Concentration in Water (mg/L) [b]	Surface Soil BAF invertebrates (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Invertebrates	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ
Inorganics														
Lead	307	0.341	0.266	0.000055	0.0014	0.0011	1	0.208	0.007	4	4.7	8.9	8.2E-01	4.3E-01
Mercury	0.720	0.0138	1.69	0.000055	0.0014	0.0011	1	0.208	0.007	0.0512	0.020	0.070	**2.6E+00**	7.3E-01
												HI	**3.4E+00**	**1.2E+00**

Notes:
a) Sources listed on Table 3-9d for invertebrate BAFs.
b) Analyte concentrations in water calculated using an equilibrium partitioning equation; see Table 3-7d.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentrations
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-14e
Calculation of Dose and Hazard Quotient for the American Mink – Bulb Slope AOPC

CPEC	EPCs		BAF	Exposure Factors						Dose	TRVs		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ
Inorganics														
Lead	307	0.0360	0.0442	0.0051	0.054	0.097	0.15	0.00284	0.974	0.005	4.7	8.9	1.0E-03	5.5E-04
Mercury	0.720	0.0138	0.0543	0.0051	0.054	0.097	0.15	0.00284	0.974	0.0000155	0.020	0.070	7.8E-04	2.2E-04
												HI	1.8E-03	7.7E-04

Notes:
a) Sources listed on Table 3-10d for mammal BAFs.
b) Lead (dissolved) maximum detected concentration in River OU Forebay surface water; see Table 3-6.
Mercury concentration in water calculated using an equilibrium partitioning equation due to lack of River OU analytical data; see Table 3-7d.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentrations
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HI = (cumulative) hazard index
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
TRV = toxicity reference value
UCL = upper confidence limit

Table 3-15a
Calculation of Dose and Hazard Quotient for the American Kestrel – Combined AOPCs

CPEC	EPCs[d]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concen-tration in Water (mg/L) [c]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Shallow Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony [b]	1.80	1.64	0.0400	0.050	0.050	0.00033	0.017	0.014	1	0.0177	0.116	0.00040	0.00037	NA	NA	No TRV	No TRV	No TRV	No TRV
Cadmium	1.97	1.67	0.0000100	0.199	0.217	0.00033	0.017	0.014	1	0.0177	0.116	0.0011	0.0010	1.47	5.88	7.4E-04	1.9E-04	6.8E-04	1.7E-04
Chromium III	567	510	0.000315	0.0430	0.0442	0.00033	0.017	0.014	1	0.0177	0.116	0.090	0.083	2.66	14.5	3.4E-02	6.2E-03	3.1E-02	5.7E-03
Copper	95.0	93.6	0.000520	0.157	0.159	0.00033	0.017	0.014	1	0.0177	0.116	0.042	0.042	4.05	12.1	1.0E-02	3.5E-03	1.0E-02	3.5E-03
Lead	398	396	0.0000360	0.0383	0.0384	0.00033	0.017	0.014	1	0.0177	0.116	0.059	0.058	1.63	3.26	3.6E-02	1.8E-02	3.6E-02	1.8E-02
Mercury	0.378	0.330	0.00727	0.0543	0.0543	0.00033	0.017	0.014	1	0.0177	0.116	0.000086	0.000077	0.0064	0.064	1.3E-02	1.3E-03	1.2E-02	1.2E-03
Nickel	227	234	3.49	0.0431	0.0424	0.00033	0.017	0.014	1	0.0177	0.116	0.044	0.044	6.71	26.8	6.5E-03	1.6E-03	6.6E-03	1.7E-03
Butyltins																			
Tributyltin	0.422	0.219	0.00349	0.0424	0.0424	0.00033	0.017	0.014	1	0.0177	0.116	0.000074	0.000042	6.8	16.9	1.1E-05	4.4E-06	6.2E-06	2.5E-06
Pesticides																			
BHC (delta)	0.00303	0.00303	0.000108	8.89	8.89	0.00033	0.017	0.014	1	0.0177	0.116	0.000068	0.000068	2	20	3.4E-05	3.4E-06	3.4E-05	3.4E-06
BHC (gamma) Lindane	0.00968	0.00968	0.000344	3.83	3.83	0.00033	0.017	0.014	1	0.0177	0.116	0.000095	0.000095	2	20	4.7E-05	4.7E-06	4.7E-05	4.7E-06
Chlordane (alpha)	0.00101	0.000952	1.50E-06	18.8	18.8	0.00033	0.017	0.014	1	0.0177	0.116	0.000048	0.000045	2.14	10.7	2.2E-05	4.5E-06	2.1E-05	4.2E-06
Chlordane (gamma)	0.0188	0.0118	2.79E-05	23.9	23.9	0.00033	0.017	0.014	1	0.0177	0.116	0.0011	0.00071	2.14	10.7	5.3E-04	1.1E-04	3.3E-04	6.7E-05
Chlordane (technical)	1.56	0.902	0.00462	47.7	47.7	0.00033	0.017	0.014	1	0.0177	0.116	0.19	0.11	2.14	10.7	8.8E-02	1.8E-02	5.1E-02	1.0E-02
Endosulfan I	0.00645	0.000547	9.54E-05	1.99	1.99	0.00033	0.017	0.014	1	0.0177	0.116	0.000033	0.0000030	10	50	3.3E-06	6.6E-07	3.0E-07	5.9E-08
Endosulfan II	0.000844	0.000756	1.25E-05	1.99	1.99	0.00033	0.017	0.014	1	0.0177	0.116	0.0000043	0.0000039	10	50	4.3E-07	8.6E-08	3.9E-07	7.7E-08
Endosulfan Sulfate	0.00108	0.00101	1.10E-05	0.970	0.970	0.00033	0.017	0.014	1	0.0177	0.116	0.0000027	0.0000025	10	50	2.7E-07	5.4E-08	2.5E-07	5.1E-08
Endrin Aldehyde	0.00314	0.00286	9.60E-05	28.7	28.7	0.00033	0.017	0.014	1	0.0177	0.116	0.00023	0.00021	0.01	0.1	2.3E-02	2.3E-03	2.1E-02	2.1E-03
Endrin Ketone	0.00261	0.00250	2.69E-05	14.1	14.1	0.00033	0.017	0.014	1	0.0177	0.116	0.000093	0.000089	0.01	0.1	9.3E-03	9.3E-04	8.9E-03	8.9E-04
Endrin	0.00421	0.00321	2.09E-05	10.4	10.4	0.00033	0.017	0.014	1	0.0177	0.116	0.00011	0.000084	0.01	0.1	1.1E-02	1.1E-03	8.4E-03	8.4E-04
Heptachlor	0.000437	0.000477	1.06E-06	8.75	8.75	0.00033	0.017	0.014	1	0.0177	0.116	0.0000097	0.000011	0.013	0.065	7.4E-04	1.5E-04	8.1E-04	1.6E-04
Methoxychlor	0.00120	0.00120	2.91E-06	3.98	3.98	0.00033	0.017	0.014	1	0.0177	0.116	0.000012	0.000012	125	625	9.7E-08	1.9E-08	9.7E-08	1.9E-08
HPAHs [b]																			
SVOCs																			
Bis(2-ethylhexyl) Phthalate	36.4	31.3	0.0303	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.094	0.081	1.1	11	8.5E-02	8.5E-03	7.3E-02	7.3E-03
Butyl Benzyl Phthalate [b]	0.0172	0.0154	0.000240	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.000045	0.000040	NA	NA	No TRV	No TRV	No TRV	No TRV
Carbazole [b]	0.272	0.312	0.00297	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.00071	0.00081	NA	NA	No TRV	No TRV	No TRV	No TRV
Dibenzofuran [b]	0.0771	0.0834	0.000842	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.00020	0.00022	NA	NA	No TRV	No TRV	No TRV	No TRV
Di-n-butyl Phthalate	0.124	0.105	0.0107	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.00034	0.00029	0.11	1.1	3.1E-03	3.1E-04	2.7E-03	2.7E-04
Di-n-octyl Phthalate [b]	0.0210	0.0194	0.0000149	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.000054	0.000050	NA	NA	No TRV	No TRV	No TRV	No TRV
VOCs																			
1,2,4-Trimethylbenzene [b]	2.94	2.86	0.479	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.0086	0.0084	NA	NA	No TRV	No TRV	No TRV	No TRV
4-Isopropyltoluene	0.00102	0.0147	0.0000911	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.0000028	0.000038	3	15.8	8.9E-07	1.8E-07	1.2E-05	2.4E-06
n-Propylbenzene [b]	0.000150	0.122	0.0000185	1	1	0.00033	0.017	0.014	1	0.0177	0.116	0.00000043	0.00031	NA	NA	No TRV	No TRV	No TRV	No TRV

Metals + Butyltin HI	1.0E-01	3.1E-02	9.7E-02	3.0E-02
Pesticides HI	1.3E-01	2.2E-02	9.0E-02	1.4E-02
Phthalates HI	8.8E-02	8.8E-03	7.6E-02	7.6E-03

Notes:
Bold indicates hazard quotient greater than 1.0.
a) Sources listed on Table 3-10e for mammal BAFs.
b) These chemicals do not have established TRVs, but will be evaluated qualitatively.
c) Cadmium, copper, and lead (dissolved), benzo(a)anthracene, benzo(b)fluoranthene, chrysene, and fluoranthene (C+F) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
d) The EPC is the 95% UCL, if calculated (see Table 1-5), or maximum detected concentration (if 95% UCL not calculated).
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7e.

Table 3-15a
Calculation of Dose and Hazard Quotient for the American Kestrel – Combined AOPCs

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BW = body weight
C+F = column + filter
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NA = not available
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-15b
Calculation of Dose and Hazard Quotient for the American Mink – Combined AOPCs

CPEC	EPCs[c]			BAFs		Exposure Factors						Doses		TRVs		Hazard Quotients			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Concentration in Water (mg/L) [b]	Surface Soil BAF mammals (kg tissue/kg soil) [a]	Shallow Soil BAF mammals (kg tissue/kg soil) [a]	Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Surface Soil Dose (mg/kg-bw/day)	Shallow Soil Dose (mg/kg-bw/day)	NOAEL TRV (mg/kg-bw/day)	LOAEL TRV (mg/kg-bw/day)	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Inorganics																			
Antimony	1.80	1.64	0.0400	0.050	0.050	0.0051	0.054	0.097	0.15	0.251	0.974	0.0035	0.0033	0.059	0.59	6.0E-02	6.0E-03	5.6E-02	5.6E-03
Cadmium	1.97	1.67	0.0000100	0.199	0.217	0.0051	0.054	0.097	0.15	0.251	0.974	0.0034	0.0029	0.770	7.70	4.4E-03	4.4E-04	3.8E-03	3.8E-04
Chromium III	567	510	0.000315	0.0430	0.0442	0.0051	0.054	0.097	0.15	0.251	0.974	0.79	0.72	2.40	12.0	3.3E-01	6.6E-02	3.0E-01	6.0E-02
Copper	95.0	93.6	0.000520	0.157	0.159	0.0051	0.054	0.097	0.15	0.251	0.974	0.16	0.15	5.60	9.34	2.8E-02	1.7E-02	2.7E-02	1.6E-02
Lead	398	396	0.0000360	0.0383	0.0384	0.0051	0.054	0.097	0.15	0.251	0.974	0.55	0.55	4.70	8.90	1.2E-01	6.2E-02	1.2E-01	6.2E-02
Mercury	0.378	0.330	0.00727	0.0543	0.0543	0.0051	0.054	0.097	0.15	0.251	0.974	0.00072	0.00065	0.02	0.07	3.6E-02	1.0E-02	3.3E-02	9.3E-03
Nickel	227	234	3.49	0.0431	0.0424	0.0051	0.054	0.097	0.15	0.251	0.974	0.41	0.41	1.70	3.40	2.4E-01	1.2E-01	2.4E-01	1.2E-01
Butyltins																			
Tributyltin	0.422	0.219	0.00349	0.0424	0.0424	0.0051	0.054	0.097	0.15	0.251	0.974	0.00068	0.00039	23.4	35	2.9E-05	1.9E-05	1.7E-05	1.1E-05
Pesticides																			
BHC (delta)	0.00303	0.00303	0.000108	8.89	8.89	0.0051	0.054	0.097	0.15	0.251	0.974	0.000063	0.000063	8	40	7.9E-06	1.6E-06	7.9E-06	1.6E-06
BHC (gamma) Lindane	0.00968	0.00968	0.000344	3.83	3.83	0.0051	0.054	0.097	0.15	0.251	0.974	0.00010	0.00010	8	40	1.2E-05	2.5E-06	1.2E-05	2.5E-06
Chlordane (alpha)	0.00101	0.000952	1.50E-06	18.8	18.8	0.0051	0.054	0.097	0.15	0.251	0.974	0.000041	0.000039	4.6	9.2	8.9E-06	4.5E-06	8.4E-06	4.2E-06
Chlordane (gamma)	0.0188	0.0118	2.79E-05	23.9	23.9	0.0051	0.054	0.097	0.15	0.251	0.974	0.00096	0.00061	4.6	9.2	2.1E-04	1.0E-04	1.3E-04	6.6E-05
Chlordane (technical)	1.56	0.902	0.00462	47.7	47.7	0.0051	0.054	0.097	0.15	0.251	0.974	0.16	0.091	4.6	9.2	3.4E-02	1.7E-02	2.0E-02	9.9E-03
Endosulfan I	0.00645	0.000547	9.54E-05	1.99	1.99	0.0051	0.054	0.097	0.15	0.251	0.974	0.000038	0.0000054	0.15	0.75	2.5E-04	5.0E-05	3.6E-05	7.2E-06
Endosulfan II	0.000844	0.000756	1.25E-05	1.99	1.99	0.0051	0.054	0.097	0.15	0.251	0.974	0.0000049	0.0000044	0.15	0.75	3.3E-05	6.6E-06	3.0E-05	5.9E-06
Endosulfan Sulfate	0.00108	0.00101	1.10E-05	0.970	0.970	0.0051	0.054	0.097	0.15	0.251	0.974	0.0000039	0.0000036	0.15	0.75	2.6E-05	5.2E-06	2.4E-05	4.9E-06
Endrin Aldehyde	0.00314	0.00286	9.60E-05	28.7	28.7	0.0051	0.054	0.097	0.15	0.251	0.974	0.00019	0.00018	0.092	0.92	2.1E-03	2.1E-04	1.9E-03	1.9E-04
Endrin Ketone	0.00261	0.00250	2.69E-05	14.1	14.1	0.0051	0.054	0.097	0.15	0.251	0.974	0.000081	0.000078	0.092	0.92	8.8E-04	8.8E-05	8.4E-04	8.4E-05
Endrin	0.00421	0.00321	2.09E-05	10.4	10.4	0.0051	0.054	0.097	0.15	0.251	0.974	0.00010	0.000074	0.092	0.92	1.1E-03	1.1E-04	8.1E-04	8.1E-05
Heptachlor	0.000437	0.000477	1.06E-06	8.75	8.75	0.0051	0.054	0.097	0.15	0.251	0.974	0.0000086	0.0000094	0.1	1	8.6E-05	8.6E-06	9.4E-05	9.4E-06
Methoxychlor	0.00120	0.00120	2.91E-06	3.98	3.98	0.0051	0.054	0.097	0.15	0.251	0.974	0.000012	0.000012	4	8	2.9E-06	1.5E-06	2.9E-06	1.5E-06
HPAHs																			
Benzo(a)anthracene	4.39	5.26	6.00E-07	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	9.4E-03	1.9E-03	1.1E-02	2.2E-03
Benzo(a)pyrene	4.57	7.15	0.000779	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	9.8E-03	2.0E-03	1.5E-02	3.1E-03
Benzo(b)fluoranthene	20.7	9.75	9.17E-07	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	4.4E-02	8.8E-03	2.1E-02	4.2E-03
Benzo(g,h,i)perylene	2.44	3.69	0.000125	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	5.2E-03	1.0E-03	7.9E-03	1.6E-03
Benzo(k)fluoranthene	19.8	11.0	0.00337	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	4.2E-02	8.5E-03	2.4E-02	4.7E-03
Benzofluoranthenes, Total	10.7	17.6	0.00182	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	2.3E-02	4.6E-03	3.8E-02	7.5E-03
Chrysene	4.51	5.79	0.00000171	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	9.6E-03	1.9E-03	1.2E-02	2.5E-03
Dibenz(a,h)anthracene	1.12	1.04	5.86E-05	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	2.4E-03	4.8E-04	2.2E-03	4.4E-04
Fluoranthene	8.02	11.9	0.0000	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	1.7E-02	3.4E-03	2.5E-02	5.1E-03
Indeno(1,2,3-cd)pyrene	2.67	3.48	7.69E-05	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	5.7E-03	1.1E-03	7.4E-03	1.5E-03
Pyrene	7.09	10.4	0.0131	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0	0	***	***	1.6E-02	3.1E-03	2.3E-02	4.5E-03
Total HPAHs	47.1	53.0	0.0108	0	0	0.0051	0.054	0.097	0.15	0.251	0.974	0.062	0.070	0.615	3.07	1.0E-01	2.0E-02	1.1E-01	2.3E-02
SVOCs																			
Bis(2-ethylhexyl) Phthalate	36.4	31.3	0.0303	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.12	0.11	18.3	183	6.8E-03	6.8E-04	5.9E-03	5.9E-04
Butyl Benzyl Phthalate	0.0172	0.0154	0.000240	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.000064	0.000058	159	470	4.1E-07	1.4E-07	3.7E-07	1.2E-07
Carbazole	0.272	0.312	0.00297	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.0010	0.0011	5	50	2.0E-04	2.0E-05	2.3E-04	2.3E-05
Dibenzofuran	0.0771	0.0834	0.000842	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.00028	0.00030	6	30	4.7E-05	9.4E-06	5.1E-05	1.0E-05
Di-n-butyl Phthalate	0.124	0.105	0.0107	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.00069	0.00062	550	1,833	1.3E-06	3.8E-07	1.1E-06	3.4E-07
Di-n-octyl Phthalate	0.0210	0.0194	1.49E-05	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.000072	0.000066	7,500	37,500	9.6E-09	1.9E-09	8.8E-09	1.8E-09

Table 3-15b
Calculation of Dose and Hazard Quotient for the American Mink – Combined AOPCs

CPEC	EPCs[c] Surface Soil (0-1 ft bgs) (mg/kg dw)	EPCs Shallow Soil (0-3 ft bgs) (mg/kg dw)	EPCs Concen-tration in Water (mg/L) [b]	BAFs Surface Soil BAF mammals (kg tissue/kg soil) [a]	BAFs Shallow Soil BAF mammals (kg tissue/kg soil) [a]	Exposure Factors Soil Ingestion Rate (kg dry/day)	Food Ingestion Rate (kg dry/day)	Water Ingestion Rate (L/day)	PF Small Mammals	AUF	BW (kg)	Doses Surface Soil Dose (mg/kg-bw/day)	Doses Shallow Soil Dose (mg/kg-bw/day)	TRVs NOAEL TRV (mg/kg-bw/day)	TRVs LOAEL TRV (mg/kg-bw/day)	Hazard Quotients Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
VOCs																			
1,2,4-Trimethylbenzene	2.94	2.86	0.479	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.022	0.022	13	65	1.7E-03	3.4E-04	1.7E-03	3.3E-04
4-Isopropyltoluene	0.00102	0.0147	9.11E-05	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.0000057	0.000052	47.5	237.5	1.2E-07	2.4E-08	1.1E-06	2.2E-07
n-Propylbenzene	0.000150	0.122	1.85E-05	1	1	0.0051	0.054	0.097	0.15	0.251	0.974	0.0000010	0.00042	60.4	302	1.6E-08	3.2E-09	6.9E-06	1.4E-06

	Surface Soil (0-1 ft bgs) NOAEL HQ	Surface Soil (0-1 ft bgs) LOAEL HQ	Shallow Soil (0-3 ft bgs) NOAEL HQ	Shallow Soil (0-3 ft bgs) LOAEL HQ
Metals + Butyltin HI	8.2E-01	2.8E-01	7.8E-01	2.8E-01
Pesticides HI	3.9E-02	1.8E-02	2.4E-02	1.0E-02
Phthalates HI	6.8E-03	6.8E-04	5.9E-03	5.9E-04

Notes:
Bold indicates hazard quotient greater than 1.0.
a) Sources listed on Table 3-10e for mammal BAFs.
b) Cadmium, copper, and lead (dissolved), benzo(a)anthracene, benzo(b)fluoranthene, chrysene, and fluoranthene (C+F) maximum detected concentrations in River OU Forebay surface water; see Table 3-6.
All other CPEC concentrations in water calculated using equilibrium partitioning equations due to lack of River OU analytical data; see Table 3-7e.
c) The EPC is the 95% UCL, if calculated (see Table 1-5), or maximum detected concentration (if 95% UCL not calculated).
*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

% = percent
AOPC = area of potential concern
AUF = Area Use Factor
BAF = bioaccumulation factor
BHC = benzene hexachloride
BW = body weight
C+F = column + filter
CPEC = chemical of potential ecological concern
Dose = average daily dose (mg/kg-bw/day)
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
kg = kilogram
kg dry/day = kilograms per day in dry weight
L/day = liters per day
LOAEL = lowest observed adverse effect level
mg/kg = milligrams per kilogram
mg/kg-bw/day = milligrams per kilogram body weight per day
mg/L = milligrams per liter
NOAEL = no observed adverse effect level
OU = operable unit
PF = portion of food item
SLV = screening level value
SVOC = semivolatile organic compound
TRV = toxicity reference value
UCL = upper confidence limit
VOC = volatile organic compound

Table 3-16
Terrestrial Plant and Soil Invertebrate Toxicity Benchmarks

Analyte	Background 95% UPL [a] (mg/kg)	Terrestrial Plant Low SLV (mg/kg)	Terrestrial Plant High SLV [b] (mg/kg)	Source	Soil Invertebrate Low SLV (mg/kg)	Soil Invertebrate High SLV [b] (mg/kg)	Source
Inorganics							
Antimony	0.176	5	25	c	78	390	d
Cadmium	0.271	32	160	d	140	700	d
Chromium [e]	28.1	1	5	f	0.4	2	g
Copper	56.7	70	350	d	80	400	d
Lead	25.5	120	600	d	1,700	8,500	d
Mercury	0.0660	0.3	1.5	c	0.1	0.5	c
Nickel	26.5	38	190	d	280	1,400	d
Butyltins							
Tributyltin	NA	NA	NA		NA	NA	
Pesticides							
BHC (delta)	NA	0.005	0.03	i	NA	NA	
BHC (gamma) Lindane	NA	0.005	0.03	h	NA	NA	
Chlordane (alpha)	NA	0.224	1.12	i	NA	NA	
Chlordane (gamma)	NA	0.224	1.12	h	NA	NA	
Chlordane (technical)	NA	0.224	1.12	i	NA	NA	
Endosulfan I	NA	NA	NA		NA	NA	
Endosulfan II	NA	NA	NA		NA	NA	
Endosulfan Sulfate	NA	NA	NA		NA	NA	
Endrin Aldehyde	NA	0.011	0.054	i	NA	NA	
Endrin Ketone	NA	0.011	0.054	i	NA	NA	
Endrin	NA	0.011	0.054	j	NA	NA	
Heptachlor	NA	1	5	k	NA	NA	
Methoxychlor	NA	NA	NA		NA	NA	
HPAHs							
Benz(a)anthracene	NA	1.2	6	k	***	***	
Benzo(a)pyrene	NA	1.2	6	k	***	***	
Benzo(b)fluoranthene	NA	1.2	6	k	***	***	
Benzo(g,h,i)perylene	NA	1.2	6	l	***	***	
Benzo(k)fluoranthene	NA	1.2	6	k	***	***	
Benzofluoranthenes, Total	NA	1.2	6	l	***	***	
Chrysene	NA	1.2	6	k	***	***	
Dibenz(a,h)anthracene	NA	1.2	6	k	***	***	
Fluoranthene	NA	1.2	6	l	***	***	
Indeno(1,2,3-cd)pyrene	NA	1.2	6	k	***	***	
Pyrene	NA	1.2	6	l	***	***	
Total HPAHs	NA	1.2	6	k	18	90	d
SVOCs							
Bis(2-ethylhexyl) Phthalate	NA	NA	NA		NA	NA	
Butyl Benzyl Phthalate	NA	NA	NA		NA	NA	
Carbazole	NA	NA	NA		NA	NA	
Dibenzofuran	NA	19	96	j	NA	NA	
Di-n-butyl Phthalate	NA	200	1,000	c	NA	NA	
Di-n-octyl Phthalate	NA	NA	NA		NA	NA	
VOCs							
1,2,4-Trimethylbenzene	NA	NA	NA		NA	NA	
4-Isopropyltoluene	NA	NA	NA		NA	NA	
n-Propylbenzene	NA	NA	NA		NA	NA	

Table 3-16
Terrestrial Plant and Soil Invertebrate Toxicity Benchmarks

Notes:

a) The Reference Area 95% UPL concentrations are shown in Appendix I, Table I-17 of the Final RI (URS. 2012. Upland and River Operable Units Remedial Investigation Report. June.).
b) High SLVs were calculated by multiplying the Low SLVs by 5.
c) Oregon Department of Environmental Quality. 1998. Guidance for Ecological Risk Assessment: Levels I, II, III, IV. Waste Management and Cleanup Division. Final. April. Updated December 2001.
d) U.S. Environmental Protection Agency (USEPA). 2005-2008. Interim Ecological Soil Screening Levels (Eco-SSLs). Available on-line at: http://www.epa.gov/ecotox/ecossl/
e) The background concentration is used for screening because it is higher than the SLV(s).
f) Efroymson RA, ME Wil, GW Suter II, and AC Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. November. ORNL. ES/ER/TM-85/R3. From Oak Ridge National Laboratory (ORNL) Risk Assessment Information System (RAIS) Database.
g) Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. November. ORNL. ES/ER/TM-126/R2. From ORNL RAIS Database.
h) USEPA. 2003. The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) Ecological Screening Levels (ESLs) for RCRA Appendix IX hazardous constituents. See the August 2003 revision of the ESLs (formerly EDQLs) at http://www.epa.gov/reg5rcra/ca/ESL.pdf.
i) The following surrogate SLVs were used: Lindane for BHC (gamma), chlordane (gamma) for other chlordanes (alpha and technical), endrin for other endrins (aldehyde and ketone)
j) Los Alamos National Laboratory ECORISK Database Release 3.1, 2012. Geometric mean of no-effect ESLs and low-effect ESLs. Online: http://www.lanl.gov/community-environment/environmental-stewardship/protection/eco-risk-assessment.php

k) USEPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Peer review Draft. EPA530-D-99-001A. August.
l) The SLV for benzo(a)pyrene was used to screen the individual HPAHs without SLVs.

*** = PAH Eco SSLs for Invertebrates are based on Total LMW PAHs and Total HMW PAHs.

% = percent
BHC = benzene hexachloride
EcoSSL = ecological soil screening level
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
mg/kg = milligrams per kilogram
NA = not available
ORNL = Oak Ridge National Laboratory
PAH = polycyclic aromatic hydrocarbons
SLV = screening level value
SVOC = semivolatile organic compound
UPL = 95 % upper prediction limit
VOC = volatile organic compound

Table 3-17
Toxicity Reference Values for Birds and Mammals

CPEC	NOAEL/NOAEC TRV for Birds (mg/kg-bw/day)		LOAEL/LOAEC TRV for Birds (mg/kg-bw/day)		NOAEL/NOAEC TRV for Mammals (mg/kg-bw/day)		LOAEL/LOAEC TRV for Mammals (mg/kg-bw/day)	
Inorganics								
Antimony	NA	a	NA	a	0.059	a	0.59	a
Cadmium	1.47	a	5.88	a	0.770	a	7.70	a
Chromium III	2.66	a	14.5	a	2.40	a	12.0	a
Copper	4.05	a	12.1	a	5.60	a	9.34	a
Lead	1.63	a	3.26	a	4.70	a	8.90	a
Mercury	0.0064	b	0.064	b	0.02	b	0.07	b
Nickel	6.71	a	26.8	a	1.70	a	3.40	a
Butyltins								
Tributyltin	6.8	b	16.9	b	23.4	c, k	35	c, k
Pesticides								
BHC (delta)	2	k	20	k	8	k	40	k
BHC (gamma) Lindane	2	c	20	c	8	c	40	j
Chlordane (alpha)	2.14	k	10.7	k	4.6	k	9.2	k
Chlordane (gamma)	2.14	k	10.7	k	4.6	k	9.2	k
Chlordane (technical)	2.14	c	10.7	c	4.6	c	9.2	c
Endosulfan I	10	c, k	50	j	0.15	c, k	0.75	j
Endosulfan II	10	c, k	50	j	0.15	c, k	0.75	j
Endosulfan Sulfate	10	c, k	50	j	0.15	c, k	0.75	j
Endrin Aldehyde	0.01	k	0.1	k	0.092	k	0.92	k
Endrin Ketone	0.01	k	0.1	k	0.092	k	0.92	k
Endrin	0.01	c	0.1	c	0.092	c	0.92	c
Heptachlor	0.013	j	0.065	e	0.1	c	1	c
Methoxychlor	125	f	625	j	4	c	8	c
HPAHs								
Benz(a)anthracene	NA	a	NA	a	***	a	***	a
Benzo(a)pyrene	NA	a	NA	a	***	a	***	a
Benzo(b)fluoranthene	NA	a	NA	a	***	a	***	a
Benzo(g,h,i)perylene	NA	a	NA	a	***	a	***	a
Benzo(k)fluoranthene	NA	a	NA	a	***	a	***	a
Benzofluoranthenes, Total	NA	a	NA	a	***	a	***	a
Chrysene	NA	a	NA	a	***	a	***	a
Dibenz(a,h)anthracene	NA	a	NA	a	***	a	***	a
Fluoranthene	NA	a	NA	a	***	a	***	a
Indeno(1,2,3-cd)pyrene	NA	a	NA	a	***	a	***	a
Pyrene	NA	a	NA	a	***	a	***	a
Total HPAHs (benzo(a)pyrene)	NA	a	NA	a	0.615	a	3.07	a
SVOCs								
Bis(2-ethylhexyl) Phthalate	1.1	b	11	b	18.3	c	183	c
Butyl Benzyl Phthalate	NA		NA		159	d	470	d
Carbazole	NA		NA		5	g	50	g
Dibenzofuran	NA		NA		6	j	30	i
Di-n-butyl Phthalate	0.11	c	1.1	c	550	c	1,833	c
Di-n-octyl Phthalate	NA		NA		7,500	e	37,500	j

Table 3-17
Toxicity Reference Values for Birds and Mammals

CPEC	NOAEL/NOAEC TRV for Birds (mg/kg-bw/day)		LOAEL/LOAEC TRV for Birds (mg/kg-bw/day)		NOAEL/NOAEC TRV for Mammals (mg/kg-bw/day)		LOAEL/LOAEC TRV for Mammals (mg/kg-bw/day)	
VOCs								
1,2,4-Trimethylbenzene	NA		NA		13	j	65	h
4-Isopropyltoluene	3.16	m	15.8	m	47.5	l	238	l
n-Propylbenzene	NA		NA		60.4	l	302	l

Notes:
*** = To be evaluated as Total HPAHs, per EcoSSL

BHC = benzene hexachloride
EcoSSL = ecological soil screening level
HPAHs = high molecular weight polycyclic aromatic hydrocarbons
LOAEL = lowest observed adverse effect level
LOAEC = lowest observed adverse effect concentration
mg/kg-bw/day = milligrams per kilogram body weight per day
NA = no available TRV
NOAEL = no observed adverse effect level
NOAEC = no observed adverse effect concentration
ORNL = Oak Ridge National Laboratory
SVOC = semivolatile organic compound
TRV = toxicity reference value
VOC = volatile organic compound

Sources:
a) Interim Ecological Soil Screening Levels (Eco-SSLs; USEPA 2005-2008).

1) The Eco-SSL NOAEL TRV is a geometric mean of the NOAEL values for reproduction and growth. If the geometric mean NOAEL TRV is lower than the lowest bounded LOAEL for reproduction, growth, or survival, then a geometric mean LOEAL TRV was calculated with the LOAELs from the studies used for the geometric mean NOAEL calculation. If the studies used for the geometric mean NOAEL do not have LOAEL values, then an uncertainty factor of 5 was used to adjust the geometric mean NOAEL to a chronic LOAEL.

2) If the geometric mean NOAEL TRV is higher than the lowest bounded LOAEL for reproduction, growth, or mortality results, then the TRV selected is equal to the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival. The selected LOAEL is the LOAEL from the same study as the highest bounded NOAEL. If no LOAEL is available from that study, then an uncertainty factor of 5 was used to adjust the selected NOAEL to chronic LOAEL.

b) LWG (2011); Appendix G: BERA, Tables 8-9 and 8-10.

<u>Birds</u>
Mercury: Heinz (1975, 1979)
Tributyltin: Schlatterer et al. (1993)
Benzo(a)pyrene: Hough et al. (1993)
Bis(2-ethylhexyl) phthalate: Peakall (1974)

<u>Mammals</u>
Mercury: Dansereau et al. (1999)

c) Sample et al. (1996), ORNL
d) USEPA Integrated Risk Information System (IRIS) database
Butyl benzyl phthalate - TRVs based on oral chronic rat toxicity (NTP 1985)
e) USEPA (1999), Appendix E, TRVs
Di-n-octyl phthalate for mammals: Heindel et al. (1989) - TRV based on chronic NOAEL
Heptachlor for birds: Hill and Camardese (1986) - TRV based on acute LOAEL for reduced survival (adjusted to chronic)
f) Hunt and Sacho (1969) - Acute five-day NOAEL of 3,750 mg/kg/day for robins fed earthworms, mortality endpoint.
Divided by 30 (USACHPPM 2000) to approximate chronic NOAEL of 125 mg/kg/day.
g) Sax (1984) - TRVs based on chronic toxicity.
h) Maltoni et al. (1997) - TRV based on chronic LOAEL.

Table 3-17
Toxicity Reference Values for Birds and Mammals

i) NTP (1989) as cited in ATSDR (1990) - TRV based on chronic toxicity of 2,3-benzofuran (reduced survival)
j) An uncertainty factor of 5 was used to adjust chronic LOAEL/LOEACs to NOAEL/NOAECs and vise-versa.
k) Surrogates used:
BHC (gamma) Lindane TRVs for BHC (delta) for birds and mammals
Chlordane TRVs for chlordane (alpha) and chlordane (gamma) for birds and mammals
Endosulfan TRVs for endosulfan I, II, and sulfate for birds and mammals
Endrin TRVs for endrin aldehyde and ketone for birds and mammals
Tin TRV, based on bis(tributyltin)oxide (TBTO) for tributyltin for mammals
l) Hazardous Substances Data Bank (HSDB)
4-Isopropyltoluene (O'Neil ed. 2006): Rat LD50 of 4,750 mg/kg/day adjusted to chronic NOAEL and LOAEL by dividing by 100 and 20, respectively (USACHPPM 2000).
n-Propylbenzene (Budavari ed. 1996): Rat LD50 of 6,040 mg/kg/day adjusted to chronic NOAEL and LOAEL by dividing by 100 and 20, respectively (USACHPPM 2000).
m) Schafer et al. (1983). Red-winged blackbird LD50 of 316 mg/kg/day adjusted to chronic NOAEL and LOAEL by dividing by 100 and 20, respectively (USACHPPM 2000).

References:

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Table 3-18a
Hazard Quotients for Terrestrial Plants - Landfill AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Inorganics								
Antimony	1.36	1.48	5	25	2.7E-01	5.4E-02	3.0E-01	5.9E-02
Chromium [b]	242	594	28.1	28.1	**8.6E+00**	**8.6E+00**	**2.1E+01**	**2.1E+01**
Copper	170	191	70	350	**2.4E+00**	4.9E-01	**2.7E+00**	5.5E-01
Lead	332	511	120	600	**2.8E+00**	5.5E-01	**4.3E+00**	8.5E-01
Mercury	1.57	1.45	0.3	1.5	**5.2E+00**	**1.0E+00**	**4.8E+00**	9.7E-01
Nickel	175	472	38	190	**4.6E+00**	9.2E-01	**1.2E+01**	**2.5E+00**
Butyltins								
Tributyltin	0.165	0.0601	NA	NA	No SLV	No SLV	No SLV	No SLV
Pesticides								
Chlordane (technical)	1.56	1.56	0.224	1.12	**7.0E+00**	**1.4E+00**	**7.0E+00**	**1.4E+00**
Heptachlor	0.00283	0.00286	1	5	2.8E-03	5.7E-04	2.9E-03	5.7E-04
HPAHs								
Benz(a)anthracene	8	10	1.2	6	**7.0E+00**	**1.4E+00**	**8.3E+00**	**1.7E+00**
Benzo(a)pyrene	9	11	1.2	6	**7.3E+00**	**1.5E+00**	**9.3E+00**	**1.9E+00**
Benzo(b)fluoranthene	16	15	1.2	6	**1.3E+01**	**2.7E+00**	**1.3E+01**	**2.5E+00**
Benzo(g,h,i)perylene	5	58	1.2	6	**3.8E+00**	7.7E-01	**4.9E+01**	**9.7E+00**
Benzo(k)fluoranthene	30	26	1.2	6	**2.5E+01**	**5.0E+00**	**2.2E+01**	**4.4E+00**
Benzofluoranthenes, Total	15	31	1.2	6	**1.2E+01**	**2.5E+00**	**2.6E+01**	**5.2E+00**
Chrysene	8	11	1.2	6	**7.0E+00**	**1.4E+00**	**9.2E+00**	**1.8E+00**
Dibenz(a,h)anthracene	4	21	1.2	6	**3.5E+00**	7.1E-01	**1.7E+01**	**3.4E+00**
Fluoranthene	15	18	1.2	6	**1.2E+01**	**2.4E+00**	**1.5E+01**	**2.9E+00**
Indeno(1,2,3-cd)pyrene	5	68	1.2	6	**4.2E+00**	8.4E-01	**5.7E+01**	**1.1E+01**
Pyrene	12	19	1.2	6	**1.0E+01**	**2.1E+00**	**1.6E+01**	**3.1E+00**
Total HPAHs	90	102	1.2	6	**7.5E+01**	**1.5E+01**	**8.5E+01**	**1.7E+01**
SVOCs								
Bis(2-ethylhexyl) Phthalate	9.68	6.38	NA	NA	No SLV	No SLV	No SLV	No SLV
Butyl Benzyl Phthalate	0.0366	0.0349	NA	NA	No SLV	No SLV	No SLV	No SLV
Carbazole	0.751	0.964	NA	NA	No SLV	No SLV	No SLV	No SLV

Table 3-18a
Hazard Quotients for Terrestrial Plants - Landfill AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Dibenzofuran	0.152	0.164	19	96	7.9E-03	1.6E-03	8.5E-03	1.7E-03
Di-n-butyl Phthalate	0.232	0.217	200	1,000	1.2E-03	2.3E-04	1.1E-03	2.2E-04
VOCs								
1,2,4-Trimethylbenzene	3.03	2.79	NA	NA	No SLV	No SLV	No SLV	No SLV

Metals HI	**2.4E+01**	**1.2E+01**	**4.6E+01**	**2.6E+01**
Pesticides HI	**7.0E+00**	**1.4E+00**	**7.0E+00**	**1.4E+00**

Notes:
a) Sources listed on Table 3-16.
b) The background concentration (95% UPL) is higher than the risk-based SLV and replaced the SLV in this table.
c) Those chemicals that do not have established SLVs will be evaluated qualitatively.
d) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAH = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
mg/kg = milligrams per kilogram
NA = not available
SLV = screening level value
SVOC = semivolatile organic compound
VOC = volatile organic compound
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-18b
Hazard Quotients for Terrestrial Plants – Sandblast Area AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Inorganics								
Antimony	2.94	2.42	5	25	5.9E-01	1.2E-01	4.8E-01	9.7E-02
Cadmium	3.20	2.63	32	160	1.0E-01	2.0E-02	8.2E-02	1.6E-02
Chromium [b]	720	579	28.1	28.1	**2.6E+01**	**2.6E+01**	**2.1E+01**	**2.1E+01**
Lead	465	529	120	600	**3.9E+00**	7.8E-01	**4.4E+00**	8.8E-01
Mercury	0.113	0.098	0.3	1.5	3.8E-01	7.5E-02	3.3E-01	6.5E-02
Nickel	353	251	38	190	**9.3E+00**	**1.9E+00**	**6.6E+00**	**1.3E+00**
Butyltins								
Tributyltin	0.481	0.248	NA	NA	No SLV	No SLV	No SLV	No SLV
Pesticides								
BHC (delta)	0.00154	0.00130	0.005	0.03	3.1E-01	6.2E-02	2.6E-01	5.2E-02
BHC (gamma) Lindane	0.00968	0.00106	0.005	0.03	**1.9E+00**	3.9E-01	2.1E-01	4.2E-02
Chlordane (alpha)	0.000815	0.000776	0.224	1.12	3.6E-03	7.3E-04	3.5E-03	6.9E-04
Chlordane (gamma)	0.0303	0.0204	0.224	1.12	1.4E-01	2.7E-02	9.1E-02	1.8E-02
Endosulfan I	0.00269	0.000809	NA	NA	No SLV	No SLV	No SLV	No SLV
Endosulfan II	0.000495	0.000447	NA	NA	No SLV	No SLV	No SLV	No SLV
Endosulfan Sulfate	0.000953	0.000889	NA	NA	No SLV	No SLV	No SLV	No SLV
Endrin Aldehyde	0.00387	0.00344	0.011	0.054	3.6E-01	7.2E-02	3.2E-01	6.4E-02
Endrin Ketone	0.00309	0.00288	0.011	0.054	2.9E-01	5.7E-02	2.7E-01	5.4E-02
Endrin	0.00504	0.00389	0.011	0.054	4.7E-01	9.4E-02	3.6E-01	7.2E-02
Heptachlor	0.000464	0.000415	1	5	4.6E-04	9.3E-05	4.2E-04	8.3E-05
Methoxychlor	0.00105	0.00104	NA	NA	No SLV	No SLV	No SLV	No SLV
HPAHs								
Benz(a)anthracene	1.75	2.45	1.2	6	**1.5E+00**	2.9E-01	**2.0E+00**	4.1E-01
Benzo(a)pyrene	1.76	2.39	1.2	6	**1.5E+00**	2.9E-01	**2.0E+00**	4.0E-01
Benzo(b)fluoranthene	1.95	2.21	1.2	6	**1.6E+00**	3.3E-01	**1.8E+00**	3.7E-01
Benzo(g,h,i)perylene	1.07	1.05	1.2	6	8.9E-01	1.8E-01	8.8E-01	1.8E-01
Benzo(k)fluoranthene	0.676	0.764	1.2	6	5.6E-01	1.1E-01	6.4E-01	1.3E-01
Benzofluoranthenes, Total	7.76	10.6	1.2	6	**6.5E+00**	**1.3E+00**	**8.8E+00**	**1.8E+00**
Chrysene	2.07	4.59	1.2	6	**1.7E+00**	3.5E-01	**3.8E+00**	7.7E-01
Dibenz(a,h)anthracene	0.244	0.238	1.2	6	2.0E-01	4.1E-02	2.0E-01	4.0E-02
Fluoranthene	4.64	10.8	1.2	6	**3.9E+00**	7.7E-01	**9.0E+00**	**1.8E+00**

Table 3-18b
Hazard Quotients for Terrestrial Plants – Sandblast Area AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Indeno(1,2,3-cd)pyrene	1.13	1.16	1.2	6	9.4E-01	1.9E-01	9.7E-01	1.9E-01
Pyrene	4.78	11.7	1.2	6	**4.0E+00**	8.0E-01	**9.8E+00**	**2.0E+00**
Total HPAHs	18.6	40.8	1.2	6	**1.5E+01**	**3.1E+00**	**3.4E+01**	**6.8E+00**
SVOCs								
Bis(2-ethylhexyl) Phthalate	98.0	77.1	NA	NA	No SLV	No SLV	No SLV	No SLV
Butyl Benzyl Phthalate	0.0171	0.0152	NA	NA	No SLV	No SLV	No SLV	No SLV
Carbazole	0.144	0.112	NA	NA	No SLV	No SLV	No SLV	No SLV
Dibenzofuran	0.0424	0.122	19	96	2.2E-03	4.4E-04	6.3E-03	1.3E-03
Di-n-butyl Phthalate	0.0804	0.0543	200	1,000	4.0E-04	8.0E-05	2.7E-04	5.4E-05
Di-n-octyl Phthalate	0.0251	0.0225	NA	NA	No SLV	No SLV	No SLV	No SLV
VOCs								
1,2,4-Trimethylbenzene	0.000230	4.62	NA	NA	No SLV	No SLV	No SLV	No SLV
4-Isopropyltoluene	0.00133	0.0201	NA	NA	No SLV	No SLV	No SLV	No SLV
n-Propylbenzene	0.000150	0.0355	NA	NA	No SLV	No SLV	No SLV	No SLV

Metals HI	**4.0E+01**	**2.8E+01**	**3.3E+01**	**2.3E+01**
Pesticides HI	**3.5E+00**	7.0E-01	**1.5E+00**	3.0E-01

Notes:
a) Sources listed on Table 3-16.
b) The background concentration (95% UPL) is higher than the risk-based SLV and replaced the SLV in this table.
c) Those chemicals that do not have established SLVs will be evaluated qualitatively.
d) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
BHC = benzene hexachloride
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAH = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
mg/kg = milligrams per kilogram
NA = not available
SLV = screening level value
SVOC = semivolatile organic compound
VOC = volatile organic compound
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-18c
Hazard Quotients for Terrestrial Plants – Pistol Range AOPC

CPEC	EPC	SLV		Hazard Quotients	
	95% UCL in Surface Soil (0-1.5 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1.5 ft bgs) Low SLV HQ	Surface Soil (0-1.5 ft bgs) High SLV HQ
Inorganics					
Lead	365	120	600	**3.0E+00**	6.1E-01

Notes:
a) Sources listed on Table 3-16.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
mg/kg = milligrams per kilogram
SLV = screening level value
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-18d
Hazard Quotients for Terrestrial Plants – Bulb Slope AOPC

CPEC	EPC	SLV		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Terrestrial Plant Low SLV (mg/kg dw) [a]	Terrestrial Plant High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ
Inorganics					
Lead	307	120	600	**2.6E+00**	5.12E-01
Mercury	0.720	0.3	1.5	**2.4E+00**	4.80E-01
			HI	**5.0E+00**	9.9E-01

Notes:
a) Sources listed on Table 3-16.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
mg/kg = milligrams per kilogram
SLV = screening level value
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-19a
Hazard Quotients for Soil Invertebrates - Landfill AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Inorganics								
Antimony	1.36	1.48	78	390	1.7E-02	3.5E-03	1.9E-02	3.8E-03
Chromium [b]	242	594	28.1	28.1	**8.6E+00**	**8.6E+00**	**2.1E+01**	**2.1E+01**
Copper	170	191	80	400	**2.1E+00**	4.3E-01	**2.4E+00**	4.8E-01
Lead	332	511	1,700	8,500	2.0E-01	3.9E-02	3.0E-01	6.0E-02
Mercury	1.57	1.45	0.1	0.5	**1.6E+01**	**3.1E+00**	**1.5E+01**	**2.9E+00**
Nickel	175	472	280	1,400	6.3E-01	1.3E-01	**1.7E+00**	3.4E-01
Butyltins								
Tributyltin	0.165	0.0601	NA	NA	No SLV	No SLV	No SLV	No SLV
Pesticides								
Chlordane (technical)	1.56	1.56	NA	NA	No SLV	No SLV	No SLV	No SLV
Heptachlor	0.00283	0.00286	NA	NA	No SLV	No SLV	No SLV	No SLV
HPAHs								
Benz(a)anthracene	8	10	***	***	4.6E-01	9.3E-02	5.5E-01	1.1E-01
Benzo(a)pyrene	9	11	***	***	4.8E-01	9.7E-02	6.2E-01	1.2E-01
Benzo(b)fluoranthene	16	15	***	***	8.9E-01	1.8E-01	8.4E-01	1.7E-01
Benzo(g,h,i)perylene	5	58	***	***	2.6E-01	5.1E-02	**3.2E+00**	6.5E-01
Benzo(k)fluoranthene	30	26	***	***	**1.7E+00**	3.4E-01	**1.5E+00**	2.9E-01
Benzofluoranthenes, Total	15	31	***	***	8.2E-01	1.6E-01	**1.7E+00**	3.5E-01
Chrysene	8	11	***	***	4.7E-01	9.3E-02	6.1E-01	1.2E-01
Dibenz(a,h)anthracene	4	21	***	***	2.4E-01	4.7E-02	**1.1E+00**	2.3E-01
Fluoranthene	15	18	***	***	8.1E-01	1.6E-01	9.7E-01	1.9E-01
Indeno(1,2,3-cd)pyrene	5	68	***	***	2.8E-01	5.6E-02	**3.8E+00**	7.6E-01
Pyrene	12	19	***	***	6.8E-01	1.4E-01	**1.0E+00**	2.1E-01
Total HPAHs	90	102	18	90	**5.0E+00**	**1.0E+00**	**5.6E+00**	**1.1E+00**
SVOC								
Bis(2-ethylhexyl) Phthalate	9.68	6.38	NA	NA	No SLV	No SLV	No SLV	No SLV
Butyl Benzyl Phthalate	0.0366	0.0349	NA	NA	No SLV	No SLV	No SLV	No SLV
Carbazole	0.751	0.964	NA	NA	No SLV	No SLV	No SLV	No SLV
Dibenzofuran	0.152	0.164	NA	NA	No SLV	No SLV	No SLV	No SLV

Table 3-19a
Hazard Quotients for Soil Invertebrates - Landfill AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Di-n-butyl Phthalate	0.232	0.217	NA	NA	No SLV	No SLV	No SLV	No SLV
VOCs								
1,2,4-Trimethylbenzene	3.03	2.79	NA	NA	No SLV	No SLV	No SLV	No SLV
				Metals HI	**2.7E+01**	**1.2E+01**	**4.0E+01**	**2.5E+01**

Notes:

a) Sources listed on Table 3-16.

b) The background concentration (95% UPL) is higher than the risk-based SLV and replaced the SLV in this table.

c) Those chemicals that do not have established SLVs will be evaluated qualitatively.

d) The EPC is the 95% UCL, if calculated (see Table 1-1), or maximum detected concentration (if 95% UCL not calculated).

Bold indicates hazard quotient greater than 1.0.

*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAH = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
mg/kg = milligrams per kilogram
NA = not available
SLV = screening level value
SVOC = semivolatile organic compound
VOC = volatile organic compound
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-19b
Hazard Quotients for Soil Invertebrates – Sandblast Area AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Inorganics								
Antimony	2.94	2.42	78	390	3.8E-02	7.5E-03	3.1E-02	6.2E-03
Cadmium	3.20	2.63	140	700	2.3E-02	4.6E-03	1.9E-02	3.8E-03
Chromium [b]	720	579	28.1	28.1	**2.6E+01**	**2.6E+01**	**2.1E+01**	**2.1E+01**
Lead	465	529	1,700	8,500	2.7E-01	5.5E-02	3.1E-01	6.2E-02
Mercury	0.113	0.098	0.1	0.5	**1.1E+00**	2.3E-01	9.8E-01	2.0E-01
Nickel	353	251	280	1,400	**1.3E+00**	2.5E-01	9.0E-01	1.8E-01
Butyltins								
Tributyltin	0.481	0.248	NA	NA	No SLV	No SLV	No SLV	No SLV
Pesticides								
BHC (delta)	0.00154	0.00130	NA	NA	No SLV	No SLV	No SLV	No SLV
BHC (gamma) Lindane	0.00968	0.00106	NA	NA	No SLV	No SLV	No SLV	No SLV
Chlordane (alpha)	0.000815	0.000776	NA	NA	No SLV	No SLV	No SLV	No SLV
Chlordane (gamma)	0.0303	0.0204	NA	NA	No SLV	No SLV	No SLV	No SLV
Endosulfan I	0.00269	0.000809	NA	NA	No SLV	No SLV	No SLV	No SLV
Endosulfan II	0.000495	0.000447	NA	NA	No SLV	No SLV	No SLV	No SLV
Endosulfan Sulfate	0.000953	0.000889	NA	NA	No SLV	No SLV	No SLV	No SLV
Endrin Aldehyde	0.00387	0.00344	NA	NA	No SLV	No SLV	No SLV	No SLV
Endrin Ketone	0.00309	0.00288	NA	NA	No SLV	No SLV	No SLV	No SLV
Endrin	0.00504	0.00389	NA	NA	No SLV	No SLV	No SLV	No SLV
Heptachlor	0.000464	0.000415	NA	NA	No SLV	No SLV	No SLV	No SLV
Methoxychlor	0.00105	0.00104	NA	NA	No SLV	No SLV	No SLV	No SLV
HPAHs								
Benz(a)anthracene	1.75	2.45	***	***	9.7E-02	1.9E-02	1.4E-01	2.7E-02
Benzo(a)pyrene	1.76	2.39	***	***	9.8E-02	2.0E-02	1.3E-01	2.7E-02
Benzo(b)fluoranthene	1.95	2.21	***	***	1.1E-01	2.2E-02	1.2E-01	2.5E-02
Benzo(g,h,i)perylene	1.07	1.05	***	***	5.9E-02	1.2E-02	5.8E-02	1.2E-02
Benzo(k)fluoranthene	0.676	0.764	***	***	3.8E-02	7.5E-03	4.2E-02	8.5E-03
Benzofluoranthenes, Total	7.76	10.6	***	***	4.3E-01	8.6E-02	5.9E-01	1.2E-01
Chrysene	2.07	4.59	***	***	1.2E-01	2.3E-02	2.6E-01	5.1E-02
Dibenz(a,h)anthracene	0.244	0.238	***	***	1.4E-02	2.7E-03	1.3E-02	2.6E-03
Fluoranthene	4.64	10.8	***	***	2.6E-01	5.2E-02	6.0E-01	1.2E-01

Table 3-19b
Hazard Quotients for Soil Invertebrates – Sandblast Area AOPC

CPEC	EPCs[d]		SLVs		Hazard Quotients[c]			
	Surface Soil (0-1 ft bgs) (mg/kg dw)	Shallow Soil (0-3 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ	Shallow Soil (0-3 ft bgs) Low SLV HQ	Shallow Soil (0-3 ft bgs) High SLV HQ
Indeno(1,2,3-cd)pyrene	1.13	1.16	***	***	6.3E-02	1.3E-02	6.4E-02	1.3E-02
Pyrene	4.78	11.7	***	***	2.7E-01	5.3E-02	6.5E-01	1.3E-01
Total HPAHs	18.6	40.8	18	90	**1.0E+00**	2.1E-01	**2.3E+00**	4.5E-01
SVOC								
Bis(2-ethylhexyl) Phthalate	98.0	77.1	NA	NA	No SLV	No SLV	No SLV	No SLV
Butyl Benzyl Phthalate	0.0171	0.0152	NA	NA	No SLV	No SLV	No SLV	No SLV
Carbazole	0.144	0.112	NA	NA	No SLV	No SLV	No SLV	No SLV
Dibenzofuran	0.0424	0.122	NA	NA	No SLV	No SLV	No SLV	No SLV
Di-n-butyl Phthalate	0.0804	0.0543	NA	NA	No SLV	No SLV	No SLV	No SLV
Di-n-octyl Phthalate	0.0251	0.0225	NA	NA	No SLV	No SLV	No SLV	No SLV
VOCs								
1,2,4-Trimethylbenzene	0.000230	4.62	NA	NA	No SLV	No SLV	No SLV	No SLV
4-Isopropyltoluene	0.00133	0.0201	NA	NA	No SLV	No SLV	No SLV	No SLV
n-Propylbenzene	0.000150	0.0355	NA	NA	No SLV	No SLV	No SLV	No SLV
				Metals HI	**2.8E+01**	**2.6E+01**	**2.3E+01**	**2.1E+01**

Notes:

a) Sources listed on Table 3-16.
b) The background concentration (95% UPL) is higher than the risk-based SLV and replaced the SLV in this table.
c) Those chemicals that do not have established SLVs will be evaluated qualitatively.
d) The EPC is the 95% UCL, if calculated (see Table 1-2), or maximum detected concentration (if 95% UCL not calculated).
Bold indicates hazard quotient greater than 1.0.
*** = To be evaluated as Total HPAHs, per EcoSSL; however, HQs for individual HPAHs were calculated using the Total HPAH SLV to determine the primary risk drivers.

% = percent
AOPC = area of potential concern
BHC = benzene hexachloride
CPEC = chemical of potential ecological concern
dw = dry weight
EcoSSL = ecological soil screening level
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HPAH = high molecular weight polycyclic aromatic hydrocarbons
HQ = hazard quotient
mg/kg = milligrams per kilogram
NA = not available
SLV = screening level value
SVOC = semivolatile organic compound
VOC = volatile organic compound
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-19c
Hazard Quotients for Soil Invertebrates – Pistol Range AOPC

CPEC	EPC	SLV		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1.5 ft bgs) Low SLV HQ	Surface Soil (0-1.5 ft bgs) High SLV HQ
Inorganics					
Lead	365	1,700	8,500	2.1E-01	4.3E-02

Notes:
a) Sources listed on Table 3-16.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HQ = hazard quotient
mg/kg = milligrams per kilogram
SLV = screening level value
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-19d
Hazard Quotients for Soil Invertebrates – Bulb Slope AOPC

CPEC	EPC	SLV		Hazard Quotients	
	95% UCL in Surface Soil (0-1 ft bgs) (mg/kg dw)	Soil Invertebrate Low SLV (mg/kg dw) [a]	Soil Invertebrate High SLV (mg/kg dw) [a]	Surface Soil (0-1 ft bgs) Low SLV HQ	Surface Soil (0-1 ft bgs) High SLV HQ
Inorganics					
Lead	307	1,700	8,500	1.8E-01	3.6E-02
Mercury	0.720	0.1	0.5	**7.2E+00**	**1.4E+00**
			HI	**7.4E+00**	**1.5E+00**

Notes:
a) Sources listed on Table 3-16.
Bold indicates hazard quotient greater than 1.0.

% = percent
AOPC = area of potential concern
CPEC = chemical of potential ecological concern
dw = dry weight
EPC = exposure point concentration
ft bgs = feet below ground surface
HI = (cumulative) hazard index
HQ = hazard quotient
mg/kg = milligrams per kilogram
SLV = screening level value
UCL = upper confidence limit
UPL = upper prediction limit

Table 3-20
Summary of Site-Specific LOAEL- and High SLV-based Risk-Based Concentrations

CEC	Shrew LOAEL RBC	Robin LOAEL RBC	Plant High SLV	Invertebrate High SLV	Site-Specific Background 95% UPL	Lowest of RBCs and SLVs, or Bkg[1]
Landfill AOPC						
Chromium	177	218	< bkg	< bkg	28.1	**28.1**
Copper	78	114	--	--	56.7	**78**
Lead	149	54	--	--	25.5	**54**
Mercury	0.19	0.21	1.50	0.50	0.066	**0.19**
Nickel	< bkg	140	190	--	26.5	**26.5**
Chlordane (tech)	0.98	1.38	1.12	--	--	**0.98**
Total HPAHs	5.92	--	6.0	90	--	**5.92**
Sandblast Area AOPC						
Antimony	2.84	--	--	--	0.176	**2.84**
Chromium	177	218	< bkg	< bkg	28.1	**28.1**
Lead	157	56	--	--	25.5	**56**
Nickel	< bkg	138	190	--	26.5	**26.5**
DEHP	--	61	--	--	--	**61**
Total HPAHs	5.92	--	6.0	--	--	**5.92**
Bulb Slope AOPC						
Mercury	--	--	--	0.50	0.066	**0.50**
Pistol Range AOPC						
Lead	151	78	--	--	25.5	**78**

Notes

Blue = Site-Specific Reference Area Background 95% UPL

All units for LOAEL-based RBCs and High SLVs expressed as mg/kg

[1] The lowest value of the LOAEL RBCs and High SLVs is shown, unless the lowest risk-based value is less than background. In which case, the site-specific background 95% UPL is shown (in blue).

AOPC = area of potential concern
Bkg = background
CEC = chemical of ecological concern
DEHP = bis(2-ethylhexyl) phthalate
HPAH = high molecular weight PAH
LOAEL = lowest observable adverse effect level

mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbons
RBC = risk-based concentration
SLV = screening level value
UPL = upper prediction limit

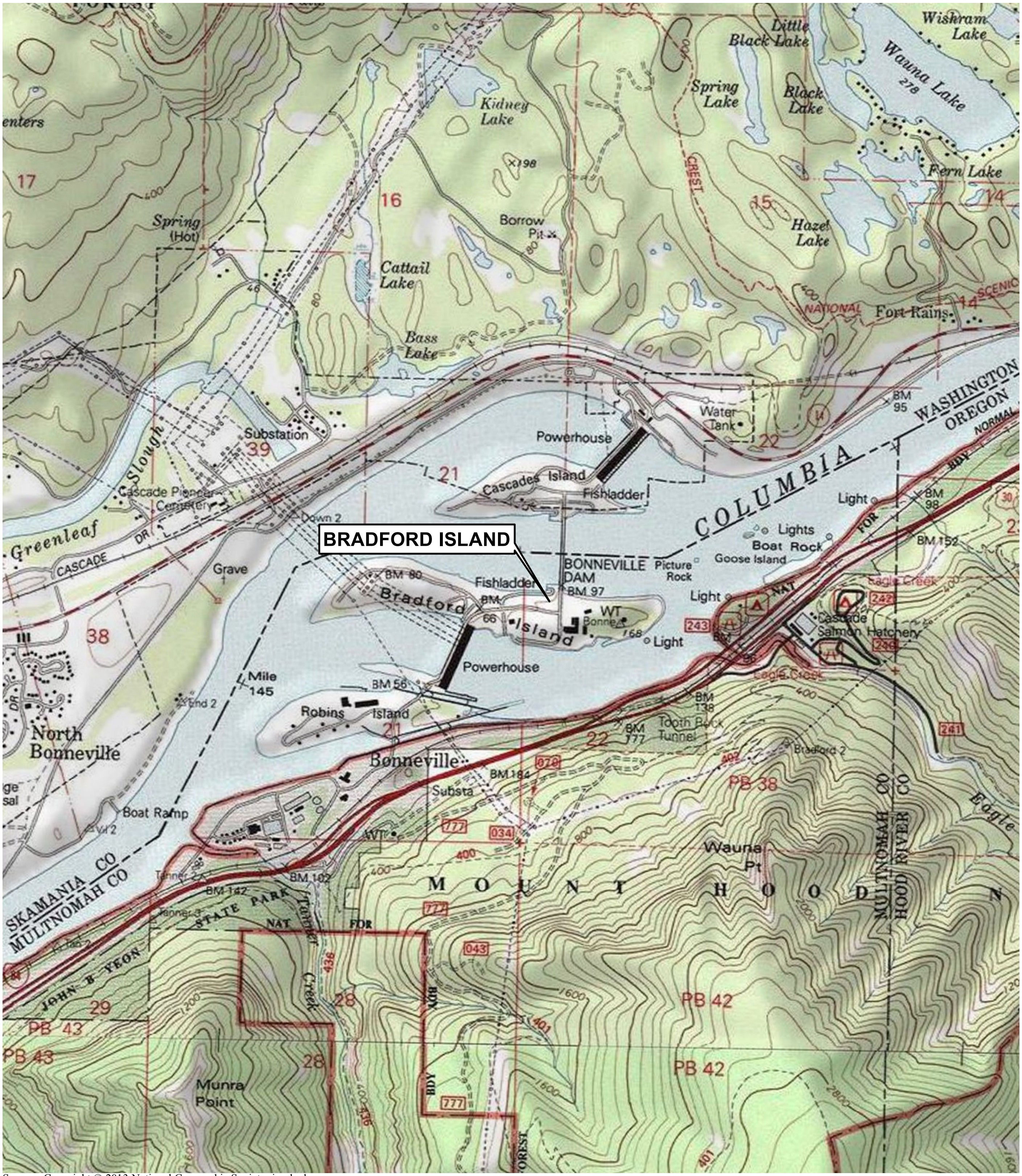
Table 3-21
Summary of Upland OU CECs for Further Evaluation in the FS

AOPC	Media	Terrestrial Plants	Soil Invertebrates	American Robin	Vagrant Shrew
Landfill	Soil	Mercury, Nickel, Chlordane, HPAHs	Mercury and HPAHs	Chromium, Copper, Lead, Mercury, Nickel, Chlordane	Chromium, Copper, Lead, Mercury, Nickel, Chlordane, HPAHs
Sandblast Area	Soil	Nickel and HPAHs	None	Chromium, Lead, Nickel	Antimony, Chromium, Lead, Nickel, HPAHs
Pistol Range	Soil	None	None	Lead	None
Bulb Slope	Soil	None	None	None	None

Notes:
No CECs were identified for the Canada goose, American kestrel, or American mink (Upland OU evaluation only).
No CECs were identified for the Combined AOPCs exposure unit.

AOPC = area of potential concern
CEC = chemical of ecological concern
FS = feasibility study
HPAH = high molecular weight PAH
OU = operable unit
PAH = polycyclic aromatic hydrocarbons

FIGURES



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VICINITY MAP

![URS]

25698014

BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 1-1

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25696528	LSM	LSM
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CASCADE LOCKS, OREGON

BONNEVILLE DAM COMPLEX

DRAWING NUMBER: FIGURE 1-2

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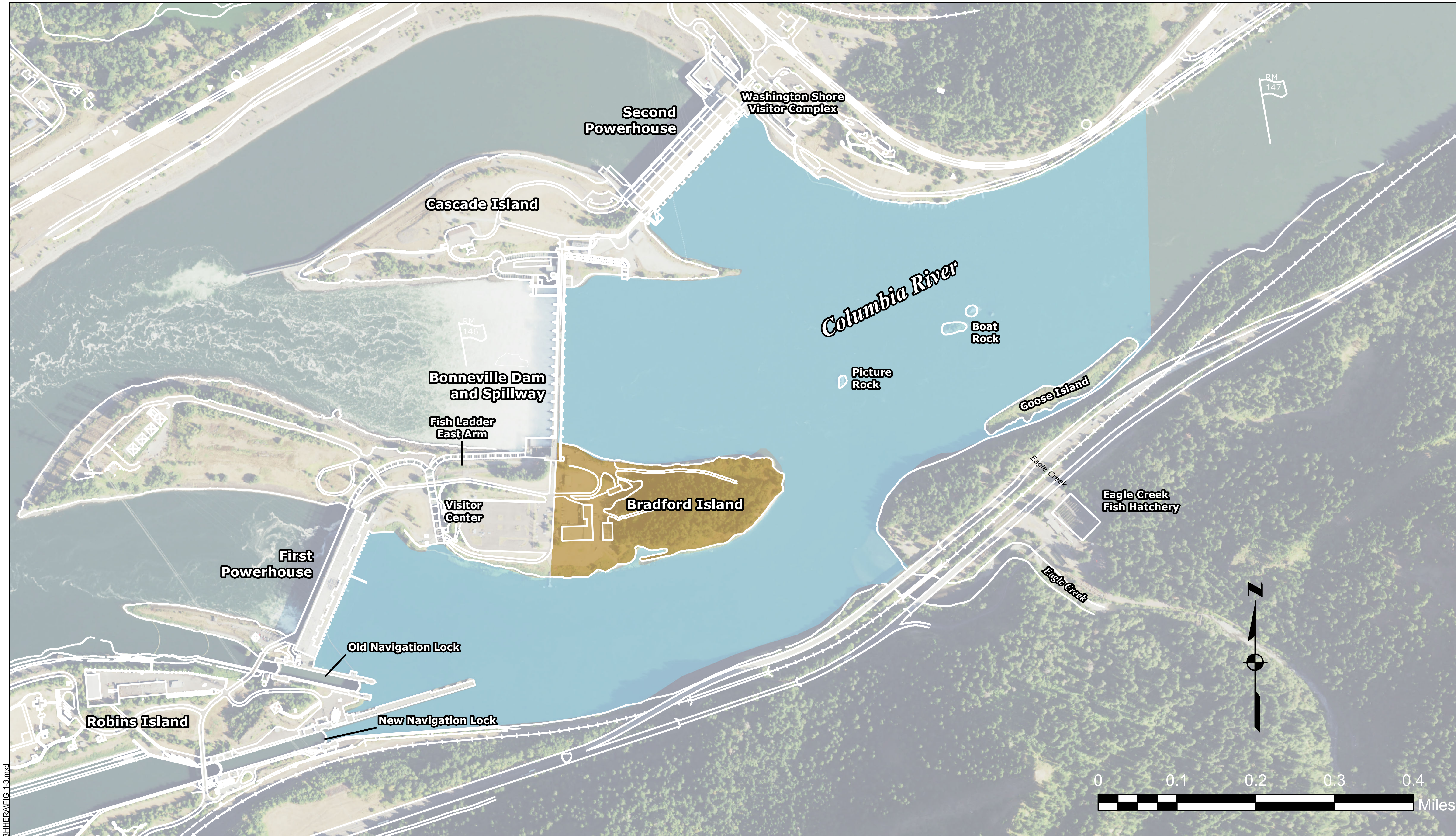

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Legend

Upland OU

River OU

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CASCADE LOCKS, OREGON

LOCATION OF OPERABLE UNITS

DRAWING NUMBER: FIGURE 1-3

GIS FILE NUMBER: FIG 1-3

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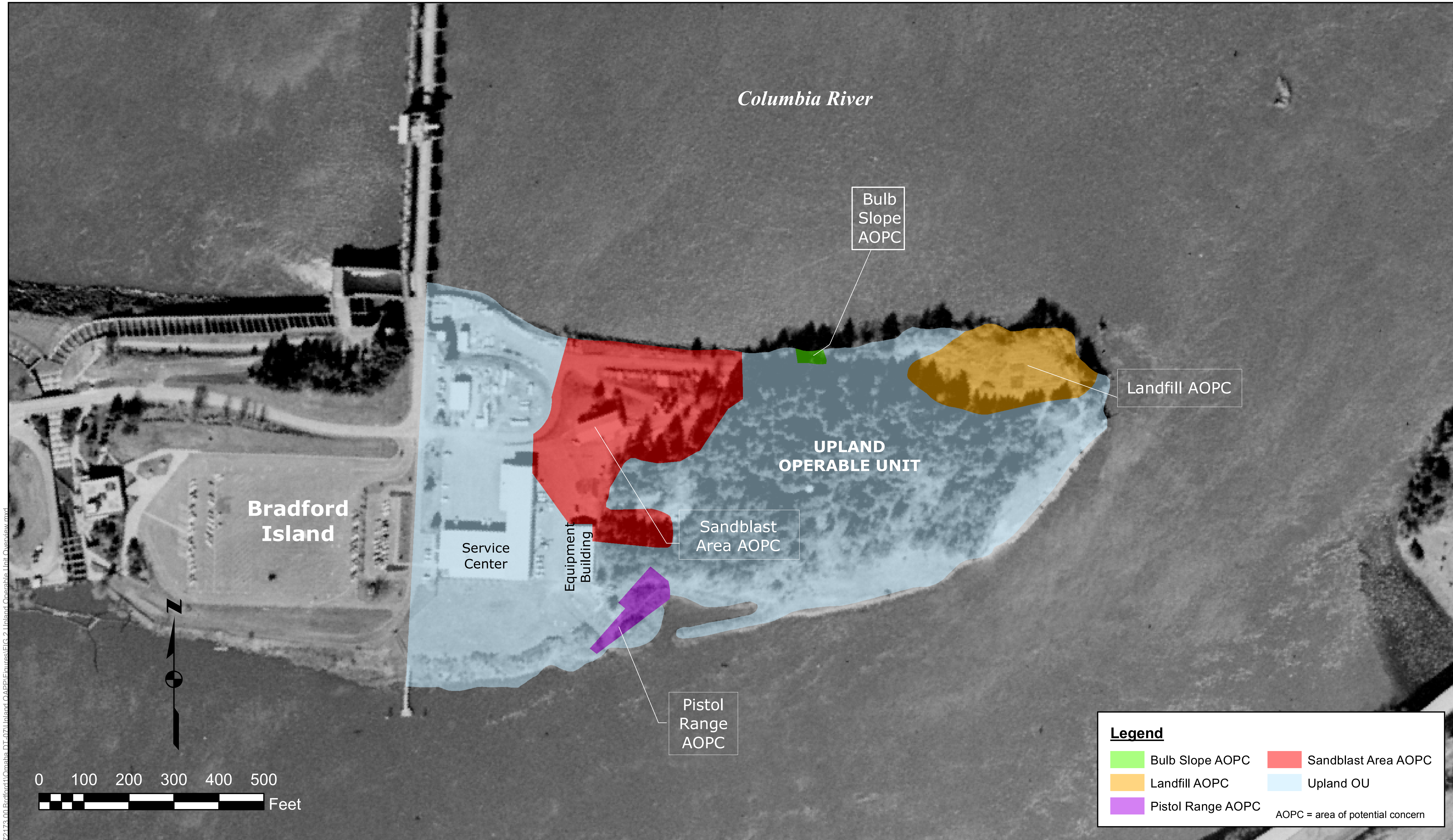
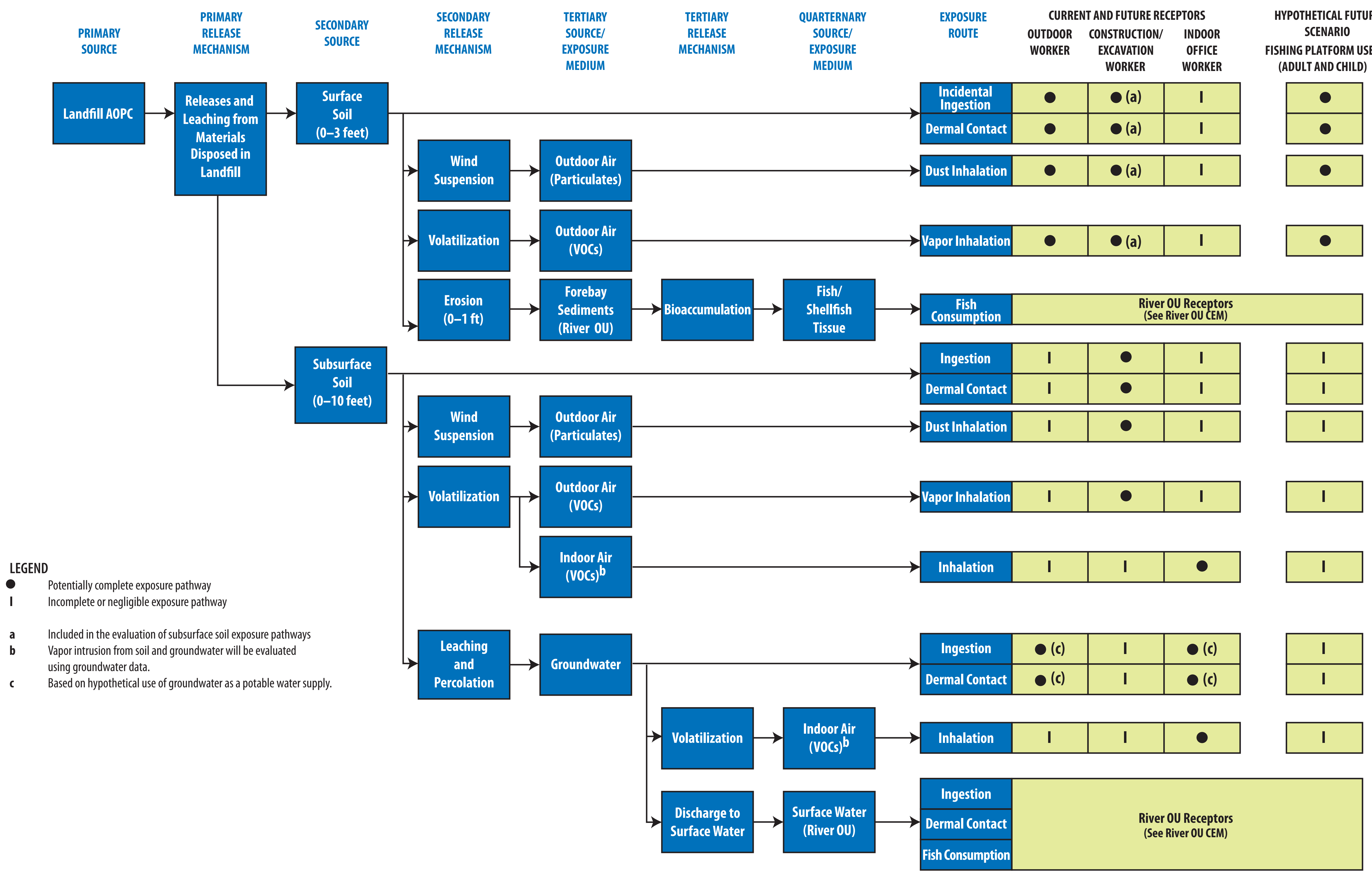


JOB No.: 25698014	DESIGNED: LSM	PROJ. ENGINEER: LSM	URS	BRADFORD ISLAND	UPLAND OPERABLE UNIT OVERVIEW	DRAWING NUMBER: FIGURE 1-4
	DRAWN BY: SB	APPROVED BY: MP	111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	CASCADE LOCKS, OREGON		GIS FILE NUMBER: FIG 1-4
	CHECKED BY: SB	DATE: JULY 2010				SHEET: REV.:



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BRADFORD ISLAND

CASCADE LOCKS, OREGON

LANDFILL AOPC

HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 2-1

GIS FILE NUMBER: FIG 2-1

SHEET: REV.

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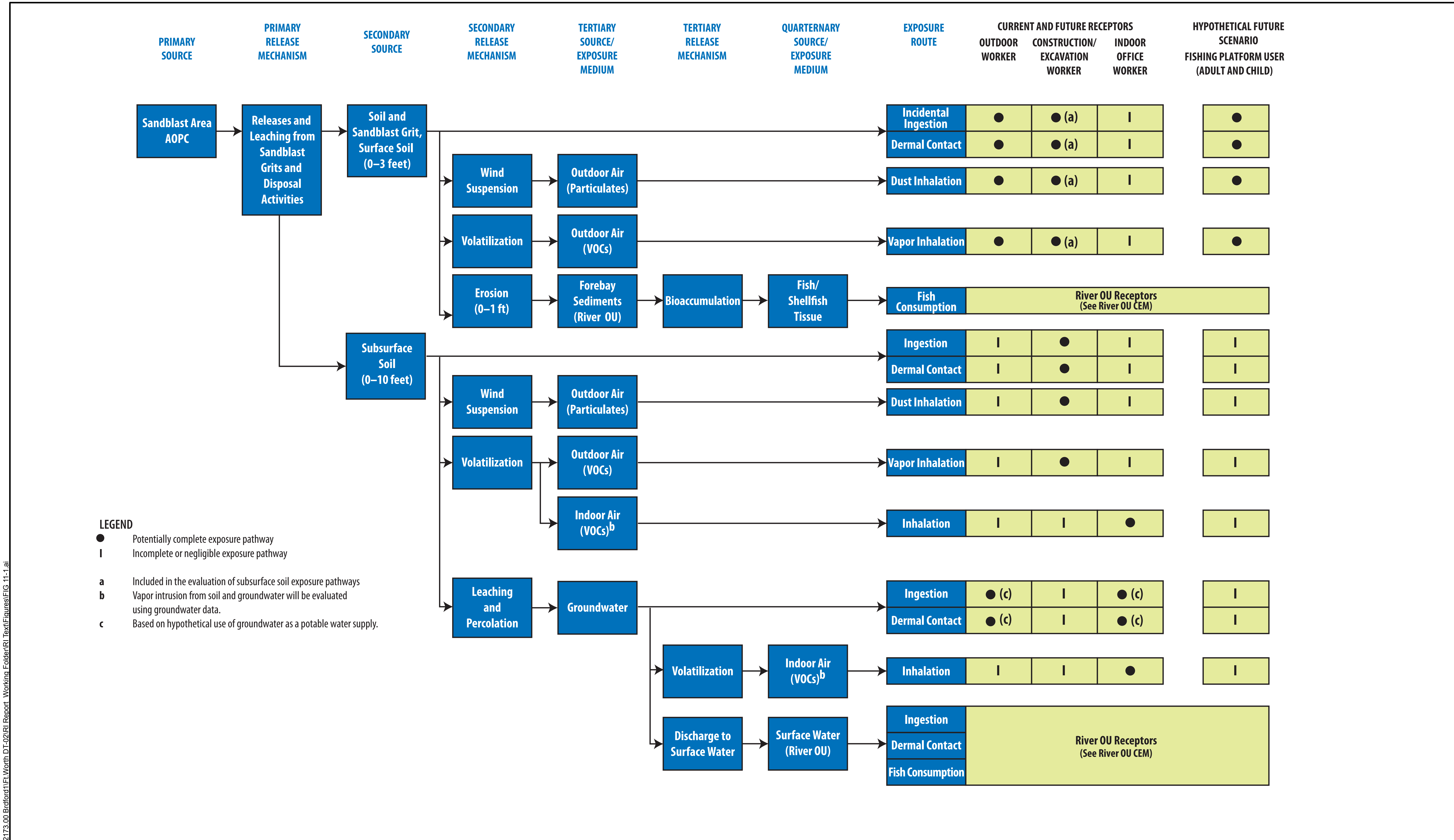

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	DRAWN BY: MS	APPROVED BY: MP	111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	CASCADE LOCKS, OREGON	HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL	GIS FILE NUMBER: FIG 2-2	
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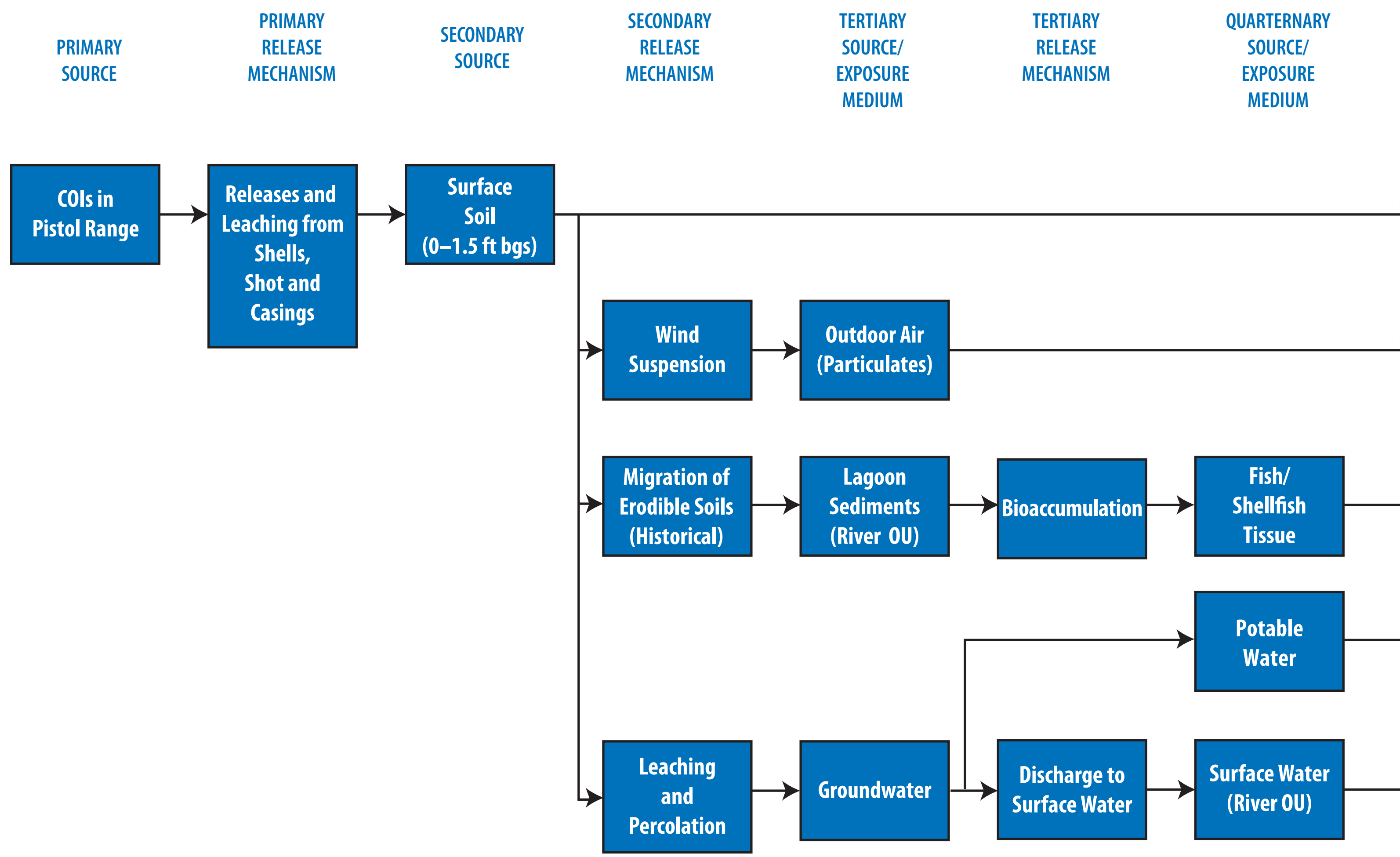

EXPOSURE ROUTE	UPLAND OU RECEPTORS: OUTDOOR WORKER	UPLAND OU RECEPTORS: CONSTRUCTION/ EXCAVATION WORKER	UPLAND OU RECEPTORS: INDOOR OFFICE WORKER	RIVER OU RECEPTORS: SUBSISTENCE FISHER	RIVER OU RECEPTORS: RECREATIONAL FISHER/WADER	RIVER OU RECEPTORS: DOWNSTREAM POTABLE WATER USER	HYPOTHETICAL FUTURE SCENARIO: FISHING PLATFORM USER (ADULT & CHILD)
Ingestion	●	●	I	I	I	I	●
Dermal Contact	●	●	I	I	I	I	●
Dust Inhalation	●	●	I	I	I	I	●
Fish Consumption	River OU Receptors (See River OU CEM)						
Ingestion	● (a)	I	● (a)	I	I	I	I
Dermal Contact	● (a)	I	● (a)	I	I	I	I
Ingestion	I	I	I	I	I	● (b)	I
Dermal Contact	I	I	I	●	●	● (b)	I
Fish Consumption	I	I	I	●	●	I	I

LEGEND
- ● Potentially complete exposure pathway
- I Incomplete or negligible exposure pathway
- a Based on hypothetical use of groundwater as a potable water supply
- b Based on use of downstream river water as a potable water supply

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PISTOL RANGE AOPC
HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

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GIS FILE NUMBER: FIG 2-3
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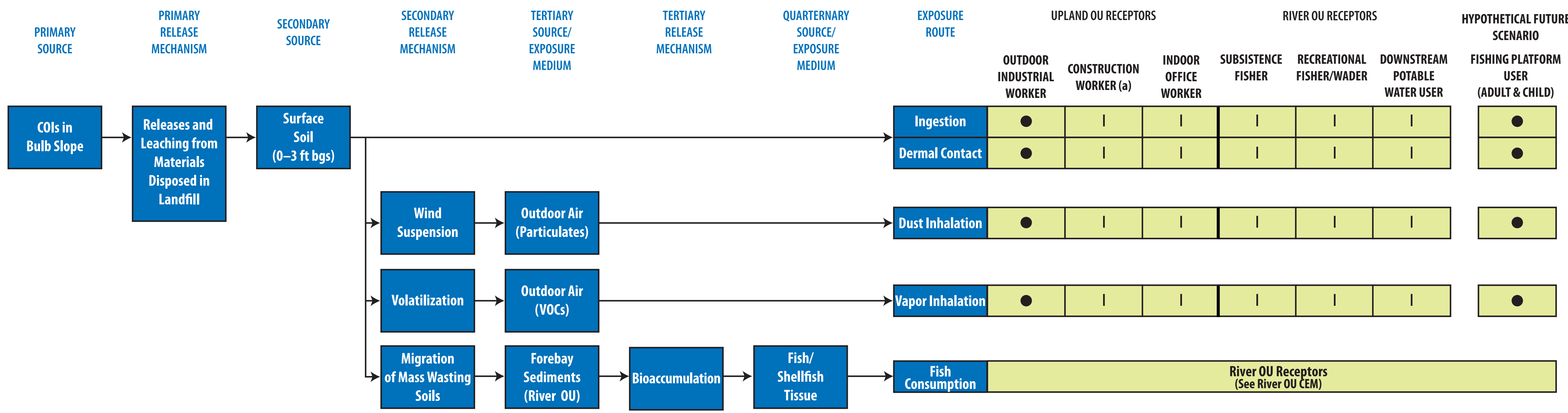

LEGEND

- ● Potentially complete exposure pathway
- I Incomplete or negligible exposure pathway
- (a) No construction or excavation activities are feasible or likely at the Bulb Slope AOPC

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BRADFORD ISLAND

CASCADE LOCKS, OREGON

BULB SLOPE AOPC

HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

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GIS FILE NUMBER: FIG 2-4
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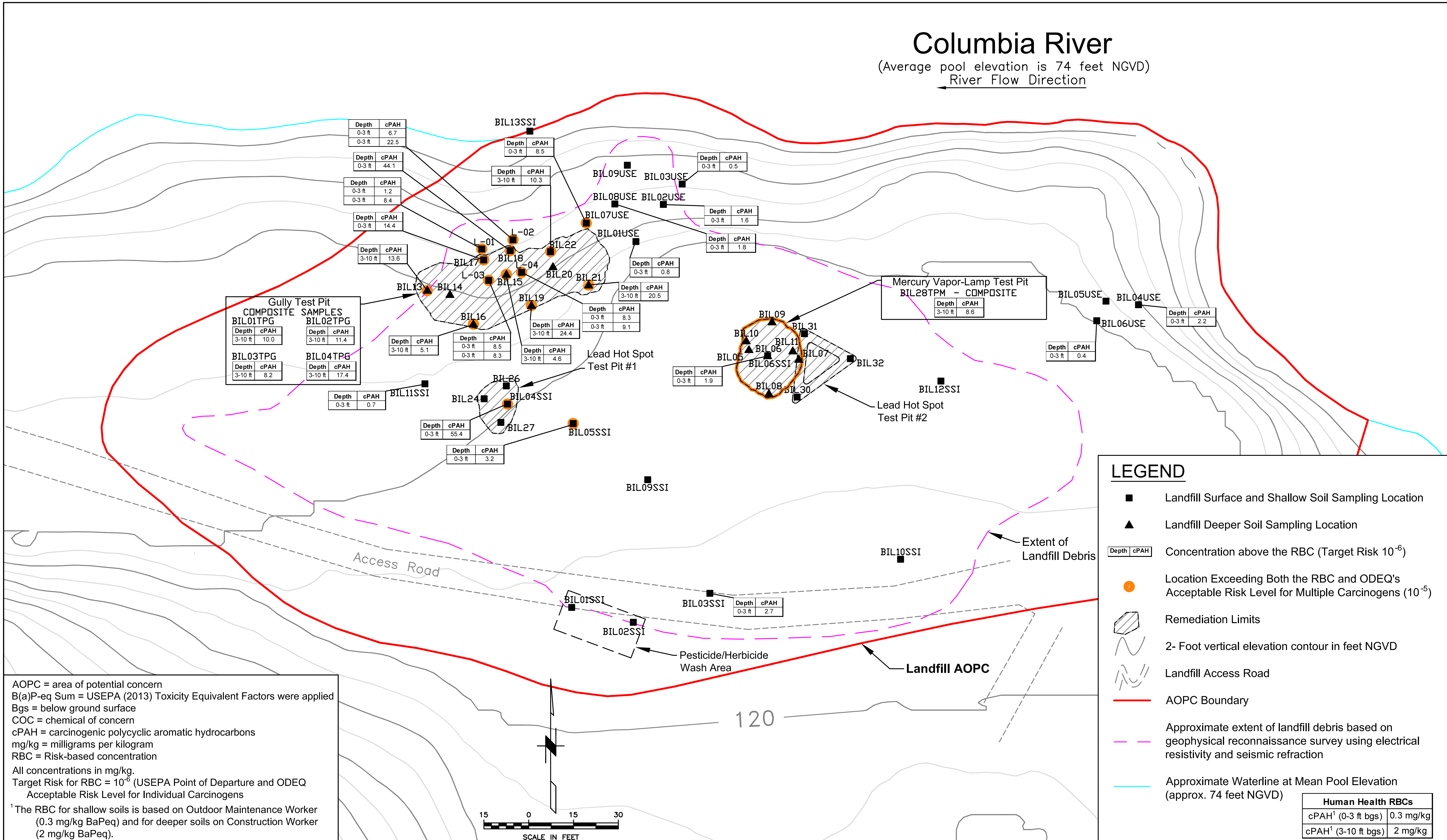

AOPC = area of potential concern
B(a)P-eq Sum = USEPA (2013) Toxicity Equivalent Factors were applied
Bgs = below ground surface
COC = chemical of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
mg/kg = milligrams per kilogram
RBC = Risk-based concentration

All concentrations in mg/kg.
Target Risk for RBC = 10^{-6} (USEPA Point of Departure and ODEQ Acceptable Risk Level for Individual Carcinogens

[1] The RBC for shallow soils is based on Outdoor Maintenance Worker (0.3 mg/kg BaPeq) and for deeper soils on Construction Worker (2 mg/kg BaPeq).

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BRADFORD ISLAND
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LANDFILL AOPC
COC LOCATIONS ABOVE OCCUPATIONAL RBCs

DRAWING NUMBER: FIGURE 2-5
CAD FILE NUMBER: FIG 2-5
SHEET: OF
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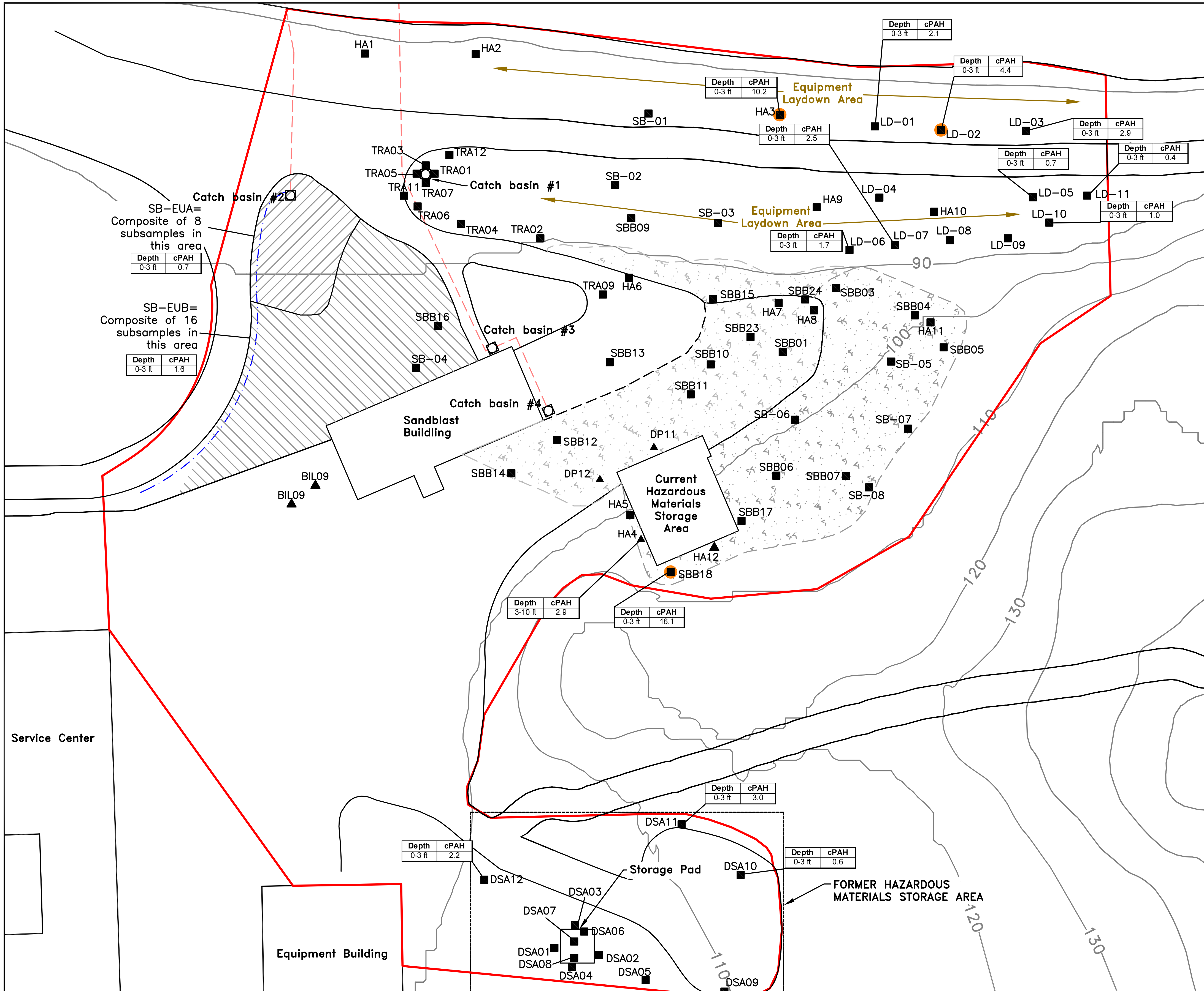
K:\bradford_island\GIS\2015\BHHERA\FIG 2-5 COC Locations above Occupational RBCs -Landfill AOPC.dwg Apr 04, 2016 - 12:43pm



LEGEND

- ▲ Sandblast Area Deeper Soil Sampling Location (3-10ft bgs)
- ■ Sandblast Area Surface and Shallow Soil Sampling Location (0-3ft bgs)
- Depth | cPAH — Concentration above the RBC (Target Risk 10^{-6})
- ● Location Exceeding Both the RBC and ODEQ's Acceptable Risk Level for Multiple Carcinogens (10^{-5})
- 110 — 10-foot Vertical Contour in Feet (NGVD)
- AOPC Boundary
- Approximate Spent Sandblast Grit Disposal Area
- Erodable Unit Sampling Area

Human Health RBCs	
cPAH[1] (0-3 ft bgs)	0.3 mg/kg
cPAH[1] (3-10 ft bgs)	2 mg/kg

AOPC = area of potential concern
B(a)P-eq Sum = USEPA (2013) Toxicity Equivalent Factors were applied
Bgs = below ground surface
COC = chemical of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
mg/kg = milligrams per kilogram
RBC = Risk-based concentration

All concentrations in mg/kg.
Target Risk for RBC= 10^{-6} (USEPA Point of Departure and ODEQ Acceptable Risk Level for Individual Carcinogens

[1] The RBC for shallow soils is based on Outdoor Maintenance Worker (0.3 mg/kg BaPeq) and for deeper soils on Construction Worker (2 mg/kg BaPeq).

K:\bradford_island\GIS\2015\BHHERA\FIG 2-6 COC Locations above Occupational RBCs - Sandblast Area AOPC.dwg Apr 04, 2016 - 12:41pm

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	CHECKED BY: HP	DATE: APRIL 2016

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CASCADE LOCKS, OREGON

SANDBLAST AREA AOPC

COC LOCATIONS ABOVE OCCUPATIONAL RBCs

DRAWING NUMBER: FIGURE 2-6
CAD FILE NUMBER: FIG 2-6
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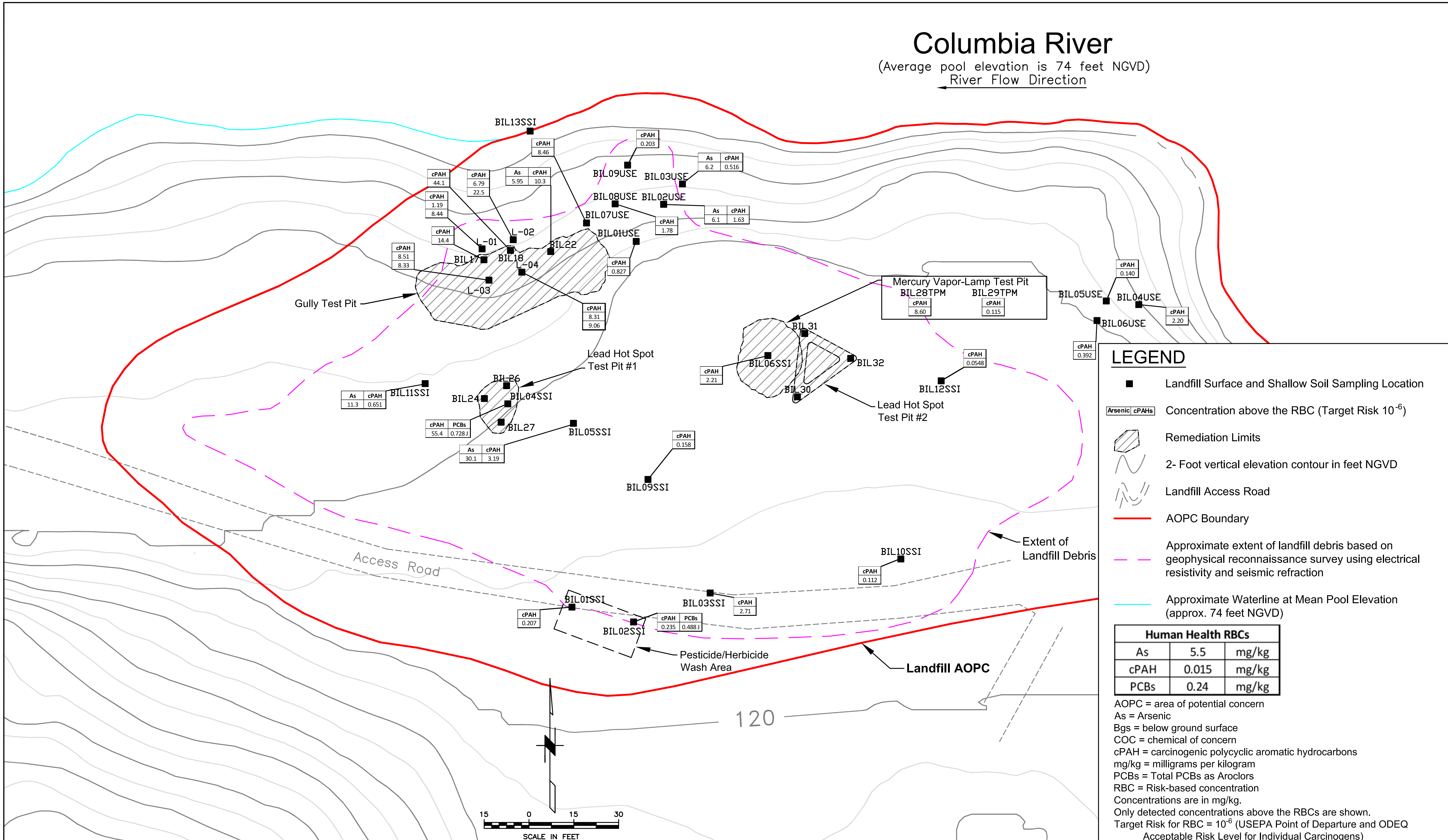
REV.



LEGEND

- Landfill Surface and Shallow Soil Sampling Location
- Arsenic | cPAHs — Concentration above the RBC (Target Risk 10^{-6})
- Remediation Limits
- 2- Foot vertical elevation contour in feet NGVD
- Landfill Access Road
- AOPC Boundary
- Approximate extent of landfill debris based on geophysical reconnaissance survey using electrical resistivity and seismic refraction
- Approximate Waterline at Mean Pool Elevation (approx. 74 feet NGVD)

Human Health RBCs		
As	5.5	mg/kg
cPAH	0.015	mg/kg
PCBs	0.24	mg/kg

AOPC = area of potential concern
As = Arsenic
Bgs = below ground surface
COC = chemical of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
mg/kg = milligrams per kilogram
PCBs = Total PCBs as Aroclors
RBC = Risk-based concentration
Concentrations are in mg/kg.
Only detected concentrations above the RBCs are shown.
Target Risk for RBC = 10^{-6} (USEPA Point of Departure and ODEQ Acceptable Risk Level for Individual Carcinogens)

No.	DATE	BY	REVISION

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LANDFILL AOPC

COC LOCATIONS ABOVE HYPOTHETICAL FISHING PLATFORM RBCs

DRAWING NUMBER: FIGURE 2-7
CAD FILE NUMBER: FIG 2-7
SHEET: OF
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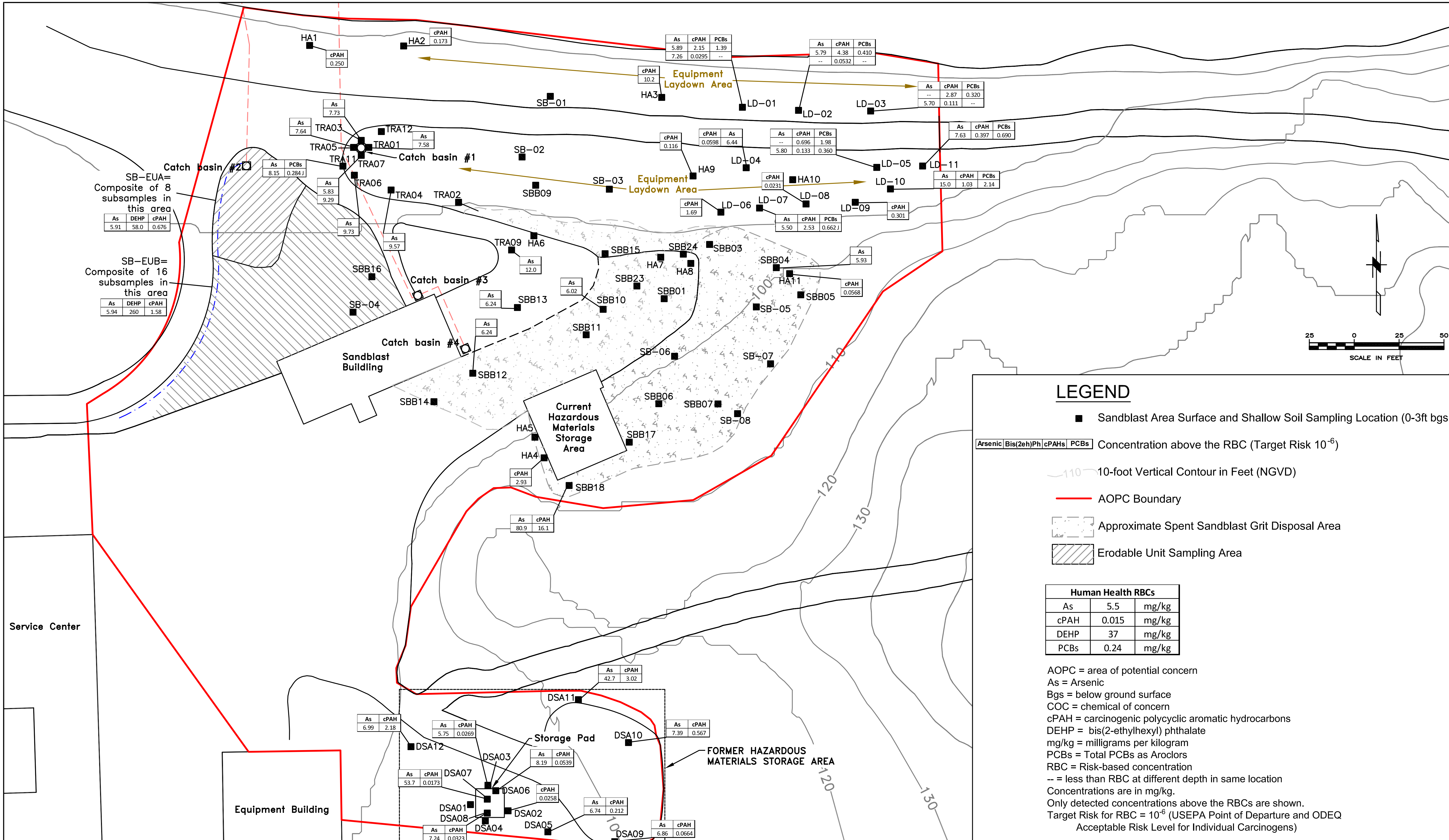
K:\bradford_island\GIS\2015\BHHERA\FIG 2-7 COC Locations above Hypothetical Fishing Platform RBCs - Landfill AOPC.dwg Apr 04, 2016 - 12:39pm



LEGEND

■ Sandblast Area Surface and Shallow Soil Sampling Location (0-3ft bgs)

| Arsenic | Bis(2eh)Ph | cPAHs | PCBs | Concentration above the RBC (Target Risk 10^{-6})

110 10-foot Vertical Contour in Feet (NGVD)

AOPC Boundary

Approximate Spent Sandblast Grit Disposal Area

Erodable Unit Sampling Area

Human Health RBCs		
As	5.5	mg/kg
cPAH	0.015	mg/kg
DEHP	37	mg/kg
PCBs	0.24	mg/kg

AOPC = area of potential concern
As = Arsenic
Bgs = below ground surface
COC = chemical of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbons
DEHP = bis(2-ethylhexyl) phthalate
mg/kg = milligrams per kilogram
PCBs = Total PCBs as Aroclors
RBC = Risk-based concentration
-- = less than RBC at different depth in same location
Concentrations are in mg/kg.
Only detected concentrations above the RBCs are shown.
Target Risk for RBC = 10^{-6} (USEPA Point of Departure and ODEQ Acceptable Risk Level for Individual Carcinogens)

No.	DATE	BY	REVISION

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SANDBLAST AREA AOPC

COC LOCATIONS ABOVE HYPOTHETICAL FISHING PLATFORM RBCs

DRAWING NUMBER: FIGURE 2-8
CAD FILE NUMBER: FIG 2-8
SHEET: OF
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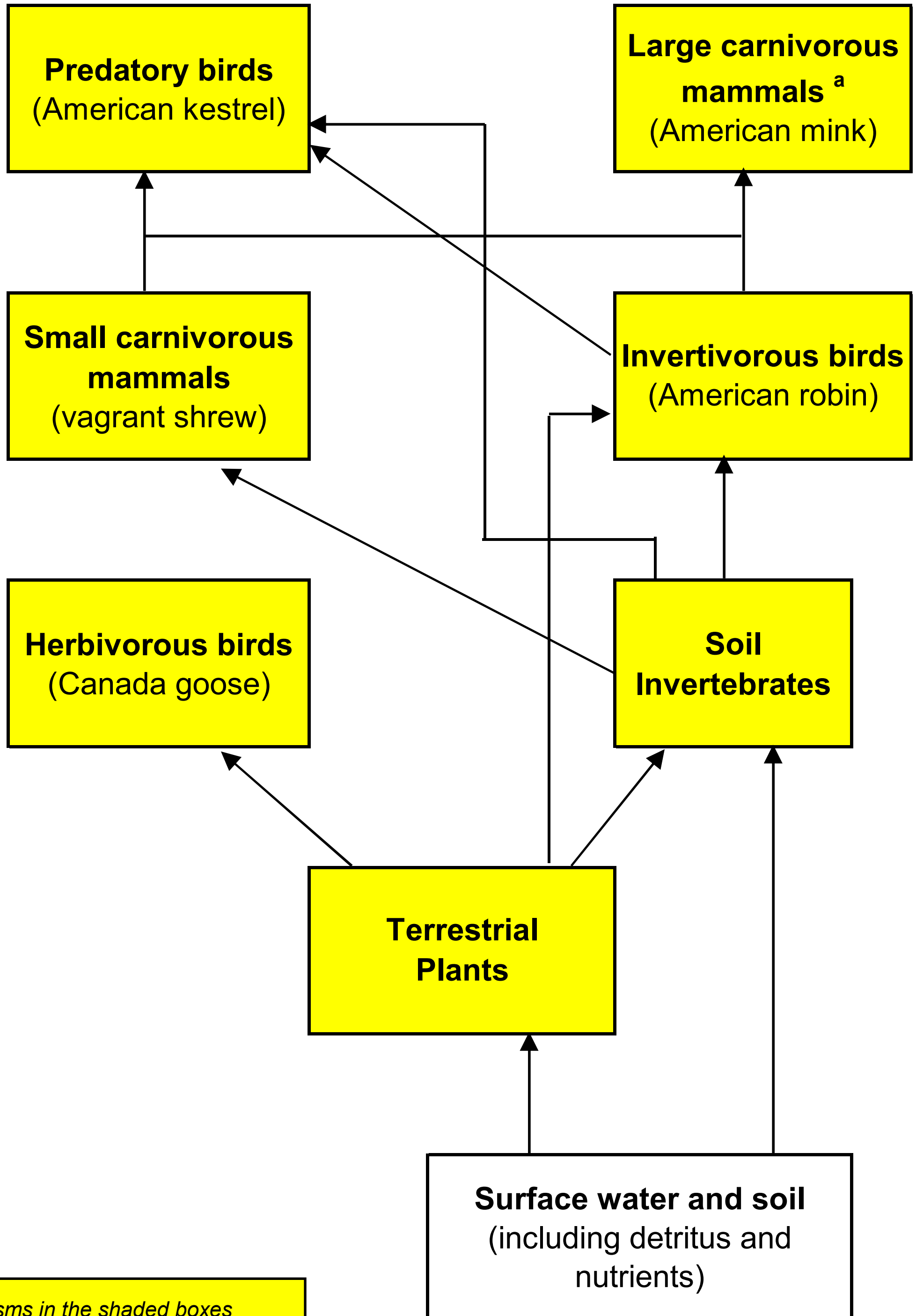
K:\bradford_island\GIS\2015\BHHERA\FIG 2-8 COC Locations above Hypothetical Fishing Platform RBCs - Sandblast AOPC.dwg Apr 04, 2016 - 12:38pm



Organisms in the shaded boxes will be evaluated for risk (representative species are shown for birds and mammals)

[a] The American mink would primarily forage in the riverine habitat adjacent to the Upland OU, but could also forage in the Upland OU when aquatic prey are scarce.

UPLAND OU FOODWEB

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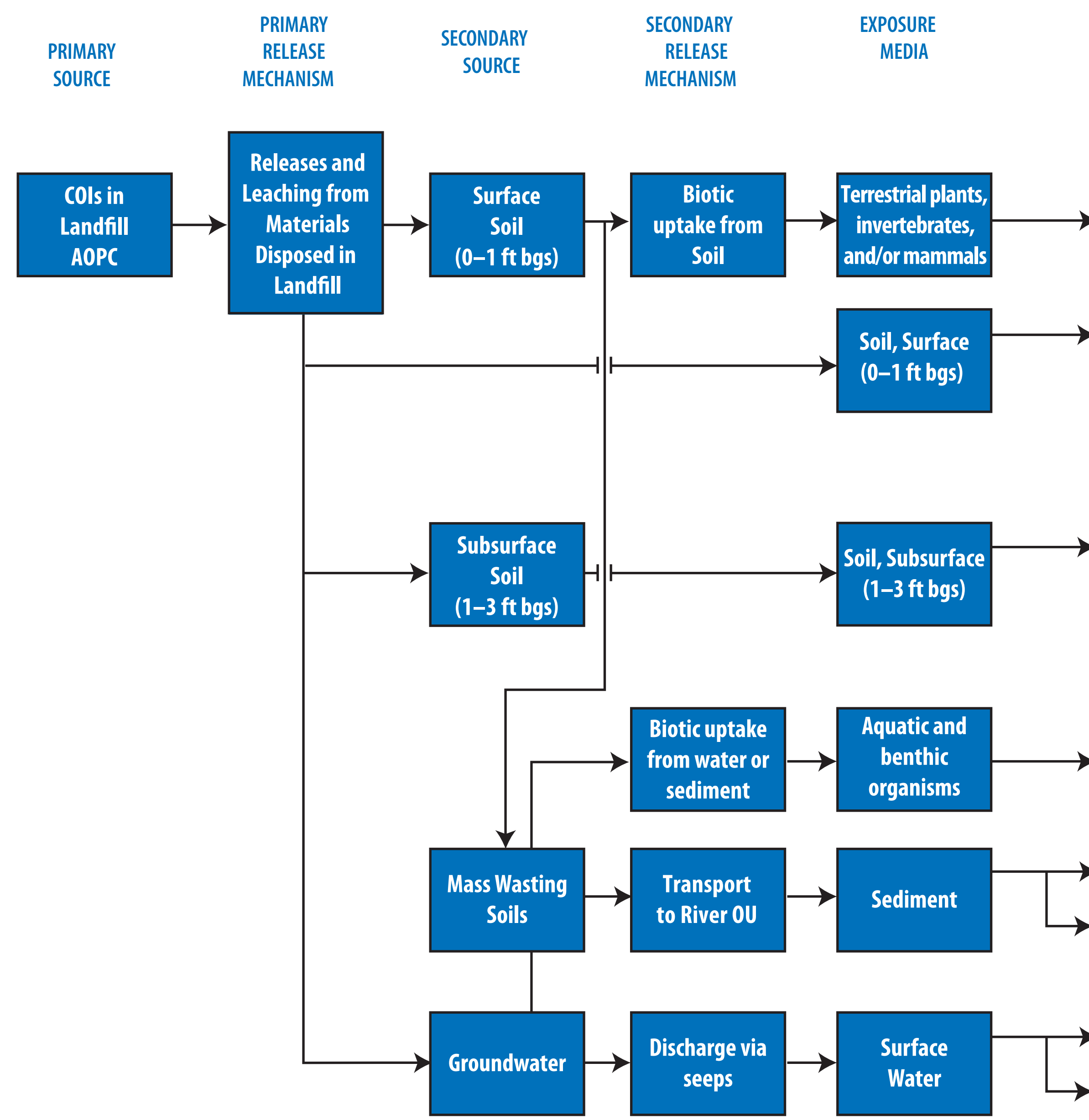
FIGURE 3-1



EXPOSURE MEDIA	EXPOSURE ROUTE	AQUATIC RECEPTORS[a]: AQUATIC BIOTA	AQUATIC RECEPTORS[a]: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Terrestrial plants, invertebrates, and/or mammals	Ingestion	NA	NA	NA	●	●	●
Soil, Surface (0–1 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●
	Root Uptake/ Dermal[b]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Soil, Subsurface (1–3 ft bgs)	Incidental Ingestion	-	-	NA	●	○	●
	Root Uptake/ Dermal[b]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-
Sediment	Ingestion	●	●	-	-	-	-
	Uptake/Dermal[b]	●	●	-	-	-	-
Surface Water	Ingestion[c]	●	●	-	-	●	●
	Uptake/Dermal[b]	●	●	-	-	○	○

LEGEND

- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.

a. The Upland OU to River OU pathways evaluated at a screening level in the Final RI report (URS 2012) were not addressed, as these receptors and pathways are considered in a separate document

b. The dermal exposure pathway for wildlife is expected to be minor due to the barrier offered by fur and feathers.

c. Highly mobile birds and mammals could ingest water from the river, while less mobile species would likely ingest water from puddles in the Upland OU.

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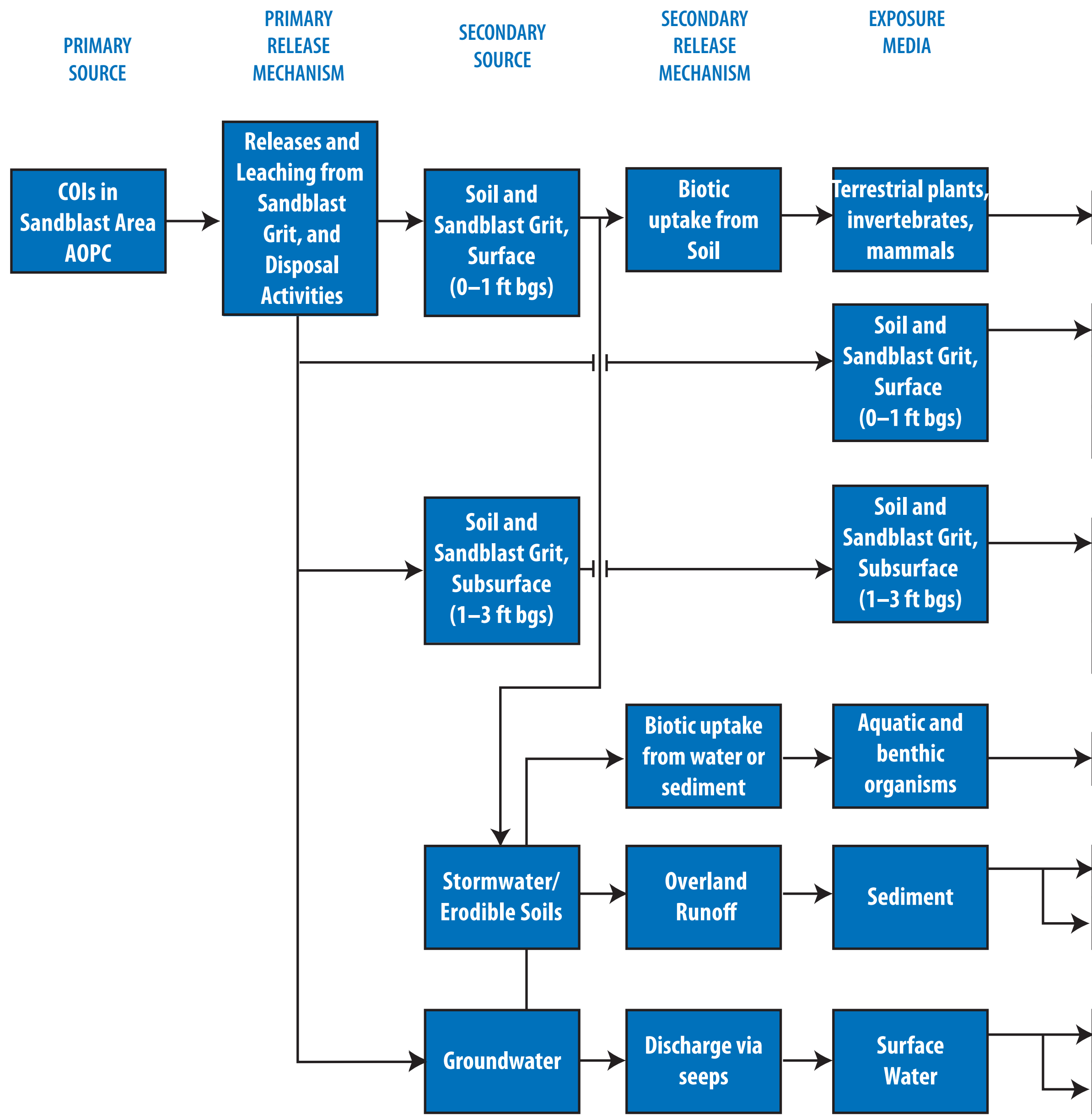
LANDFILL AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-2
GIS FILE NUMBER: FIG 3-2
SHEET: REV.

O:\25692709 USACE\53-F0072173.00 Brdford1\Ft Worth DT-02\RI Report Working Folder\RI Text\Figures\FIG 12-2.ai



Exposure Media	Exposure Route	Aquatic Receptors: Aquatic Biota	Aquatic Receptors: Benthic Organisms	Terrestrial Receptors: Terrestrial Plants	Terrestrial Receptors: Soil Invertebrates	Terrestrial Receptors: Birds	Terrestrial Receptors: Mammals	Hypothetical Future Scenario: Fishing Platform User (Adult & Child)
Terrestrial plants, invertebrates, mammals	Ingestion	NA	NA	NA	●	●	●	●
Soil and Sandblast Grit, Surface (0–1 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●	●
	Root Uptake/ Dermal	-	-	●	●	○	○	●
	Inhalation	-	-	NA	NA	○	○	●
Soil and Sandblast Grit, Subsurface (1–3 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●	I
	Root Uptake/ Dermal	-	-	●	○	○	○	I
	Inhalation	-	-	NA	NA	○	○	I
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-	I
Sediment	Ingestion	●	●	-	-	-	-	I
	Uptake/Dermal*	●	●	-	-	-	-	I
Surface Water	Ingestion	●	●	-	-	-	-	I
	Uptake/Dermal*	●	●	-	-	-	-	I

LEGEND
- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.
*The dermal exposure pathway for aquatic-dependent wildlife is expected to be minor due to the barrier offered by fur and feathers.

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BRADFORD ISLAND
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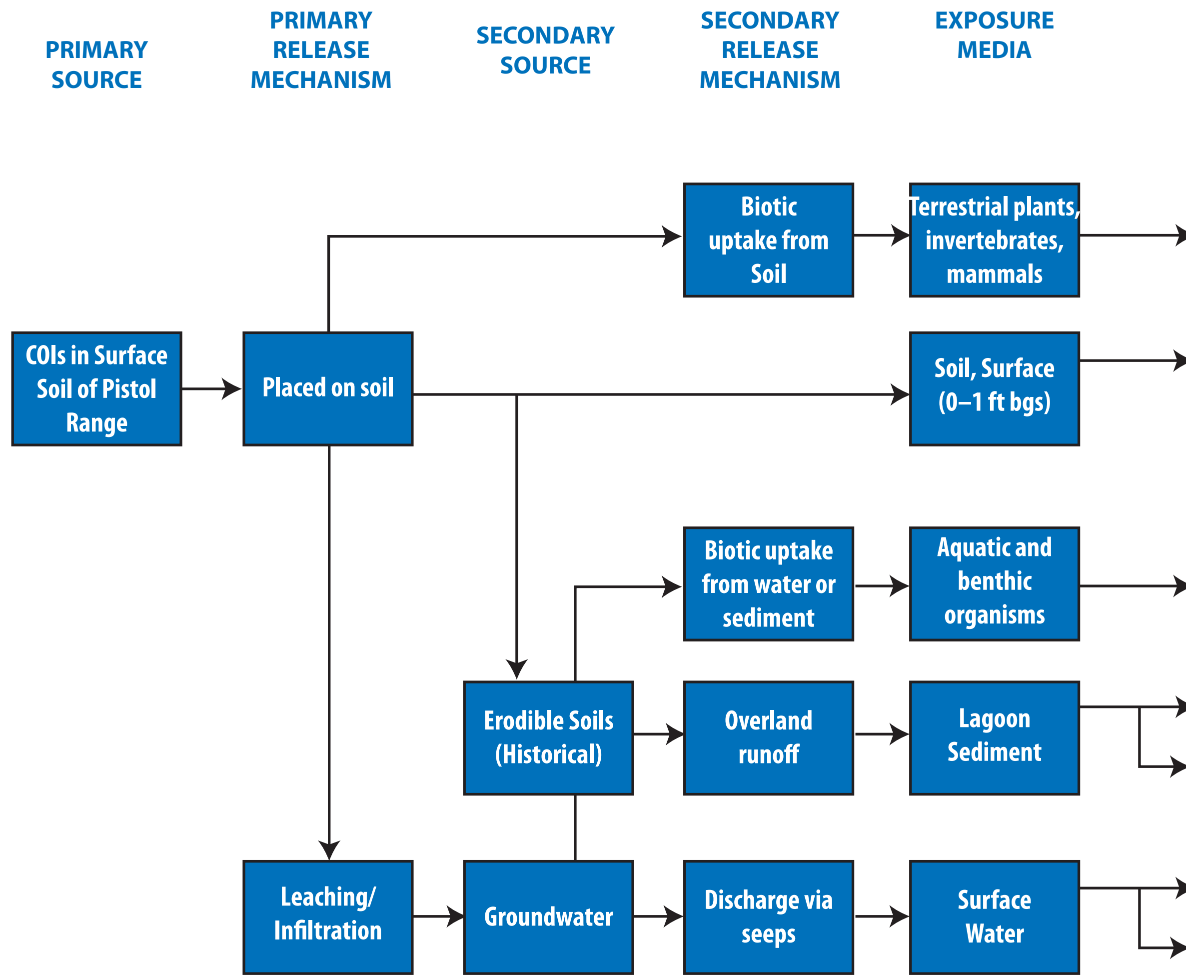
SANDBLAST AREA AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-3
GIS FILE NUMBER: FIG 3-3
SHEET: REV.



EXPOSURE MEDIA	EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Terrestrial plants, invertebrates, mammals	Ingestion	NA	NA	NA	●	●	●
Soil, Surface (0–1 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●
	Root Uptake/ Dermal	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-
Lagoon Sediment	Ingestion	●	●	-	-	-	-
	Uptake/Dermal*	●	●	-	-	-	-
Surface Water	Ingestion	●	●	-	-	-	-
	Uptake/Dermal*	●	●	-	-	-	-

LEGEND
- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.
*The dermal exposure pathway for aquatic-dependent wildlife is expected to be minor due to the barrier offered by fur and feathers.

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PISTOL RANGE AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-4
GIS FILE NUMBER: FIG 3-4
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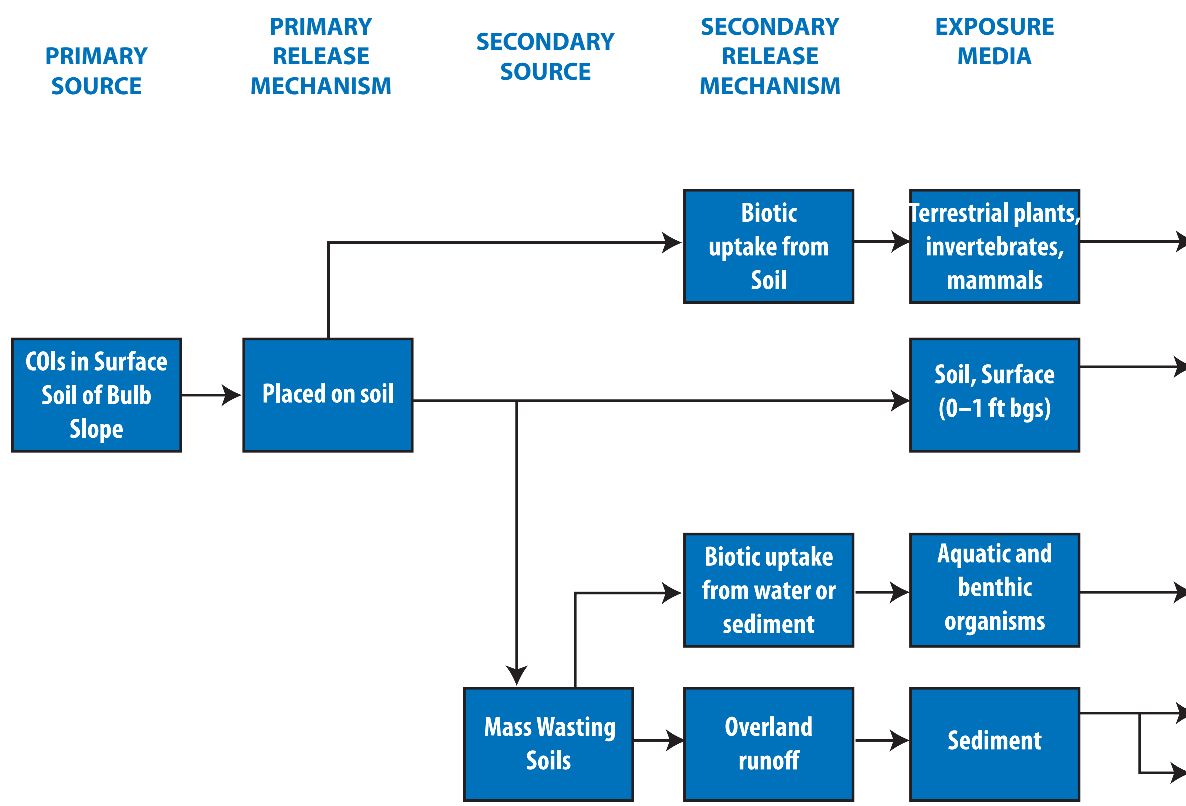
O:\25692709 USACE\53-F0072173.00 Brdford1\Ft.Worth DT-02\RI Report_Working Folder\RI Text\Figures\FIG 12-4.ai



EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Ingestion	NA	NA	NA	●	●	●
Incidental Ingestion	-	-	NA	●	●	●
Root Uptake/ Dermal	-	-	●	●	○	○
Inhalation	-	-	NA	NA	○	○
Ingestion	●	●	-	-	-	-
Ingestion	●	●	-	-	-	-
Uptake/Dermal*	●	●	-	-	-	-

LEGEND
- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.
*The dermal exposure pathway for aquatic-dependent wildlife is expected to be minor due to the barrier offered by fur and feathers.

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BRADFORD ISLAND
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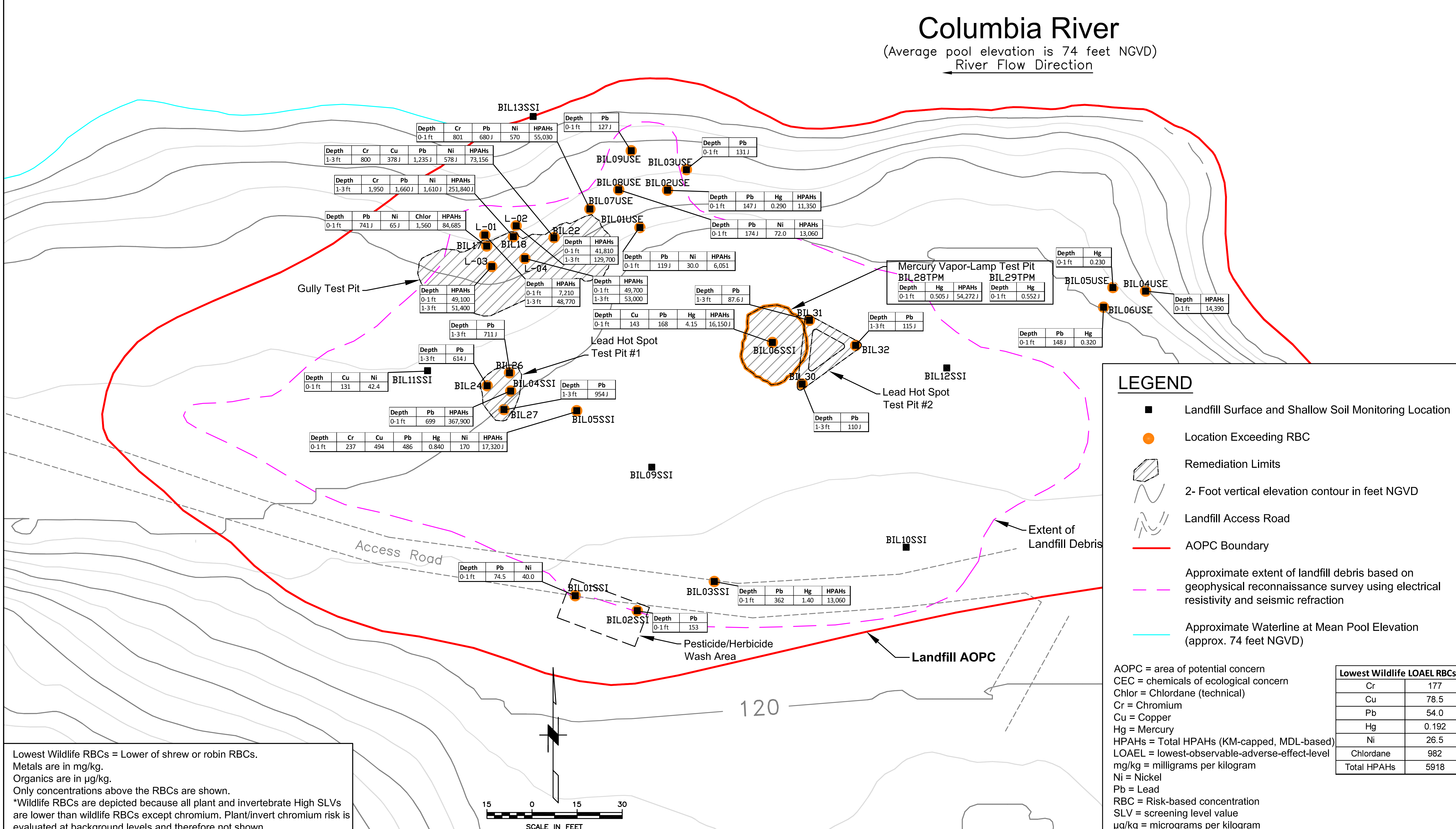
BULB SLOPE AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-5
GIS FILE NUMBER: FIG 3-5
SHEET: REV.



LEGEND

- ■ Landfill Surface and Shallow Soil Monitoring Location
- ● Location Exceeding RBC
- Remediation Limits
- 2- Foot vertical elevation contour in feet NGVD
- Landfill Access Road
- AOPC Boundary
- Approximate extent of landfill debris based on geophysical reconnaissance survey using electrical resistivity and seismic refraction
- Approximate Waterline at Mean Pool Elevation (approx. 74 feet NGVD)

AOPC = area of potential concern
CEC = chemicals of ecological concern
Chlor = Chlordane (technical)
Cr = Chromium
Cu = Copper
Hg = Mercury
HPAHs = Total HPAHs (KM-capped, MDL-based)
LOAEL = lowest-observable-adverse-effect-level
mg/kg = milligrams per kilogram
Ni = Nickel
Pb = Lead
RBC = Risk-based concentration
SLV = screening level value
µg/kg = micrograms per kilogram

Lowest Wildlife LOAEL RBCs*	
Cr	177
Cu	78.5
Pb	54.0
Hg	0.192
Ni	26.5
Chlordane	982
Total HPAHs	5918

Lowest Wildlife RBCs = Lower of shrew or robin RBCs.
Metals are in mg/kg.
Organics are in µg/kg.
Only concentrations above the RBCs are shown.
*Wildlife RBCs are depicted because all plant and invertebrate High SLVs are lower than wildlife RBCs except chromium. Plant/invert chromium risk is evaluated at background levels and therefore not shown.

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LANDFILL AOPC
CEC LOCATIONS ABOVE RBCs

DRAWING NUMBER: FIGURE 3-6
CAD FILE NUMBER: FIG 3-6
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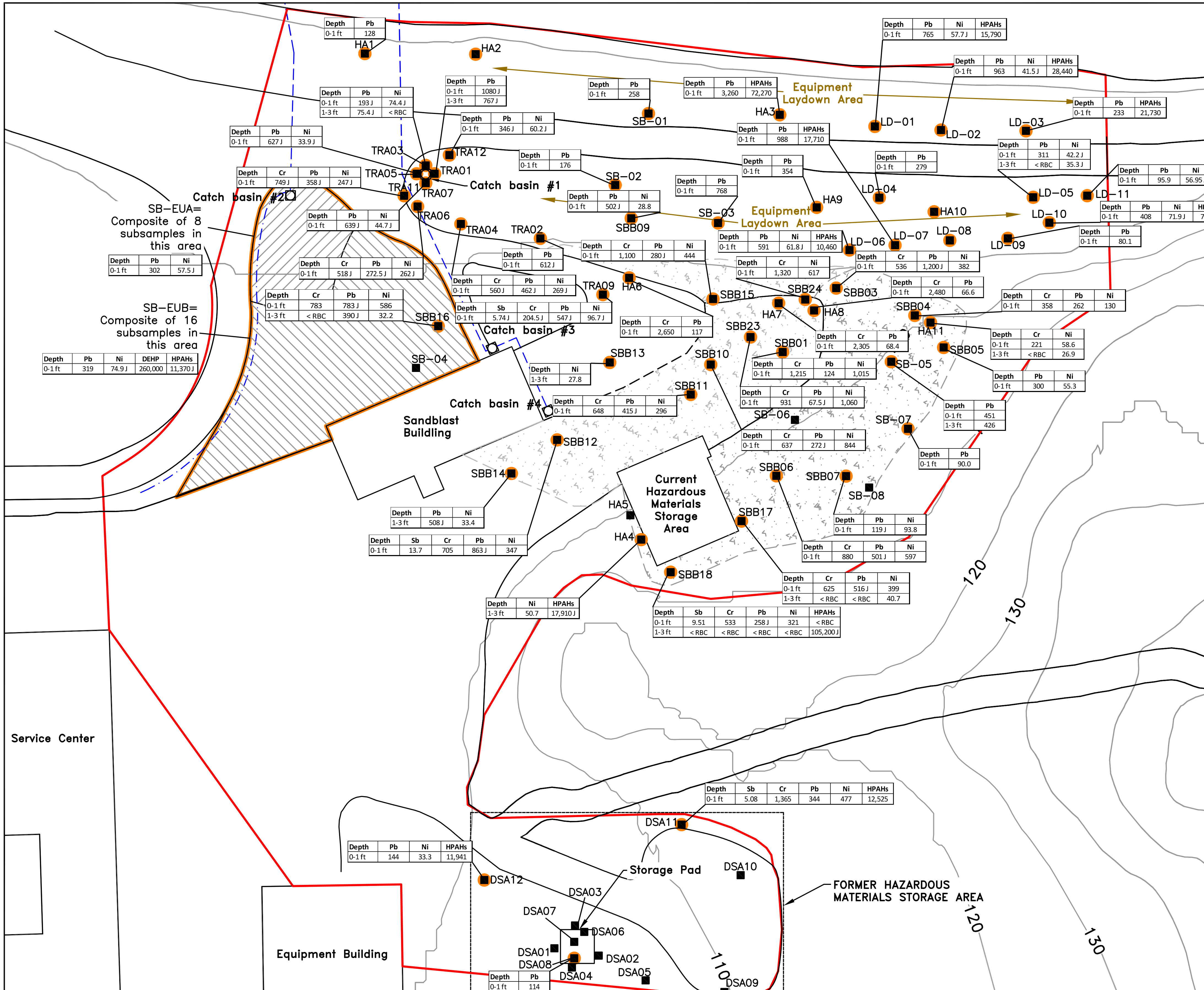
K:\bradford_island\GIS\2015\BHHERA\FIG 3-6 CEC Locations above RBCs -- Landfill AOPC.dwg Apr 04, 2016 -- 12:34pm



LEGEND

- AOPC Boundary
- Sandblast Area Surface and Shallow Soil Sampling Location
- Location Exceeding RBC
- 10-foot Vertical Contour in Feet (NGVD)
- Approximate Spent Sandblast Grit Disposal Area
- Erodable Unit Sampling Area

AOPC = area of potential concern
CEC = chemicals of ecological concern
Cr = Chromium
DEHP = Bis(2-ethylhexyl) Phthalate
HPAHs = Total HPAHs (KM-capped, MDL-based)
LOAEL = lowest-observable-adverse-effect-level
Lowest Wildlife RBCs = Lower of shrew or robin RBCs.
mg/kg = milligrams per kilogram
Ni = Nickel
Pb = Lead
RBC = Risk-based concentration
Sb = Antimony
SLV = screening level value
µg/kg = micrograms per kilogram
Metals are in mg/kg.
Organics are in µg/kg.
Only concentrations above the RBCs are shown.
*Wildlife RBCs are depicted because all plant and invertebrate High SLVs are lower than wildlife RBCs except chromium. Plant/invert chromium risk is evaluated at background levels and therefore not shown.

Lowest Wildlife LOAEL RBCs*	
Sb	2.84
Cr	177
Pb	56.2
Ni	26.5
DEHP	61367
Total HPAHs	5924

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SANDBLAST AREA AOPC
CEC LOCATIONS ABOVE RBCs

DRAWING NUMBER: FIGURE 3-7
CAD FILE NUMBER: FIG 3-7
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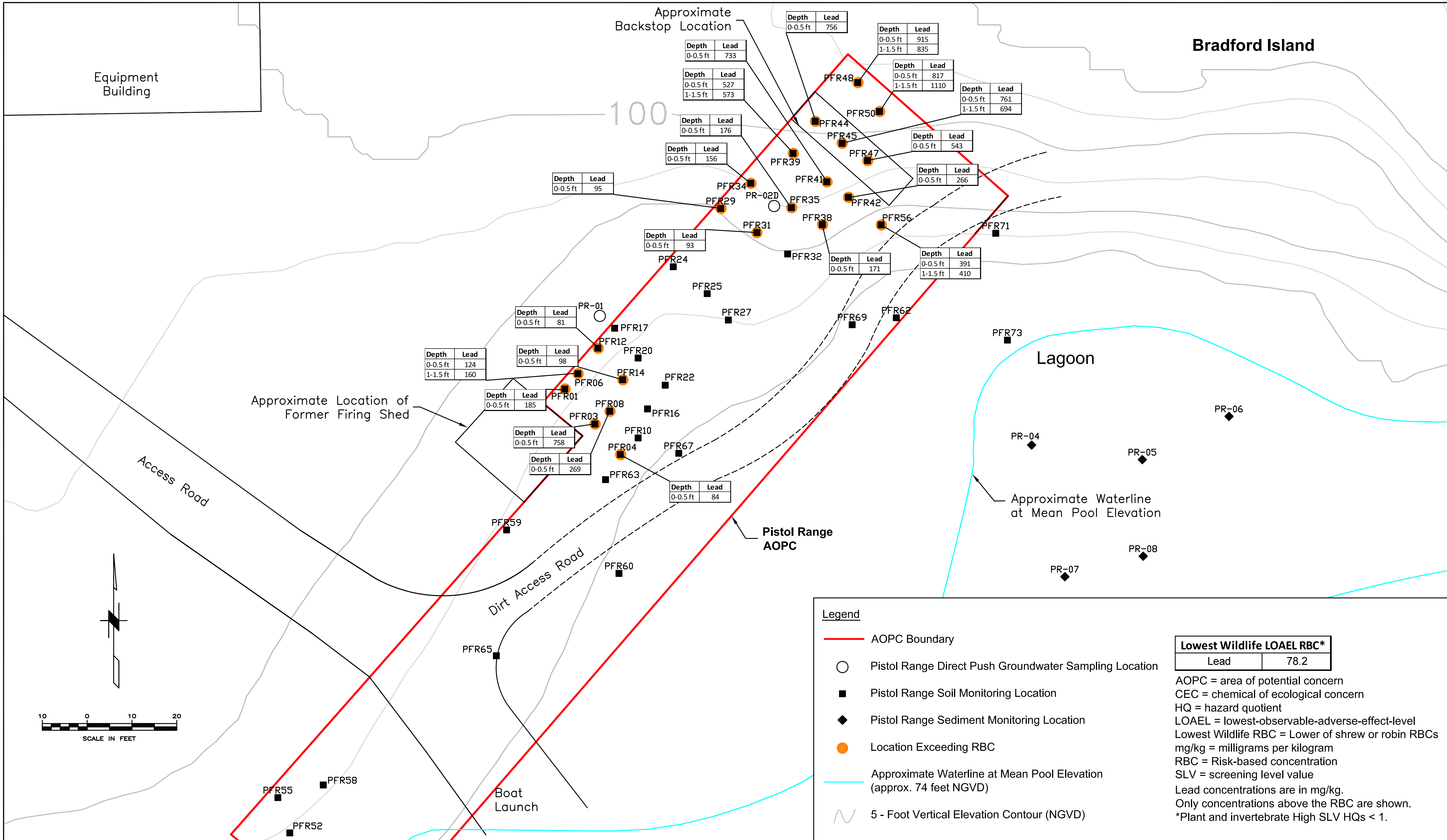
K:\bradford_island\GIS\2015\BHHERA\FIG 3-7 CEC Locations above RBCs – Sandblast Area AOPC.dwg Apr 04, 2016 – 12:36pm



K:\bradford_island\GIS\2015\BHHERA\FIG 3-8 CEC Locations above RBCs - Pistol Range AOPC.dwg Apr 04, 2016 - 12:30pm

No.	DATE	BY	REVISION

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PISTOL RANGE AOPC
CEC LOCATIONS ABOVE RBCs

DRAWING NUMBER: FIGURE 3-8
CAD FILE NUMBER: FIG 3-8
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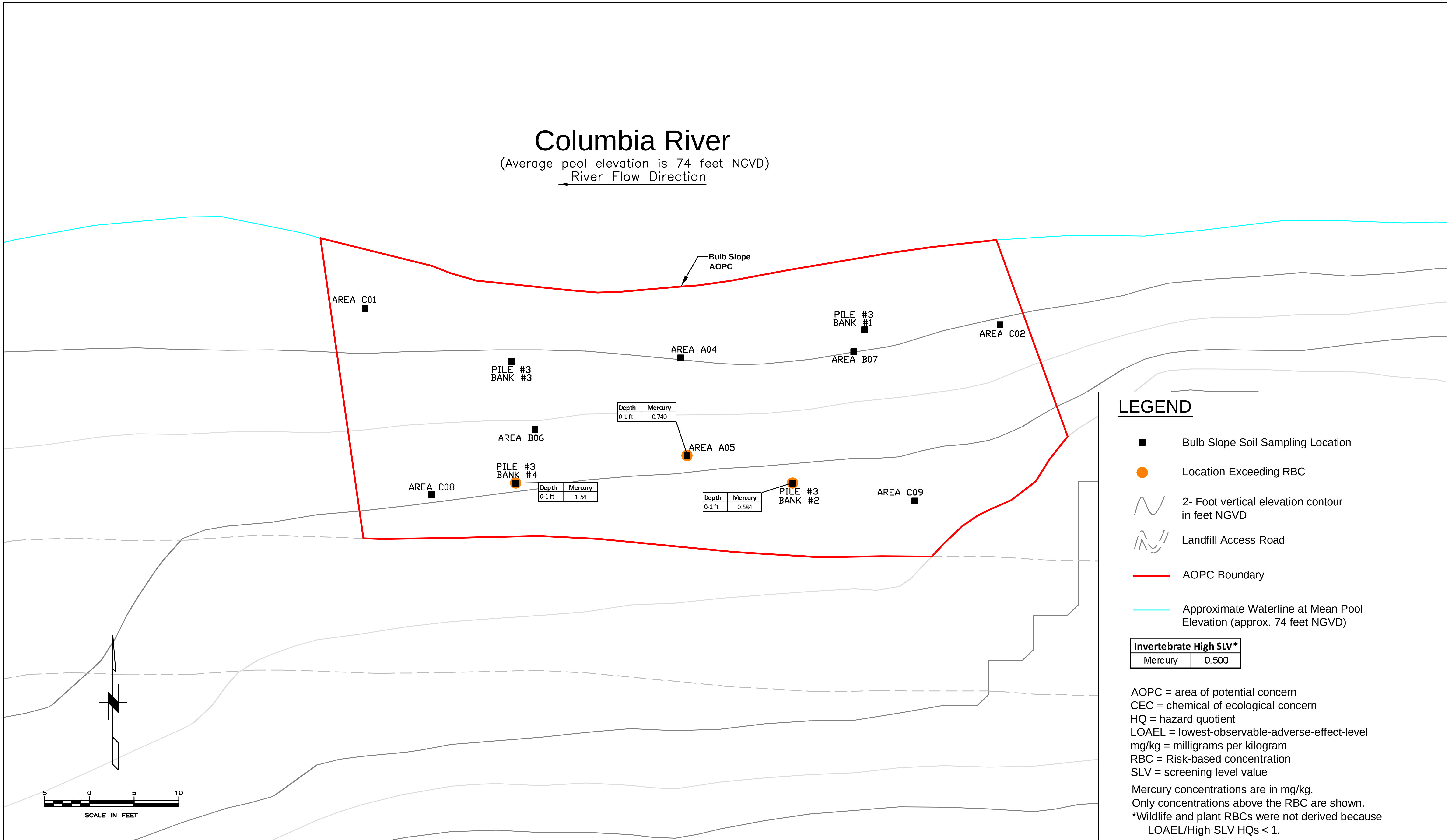

No.	DATE	BY	REVISION

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BULB SLOPE AOPC

CEC LOCATIONS ABOVE RBCs

DRAWING NUMBER: FIGURE 3-9
CAD FILE NUMBER: FIG 3-9
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K:\bradford_island\GIS\2015\BHHERA\FIG 3-9 CEC Locations above RBCs - Bulb Slope AOPC.dwg Nov 02, 2015 - 4:03pm

APPENDIX A

BHHRA Calculation Spreadsheets

Appendix A
BHHRA Calculation Spreadsheets

ABBREVIATIONS

% = percent
-- = data not available or not calculated
µg= microgram
ABS_d = Dermal Soil Absorption Fraction
ADAF = age-dependent adjustment factor

Afw = Soil-to-Skin Adherence Fraction, worker
AOPC = area of potential concern
Atc = Averaging Time, carcinogens
$AT_{nc,a}$ = Averaging Time, noncarcinogens, adult
BW_a = Body Weight, adult
C_{air} = COPC Concentration in air
CF = Conversion Factor
CF_i = Unit conversion factor
cm^2 = square centimeter
cm^3 = cubic centimeter
COPC = chemical of potential concern
C_{soil} = COPC Concentration in Soil
D_A = Apparent Diffusivity
DEHP = bis(2-ethylhexyl)phthalate
D_i = Diffusivity in air
D_w = Diffusivity in water
EC_w = Fraction of EV in Contact with Soil, worker
ED_w = Exposure Duration, worker
EF_w = Exposure Frequency, worker
ET_w = Exposure Time, worker
EV = event
EV_w = Event Frequency, worker
FI_w = Fraction Contaminated Soil Ingested, worker
F_{OC} = Default organic-carbon content
g = gram
H' = Henry's law constant
HQ = hazard quotient
IRAF = Infant Risk Adjustment Factor
IRS_w = Soil Ingestion Rate, worker
IUR = Inhalation Unit-Risk Factor
K_d = Soil-water partition coefficient for organics: Kd= KOC× FOC
kg = kilogram
KM - capped = Kaplan–Meier-based with Efron's bias correction, capped
K_{OC} = Soil-organic carbon partition coefficient
K_p = permeability coefficient from water
m^3 = cubic meter
MCi = maximum concentration inhaled
n = Total soil porosity (expressed as $L_{porespace}/L_{soil}$)
NRP = not reliably predicted
PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl
PEF = Particulate Emission Factor (non-VOCs), default
Q/C = Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles
θ_a = Air-filled soil porosity (expressed as L_{air}/L_{soil})
θ_w = Water-filled soil porosity (expressed as L_{water}/L_{soil})
ρ_β = Dry soil bulk density
RfC = Inhalation Reference Concentration
RfD_d = Oral Reference Dose Adjusted for GI Absorption
RfD_O = Oral Reference Dose
RME = reasonable maximum exposure
RSL = regional screening level
s = second
SA_w = Exposed Body Surface Area, worker
SF_d = Oral Slope Factor Adjusted for GI Absorption
SF_O = Oral Slope Factor
SVOC = semivolatile organic compound
t* = time it takes to reach steady state
T_{worker} = Exposure interval, worker
VF = volatilization factor
VOC = volatile organic chemical
yr = year

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Table A-1.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Outdoor Maintenance Worker RME, Landfill AOPC

Definition	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
Body Weight	BW_a	80	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Fraction Contaminated Soil Ingested, worker	FI_w	1.0	unitless
Soil Ingestion Rate, worker	IRS_w	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(\text{mg/kg-day})^{-1}$

Equations

Cancer Risk:

$$Risk = SF_o \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365 day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,a} \times 365 day/year} \right] \right\}$$

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(\text{mg/kg-day})^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Inorganic Constituents							
Arsenic	1.05E+01	1.50E+00	2.60E-06	7%	3.00E-04	1.62E-02	98%
Chromium (III)	5.94E+02	No Toxicity Value	--	--	1.50E+00	3.05E-04	2%
Lead	5.11E+02	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]anthracene	9.96E+00	7.30E-01	2.00E-06	5%	No Toxicity Value	--	--
Benzo[a]pyrene	1.12E+01	7.30E+00	2.25E-05	57%	No Toxicity Value	--	--
Benzo[b]fluoranthene	1.52E+01	7.30E-01	3.05E-06	8%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.06E+00	7.30E+00	4.14E-06	10%	No Toxicity Value	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	7.30E-01	1.37E-06	3%	No Toxicity Value	--	--
Benzofluoranthenes, total	1.88E+01	7.30E-01	3.77E-06	10%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 3.9E-05			Hazard Index 1.6E-02	

Table A-1.2

Derivation of Inhalation Factors for Inhalation Exposures, Outdoor Maintenance Worker RME, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient	K_d	chemical-specific	cm^3/g
for organics: $Kd=K_{OC}\times F_{OC}$			
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 25-yr occupational worker	T_{Worker}	7.88E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{\left(3.14 \times D_A \times T_{[receptor]}\right)^{1/2}}{\left(2 \times \rho_b \times D_A\right)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	D_i (cm^2/s)	Reference	D_w (cm^2/s)	Reference	H' (dimensionless)	Reference	K_{OC} (cm^3/g)	Reference	K_d (cm^3/g)	D_A (cm^2/s)	**VFs** (VOCs) Occupational m^3/kg	**PEF** (non-VOCs) m^3/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA 2012)	5.943E-06	RSLs ("WATER9"; USEPA 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA 2011a)	176900	EPISuite v4.10 (USEPA 2011a); MCI-estimated	1769	7.523E-10	non-VOC	1.360E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	5874	1.396E-11	non-VOC	1.360E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	5994	1.704E-11	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.207E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	19120	2.457E-12	non-VOC	1.360E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA 2012)	5.233E-06	RSLs ("WATER9"; USEPA 2012)	0.0000656	EPISuite v4.10 (USEPA 2011a)	3470000	EPISuite v4.10 (USEPA 2011a)	34700	5.359E-12	non-VOC	1.360E+09
Benzofluoranthenes, total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	5994	1.704E-11	non-VOC	1.360E+09

Table A-1.3
Risk and Hazard Estimates: Inhalation, Outdoor Maintenance Worker RME, Landfill AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Exposure Time, worker	ET_w	8.00	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

$$Risk = IUR \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365 \ days / year \times 24 \ hours / day} \right)$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365 \ days / year \times 24 \ hours / day} \right)$$

where:

$$C_{air} = \frac{C_{soil}}{VF \ or \ PEF} \times 1000 \ \frac{\mu g}{mg}$$

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Arsenic	1.05E+01	1.360E+09	7.72E-06	4.30E-03	1.46E-09	57%	1.50E-02	6.35E-05	100%
Chromium (III)	5.94E+02	1.360E+09	4.37E-04	No Toxicity Value	--	--	No Toxicity Value	--	--
Lead	5.11E+02	1.360E+09	3.76E-04	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	9.96E+00	1.360E+09	7.32E-06	1.10E-04	5.91E-11	2%	No Toxicity Value	--	--
Benzo[a]pyrene	1.12E+01	1.360E+09	8.24E-06	1.10E-03	6.65E-10	26%	No Toxicity Value	--	--
Benzo[b]fluoranthene	1.52E+01	1.360E+09	1.12E-05	1.10E-04	9.02E-11	4%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.06E+00	1.360E+09	1.51E-06	1.20E-03	1.33E-10	5%	No Toxicity Value	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	1.360E+09	5.00E-06	1.10E-04	4.04E-11	2%	No Toxicity Value	--	--
Benzofluoranthenes, total	1.88E+01	1.360E+09	1.38E-05	1.10E-04	1.11E-10	4%	No Toxicity Value	--	--
				Pathway Sums:	Cancer Risk 2.6E-09			Hazard Index 6.3E-05	

Table A-1.4
Risk and Hazard Estimates: Dermal Contact with Soil, Outdoor Maintenance Worker RME, Landfill AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, worker	AF_w	0.12	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, worker	EC_w	1	unitless
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Event Frequency, worker	EV_w	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, worker	SA_s	3527	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_c \times 365\, day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_{nc,a} \times 365\, day/year} \right] \right\}$$

Analyte	**C_{soil}** (mg/kg)	**ABS_d** (unitless)	**SF_d** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_d** (mg/kg-day)	**Hazard Quotient** (dimensionless)	**% of Total**
Inorganic Constituents								
Arsenic	1.05E+01	3.00E-02	1.50E+00	3.30E-07	2%	3.00E-04	2.05E-03	67%
Chromium (III)	5.94E+02	1.00E-02		--	--	1.95E-02	9.93E-04	33%
Lead	5.11E+02	1.00E-02		--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]anthracene	9.96E+00	1.30E-01	7.30E-01	1.10E-06	5%	--	--	--
Benzo[a]pyrene	1.12E+01	1.30E-01	7.30E+00	1.24E-05	60%	--	--	--
Benzo[b]fluoranthene	1.52E+01	1.30E-01	7.30E-01	1.68E-06	8%	--	--	--
Dibenz[a,h]anthracene	2.06E+00	1.30E-01	7.30E+00	2.28E-06	11%	--	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	1.30E-01	7.30E-01	7.52E-07	4%	--	--	--
Benzofluoranthenes, total	1.88E+01	1.30E-01	7.30E-01	2.08E-06	10%	--	--	--
			Pathway Sums:	Cancer Risk 2.1E-05			Hazard Index 3.0E-03	

Table A-2.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Outdoor Maintenance Worker CTE, Landfill AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs	
Body Weight	BW_a	80	kg	$$Risk = SF_o \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365\,day/year} \right] \right\}$$
Conversion Factor	CF_o	1E-06	kg/mg	
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, worker	ED_w	6	yrs	Noncancer Hazard:
Exposure Frequency, worker	EF_w	225	days/yr	
Fraction Contaminated Soil Ingested, worker	FI_w	1.0	unitless	$$Hazard = \frac{1}{RfD_o} \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,a} \times 365\,day/year} \right] \right\}$$
Soil Ingestion Rate, worker	IRS_w	50	mg/day	
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day	
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Inorganic Constituents							
Arsenic	1.05E+01	1.50E+00	3.12E-07	7%	3.00E-04	8.09E-03	98%
Chromium (III)	5.94E+02	No Toxicity Value	--	--	1.50E+00	1.53E-04	2%
Lead	5.11E+02	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]anthracene	9.96E+00	7.30E-01	2.40E-07	5%	No Toxicity Value	--	--
Benzo[a]pyrene	1.12E+01	7.30E+00	2.70E-06	57%	No Toxicity Value	--	--
Benzo[b]fluoranthene	1.52E+01	7.30E-01	3.66E-07	8%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.06E+00	7.30E+00	4.97E-07	10%	No Toxicity Value	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	7.30E-01	1.64E-07	3%	No Toxicity Value	--	--
Benzofluoranthenes, total	1.91E+01	7.30E-01	4.60E-07	10%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 4.7E-06			Hazard Index 8.2E-03	

Table A-2.2
Derivation of Inhalation Factors for Inhalation Exposures, Outdoor Maintenance Worker CTE, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.320E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 6-yr occupational worker	T_{Worker}	1.89E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{\left(3.14 \times D_A \times T_{[receptor]}\right)^{1/2}}{\left(2 \times \rho_b \times D_A\right)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	D_i (cm²/s)	Reference	D_w (cm²/s)	Reference	H' (dimensionless)	Reference	K_{OC} (cm³/g)	Reference	K_d (cm³/g)	D_A (cm²/s)	**VFs** (VOCs) Occupational m³/kg	**PEF** (non-VOCs) m³/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.36E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.36E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	900	0	non-VOC	1.36E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA, 2012)	5.94E-06	RSLs ("WATER9"; USEPA, 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA, 2011a)	176900	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	1769	7.5E-10	non-VOC	1.36E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	5874	1.4E-11	non-VOC	1.36E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	599400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	5994	1.7E-11	non-VOC	1.36E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA, 2012)	5.21E-06	RSLs ("WATER9"; USEPA, 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA, 2011a)	1912000	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	19120	2.5E-12	non-VOC	1.36E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA, 2012)	5.23E-06	RSLs ("WATER9"; USEPA, 2012)	0.0000656	EPISuite v4.10 (USEPA, 2011a)	3470000	EPISuite v4.10 (USEPA, 2011a)	34700	5.4E-12	non-VOC	1.36E+09
Benzofluoranthenes, total	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	599400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	5994	1.7E-11	non-VOC	1.36E+09

Table A-2.3
Risk and Hazard Estimates: Inhalation, Outdoor Maintenance Worker CTE, Landfill AOPC

Description	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs	$Risk = IUR \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365\ days\ /\ year \times 24\ hours\ /\ day} \right)$
COPC Concentration in air	C_{air}	chemical-specific	µg/m^3	
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, worker	ED_w	6	yrs	Noncancer Hazard:
Exposure Frequency, worker	EF_w	225	days/yr	$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365\ days\ /\ year \times 24\ hours\ /\ day} \right)$
Exposure Time, worker	ET_w	8.00	hours/day	
Inhalation Unit-Risk Factor	IUR	chemical-specific	(µg/m^3)$^{-1}$	
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg	
Inhalation Reference Concentration	RfC	chemical-specific	µg/m^3	where: $C_{air} = \frac{C_{soil}}{VF\ or\ PEF} \times 1000\ \frac{\mu g}{mg}$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg	

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} (µg/m^3)	IUR (µg/m^3)$^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC (µg/m^3)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Arsenic	1.05E+01	1.360E+09	7.72E-06	4.30E-03	3.51E-10	57%	1.50E-02	6.35E-05	100%
Chromium (III)	5.94E+02	1.360E+09	4.37E-04	No Toxicity Value	--	--	No Toxicity Value	--	--
Lead	5.11E+02	1.360E+09	3.76E-04	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	9.96E+00	1.360E+09	7.32E-06	1.10E-04	1.42E-11	2%	No Toxicity Value	--	--
Benzo[a]pyrene	1.12E+01	1.360E+09	8.24E-06	1.10E-03	1.60E-10	26%	No Toxicity Value	--	--
Benzo[b]fluoranthene	1.52E+01	1.360E+09	1.12E-05	1.10E-04	2.17E-11	4%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.06E+00	1.360E+09	1.51E-06	1.20E-03	3.20E-11	5%	No Toxicity Value	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	1.360E+09	5.00E-06	1.10E-04	9.69E-12	2%	No Toxicity Value	--	--
Benzofluoranthenes, total	1.91E+01	1.360E+09	1.40E-05	1.10E-04	2.72E-11	4%	No Toxicity Value	--	--
				Pathway Sums:	Cancer Risk 6.2E-10			Hazard Index 6.3E-05	

Table A-2.4
Risk and Hazard Estimates: Dermal Contact with Soil, Outdoor Maintenance Worker CTE, Landfill AOPC

Description	Variable	Value	Units
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, worker	AF_w	0.02	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, worker	EC_w	1	unitless
Exposure Duration, worker	ED_w	6	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Event Frequency, worker	EV_w	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, worker	SA_w	3300	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_c \times 365\, day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_{nc,a} \times 365\, day/year} \right] \right\}$$

Analyte	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents								
Arsenic	1.05E+01	3.00E-02	1.50E+00	1.24E-08	2%	3.00E-04	3.20E-04	67%
Chromium (III)	5.94E+02	1.00E-02		--	--	1.95E-02	1.55E-04	33%
Lead	5.11E+02	1.00E-02		--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]anthracene	9.96E+00	1.30E-01	7.30E-01	4.12E-08	5%	--	--	--
Benzo[a]pyrene	1.12E+01	1.30E-01	7.30E+00	4.63E-07	60%	--	--	--
Benzo[b]fluoranthene	1.52E+01	1.30E-01	7.30E-01	6.29E-08	8%	--	--	--
Dibenz[a,h]anthracene	2.06E+00	1.30E-01	7.30E+00	8.52E-08	11%	--	--	--
Indeno[1,2,3-cd]pyrene	6.80E+00	1.30E-01	7.30E-01	2.81E-08	4%	--	--	--
Benzofluoranthenes, total	1.91E+01	1.30E-01	7.30E-01	7.90E-08	10%	--	--	--
			Pathway Sums:	Cancer Risk: 7.7E-07			Hazard Index: 4.8E-04	

Table A-3.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Construction Worker RME, Landfill AOPC

Definition	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight	BW_{cw}	80	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Fraction Contaminated Soil Ingested, construction worker	FI_{cw}	1.0	unitless
Soil Ingestion Rate, worker	IRS_{cw}	330	mg/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Cancer Risk:

$$Risk = SF_o \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_c \times 365\ day\ /\ year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_{nc,cw} \times 365\ day\ /\ year} \right) \right]$$

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)							
Tetrachloroethene	1.27E+02	2.10E-03	1.08E-08	< 1%	6.00E-03	5.98E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	1.08E+01	7.30E+00	3.18E-06	100%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 3.2E-06			Hazard Index 6.0E-02	

Table A-3.2
Derivation of Inhalation Factors for Inhalation Exposures, Construction Worker RME, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.000E+06	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 1-yr construction worker	T_{cw}	3.15E+07	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C)\times\frac{(3.14\times D_A\times T_{[receptor]})^{1/2}}{(2\times\rho_b\times D_A)}\times CF_i$$

based on:

$$DA=\frac{\left[\left(\Theta_a^{10/3}D_iH'+\Theta_w^{10/3}D_w\right)/n^2\right]}{\rho_B Kd+\Theta_w+\Theta_a H'}$$

Analyte	**D_i** (cm^2/s)	Reference	**D_w** (cm^2/s)	Reference	**H'** (dimensionless)	Reference	**K_{OC}** (cm^3/g)	Reference	**K_d** (cm^3/g)	**D_A** (cm^2/s)	**VFs** (VOCs) Construction m^3/kg	**PEF** (non-VOCs) m^3/kg
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA, 2012)	9.46E-06	RSLs ("WATER9"; USEPA, 2012)	0.7238	Experimental, EPISuite v4.10 (USEPA, 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0.9494	0.001597	609.6009273	use VF
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	1.87E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	5874	1.4E-11	non-VOC	1.000E+06

Table A-3.3
Risk and Hazard Estimates: Inhalation, Construction Worker, Landfill AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Exposure Time, construction worker	ET_{cw}	8	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.00E+06	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_c \times 365 \ days \ / \ year \times 24 \ hours \ / \ day} \right)$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_{nc,cw} \times 365 \ days \ / \ year \times 24 \ hours \ / \ day} \right)$$

where: $$C_{air} = \frac{C_{soil}}{VF \ or \ PEF} \times 1000 \ \frac{\mu g}{mg}$$

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	1.27E+02	6.10E+02	2.08E+02	2.60E-07	1.77E-07	82%	4.00E+01	1.19E+00	100%
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	1.08E+01	1.00E+06	1.08E-02	1.10E-03	3.87E-08	18%	No Toxicity Value	--	--
				Pathway Sums:	Cancer Risk 2.2E-07			Hazard Index 1.2E+00	

Table A-3.4

Risk and Hazard Estimates: Dermal Contact with Soil, Construction Worker RME, Landfill AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, construction worker	AF_{cw}	0.3	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight, adult	BW_{cw}	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, construction worker	EC_{cw}	1	unitless
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Event Frequency, construction worker	EV_{cw}	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, construction worker	SA_{cw}	3527	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_c \times 365 \ day/year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_{nc,cw} \times 365 \ day/year} \right) \right]$$

Analyte	**C_{soil}** (mg/kg)	**ABS_d** (unitless)	**SF_d** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_d** (mg/kg-day)	**Hazard Quotient** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)	1.00E+00							
Tetrachloroethene	1.27E+02	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	1.08E+01	1.30E-01	7.30E+00	1.33E-06	100%	--	--	--
Pathway Sums:				Cancer Risk: 1.3E-06			Hazard Index: <0.1	

Table A-4.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Construction Worker CTE, Landfill AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs	
Body Weight	BW_{cw}	80	kg	$Risk = SF_o \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_c \times 365 \ day / year} \right) \right]$
Conversion Factor	CF_o	1E-06	kg/mg	
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, construction worker	ED_{cw}	1	yrs	Noncancer Hazard:
Exposure Frequency, construction worker	EF_{cw}	250	days/yr	
Fraction Contaminated Soil Ingested, construction worker	FI_{cw}	1.0	unitless	$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_{nc,cw} \times 365 \ day / year} \right) \right]$
Soil Ingestion Rate, worker	IRS_{cw}	100	mg/day	
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day	
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)							
Tetrachloroethene	1.27E+02	2.10E-03	1.63E-09	< 1%	6.00E-03	1.81E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	1.08E+01	7.30E+00	4.82E-07	100%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 4.8E-07			Hazard Index 1.8E-02	

Table A-4.2
Derivation of Inhalation Factors for Inhalation Exposures, Construction Worker CTE, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.000E+06	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 0.5-yr construction worker	T_{cw}	1.58E+07	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{(3.14 \times D_A \times T_{receptor})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	D_i (cm²/s)	D_i Reference	D_w (cm²/s)	D_w Reference	H' (dimensionless)	H' Reference	K_{OC} (cm³/g)	K_{OC} Reference	K_d (cm³/g)	D_A (cm²/s)	**VFs** (VOCs) (a) Construction m³/kg	**PEF** (non-VOCs) m³/kg
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA, 2012)	9.46E-06	RSLs ("WATER9"; USEPA, 2012)	0.724	Experimental, EPISuite v4.10 (USEPA, 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	0.00805	--	use VF
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	1.87E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.000E+06

Notes
(a) The VF for this receptor pathway is not calculated.

Table A-4.3
Risk and Hazard Estimates: Inhalation, Construction Worker CTE, Landfill AOPC

Description	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	0.5	yrs	
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$	$Risk = IUR \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_c \times 365 \ days/year \times 24 \ hours/day} \right)$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, construction worker	ED_{cw}	0.5	yrs	Noncancer Hazard:
Exposure Frequency, construction worker	EF_{cw}	250	days/yr	
Exposure Time, construction worker	ET_{cw}	8	hours/day	$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_{nc,cw} \times 365 \ days/year \times 24 \ hours/day} \right)$
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$	
Particulate Emission Factor (non-VOCs)	PEF	1.00E+06	m^3/kg	
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$	where: $C_{air} = \frac{C_{soil}}{VF \ or \ PEF} \times 1000 \frac{\mu g}{mg}$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg	

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)	1								
Tetrachloroethene	1.27E+02	--	--	2.60E-07	--	--	4.00E+01	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	1.08E+01	1.00E+06	1.08E-02	1.10E-03	1.94E-08	100%	No Toxicity Value	--	--

	Cancer Risk	Hazard Index
Pathway Sums:	1.9E-08	--

Table A-4.4
Risk and Hazard Estimates: Dermal Contact with Soil, Construction Worker CTE, Landfill AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, construction worker	AF_{cw}	0.1	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight, adult	BW_{cw}	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, construction worker	EC_{cw}	1	unitless
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Event Frequency, construction worker	EV_{cw}	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, construction worker	SA_{cw}	3300	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_c \times 365 \ day/year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_{nc,cw} \times 365 \ day/year} \right) \right]$$

Analyte	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Hazard Quotient (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)	1.00E+00							
Tetrachloroethene	1.27E+02	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	1.08E+01	1.30E-01	7.30E+00	2.07E-07	100%	--	--	--
			Pathway Sums:	Cancer Risk 2.1E-07			Hazard Index 0.00E+00	

Table A-5.NI

Nursing Infant: Hypothetical Fishing Platform User: Current Scenario : RME Summary - Landfill AOPC

Definition	Variable	Value	Source	Equations	
Infant Risk Adjustment Factor	IRAF	Chemical Specific	ODEQ 2010		
Carcinogenic IRAFc					
Total PCB	IRAFc_pcb	0.6	ODEQ 2010	Infant Cancer Risk =	Mother Risk x IRAFc
Noncancer IRAFnc					
Total PCB	IRAFnc_pcb	4	ODEQ 2010	Infant Noncancer Hazard =	Child HQ x IRAFnc

		Mother		Infant	
Analyte	C_{soilt} (mg/kg)	**Cancer Risk (adult)**	**Hazard Quotient (child)**	**Cancer Risk**	**Hazard Quotient**
Total PCBs as Congeners (KM-based, capped)	4E-01	1.7E-06	3.6E-01	1.0E-06	**1.5**

Table A-5.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: Current Scenario RME, Landfill AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	100	mg/day
Soil Ingestion Rate (child)	IRS_c	200	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations / Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_o \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365 \frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365 \frac{day}{year}} \right) \right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year} \right) \right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{ C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a} \right)}{AT_c \times 365 \frac{days}{year}} + \frac{IRS_c}{BW_c} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year} \right) \right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents									
Arsenic	0.00E+00	1.05E+01	1.50E+00	1.42E-05	2%	3.00E-04	2.80E-01	34%	2.63E-02
Chromium (III)	0.00E+00	5.94E+02	No Toxicity Value	--	--	1.50E+00	5.28E-03	< 1%	4.95E-04
Lead	0.00E+00	0.00E+00	8.50E-03	0.00E+00	< 1%	No Toxicity Value	--	--	--
Mercury	0.00E+00	1.45E+00	No Toxicity Value	--	--	1.60E-04	1.21E-01	14%	1.13E-02
Polychlorinated Biphenyls (PCBs) - Mixtures									
Total PCBs	0.00E+00	4.10E-01	2.00E+00	1.23E-06	< 1%	2.00E-05	2.73E-01	33%	2.56E-02
Volatile Organic Compounds (VOCs)									
Naphthalene	0.00E+00	3.83E+00	No Toxicity Value	--	--	2.00E-02	2.55E-03	< 1%	2.39E-04
Pesticides									
MCPP	0.00E+00	1.12E+01	No Toxicity Value	--	--	1.00E-03	1.49E-01	18%	1.40E-02
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	M	9.96E+00	7.30E-01	4.95E-05	5%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	1.12E+01	7.30E+00	5.57E-04	59%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	7.30E-01	7.56E-05	8%	No Toxicity Value	--	--	--

Table A-5.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: Current Scenario RME, Landfill AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0\text{-}2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2\text{-}6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6\text{-}16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16\text{-}26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	$ED_{0\text{-}2}$	2	yrs
Exposure Duration, child 2-6	$ED_{2\text{-}6}$	4	yrs
Exposure Duration, child 6-16	$ED_{6\text{-}16}$	10	yrs
Exposure Duration, adult 16-26	$ED_{16\text{-}26}$	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	100	mg/day
Soil Ingestion Rate (child)	IRS_c	200	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\,\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\,\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \Bigg[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\Bigg]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\,\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	No Toxicity Value	--	--	3.00E-02	2.59E-03	< 1%	2.43E-04
Benzo[k]fluoranthene	M	2.63E+01	7.30E-02	1.31E-05	1%	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	7.30E-01	9.34E-05	10%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.06E+00	7.30E+00	1.02E-04	11%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	7.30E-01	3.38E-05	4%	No Toxicity Value	--	--	--
			Pathway Sum:	Cancer Risk 9.4E-04		Pathway Sum:	Hazard Index (Child) 0.83		Hazard Index (Adult) 0.078

Table A-5.2
Derivation of Inhalation Factors for Inhalation Exposures, Hypothetical Fishing Platform User: Current Scenario RME, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.006	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC} \times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C_{vol}	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 30-yr resident	$T_{Resident}$	8.20E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = Q/C_{vol} \times \frac{(3.14 \times D_A \times T_{resident})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$D_A = \frac{\left[\left(\theta_a{}^{10/3} D_i H' + \theta_w{}^{10/3} D_w\right)/n^2\right]}{\rho_B K_d + \theta_w + \theta_a H'}$$

Analyte	D_i (cm^2/s)	D_i Reference	D_w (cm^2/s)	D_w Reference	H' (dimensionless)	H' Reference	K_{OC} (cm^3/g)	K_{OC} Reference	K_d (cm^3/g)	D_A (cm^2/s)	VFs (VOCs) Residential m^3/kg	PEF (non-VOCs) m^3/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Mercury	0.0307	Exhibit C-1, USEPA 2002e	0.0000063	Exhibit C-1, USEPA [2002e]	0.467116057	RSL ("SSL"; USEPA, 2012)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	52	1.42E-05	32929.7937	use VF
Polychlorinated Biphenyls (PCBs) - Mixtures												
Total PCBs	0.040076	RSLs ("WATER9"; USEPA 2012)	4.6826E-06	RSLs ("WATER9"; USEPA 2012)	0.011572806	Experimental, EPISuite v4.10 (USEPA 2011a)	130500	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	0.000235	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Naphthalene	0.0604994	RSLs ("WATER9"; USEPA 2012)	8.377E-06	RSLs ("WATER9"; USEPA 2012)	0.017993055	Experimental, EPISuite v4.10 (USEPA 2011a)	1544	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	0.000546	5316.643215	use VF
Pesticides												
MCPP	0.0529988	RSLs ("WATER9"; USEPA 2012)	6.1925E-06	RSLs ("WATER9"; USEPA 2012)	3.66404E-08	Experimental, EPISuite v4.10 (USEPA 2011a)	48.51	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	4.01E-07	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA 2012)	5.9431E-06	RSLs ("WATER9"; USEPA 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA 2011a)	176900	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.33E-05	non-VOC	1.360E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.360E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.02E-06	non-VOC	1.360E+09
Benzo[g,h,i]perylene	0	0	0	0	1.35357E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	1951000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0	non-VOC	1.360E+09
Benzo[k]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.38817E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	9.48E-07	non-VOC	1.360E+09
Benzofluoranthenes, Total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.02E-06	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.2073E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	4.7E-07	non-VOC	1.360E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA 2012)	5.2327E-06	RSLs ("WATER9"; USEPA 2012)	0.0000656	EPISuite v4.10 (USEPA 2011a)	3470000	EPISuite v4.10 (USEPA 2011a)	0	1.86E-06	non-VOC	1.360E+09

Table A-5.3
Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Landfill AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	26	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	µg/m^3
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	26	yrs
Exposure Frequency	EF_r	365	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	(µg/m^3)$^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	µg/m^3
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\,\frac{day}{year} \times 24\,\frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \Bigg[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \Bigg]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365\,\frac{day}{year} \times 24\,\frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000\ \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} (µg/m^3)	IUR (µg/m^3)$^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC (µg/m^3)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents											
Arsenic	0.00E+00	1.05E+01	1.360E+09	7.72E-06	4.30E-03	7.40E-09	< 1%	1.50E-02	3.09E-04	< 1%	3.09E-04
Chromium (III)	0.00E+00	5.94E+02	1.360E+09	4.37E-04	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Lead	0.00E+00	0.00E+00	1.360E+09	0.00E+00	1.20E-05	0.00E+00	< 1%	No Toxicity Value	--	--	--
Mercury	0.00E+00	1.45E+00	3.293E+04	4.40E-02	No Toxicity Value	--	--	3.00E-01	1.47E-01	38%	1.47E-01
Polychlorinated Biphenyls (PCBs) - Mixtures											
Total PCBs	0.00E+00	4.10E-01	1.360E+09	3.01E-07	5.70E-04	6.38E-11	< 1%	No Toxicity Value	--	--	--
Volatile Organic Compounds (VOCs)											
Naphthalene	0.00E+00	3.83E+00	5.317E+03	7.20E-01	3.40E-05	9.10E-06	100%	3.00E+00	2.40E-01	62%	2.40E-01
Pesticides											
MCPP	0.00E+00	1.12E+01	1.360E+09	8.24E-06	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	M	9.96E+00	1.360E+09	7.32E-06	1.10E-04	8.29E-10	< 1%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	1.12E+01	1.360E+09	8.24E-06	1.10E-03	9.32E-09	< 1%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	1.360E+09	1.12E-05	1.10E-04	1.26E-09	< 1%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	1.360E+09	4.28E-06	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Benzo[k]fluoranthene	M	2.63E+01	1.360E+09	1.93E-05	1.10E-04	2.19E-09	< 1%	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	1.360E+09	1.38E-05	1.10E-04	1.56E-09	< 1%	No Toxicity Value	--	--	--

Table A-5.3
Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Landfill AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	26	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	26	yrs
Exposure Frequency	EF_r	365	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \left[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \right]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000 \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Dibenz[a,h]anthracene	M	2.06E+00	1.360E+09	1.51E-06	1.20E-03	1.87E-09	< 1%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	1.360E+09	5.00E-06	1.10E-04	5.66E-10	< 1%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	9.1E-06	Pathway Sum:	0.39	0.39

Table A-5.4

Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: RME, Landfill AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.07	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.2	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times \left[C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)\right]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents										
Arsenic	0.00E+00	1.05E+01	3.00E-02	1.50E+00	1.20E-06	< 1%	3.00E-04	1.99E-02	12%	3.33E-03
Chromium (III)	0.00E+00	5.94E+02	1.00E-02	--	--	--	1.95E-02	9.64E-03	6%	1.61E-03
Lead	0.00E+00	0.00E+00	1.00E-02	8.50E-03	0.00E+00	< 1%	--	--	--	--
Mercury	0.00E+00	1.45E+00	1.00E-02	--	--	--	1.60E-04	2.87E-03	2%	4.78E-04
Polychlorinated Biphenyls (PCBs) - Mixtures										
Total PCBs	0.00E+00	4.10E-01	1.40E-01	2.00E+00	4.84E-07	< 1%	2.00E-05	9.08E-02	57%	1.51E-02
Volatile Organic Compounds (VOCs)										
Naphthalene	0.00E+00	3.83E+00	1.30E-01	--	--	--	2.00E-02	7.88E-04	< 1%	1.31E-04
Pesticides										
MCPP	0.00E+00	1.12E+01	1.00E-01	--	--	--	1.00E-03	3.54E-02	22%	5.91E-03

Table A-5.4

Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: RME, Landfill AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.07	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.2	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times \left[C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)\right]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Polycyclic Aromatic Hydrocarbons (PAHs)										
Benzo[a]anthracene	M	9.96E+00	1.30E-01	7.30E-01	1.65E-05	5%	--	--	--	--
Benzo[a]pyrene	M	1.12E+01	1.30E-01	7.30E+00	1.86E-04	60%	--	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	1.30E-01	7.30E-01	2.52E-05	8%	--	--	--	--
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	1.30E-01	--	--	--	3.00E-02	7.98E-04	< 1%	1.33E-04
Benzo[k]fluoranthene	M	2.63E+01	1.30E-01	7.30E-02	4.36E-06	1%	--	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	1.30E-01	7.30E-01	3.12E-05	10%	--	--	--	--
Dibenz[a,h]anthracene	M	2.06E+00	1.30E-01	7.30E+00	3.42E-05	11%	--	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	1.30E-01	7.30E-01	1.13E-05	4%	--	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	3.1E-04	Pathway Sum:	0.16	0.027

Table A-6.NI

Nursing Infant: Hypothetical Fishing Platform User: CTE Summary - Landfill AOPC

Definition	Variable	Value	Source	Equations	
Infant Risk Adjustment Factor	IRAF	Chemical Specific	ODEQ 2010		
Carcinogenic IRAFc					
Total PCB	IRAFc_pcb	0.6	ODEQ 2010	Infant Cancer Risk =	Mother Risk x IRAFc
Noncancer IRAFnc					
Total PCB	IRAFnc_pcb	4	ODEQ 2010	Infant Noncancer Hazard =	Child HQ x IRAFnc

		Mother		Infant	
Analyte	C_{soilt} (mg/kg)	**Cancer Risk (adult)**	**Hazard Quotient (child)**	**Cancer Risk**	**Hazard Quotient**
Total PCBs as Congeners (KM-based, capped)	4E-01	2.3E-07	6.4E-02	1.4E-07	0.26

Table A-6.1

Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: CTE, Landfill AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0\text{-}2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2\text{-}6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6\text{-}16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16\text{-}26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	$ED_{0\text{-}2}$	2	yrs
Exposure Duration, child 2-6	$ED_{2\text{-}6}$	4	yrs
Exposure Duration, child 6-16	$ED_{6\text{-}16}$	10	yrs
Exposure Duration, adult 16-26	$ED_{16\text{-}26}$	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	50	mg/day
Soil Ingestion Rate (child)	IRS_c	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations — Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\,\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\,\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\,\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	**Mutagen?**	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard (Child)** (dimensionless)	**% of Total**	**Noncancer Hazard (Adult)** (dimensionless)
Inorganic Constituents									
Arsenic	0.00E+00	1.05E+01	1.50E+00	2.35E-06	1%	3.00E-04	5.83E-02	34%	5.47E-03
Chromium (III)	0.00E+00	5.94E+02	No Toxicity Value	--	--	1.50E+00	1.10E-03	< 1%	1.03E-04
Lead	0.00E+00	0.00E+00	8.50E-03	0.00E+00	< 1%	No Toxicity Value	--	--	--
Mercury	0.00E+00	1.45E+00	No Toxicity Value	--	--	1.60E-04	2.52E-02	14%	2.36E-03
Polychlorinated Biphenyls (PCBs) - Mixtures									
Total PCBs	0.00E+00	4.10E-01	2.00E+00	2.04E-07	< 1%	2.00E-05	5.69E-02	33%	5.34E-03
Volatile Organic Compounds (VOCs)									
Naphthalene	0.00E+00	3.83E+00	No Toxicity Value	--	--	2.00E-02	5.32E-04	< 1%	4.98E-05
Pesticides									
MCPP	0.00E+00	1.12E+01	No Toxicity Value	--	--	1.00E-03	3.11E-02	18%	2.92E-03
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	M	9.96E+00	7.30E-01	1.03E-05	5%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	1.12E+01	7.30E+00	1.16E-04	59%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	7.30E-01	1.57E-05	8%	No Toxicity Value	--	--	--

Table A-6.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: CTE, Landfill AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	50	mg/day
Soil Ingestion Rate (child)	IRS_c	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\,\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\,\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\,\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	No Toxicity Value	--	--	3.00E-02	5.39E-04	< 1%	5.05E-05
Benzo[k]fluoranthene	M	2.63E+01	7.30E-02	2.72E-06	1%	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	7.30E-01	1.94E-05	10%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.06E+00	7.30E+00	2.13E-05	11%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	7.30E-01	7.04E-06	4%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	2.0E-04	Pathway Sum:	0.17	0.016

Table A-6.2
Derivation of Inhalation Factors for Inhalation Exposures, Hypothetical Fishing Platform User: CTE, Landfill AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.006	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C_{vol}	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 30-yr resident	$T_{Resident}$	2.80E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = Q/C_{vol} \times \frac{(3.14 \times D_A \times T_{resident})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$D_A = \frac{\left[\left(\theta_a^{10/3} D_i H' + \theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B K_d + \theta_w + \theta_a H'}$$

Analyte	D_i (cm^2/s)	D_i Reference	D_w (cm^2/s)	D_w Reference	H' (dimensionless)	H' Reference	K_{OC} (cm^3/g)	K_{OC} Reference	K_d (cm^3/g)	D_A (cm^2/s)	VFs (VOCs) Residential m^3/kg	PEF (non-VOCs) m^3/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Mercury	0.0307	Exhibit C-1, USEPA 2002e	0.0000063	Exhibit C-1, USEPA 2002e	0.467116057	RSL ("SSL"; USEPA 2012)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	52	1.42E-05	19242.4825	use VF
Polychlorinated Biphenyls (PCBs) - Mixtures												
Total PCBs	0.040076	RSLs ("WATER9"; USEPA 2012)	4.6826E-06	RSLs ("WATER9"; USEPA 2012)	0.011572806	Experimental, EPISuite v4.10 (USEPA 2011a)	130500	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0.000235	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Naphthalene	0.0604994	RSLs ("WATER9"; USEPA 2012)	8.377E-06	RSLs ("WATER9"; USEPA 2012)	0.017993055	Experimental, EPISuite v4.10 (USEPA 2011a)	1544	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0.000546	3106.7736	use VF
Pesticides												
MCPP	0.0529988	RSLs ("WATER9"; USEPA 2012)	6.1925E-06	RSLs ("WATER9"; USEPA 2012)	3.66404E-08	Experimental, EPISuite v4.10 (USEPA 2011a)	48.51	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	4.01E-07	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA 2012)	5.9431E-06	RSLs ("WATER9"; USEPA 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA 2011a)	176900	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.33E-05	non-VOC	1.360E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.360E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.02E-06	non-VOC	1.360E+09
Benzo[g,h,i]perylene	0	0	0	0	1.35357E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	1951000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0	non-VOC	1.360E+09
Benzo[k]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.38817E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	9.48E-07	non-VOC	1.360E+09
Benzofluoranthenes, Total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.5597E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.02E-06	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.2073E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	4.7E-07	non-VOC	1.360E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA 2012)	5.2327E-06	RSLs ("WATER9"; USEPA 2012)	0.0000656	EPISuite v4.10 (USEPA 2011a)	3470000	EPISuite v4.10 (USEPA 2011a)	0	1.86E-06	non-VOC	1.360E+09

Table A-6.3
Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Landfill AOPC

Description	Variable	Value	Units
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	9	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	9	yrs
Exposure Frequency	EF_r	152	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \Bigg[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \Bigg]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000 \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents											
Arsenic	0.00E+00	1.05E+01	1.360E+09	7.72E-06	4.30E-03	1.07E-09	< 1%	1.50E-02	1.29E-04	< 1%	1.29E-04
Chromium (III)	0.00E+00	5.94E+02	1.360E+09	4.37E-04	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Lead	0.00E+00	0.00E+00	1.360E+09	0.00E+00	1.20E-05	0.00E+00	< 1%	No Toxicity Value	--	--	--
Mercury	0.00E+00	1.45E+00	1.924E+04	7.54E-02	No Toxicity Value	--	--	3.00E-01	1.05E-01	38%	1.05E-01
Polychlorinated Biphenyls (PCBs) - Mixtures											
Total PCBs	0.00E+00	4.10E-01	1.360E+09	3.01E-07	5.70E-04	9.20E-12	< 1%	No Toxicity Value	--	--	--
Volatile Organic Compounds (VOCs)											
Naphthalene	0.00E+00	3.83E+00	3.107E+03	1.23E+00	3.40E-05	2.24E-06	100%	3.00E+00	1.71E-01	62%	1.71E-01
Pesticides											
MCPP	0.00E+00	1.12E+01	1.360E+09	8.24E-06	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	M	9.96E+00	1.360E+09	7.32E-06	1.10E-04	3.45E-10	< 1%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	1.12E+01	1.360E+09	8.24E-06	1.10E-03	3.88E-09	< 1%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	1.360E+09	1.12E-05	1.10E-04	5.27E-10	< 1%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	1.360E+09	4.28E-06	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Benzo[k]fluoranthene	M	2.63E+01	1.360E+09	1.93E-05	1.10E-04	9.11E-10	< 1%	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	1.360E+09	1.38E-05	1.10E-04	6.51E-10	< 1%	No Toxicity Value	--	--	--

Table A-6.3
Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Landfill AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	9	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	µg/m^3
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	9	yrs
Exposure Frequency	EF_r	152	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	(µg/m^3)$^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	µg/m^3
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \Bigg[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \Bigg]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000 \frac{\mu g}{mg}$$

Analyte	**Mutagen?**	**C_{soil}** (mg/kg)	**VF (VOCs)** or **PEF (non-VOCs)** (m^3/kg)	**C_{air}** (µg/m^3)	**IUR** (µg/m^3)$^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfC** (µg/m^3)	**Noncancer Hazard (Child)** (dimensionless)	**% of Total**	**Noncancer Hazard (Adult)** (dimensionless)
Dibenz[a,h]anthracene	M	2.06E+00	1.360E+09	1.51E-06	1.20E-03	7.79E-10	< 1%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	1.360E+09	5.00E-06	1.10E-04	2.36E-10	< 1%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	2.3E-06	Pathway Sum:	0.28	0.28

Table A-6.4
Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: CTE, Landfill AOPC

Description	Variable	Value	Units
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.01	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.04	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times \left[C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)\right]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents										
Arsenic	0.00E+00	1.05E+01	3.00E-02	1.50E+00	6.79E-08	< 1%	3.00E-04	1.66E-03	12%	1.98E-04
Chromium (III)	0.00E+00	5.94E+02	1.00E-02	--	--	--	1.95E-02	8.03E-04	6%	9.56E-05
Lead	0.00E+00	0.00E+00	1.00E-02	8.50E-03	0.00E+00	< 1%	--	--	--	--
Mercury	0.00E+00	1.45E+00	1.00E-02	--	--	--	1.60E-04	2.39E-04	2%	2.85E-05
Polychlorinated Biphenyls (PCBs) - Mixtures										
Total PCBs	0.00E+00	4.10E-01	1.40E-01	2.00E+00	2.75E-08	< 1%	2.00E-05	7.56E-03	57%	9.01E-04
Volatile Organic Compounds (VOCs)										
Naphthalene	0.00E+00	3.83E+00	1.30E-01	--	--	--	2.00E-02	6.56E-05	< 1%	7.82E-06
Pesticides										
MCPP	0.00E+00	1.12E+01	1.00E-01	--	--	--	1.00E-03	2.95E-03	22%	3.52E-04

Table A-6.4
Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: CTE, Landfill AOPC

Description	Variable	Value	Units
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0\text{-}2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2\text{-}6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6\text{-}16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16\text{-}26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.01	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.04	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	$ED_{0\text{-}2}$	2	yrs
Exposure Duration, child 2-6	$ED_{2\text{-}6}$	4	yrs
Exposure Duration, child 6-16	$ED_{6\text{-}16}$	10	yrs
Exposure Duration, adult 16-26	$ED_{16\text{-}26}$	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	(mg/kg-day)$^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times \left[C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)\right]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d (mg/kg-day)$^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Polycyclic Aromatic Hydrocarbons (PAHs)										
Benzo[a]anthracene	M	9.96E+00	1.30E-01	7.30E-01	1.31E-06	5%	--	--	--	--
Benzo[a]pyrene	M	1.12E+01	1.30E-01	7.30E+00	1.47E-05	60%	--	--	--	--
Benzo[b]fluoranthene	M	1.52E+01	1.30E-01	7.30E-01	2.00E-06	8%	--	--	--	--
Benzo[g,h,i]perylene	0.00E+00	5.82E+00	1.30E-01	--	--	--	3.00E-02	6.65E-05	< 1%	7.92E-06
Benzo[k]fluoranthene	M	2.63E+01	1.30E-01	7.30E-02	3.45E-07	1%	--	--	--	--
Benzofluoranthenes, Total	M	1.88E+01	1.30E-01	7.30E-01	2.47E-06	10%	--	--	--	--
Dibenz[a,h]anthracene	M	2.06E+00	1.30E-01	7.30E+00	2.71E-06	11%	--	--	--	--
Indeno[1,2,3-cd]pyrene	M	6.80E+00	1.30E-01	7.30E-01	8.93E-07	4%	--	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult
Pathway Sum:	2.5E-05	Pathway Sum:	0.013	0.0016

Table A-7.1
Risk and Hazard Estimates - Ingestion of Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Landfill AOPC

Definitions	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor, ingestion	CF_o	1.0E-03	mg/µg
COPC Concentration in Water	C_{water}	chemical-specific	µg/L
Exposure Duration, worker	ED_w	1	yrs
Exposure Frequency, worker	EF_w	9	days/yr
Fraction Contaminated Water Ingested, worker	FI_w	1.0	unitless
Water Ingestion Rate, worker	IRW_w	0.02	L/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Carcinogenic:

$$Risk = SF_o \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365\, day / year} \right) \right]$$

Noncarcinogenic:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,w} \times 365\, day / year} \right) \right]$$

Analyte	**C_{water}** (*µg/L*)	**SF_o** (*mg/kg-day*)$^{-1}$	**Cancer Risk** (*dimensionless*)	**% of Total**	**RfD_o** (*mg/kg-day*)	**Noncancer Hazard** (*dimensionless*)	**% of Total**
Inorganic Constituents							
Antimony	2.23E-01	No Toxicity Value	--	--	4.00E-04	3.44E-06	< 1%
Iron	2.91E+04	No Toxicity Value	--	--	7.00E-01	2.56E-04	55%
Mercury	7.69E-02	No Toxicity Value	--	--	1.60E-04	2.96E-06	< 1%
Thallium	2.38E-01	No Toxicity Value	--	--	1.00E-05	1.47E-04	31%
Zinc	2.07E+03	No Toxicity Value	--	--	3.00E-01	4.25E-05	9%
Phthalates							
di-n-octyl phthalate	4.61E+00	No Toxicity Value	--	--	1.00E-02	2.84E-06	< 1%
Volatile Organic Compounds (VOCs)							
Acetone	1.54E+01	No Toxicity Value	--	--	9.00E-01	1.05E-07	< 1%
Chloroform	3.70E+00	3.10E-02	1.01E-11	14%	1.00E-02	2.28E-06	< 1%
Isopropylbenzene	4.60E+00	No Toxicity Value	--	--	1.00E-01	2.84E-07	< 1%
Tetrachloroethene	8.78E+00	2.10E-03	1.62E-12	2%	6.00E-03	9.02E-06	2%
Vinyl Chloride	9.55E-01	7.20E-01	6.06E-11	84%	3.00E-03	1.96E-06	< 1%
n-propylbenzene	2.00E+00	No Toxicity Value	--	--	1.00E-01	1.23E-07	< 1%
1,2,4-trimethylbenzene	5.20E+00	No Toxicity Value	--	--	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 7.2E-11			Hazard Index 4.7E-04	

Table A-7.2

Risk and Hazard Estimates - Inhalation of Volatile Compounds from Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Landfill AOPC

Definition	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs
Body Weight, adult	BW_a	80	kg
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in water	C_{water}	chemical-specific	µg/L
Exposure Duration, worker	ED_w	1	yrs
Exposure Frequency, worker	EF_w	9	days/yr
Exposure Time, worker	ET_w	4.00	hours
Air Inhalation Rate, worker	IRA_w	20	m^3/workday
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Inhalation Unit-Risk Factor	URF	chemical-specific	$(\mu g/m^3)^{-1}$
Volatilization Factor	VF	chemical-specific	L/m^3

Risk and Hazard Equations

Cancer Risk:

$$Risk = URF \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365 \ days / year \times 24} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365 days / year \times 24 hours / day} \right) \right]$$

where:

$$C_{air} = C_{water} \times VF$$

Analyte	C_{water} ($\mu g/L$)	VF (L/m^3)	C_{air} ($\mu g/m^3$)	URF_i $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Phthalates									
di-n-octyl phthalate	4.61E+00	non-VOC	--	No Toxicity Value	--	--	No Toxicity Value	--	--
Volatile Organic Compounds (VOCs)									
Acetone	1.54E+01	4.12E+00	6.34E+01	No Toxicity Value	--	--	3.10E+04	8.41E-06	< 1%
Chloroform	3.70E+00	9.35E+00	3.46E+01	2.30E-05	4.67E-08	94%	9.80E+01	1.45E-03	4%
Isopropylbenzene	4.60E+00	9.55E+00	4.39E+01	No Toxicity Value	--	--	4.00E+02	4.51E-04	1%
Tetrachloroethene	8.78E+00	7.53E+00	6.61E+01	2.60E-07	1.01E-09	2%	4.00E+01	6.79E-03	20%
Vinyl Chloride	9.55E-01	8.31E+00	7.93E+00	4.40E-06	2.05E-09	4%	1.00E+02	3.26E-04	< 1%
n-propylbenzene	2.00E+00	8.46E+00	1.69E+01	No Toxicity Value	--	--	1.00E+03	6.96E-05	< 1%
1,2,4-trimethylbenzene	5.20E+00	8.36E+00	4.35E+01	No Toxicity Value	--	--	7.00E+00	2.55E-02	74%

	Cancer Risk	Hazard Index
Pathway Sums:	5.0E-08	3.5E-02

Table A-7.3

Estimation of Kp, Tau(event), B, and t* for Organic Compounds: Excavation/Trench Worker, Exposure to Groundwater - RME, Landfill AOPC

Definition	Variable	Value		Equations
Permeability coefficient from water	K_p	Calculated (Equation 1)	cm/hr	1) $K_p = 10^{(-2.8+0.66\,LogK_{OW} - 0.0056\,MW)}$
Octanol:water partition coefficient	K_{ow}	Chemical-specific	dimensionless	
Molecular weight	MW	Chemical-specific	g/mole	2) $\tau_{event} = \frac{(l_{sc})^2}{6D_{sc}}$
Lag time per event	τ_{event}	Calculated (Equation 2)	hr/event	
Thickness of the strateum corneum	l_{sc}	0.001	cm	
Effective diffusion coefficient, through the stratum corneum	D_{sc}	Calculated (Equation 2)	cm^2/hr	where: $D_{sc} = l_{sc} \times 10^{(-2.8-0.0056\,MW)}$
Relative contribution of permeability coefficients in stratum corneum and viable epidermis	B	Calculated (Equation 3)	dimensionless	
Time it takes to reach steady state	t*	Calculated (Equation 4)	hr	3) $B = K_p \frac{\sqrt{MW}}{2.6}$ (as an approximation)
Correlation coefficient	b	Calculated (Equation 4)	dimensionless	
Correlation coefficient	c	Calculated (Equation 4)	dimensionless	

4) $If\ \ B \le 0.6: \quad t^* = 2.4\tau_{event}$

$$If\ \ B > 0.6: \quad t^* = 6\tau_{event}\left(b - \sqrt{b^2 - c^2}\right)$$

where: $c = \frac{1 + 3B + 3B^2}{3 \times (1 + B)}$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

Analyte	MW (*g/mole*)	$LogK_{OW}$ (*dimensionless*)	Kp[a] (*cm/hr*)	τ_{event} (*hr/event*)	B (*dimensionless*)	c (*dimensionless*)	b (*dimensionless*)	t* (*hr*)
Inorganic Constituents								
Phthalates								
di-n-octyl phthalate	390.57	8.10E+00	NRP	1.62E+01	--	--	--	--
Volatile Organic Compounds (VOCs)								
Acetone	58.08	-2.40E-01	5.20E-04	2.22E-01	1.53E-03	3.34E-01	3.04E-01	5.34E-01
Chloroform	119.38	1.97E+00	6.79E-03	4.90E-01	2.85E-02	3.53E-01	3.21E-01	1.18E+00
Isopropylbenzene	120.2	3.66E+00	8.76E-02	4.95E-01	3.69E-01	6.13E-01	5.81E-01	1.19E+00
Tetrachloroethene	165.83	3.40E+00	3.28E-02	8.92E-01	1.62E-01	4.49E-01	4.11E-01	2.14E+00
Vinyl Chloride	62.5	1.62E+00	8.30E-03	2.35E-01	2.52E-02	3.50E-01	3.19E-01	5.65E-01
n-propylbenzene	120.2	3.69E+00	9.17E-02	4.95E-01	3.87E-01	6.27E-01	5.97E-01	1.19E+00
1,2,4-trimethylbenzene	120.2	3.63E+00	8.37E-02	4.95E-01	3.53E-01	5.99E-01	5.66E-01	1.19E+00

[a] NRP = Not reliably predicted; the compound's chemical properties fall outside the Effective Prediction Domain for Kp (Equations 3.9 and 3.10; USEPA, 2004a).

-- = No value

Table A-7.4
Calculation of Dose Absorbed Per Unit Area Per Event: Excavation/Trench Worker, Exposure to Groundwater - RME, Landfill AOPC

Definition	Variable	Value		Equations
Relative contribution of permeability coefficients in stratum corneum and viable epidermis	B	Chemical-specific	dimensionless	*Organics:* If $t_{event} \leq t^*$, then:
Concentration of chemical in water	C_{water}	Measured	µg/L	$DA_{event} = 2 FA_w \times K_p \times (C_{water} \times CF_d) \times \left(\sqrt{\frac{6 \tau_{event} \, t_{event}}{\pi}}\right)$
Conversion Factor	CF_d	1.0E-06	(mg L) / (µg cm^3)	
Dose absorbed per unit area per event	DA_{event}	Calculated	mg/cm^2-event	If $t_{event} > t^*$, then:
Fraction Absorbed, worker	FA_w	Chemical-specific	dimensionless	$DA_{event} = FA_w \times K_p \times (C_{water} \times CF_d) \times \left[\frac{t_{event}}{1+B} + 2 \tau_{event} \left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
Permeability coefficient from water	K_p	Chemical-specific	cm/hr	
Lag time per event	τ_{event}	Chemical-specific	hr/event	
Duration of event	t_{event}	2	hr/event	*Inorganics:*
Time it takes to reach steady state	t*	Chemical-specific	hr	$DA_{event} = K_p \times (C_{water} \times CF_d) \times t_{event}$

Analyte	FA_W[a] (*dimensionless*)	K_p[b] (*cm/hr*)	C_{water}[c] (*µg/L*)	τ_{event}[d] (*hr/event*)	t*[d] (*hr*)	B[d] (*dimensionless*)	DA_{event} (*mg/cm^2-event*)
Inorganic Constituents							
Antimony	--	1.00E-03	2.23E-01	5.26E-01	1.26E+00	4.30E-03	4.46E-10
Iron	--	1.00E-03	2.91E+04	2.16E-01	5.19E-01	2.87E-03	5.82E-05
Mercury	--	1.00E-03	7.69E-02	1.40E+00	3.35E+00	5.45E-03	1.54E-10
Thallium	--	1.00E-03	2.38E-01	1.47E+00	3.52E+00	5.50E-03	4.76E-10
Zinc	--	6.00E-04	2.07E+03	2.51E-01	6.02E-01	1.89E-03	2.48E-06
Phthalates							
di-n-octyl phthalate	1	NRP	4.61E+00	1.62E+01	--	--	--
Volatile Organic Compounds (VOCs)							
Acetone	1	5.20E-04	1.54E+01	2.22E-01	5.34E-01	1.53E-03	1.96E-08
Chloroform	1	6.79E-03	3.70E+00	4.90E-01	1.18E+00	2.85E-02	7.42E-08
Isopropylbenzene	1	8.76E-02	4.60E+00	4.95E-01	1.19E+00	3.69E-01	1.12E-06
Tetrachloroethene	1	3.28E-02	8.78E+00	8.92E-01	2.14E+00	1.62E-01	1.06E-06
Vinyl Chloride	1	8.30E-03	9.55E-01	2.35E-01	5.65E-01	2.52E-02	1.93E-08
n-propylbenzene	1	9.17E-02	2.00E+00	4.95E-01	1.19E+00	3.87E-01	5.11E-07
1,2,4-trimethylbenzene	1	8.37E-02	5.20E+00	4.95E-01	1.19E+00	3.53E-01	1.22E-06

[a] FA_r for organic chemicals is from Exhibit B-3, USEPA (2004. RAGS Part E. EPA/540/R/99/005); for chemicals not listed in Exhibit B-3, a default value of 1.0 was used.

[b] K_p for inorganics is from USEPA (2004. RAGS Part E. EPA/540/R/99/005).
K_p for organics is from Table A-9.3
NRP = Not Reliably Predicted (see Table A-9.3).

[c] from Table A-9.3.

[d] from Table A-9.3.

Table A-7.5

Risk and Hazard Estimates: Dermal Contact with Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Landfill AOPC

Definition	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs
Body Weight, adult	BW_a	80	kg
COPC Absorbed Dose per Event	DA_{event}	chemical-specific	mg/cm^2-event
Exposure Duration, worker	ED_w	1	yrs
Exposure Frequency, worker	EF_w	9	days/yr
Event Frequency, worker	EV_w	2	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	(mg/kg-day)
Exposed Body Surface Area, worker	SA_a	5700	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Carcinogenic:

$$Risk = SF_d \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_c \times 365\ day\ /\ year} \right) \right]$$

Noncarcinogenic:

$$Hazard = \frac{1}{RfD_d} \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_{nc,w} \times 365\ day\ /\ year} \right) \right]$$

Analyte	DA_{event} (*mg/cm^2-event*)	SF_D (*mg/kg-day*)$^{-1}$	Cancer Risk (*dimensionless*)	% of Total	RfD_D (mg/kg-day)	Hazard Quotient (*dimensionless*)	% of Total
Inorganic Constituents							
Antimony	4.46E-10		--		6.00E-05	2.61E-05	2%
Iron	5.82E-05		--		7.00E-01	2.92E-04	23%
Mercury	1.54E-10		--		1.60E-04	3.38E-06	< 1%
Thallium	4.76E-10		--		1.00E-05	1.67E-04	13%
Zinc	2.48E-06		--		3.00E-01	2.91E-05	2%
Phthalates							
di-n-octyl phthalate	--		--		1.00E-02	--	
Volatile Organic Compounds (VOCs)							
Acetone	1.96E-08		--		9.00E-01	7.64E-08	< 1%
Chloroform	7.42E-08	3.10E-02	1.15E-10	12%	1.00E-02	2.61E-05	2%
Isopropylbenzene	1.12E-06		--		1.00E-01	3.95E-05	3%
Tetrachloroethene	1.06E-06	2.10E-03	1.12E-10	12%	6.00E-03	6.22E-04	50%
Vinyl Chloride	1.93E-08	7.20E-01	6.97E-10	75%	3.00E-03	2.26E-05	2%
n-propylbenzene	5.11E-07		--		1.00E-01	1.80E-05	1%
1,2,4-trimethylbenzene	1.22E-06		--			--	

	Cancer Risk	Hazard Index
Pathway Sums:	9.2E-10	1.2E-03

Table A-8.1

Risk and Hazard Estimates: Incidental Ingestion of Soil, Outdoor Maintenance Worker RME, Sandblast Area AOPC

Definition	Variable	Value	Units
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
Body Weight	BW_a	80	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Fraction Contaminated Soil Ingested, worker	FI_w	1.0	unitless
Soil Ingestion Rate, worker	IRS_w	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Cancer Risk:

$$Risk = SF_o \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365\,day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,a} \times 365\,day/year} \right] \right\}$$

Analyte	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (dimensionless)	% of Total
Inorganic Constituents							
Arsenic	9.71E+00	1.50E+00	2.40E-06	27%	3.00E-04	1.50E-02	80%
Chromium (III)	5.79E+02	No Toxicity Value	--	--	1.50E+00	2.97E-04	2%
Lead	0.00E+00	8.50E-03	0.00E+00	< 1%	No Toxicity Value	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	2.39E+00	7.30E+00	4.80E-06	53%	No Toxicity Value	--	--
Benzofluoranthenes Total	6.36E+00	7.30E-01	1.28E-06	14%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.38E-01	7.30E+00	4.78E-07	5%	No Toxicity Value	--	--
Volatile Organic Compounds (VOCs)							
Tetrachloroethene	2.73E+01	2.10E-03	1.58E-08	< 1%	6.00E-03	3.51E-03	19%

	Cancer Risk	Hazard Index
Pathway Sum:	9.0E-06	1.9E-02

Table A-8.2

Derivation of Inhalation Factors for Inhalation Exposures, Outdoor Maintenance Worker RME, Sandblast Area AOPC

Description:	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient	K_d	chemical-specific	cm^3/g
for organics: $Kd=K_{OC}\times F_{OC}$			
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 25-yr occupational worker	T_{Worker}	7.88E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{(3.14 \times D_A \times T_{[receptor]})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$DA = \frac{\left[(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	D_i (cm²/s)	Reference	D_w (cm²/s)	Reference	H' (dimensionless)	Reference	K_{OC} (cm³/g)	Reference	K_d (cm³/g)	D_A (cm²/s)	VFs (VOCs) Occupational m³/kg	PEF (non-VOCs) m³/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.6E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	5874	1.4E-11	non-VOC	1.360E+09
Benzofluoranthenes Total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.6E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	5994	1.7E-11	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.2E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	19120	2.46E-12	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA 2012)	9.5E-06	RSLs ("WATER9"; USEPA 2012)	0.723811518	Experimental, EPISuite v4.10 (USEPA 2011a)	94.94	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0.9494	0.001597	3048.004637	use VF

Table A-8.3

Risk and Hazard Estimates: Inhalation, Outdoor Maintenance Worker, Sandblast Area AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Exposure Time, worker	ET_w	8.00	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

$$Risk = IUR \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365\ days\ /\ year \times 24\ hours\ /\ day} \right)$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365\ days\ /\ year \times 24\ hours\ /\ day} \right)$$

where:

$$C_{air} = \frac{C_{soil}}{VF\ or\ PEF} \times 1000\ \frac{\mu g}{mg}$$

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Arsenic	9.71E+00	1.360E+09	7.14E-06	4.30E-03	1.35E-09	< 1%	1.50E-02	5.87E-05	< 1%
Chromium (III)	5.79E+02	1.360E+09	4.26E-04	No Toxicity Value	--	--	No Toxicity Value	--	--
Lead	0.00E+00	1.360E+09	0.00E+00	1.20E-05	0.00E+00	< 1%	No Toxicity Value	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	2.39E+00	1.360E+09	1.76E-06	1.10E-03	1.42E-10	< 1%	No Toxicity Value	--	--
Benzofluoranthenes Total	6.36E+00	1.360E+09	4.68E-06	1.10E-04	3.78E-11	< 1%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.38E-01	1.360E+09	1.75E-07	1.20E-03	1.54E-11	< 1%	No Toxicity Value	--	--
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	2.73E+01	3.048E+03	8.96E+00	2.60E-07	1.71E-07	99%	4.00E+01	4.60E-02	100%
				Pathway Sums:	Cancer Risk 1.7E-07			Hazard Index 4.6E-02	

Table A-8.4

Risk and Hazard Estimates: Dermal Contact with Soil, Outdoor Maintenance Worker RME, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, worker	AF_w	0.12	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	25	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, worker	EC_w	1	unitless
Exposure Duration, worker	ED_w	25	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Event Frequency, worker	EV_w	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, worker	SA_w	3527	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_c \times 365\, day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_{nc,a} \times 365\, day/year} \right] \right\}$$

Analyte	**C_{soil}** (mg/kg)	**ABS_d** (unitless)	**SF_d** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_d** (mg/kg-day)	**Hazard Quotient** (dimensionless)	**% of Total**
Inorganic Constituents								
Arsenic	9.71E+00	3.00E-02	1.50E+00	3.05E-07	8%	3.00E-04	1.90E-03	66%
Chromium (III)	5.79E+02	1.00E-02		--	--	1.95E-02	9.68E-04	34%
Lead	0.00E+00	1.00E-02	8.50E-03	0.00E+00	< 1%	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	2.39E+00	1.30E-01	7.30E+00	2.64E-06	68%	--	--	--
Benzofluoranthenes Total	6.36E+00	1.30E-01	7.30E-01	7.03E-07	18%	--	--	--
Dibenz[a,h]anthracene	2.38E-01	1.30E-01	7.30E+00	2.63E-07	7%	--	--	--
Volatile Organic Compounds (VOCs)								
Tetrachloroethene	2.73E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	< 1%
			Pathway Sums:	Cancer Risk 3.9E-06			Hazard Index 2.9E-03	

Table A-9.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Outdoor Maintenance Worker CTE, Sandblast Area AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs	
Body Weight	BW_a	80	kg	
Conversion Factor	CF_o	1E-06	kg/mg	
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, worker	ED_w	6	yrs	Noncancer Hazard:
Exposure Frequency, worker	EF_w	225	days/yr	
Fraction Contaminated Soil Ingested, worker	FI_w	1.0	unitless	
Soil Ingestion Rate, worker	IRS_w	50	mg/day	
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day	
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Cancer Risk:

$$Risk = SF_o \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365 day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left\{ C_{soil} \times \left[\frac{IRS_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,a} \times 365 day/year} \right] \right\}$$

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Inorganic Constituents							
Arsenic	9.71E+00	1.50E+00	2.89E-07	26%	3.00E-04	7.48E-03	80%
Chromium (III)	5.79E+02	No Toxicity Value	--	--	1.50E+00	1.49E-04	2%
Lead	4.18E+02	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	2.39E+00	7.30E+00	5.76E-07	52%	No Toxicity Value	--	--
Benzofluoranthenes Total	7.84E+00	7.30E-01	1.89E-07	17%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.38E-01	7.30E+00	5.74E-08	5%	No Toxicity Value	--	--
Tetrachloroethene	2.73E+01	2.10E-03	1.89E-09	< 1%	6.00E-03	1.75E-03	19%

	Cancer Risk	Hazard Index
Pathway Sum:	1.1E-06	9.4E-03

Table A-9.2
Derivation of Inhalation Factors for Inhalation Exposures, Outdoor Maintenance Worker CTE, Sandblast Area AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 6-yr occupational worker	T_{Worker}	1.89E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{(3.14 \times D_A \times T_{[receptor]})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	**D_i** (cm²/s)	Reference	**D_w** (cm²/s)	Reference	**H'** (dimensionless)	Reference	**K_{OC}** (cm³/g)	Reference	**K_d** (cm³/g)	**D_A** (cm²/s)	**VFs** (VOCs) Occupational m³/kg	**PEF** (non-VOCs) m³/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.6	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.002	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	0.0000187	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.360E+09
Benzofluoranthenes Total	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	0.00002687	Experimental, EPISuite v4.10 (USEPA, 2011a)	599400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	1.02E-06	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA, 2012)	5.21E-06	RSLs ("WATER9"; USEPA, 2012)	0.00000577	Experimental, EPISuite v4.10 (USEPA, 2011a)	1912000	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	4.7E-07	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA, 2012)	9.46E-06	RSLs ("WATER9"; USEPA, 2012)	0.724	Experimental, EPISuite v4.10 (USEPA, 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	0.008045	--	use VF

Table A-9.3
Risk and Hazard Estimates: Inhalation, Outdoor Maintenance Worker, Sandblast Area AOPC

Description	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs	
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$	
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, worker	ED_w	6	yrs	Noncancer Hazard:
Exposure Frequency, worker	EF_w	225	days/yr	
Exposure Time, worker	ET_w	8.00	hours/day	
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$	
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg	
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$	where:
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg	

Cancer Risk:

$$Risk = IUR \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365 \ days / year \times 24 \ hours / day} \right)$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365 \ days / year \times 24 \ hours / day} \right)$$

where:

$$C_{air} = \frac{C_{soil}}{VF \ or \ PEF} \times 1000 \ \frac{\mu g}{mg}$$

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Arsenic	9.71E+00	1.360E+09	7.14E-06	4.30E-03	3.24E-10	87%	1.50E-02	5.87E-05	100%
Chromium (III)	5.79E+02	1.360E+09	4.26E-04	No Toxicity Value	--	--	No Toxicity Value	--	--
Lead	4.18E+02	1.360E+09	3.07E-04	--	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	2.39E+00	1.360E+09	1.76E-06	1.10E-03	3.40E-11	9%	No Toxicity Value	--	--
Benzofluoranthenes Total	7.84E+00	1.360E+09	5.77E-06	1.10E-04	1.12E-11	3%	No Toxicity Value	--	--
Dibenz[a,h]anthracene	2.38E-01	1.360E+09	1.75E-07	1.20E-03	3.70E-12	< 1%	No Toxicity Value	--	--
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	2.73E+01	--	--	2.60E-07	--	--	4.00E+01	--	--

	Cancer Risk	Hazard Index
Pathway Sums:	3.7E-10	5.9E-05

Table A-9.4

Risk and Hazard Estimates: Dermal Contact with Soil, Outdoor Maintenance Worker CTE, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, worker	AF_w	0.02	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	6	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, worker	EC_w	1	unitless
Exposure Duration, worker	ED_w	6	yrs
Exposure Frequency, worker	EF_w	225	days/yr
Event Frequency, worker	EV_w	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, worker	SA_w	3300	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

$$Risk = SF_d \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_c \times 365\, day/year} \right] \right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left\{ C_{soil} \times \left[\frac{AF_w \times ABS_d \times EF_w \times ED_w \times EV_w \times EC_w \times SA_w \times CF_d}{BW_a \times AT_{nc,a} \times 365\, day/year} \right] \right\}$$

Analyte	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents								
Arsenic	9.71E+00	3.00E-02	1.50E+00	1.14E-08	7%	3.00E-04	2.96E-04	66%
Chromium (III)	5.79E+02	1.00E-02		--	--	1.95E-02	1.51E-04	34%
Lead	4.18E+02	1.00E-02		--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	2.39E+00	1.30E-01	7.30E+00	9.89E-08	65%	--	--	--
Benzofluoranthenes Total	7.84E+00	1.30E-01	7.30E-01	3.24E-08	21%	--	--	--
Dibenz[a,h]anthracene	2.38E-01	1.30E-01	7.30E+00	9.85E-09	6%	--	--	--
Volatile Organic Compounds (VOCs)								
Tetrachloroethene	2.73E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	< 1%

	Cancer Risk	Hazard Index
Pathway Sums:	1.5E-07	4.5E-04

Table A-10.1

Risk and Hazard Estimates: Incidental Ingestion of Soil, Construction Worker RME, Sandblast Area AOPC

Definition	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight	BW_{cw}	80	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Fraction Contaminated Soil Ingested, construction worker	FI_{cw}	1.0	unitless
Soil Ingestion Rate, worker	IRS_{cw}	330	mg/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Cancer Risk:

$$Risk = SF_o \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_c \times 365 \ day / year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_{nc,cw} \times 365 \ day / year} \right) \right]$$

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)							
Tetrachloroethene	9.90E+01	2.10E-03	8.39E-09	< 1%	6.00E-03	4.66E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	3.98E+00	7.30E+00	1.17E-06	99%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 1.2E-06			Hazard Index 4.7E-02	

Table A-10.2

Derivation of Inhalation Factors for Inhalation Exposures, Construction Worker RME, Sandblast Area AOPC

Description:	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.000E+06	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 1-yr construction worker	T_{cw}	3.15E+07	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{(3.14 \times D_A \times T_{[receptor]})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	**D_i** (cm²/s)	Reference	**D_w** (cm²/s)	Reference	**H'** (dimensionless)	Reference	**K_{OC}** (cm³/g)	Reference	**K_d** (cm³/g)	**D_A** (cm²/s)	**VFs** (VOCs) Construction m³/kg	**PEF** (non-VOCs) m³/kg
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA, 2012)	9.46E-06	RSLs ("WATER9"; USEPA, 2012)	0.724	Experimental, EPISuite v4.10 (USEPA, 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0.9494	0.0016	609.6009273	use VF
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	1.87E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.000E+06

Table A-10.3

Risk and Hazard Estimates: Inhalation, Construction Worker, Sandblast Area AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Exposure Time, construction worker	ET_{cw}	8	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.00E+06	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_c \times 365\ days/year \times 24\ hours/day} \right)$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_{nc,cw} \times 365\ days/year \times 24\ hours/day} \right)$$

where:

$$C_{air} = \frac{C_{soil}}{VF\ or\ PEF} \times 1000\ \frac{\mu g}{mg}$$

Analyte	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	9.90E+01	6.10E+02	1.62E+02	2.60E-07	1.38E-07	91%	4.00E+01	9.27E-01	100%
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	3.98E+00	1.00E+06	3.98E-03	1.10E-03	1.43E-08	9%	No Toxicity Value	--	--

	Cancer Risk	Hazard Index
Pathway Sums:	1.5E-07	9.3E-01

Table A-10.4

Risk and Hazard Estimates: Dermal Contact with Soil, Construction Worker RME, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, construction worker	AF_{cw}	0.3	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight, adult	BW_{cw}	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, construction worker	EC_{cw}	1	unitless
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Event Frequency, construction worker	EV_{cw}	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, construction worker	SA_{cw}	3527	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Cancer Risk:

$$Risk = SF_d \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_c \times 365\ day/year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_{nc,cw} \times 365\ day/year} \right) \right]$$

Analyte	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Hazard Quotient (dimensionless)	% of Total
Volatile Organic Compounds (VOCs)								
Tetrachloroethene	9.90E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	3.98E+00	1.30E-01	7.30E+00	4.89E-07	100%	--	--	--

	Cancer Risk	Hazard Index
Pathway Sums:	4.9E-07	0.00E+00

Table A-11.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Construction Worker CTE, Sandblast Area AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs	$$Risk = SF_o \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_c \times 365\ day / year} \right) \right]$$
Body Weight	BW_{cw}	80	kg	
Conversion Factor	CF_o	1E-06	kg/mg	
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, construction worker	ED_{cw}	1	yrs	Noncancer Hazard:
Exposure Frequency, construction worker	EF_{cw}	250	days/yr	
Fraction Contaminated Soil Ingested, construction worker	FI_{cw}	1.0	unitless	$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_{cw} \times EF_{cw} \times ED_{cw} \times FI_{cw} \times CF_o}{BW_{cw} \times AT_{nc,cw} \times 365\ day / year} \right) \right]$$
Soil Ingestion Rate, worker	IRS_{cw}	100	mg/day	
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day	
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	**C_{soil}** (mg/kg)	**SF_o** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_o** (mg/kg-day)	**Noncancer Hazard** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)							
Tetrachloroethene	9.90E+01	2.10E-03	1.27E-09	< 1%	6.00E-03	1.41E-02	100%
Polycyclic Aromatic Hydrocarbons (PAHs)							
Benzo[a]pyrene	3.98E+00	7.30E+00	1.78E-07	99%	No Toxicity Value	--	--
		Pathway Sum:	Cancer Risk 1.8E-07			Hazard Index 1.4E-02	

Table A-11.2
Derivation of Inhalation Factors for Inhalation Exposures, Construction Worker CTE, Sandblast Area AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.01	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient for organics: $Kd=K_{OC}\times F_{OC}$	K_d	chemical-specific	cm^3/g
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.000E+06	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source	Q/C	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 0.5-yr construction worker	T_{cw}	1.58E+07	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = (Q/C) \times \frac{(3.14 \times D_A \times T_{[receptor]})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$DA = \frac{\left[\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right) / n^2\right]}{\rho_B Kd + \Theta_w + \Theta_a H'}$$

Analyte	**D_i** (cm^2/s)	Reference	**D_w** (cm^2/s)	Reference	**H'** (dimensionless)	Reference	**K_{OC}** (cm^3/g)	Reference	**K_d** (cm^3/g)	**D_A** (cm^2/s)	**VFs** (VOCs) Construction m^3/kg	**PEF** (non-VOCs) m^3/kg
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA, 2012)	9.46E-06	RSLs ("WATER9"; USEPA, 2012)	0.723811518	Experimental, EPISuite v4.10 (USEPA, 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	0.008045	--	use VF
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA, 2012)	5.56E-06	RSLs ("WATER9"; USEPA, 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA, 2011a)	587400	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.000E+06

Table A-11.3
Risk and Hazard Estimates: Inhalation, Construction Worker, Sandblast Area AOPC

Description	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	0.5	yrs	
COPC Concentration in air	C_{air}	chemical-specific	µg/m³	$Risk = IUR \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_c \times 365\ days/year \times 24\ hours/day} \right)$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg	
Exposure Duration, construction worker	ED_{cw}	0.5	yrs	Noncancer Hazard:
Exposure Frequency, construction worker	EF_{cw}	250	days/yr	
Exposure Time, construction worker	ET_{cw}	8	hours/day	$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_{cw} \times EF_{cw} \times ET_{cw}}{AT_{nc,cw} \times 365\ days/year \times 24\ hours/day} \right)$
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$	
Particulate emission factor (non-VOCs)	PEF	1.00E+06	m³/kg	
Inhalation Reference Concentration	RfC	chemical-specific	µg/m³	where: $C_{air} = \frac{C_{soil}}{VF\ or\ PEF} \times 1000\ \frac{\mu g}{mg}$
Volatilization Factor for VOCs	VF	chemical-specific	m³/kg	

Analyte	**C_{soil}** (mg/kg)	**VF (VOCs)** or **PEF (non-VOCs)** (m³/kg)	**C_{air}** (µg/m³)	**IUR** $(\mu g/m^3)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfC** (µg/m³)	**Hazard Quotient** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	9.90E+01	--	--	2.60E-07	--	--	4.00E+01	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]pyrene	3.98E+00	1.00E+06	3.98E-03	1.10E-03	7.14E-09	100%	No Toxicity Value	--	--
				Pathway Sums:	<u>Cancer Risk</u> 7.1E-09			<u>Hazard Index</u> --	

Table A-11.4
Risk and Hazard Estimates: Dermal Contact with Soil, Construction Worker CTE, Sandblast Area AOPC

Description	Variable	Value	Units
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Soil-to-Skin Adherence Fraction, construction worker	AF_{cw}	0.1	mg/cm^2-day
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, construction worker	$AT_{nc,cw}$	1	yrs
Body Weight, adult	BW_{cw}	80	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil, construction worker	EC_{cw}	1	unitless
Exposure Duration, construction worker	ED_{cw}	1	yrs
Exposure Frequency, construction worker	EF_{cw}	250	days/yr
Event Frequency, construction worker	EV_{cw}	1	events/day
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, construction worker	SA_{cw}	3300	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Cancer Risk:

$$Risk = SF_d \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_c \times 365\ day/year} \right) \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_{cw} \times ABS_d \times EF_{cw} \times ED_{cw} \times EV_{cw} \times EC_{cw} \times SA_{cw} \times CF_d}{BW_{cw} \times AT_{nc,cw} \times 365\ day/year} \right) \right]$$

Analyte	**C_{soil}** (mg/kg)	**ABS_d** (unitless)	**SF_d** $(mg/kg\text{-}day)^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_d** (mg/kg-day)	**Hazard Quotient** (dimensionless)	**% of Total**
Volatile Organic Compounds (VOCs)								
Tetrachloroethene	9.90E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	--
Polycyclic Aromatic Hydrocarbons (PAHs)								
Benzo[a]pyrene	3.98E+00	1.30E-01	7.30E+00	7.62E-08	100%	--	--	--
			Pathway Sums:	Cancer Risk: 7.6E-08			Hazard Index: 0.00E+00	

Table A-12.NI

Nursing Infant: Hypothetical Fishing Platform User: RME Summary - Sandblast Area AOPC

Definition	Variable	Value	Source	Equations	
Infant Risk Adjustment Factor	IRAF	Chemical Specific	ODEQ 2010		
Carcinogenic IRAFc					
Total PCB	IRAFc_pcb	0.6	ODEQ 2010	Infant Cancer Risk =	Mother Risk x IRAFc
Noncancer IRAFnc					
Total PCB	IRAFnc_pcb	4	ODEQ 2010	Infant Noncancer Hazard =	Child HQ x IRAFnc

		Mother		Infant	
Analyte	**C_{soilt}** (mg/kg)	**Cancer Risk (adult)**	**Hazard Quotient (child)**	**Cancer Risk**	**Hazard Quotient**
Total PCBs as Congeners (KM-based, capped)	4E-01	1.8E-06	3.7E-01	1.1E-06	1.5

Table A-12.1

Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: RME, Sandblast Area AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0\text{-}2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2\text{-}6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6\text{-}16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16\text{-}26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	$ED_{0\text{-}2}$	2	yrs
Exposure Duration, child 2-6	$ED_{2\text{-}6}$	4	yrs
Exposure Duration, child 6-16	$ED_{6\text{-}16}$	10	yrs
Exposure Duration, adult 16-26	$ED_{16\text{-}26}$	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	100	mg/day
Soil Ingestion Rate (child)	IRS_c	200	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\,\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\,\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \Bigg[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\Bigg]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\,\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents									
Arsenic	0.00E+00	9.71E+00	1.50E+00	1.31E-05	6%	3.00E-04	2.59E-01	30%	2.43E-02
Chromium (III)	0.00E+00	5.79E+02	No Toxicity Value	--	--	1.50E+00	5.15E-03	< 1%	4.83E-04
Lead	0.00E+00	4.18E+02	--	--	--	No Toxicity Value	--	--	--
Nickel	0.00E+00	2.51E+02	No Toxicity Value	--	--	2.00E-02	1.67E-01	19%	1.57E-02
Polychlorinated Biphenyls (PCBs) - Mixtures									
Total PCBs	0.00E+00	4.19E-01	2.00E+00	1.26E-06	< 1%	2.00E-05	2.79E-01	32%	2.62E-02
Volatile Organic Compounds (VOCs)									
Tetrachloroethene	0.00E+00	2.63E+01	2.10E-03	8.28E-08	< 1%	6.00E-03	5.84E-02	7%	5.48E-03
Trichloroethene	0.00E+00	1.78E+00	4.60E-02	1.23E-07	< 1%	5.00E-04	4.75E-02	5%	4.45E-03
Semivolatile Organic Compounds (SVOCs)									
DEHP	0.00E+00	7.71E+01	1.40E-02	1.62E-06	< 1%	2.00E-02	5.14E-02	6%	4.82E-03

Table A-12.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: RME, Sandblast Area AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	100	mg/day
Soil Ingestion Rate (child)	IRS_c	200	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	M	2.45E+00	7.30E-01	1.22E-05	6%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	2.39E+00	7.30E+00	1.19E-04	57%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	7.30E-01	1.10E-05	5%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene	0.00E+00	1.05E+00	No Toxicity Value	--	--	3.00E-02	4.67E-04	< 1%	4.38E-05
Benzofluoranthenes, Total	M	6.36E+00	7.30E-01	3.16E-05	15%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	7.30E+00	1.18E-05	6%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	1.16E+00	7.30E-01	5.77E-06	3%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	2.1E-04	Pathway Sum:	0.87	0.081

Table A-12.2
Derivation of Inhalation Factors for Inhalation Exposures, Hypothetical Fishing Platform User: RME, Sandblast Area AOPC

Description	Variable	Value	Units	VF Derivation
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2	$$VFs = Q/C_{vol} \times \frac{(3.14 \times D_A \times T_{resident})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$
Apparent Diffusivity	D_A	derived	cm^2/s	
Diffusivity in air	D_i	chemical-specific	cm^2/s	
Diffusivity in water	D_w	chemical-specific	cm^2/s	
Default organic-carbon content	F_{OC}	0.006	g/g	
Henry's law constant	H'	chemical-specific	dimensionless	
Soil-water partition coefficient	K_d	chemical-specific	cm^3/g	
for organics: $Kd=K_{OC} \times F_{OC}$				based on:
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g	$$D_A = \frac{\left[\left(\theta_a{}^{10/3} D_i H' + \theta_w{}^{10/3} D_w\right)/n^2\right]}{\rho_B K_d + \theta_w + \theta_a H'}$$
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$	
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg	
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C_{vol}	73.44	g/m^2-s per kg/m^3	
Dry soil bulk density	ρ_b	1.5	g/cm^3	
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}	
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}	
Exposure interval, 30-yr resident	$T_{Resident}$	8.20E+08	seconds	
Volatilization Factor for soil	VFs	derived	m^3/kg	

	D_i		D_w		H'		K_{OC}		K_d	D_A	VFs (VOCs) Residential	PEF (non-VOCs)
Analyte	(cm^2/s)	Reference	(cm^2/s)	Reference	(dimensionless)	Reference	(cm^3/g)	Reference	(cm^3/g)	(cm^2/s)	m^3/kg	m^3/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA, 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Nickel	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA 2011a); MCI-estimated	65	0	non-VOC	1.360E+09
Polychlorinated Biphenyls (PCBs) - Mixtures												
Total PCBs	0.040076	RSLs ("WATER9"; USEPA 2012)	4.7E-06	RSLs ("WATER9"; USEPA 2012)	0.011572806	Experimental, EPISuite v4.10 (USEPA 2011a)	130500	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0.00024	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA 2012)	9.5E-06	RSLs ("WATER9"; USEPA 2012)	0.723811518	Experimental, EPISuite v4.10 (USEPA 2011a)	94.94	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0.00805	1384.893971	use VF
Trichloroethene	0.0686618	RSLs ("WATER9"; USEPA 2012)	1E-05	RSLs ("WATER9"; USEPA 2012)	0.402799065	Experimental, EPISuite v4.10 (USEPA 2011a)	60.7	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0.3642	0.00266	2410.681404	use VF
Semivolatile Organic Compounds (SVOCs)												
DEHP	0.0173403	RSLs ("WATER9"; USEPA 2012)	4.2E-06	RSLs ("WATER9"; USEPA 2012)	1.10412E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	119600	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	3.7E-07	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA 2012)	5.9E-06	RSLs ("WATER9"; USEPA 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA 2011a)	176900	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1.3E-05	non-VOC	1.360E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.6E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	8.2E-07	non-VOC	1.360E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.6E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1E-06	non-VOC	1.360E+09
Benzo[g,h,i]perylene	0	0	0	0	1.35357E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	1951000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	0	non-VOC	1.360E+09
Benzofluoranthenes, Total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.6E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	1E-06	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.2E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0	4.7E-07	non-VOC	1.360E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA 2012)	5.2E-06	RSLs ("WATER9"; USEPA 2012)	0.0000656	EPISuite v4.10 (USEPA 2011a)	3470000	EPISuite v4.10 (USEPA 2011a)	0	1.9E-06	non-VOC	1.360E+09

Table A-12.3

Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Sandblast Area AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	26	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	26	yrs
Exposure Frequency	EF_r	365	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\frac{day}{year} \times 24\frac{hour}{day}}\right)$$

Mutagens:

$$Risk = IUR \times \Bigg[C_{air} \times EF_r \times ET_r \times \left\{\frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day}\right\}\Bigg]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1\right\}\right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365\frac{day}{year} \times 24\frac{hour}{day}}\right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF\ \text{or}\ PEF} \times 1000\ \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents											
Arsenic	0.00E+00	9.71E+00	1.360E+09	7.14E-06	4.30E-03	6.84E-09	< 1%	1.50E-02	2.86E-04	< 1%	2.86E-04
Chromium (III)	0.00E+00	5.79E+02	1.360E+09	4.26E-04	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Lead	0.00E+00	4.18E+02	1.360E+09	3.07E-04	--	--	--	No Toxicity Value	--	--	--
Nickel	0.00E+00	2.51E+02	1.360E+09	1.85E-04	2.60E-04	1.78E-08	< 1%	9.00E-02	2.05E-03	< 1%	2.05E-03
Polychlorinated Biphenyls (PCBs) - Mixtures											
Total PCBs	0.00E+00	4.19E-01	1.360E+09	3.08E-07	5.70E-04	6.52E-11	< 1%	No Toxicity Value	--	--	--
Volatile Organic Compounds (VOCs)											
Tetrachloroethene	0.00E+00	2.63E+01	1.385E+03	1.90E+01	2.60E-07	1.83E-06	61%	4.00E+01	4.75E-01	56%	4.75E-01
Trichloroethene	0.00E+00	1.78E+00	2.411E+03	7.38E-01	4.10E-06	1.12E-06	38%	2.00E+00	3.69E-01	44%	3.69E-01
Semivolatile Organic Compounds (SVOCs)											
DEHP	0.00E+00	7.71E+01	1.360E+09	5.67E-05	2.40E-06	5.05E-11	< 1%	No Toxicity Value	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	M	2.45E+00	1.360E+09	1.80E-06	1.10E-04	2.04E-10	< 1%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	2.39E+00	1.360E+09	1.76E-06	1.10E-03	1.99E-09	< 1%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	1.360E+09	1.63E-06	1.10E-04	1.84E-10	< 1%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene	0.00E+00	1.05E+00	1.360E+09	7.72E-07	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	6.36E+00	1.360E+09	4.68E-06	1.10E-04	5.29E-10	< 1%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	1.360E+09	1.75E-07	1.20E-03	2.16E-10	< 1%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	1.16E+00	1.360E+09	8.53E-07	1.10E-04	9.65E-11	< 1%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult)
Pathway Sum:	3.0E-06	Pathway Sum:	8.5E-01	8.5E-01

Table A-12.4
Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: RME, Sandblast Area AOPC

Description	Variable	Value	Units
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.07	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.2	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times [C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents										
Arsenic	0.00E+00	9.71E+00	3.00E-02	1.50E+00	1.11E-06	2%	3.00E-04	1.84E-02	8%	3.07E-03
Chromium (III)	0.00E+00	5.79E+02	1.00E-02	--	--	--	1.95E-02	9.39E-03	4%	1.57E-03
Lead	0.00E+00	4.18E+02	1.00E-02	--	--	--	--	--	--	--
Nickel	0.00E+00	2.51E+02	1.00E-02	--	--	--	8.00E-04	9.93E-02	43%	1.66E-02
Polychlorinated Biphenyls (PCBs) - Mixtures										
Total PCBs	0.00E+00	4.19E-01	1.40E-01	2.00E+00	4.95E-07	< 1%	2.00E-05	9.28E-02	40%	1.55E-02
Volatile Organic Compounds (VOCs)										
Tetrachloroethene	0.00E+00	2.63E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	< 1%	0.00E+00
Trichloroethene	0.00E+00	1.78E+00	0.00E+00	4.60E-02	0.00E+00	< 1%	5.00E-04	0.00E+00	< 1%	0.00E+00
Semivolatile Organic Compounds (SVOCs)										
DEHP	0.00E+00	7.71E+01	1.00E-01	1.40E-02	4.56E-07	< 1%	2.00E-02	1.22E-02	5%	2.03E-03

Table A-12.4

Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: RME, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.07	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.2	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	20	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	20	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	365	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times \left[C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)\right]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Polycyclic Aromatic Hydrocarbons (PAHs)										
Benzo[a]anthracene	M	2.45E+00	1.30E-01	7.30E-01	4.06E-06	6%	--	--	--	--
Benzo[a]pyrene	M	2.39E+00	1.30E-01	7.30E+00	3.96E-05	60%	--	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	1.30E-01	7.30E-01	3.67E-06	6%	--	--	--	--
Benzo[g,h,i]perylene	0.00E+00	1.05E+00	1.30E-01	--	--	--	3.00E-02	1.44E-04	< 1%	2.40E-05
Benzofluoranthenes, Total	M	6.36E+00	1.30E-01	7.30E-01	1.06E-05	16%	--	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	1.30E-01	7.30E+00	3.95E-06	6%	--	--	--	--
Indeno[1,2,3-cd]pyrene	M	1.16E+00	1.30E-01	7.30E-01	1.92E-06	3%	--	--	--	--
					Cancer Risk			Hazard Index (Child)		Hazard Index (Adult
				Pathway Sum:	6.6E-05		Pathway Sum:	2.3E-01		3.9E-02

Table A-13.NI

Nursing Infant: Hypothetical Fishing Platform User: CTE Summary - Sandblast Area AOPC

Definition	Variable	Value	Source	Equations	
Infant Risk Adjustment Factor	IRAF	Chemical Specific	ODEQ 2010		
Carcinogenic IRAFc					
Total PCB	IRAFc_pcb	0.6	ODEQ 2010	Infant Cancer Risk =	Mother Risk x IRAFc
Noncancer IRAFnc					
Total PCB	IRAFnc_pcb	4	ODEQ 2010	Infant Noncancer Hazard =	Child HQ x IRAFnc

Analyte	**C_{soilt}** (mg/kg)	**Mother** **Cancer Risk (adult)**	**Mother** **Hazard Quotient (child)**	**Infant** **Cancer Risk**	**Infant** **Hazard Quotient**
Total PCBs as Congeners (KM-based, capped)	4E-01	2.4E-07	6.6E-02	1.4E-07	0.26

Table A-13.1

Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: CTE, Sandblast Area AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	50	mg/day
Soil Ingestion Rate (child)	IRS_c	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents									
Arsenic		9.71E+00	1.50E+00	2.18E-06	5%	3.00E-04	5.39E-02	30%	5.05E-03
Chromium (III)		5.79E+02	No Toxicity Value	--	--	1.50E+00	1.07E-03	< 1%	1.00E-04
Lead		4.18E+02	--	--	--	No Toxicity Value	--	--	--
Nickel		2.51E+02	No Toxicity Value	--	--	2.00E-02	3.48E-02	19%	3.27E-03
Polychlorinated Biphenyls (PCBs) - Mixtures									
Total PCBs		4.19E-01	2.00E+00	2.09E-07	< 1%	2.00E-05	5.82E-02	32%	5.45E-03
Volatile Organic Compounds (VOCs)									
Tetrachloroethene		2.63E+01	2.10E-03	1.38E-08	< 1%	6.00E-03	1.22E-02	7%	1.14E-03
Trichloroethene		1.78E+00	4.60E-02	2.04E-08	< 1%	5.00E-04	9.88E-03	5%	9.27E-04
Semivolatile Organic Compounds (SVOCs)									
DEHP		7.71E+01	1.40E-02	2.69E-07	< 1%	2.00E-02	1.07E-02	6%	1.00E-03

Table A-13.1
Risk and Hazard Estimates: Incidental Ingestion of Soil, Hypothetical Fishing Platform User: CTE, Sandblast Area AOPC

Definition	Variable	Value	
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight	BW_a	80	kg
Body Weight	BW_c	15	kg
Conversion Factor	CF_o	1E-06	kg/mg
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Fraction Contaminated Soil Ingested	FI	1.0	unitless
Soil Ingestion Rate (adult)	IRS_a	50	mg/day
Soil Ingestion Rate (child)	IRS_c	100	mg/day
Oral Reference Dose	RfD_O	chemical-specific	(mg/kg-day)
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations Value

Cancer Risk:

Nonmutagens:

$$Risk = SF_o \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_a \times ED_a}{BW_a \times AT_c \times 365\frac{day}{year}} + \frac{IRS_c \times ED_c}{BW_c \times AT_c \times 365\frac{day}{year}}\right)\right]$$

Mutagens:

$$Risk = SF_O \times \left[C_{soil} \times EF_r \times FI \times CF_O \times \left(\frac{IRS_c \times ED_{0-2} \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_c \times ED_{2-6} \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{6-16} \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{IRS_a \times ED_{16-26} \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right)\right]$$

Vinyl Chloride:

$$Risk = SF_O \times \left\{C_{soil} \times FI \times CF_O \times \left[\frac{EF_r \times \left(\frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}\right)}{AT_c \times 365\frac{days}{year}} + \frac{IRS_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{soil} \times \left(\frac{IRS_c \times ED_c \times EF_r \times FI \times CF_o}{BW_c \times AT_{nc,c} \times 365\ day/year}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	SF_o $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_o (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Polycyclic Aromatic Hydrocarbons (PAHs)									
Benzo[a]anthracene	M	2.45E+00	7.30E-01	2.54E-06	6%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	2.39E+00	7.30E+00	2.47E-05	58%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	7.30E-01	2.29E-06	5%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene		1.05E+00	No Toxicity Value	--	--	3.00E-02	9.72E-05	< 1%	9.11E-06
Benzofluoranthenes, Total	M	6.36E+00	7.30E-01	6.58E-06	15%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	7.30E+00	2.46E-06	6%	No Toxicity Value	--	--	--
Indeno[1,2,3-cd]pyrene	M	1.16E+00	7.30E-01	1.20E-06	3%	No Toxicity Value	--	--	--
			Pathway Sum:	Cancer Risk 4.2E-05		Pathway Sum:	Hazard Index (Child) 0.18		Hazard Index (Adult) 0.017

Table A-13.2
Derivation of Inhalation Factors for Inhalation Exposures, Hypothetical Fishing Platform User: CTE, Sandblast Area AOPC

Description	Variable	Value	Units
Unit conversion factor	CF_i	1.00E-04	m^2/cm^2
Apparent Diffusivity	D_A	derived	cm^2/s
Diffusivity in air	D_i	chemical-specific	cm^2/s
Diffusivity in water	D_w	chemical-specific	cm^2/s
Default organic-carbon content	F_{OC}	0.006	g/g
Henry's law constant	H'	chemical-specific	dimensionless
Soil-water partition coefficient	K_d	chemical-specific	cm^3/g
for organics: $Kd=K_{OC}\times F_{OC}$			
Soil-organic carbon partition coefficient	K_{OC}	chemical-specific	cm^3/g
Total soil porosity	n	0.43	$L_{porespace}/L_{soil}$
Particulate Emission Factor (non-VOCs), default	PEF	1.360E+09	m^3/kg
Inverse of the mean concentration at the center of a 0.5-acre square source in Los Angeles	Q/C_{vol}	73.44	g/m^2-s per kg/m^3
Dry soil bulk density	ρ_b	1.5	g/cm^3
Air-filled soil porosity	θ_a	0.28	L_{air}/L_{soil}
Water-filled soil porosity	θ_w	0.15	L_{water}/L_{soil}
Exposure interval, 30-yr resident	$T_{Resident}$	2.80E+08	seconds
Volatilization Factor for soil	VFs	derived	m^3/kg

VF Derivation

$$VFs = Q/C_{vol} \times \frac{(3.14 \times D_A \times T_{resident})^{1/2}}{(2 \times \rho_b \times D_A)} \times CF_i$$

based on:

$$D_A = \frac{\left[\left(\theta_a{}^{10/3} D_i H' + \theta_w{}^{10/3} D_w\right)/n^2\right]}{\rho_B K_d + \theta_w + \theta_a H'}$$

Analyte	D_i (cm^2/s)	D_i Reference	D_w (cm^2/s)	D_w Reference	H' (dimensionless)	H' Reference	K_{OC} (cm^3/g)	K_{OC} Reference	K_d (cm^3/g)	D_A (cm^2/s)	VFs (VOCs) Residential m^3/kg	PEF (non-VOCs) m^3/kg
Inorganic Constituents												
Arsenic	0	0	0	0	31.61052561	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	29	0	non-VOC	1.360E+09
Chromium (III)	0	0	0	0	0	0	0	0	1800000	0	non-VOC	1.360E+09
Lead	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	900	0	non-VOC	1.360E+09
Nickel	0	0	0	0	1.001885999	Bond Method estimate, EPISuite v4.10 (USEPA 2011a)	13.22	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	65	0	non-VOC	1.360E+09
Polychlorinated Biphenyls (PCBs) - Mixtures												
Total PCBs	0.040076	RSLs ("WATER9"; USEPA 2012)	4.683E-06	RSLs ("WATER9"; USEPA 2012)	0.011572806	Experimental, EPISuite v4.10 (USEPA 2011a)	130500	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	783	3.1E-08	non-VOC	1.360E+09
Volatile Organic Compounds (VOCs)												
Tetrachloroethene	0.0504664	RSLs ("WATER9"; USEPA 2012)	9.455E-06	RSLs ("WATER9"; USEPA 2012)	0.723811518	Experimental, EPISuite v4.10 (USEPA 2011a)	94.94	EPISuite v4.10 (USEPA, 2011a); MCI-estimated	0.56964	0.00235	1497.209542	use VF
Trichloroethene	0.0686618	RSLs ("WATER9"; USEPA 2012)	0.0000102	RSLs ("WATER9"; USEPA 2012)	0.402799065	Experimental, EPISuite v4.10 (USEPA 2011a)	60.7	EPISuite v4.10 (USEPA 2011a); MCI-estimated	0.3642	0.00266	1408.678568	use VF
Semivolatile Organic Compounds (SVOCs)												
DEHP	0.0173403	RSLs ("WATER9"; USEPA 2012)	4.181E-06	RSLs ("WATER9"; USEPA 2012)	1.10412E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	119600	EPISuite v4.10 (USEPA 2011a); MCI-estimated	717.6	5.1E-11	non-VOC	1.360E+09
Polycyclic Aromatic Hydrocarbons (PAHs)												
Benzo[a]anthracene	0.0508647	RSLs ("WATER9"; USEPA 2012)	5.943E-06	RSLs ("WATER9"; USEPA 2012)	0.00049072	Experimental, EPISuite v4.10 (USEPA 2011a)	176900	EPISuite v4.10 (USEPA 2011a); MCI-estimated	1061.4	1.3E-09	non-VOC	1.360E+09
Benzo[a]pyrene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	1.86882E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	587400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	3524.4	2.3E-11	non-VOC	1.360E+09
Benzo[b]fluoranthene	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	3596.4	2.8E-11	non-VOC	1.360E+09
Benzo[g,h,i]perylene	0	0	0	0	1.35357E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	1951000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	11706	0	non-VOC	1.360E+09
Benzofluoranthenes, Total	0.0475831	RSLs ("WATER9"; USEPA 2012)	5.56E-06	RSLs ("WATER9"; USEPA 2012)	2.68669E-05	Experimental, EPISuite v4.10 (USEPA 2011a)	599400	EPISuite v4.10 (USEPA 2011a); MCI-estimated	3596.4	2.8E-11	non-VOC	1.360E+09
Dibenz[a,h]anthracene	0.0445672	RSLs ("WATER9"; USEPA 2012)	5.207E-06	RSLs ("WATER9"; USEPA 2012)	5.76596E-06	Experimental, EPISuite v4.10 (USEPA 2011a)	1912000	EPISuite v4.10 (USEPA 2011a); MCI-estimated	11472	4.1E-12	non-VOC	1.360E+09
Indeno[1,2,3-cd]pyrene	0.0447842	RSLs ("WATER9"; USEPA 2012)	5.233E-06	RSLs ("WATER9"; USEPA 2012)	0.0000656	EPISuite v4.10 (USEPA 2011a)	3470000	EPISuite v4.10 (USEPA 2011a)	20820	8.9E-12	non-VOC	1.360E+09

Table A-13.3

Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Sandblast Area AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	9	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	9	yrs
Exposure Frequency	EF_r	152	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \left[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \right]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000 \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Inorganic Constituents											
Arsenic		9.71E+00	1.360E+09	7.14E-06	4.30E-03	9.86E-10	< 1%	1.50E-02	1.19E-04	< 1%	1.19E-04
Chromium (III)		5.79E+02	1.360E+09	4.26E-04	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Lead		4.18E+02	1.360E+09	3.07E-04	--	--	--	No Toxicity Value	--	--	--
Nickel		2.51E+02	1.360E+09	1.85E-04	2.60E-04	2.57E-09	< 1%	9.00E-02	8.54E-04	< 1%	8.54E-04
Polychlorinated Biphenyls (PCBs) - Mixtures											
Total PCBs		4.19E-01	1.360E+09	3.08E-07	5.70E-04	9.40E-12	< 1%	No Toxicity Value	--	--	--
Volatile Organic Compounds (VOCs)											
Tetrachloroethene		2.63E+01	1.497E+03	1.76E+01	2.60E-07	2.45E-07	46%	4.00E+01	1.83E-01	41%	1.83E-01
Trichloroethene		1.78E+00	1.409E+03	1.26E+00	4.10E-06	2.77E-07	53%	2.00E+00	2.63E-01	59%	2.63E-01
Semivolatile Organic Compounds (SVOCs)											
DEHP		7.71E+01	1.360E+09	5.67E-05	2.40E-06	7.28E-12	< 1%	No Toxicity Value	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)											
Benzo[a]anthracene	M	2.45E+00	1.360E+09	1.80E-06	1.10E-04	8.49E-11	< 1%	No Toxicity Value	--	--	--
Benzo[a]pyrene	M	2.39E+00	1.360E+09	1.76E-06	1.10E-03	8.28E-10	< 1%	No Toxicity Value	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	1.360E+09	1.63E-06	1.10E-04	7.66E-11	< 1%	No Toxicity Value	--	--	--
Benzo[g,h,i]perylene		1.05E+00	1.360E+09	7.72E-07	No Toxicity Value	--	--	No Toxicity Value	--	--	--
Benzofluoranthenes, Total	M	6.36E+00	1.360E+09	4.68E-06	1.10E-04	2.20E-10	< 1%	No Toxicity Value	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	1.360E+09	1.75E-07	1.20E-03	9.00E-11	< 1%	No Toxicity Value	--	--	--

Table A-13.3
Risk and Hazard Estimates: Inhalation, Hypothetical Fishing Platform User: Sandblast Area AOPC

Description	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, resident	$AT_{nc,r}$	9	yrs
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Averaging Time, carcinogens	AT_c	70	yrs
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$
COPC Concentration in soil	C_{soil}	chemical-specific	mg/kg
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Duration, resident	ED_r	9	yrs
Exposure Frequency	EF_r	152	days/yr
Exposure Time	ET_r	24	hours/day
Inhalation Unit-Risk Factor	IUR	chemical-specific	$(\mu g/m^3)^{-1}$
Particulate emission factor (non-VOCs)	PEF	1.360E+09	m^3/kg
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$
Volatilization Factor for VOCs	VF	chemical-specific	m^3/kg

Equations

Cancer Risk:

Nonmutagens:

$$Risk = IUR \times C_{air} \times \left(\frac{ED_r \times EF_r \times ET_r}{AT_c \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Mutagens:

$$Risk = IUR \times \Bigg[C_{air} \times EF_r \times ET_r \times \left\{ \frac{ED_{0-2} \times ADAF_{0-2}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{2-6} \times ADAF_{2-6}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{6-16} \times ADAF_{6-16}}{AT_c \times 365\ days/year \times 24\ hours/day} + \frac{ED_{16-26} \times ADAF_{16-26}}{AT_c \times 365\ days/year \times 24\ hours/day} \right\} \Bigg]$$

Vinyl Chloride:

$$Risk = IUR \times \left[C_{air} \times \left\{ \frac{ED_r \times EF_r \times ET_r}{AT_c \times 365\ days/year \times 24\ hours/day} + 1 \right\} \right]$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfC} \times C_{air} \times \left(\frac{ED_c \times EF_r \times ET_r}{AT_{nc,r} \times 365 \frac{day}{year} \times 24 \frac{hour}{day}} \right)$$

Where:

$$C_{air} = \frac{C_{soil}}{VF \text{ or } PEF} \times 1000\ \frac{\mu g}{mg}$$

Analyte	Mutagen?	C_{soil} (mg/kg)	VF (VOCs) or PEF (non-VOCs) (m^3/kg)	C_{air} ($\mu g/m^3$)	IUR $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Indeno[1,2,3-cd]pyrene	M	1.16E+00	1.360E+09	8.53E-07	1.10E-04	4.02E-11	< 1%	No Toxicity Value	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adul
Pathway Sum:	5.3E-07	Pathway Sum:	4.5E-01	4.5E-01

Table A-13.4

Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: CTE, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.01	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.04	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	(mg/kg-day)$^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times [C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)]$$

Mutagens:

$$Risk = SF_d \times \Big\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \Big[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\Big]\Big\}$$

Vinyl Chloride:

$$Risk = SF_d \times \Big\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\Big\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	**Mutagen?**	**C_{soil}** (mg/kg)	**ABS_d** (unitless)	**SF_d** (mg/kg-day)$^{-1}$	**Cancer Risk** (dimensionless)	**% of Total**	**RfD_d** (mg/kg-day)	**Noncancer Hazard (Child)** (dimensionless)	**% of Total**	**Noncancer Hazard (Adult)** (dimensionless)
Inorganic Constituents										
Arsenic		9.71E+00	3.00E-02	1.50E+00	6.27E-08	1%	3.00E-04	1.54E-03	8%	1.83E-04
Chromium (III)		5.79E+02	1.00E-02	--	--	--	1.95E-02	7.82E-04	4%	9.32E-05
Lead		4.18E+02	1.00E-02	--	--	--	--	--	--	--
Nickel		2.51E+02	1.00E-02	--	--	--	8.00E-04	8.27E-03	43%	9.85E-04
Polychlorinated Biphenyls (PCBs) - Mixtures										
Total PCBs		4.19E-01	1.40E-01	2.00E+00	2.81E-08	< 1%	2.00E-05	7.73E-03	40%	9.21E-04
Volatile Organic Compounds (VOCs)										
Tetrachloroethene		2.63E+01	0.00E+00	2.10E-03	0.00E+00	< 1%	6.00E-03	0.00E+00	< 1%	0.00E+00
Trichloroethene		1.78E+00	0.00E+00	4.60E-02	0.00E+00	< 1%	5.00E-04	0.00E+00	< 1%	0.00E+00

Table A-13.4
Risk and Hazard Estimates: Dermal Contact with Soil, Hypothetical Fishing Platform User: CTE, Sandblast Area AOPC

Description	Variable	Value	
Dermal Soil Absorption Fraction	ABS_d	chemical-specific	unitless
Age-dependent Adjustment Factor, 0-2	$ADAF_{0-2}$	10	yrs
Age-dependent Adjustment Factor, 2-6	$ADAF_{2-6}$	3	yrs
Age-dependent Adjustment Factor, 6-16	$ADAF_{6-16}$	3	yrs
Age-dependent Adjustment Factor, 16-26	$ADAF_{16-26}$	1	yrs
Soil-to-Skin Adherence Fraction	AF_a	0.01	mg/cm^2-day
Soil-to-Skin Adherence Fraction	AF_c	0.04	mg/cm^2-day
Averaging Time, Carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, adult	$AT_{nc,a}$	3	yrs
Averaging Time, noncarcinogens, child	$AT_{nc,c}$	6	yrs
Body Weight, adult	BW_a	80	kg
Body Weight, child	BW_c	15	kg
Conversion Factor	CF_d	1E-06	kg/mg
COPC Concentration in Soil	C_{soil}	chemical-specific	mg/kg
Fraction of EV in Contact with Soil	EC	1	unitless
Exposure Duration, child 0-2	ED_{0-2}	2	yrs
Exposure Duration, child 2-6	ED_{2-6}	4	yrs
Exposure Duration, child 6-16	ED_{6-16}	10	yrs
Exposure Duration, adult 16-26	ED_{16-26}	10	yrs
Exposure Duration, adult	ED_a	3	yrs
Exposure Duration, child	ED_c	6	yrs
Exposure Frequency, resident	EF_r	152	days/yr
Event Frequency	EV	1	events/day
Refererenc Dose Adjusted for GI Absorption	RfD_d	chemical-specific	mg/kg-day
Exposed Body Surface Area, adult	SA_a	6032	cm^2
Exposed Body Surface Area, child	SA_c	2373	cm^2
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations:

Cancer Risk:

Nonmutagens:

$$Risk = SF_d \times [C_{soil} \times ED_a \times EF \times EV \times EC \times ABS_d \times CF_d \times \left(\frac{AF_a \times SA_a}{BW_a \times AT_c \times 365\ day/year} + \frac{AF_c \times ED_c \times SA_c}{BW_c \times AT_c \times 365\ day/year}\right)]$$

Mutagens:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{ED_{0-2} \times AF_c \times SA_c \times ADAF_{0-2}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{2-6} \times AF_c \times SA_c \times ADAF_{2-6}}{BW_c \times AT_c \times 365\ days/year} + \frac{ED_{6-16} \times AF_a \times SA_a \times ADAF_{6-16}}{BW_a \times AT_c \times 365\ days/year} + \frac{ED_{16-26} \times AF_a \times SA_a \times ADAF_{16-26}}{BW_a \times AT_c \times 365\ days/year}\right]\right\}$$

Vinyl Chloride:

$$Risk = SF_d \times \left\{C_{soil} \times EF_r \times EV \times EC \times ABS_d \times CF_d \times \left[\frac{EF_r \times \left(\frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}\right)}{AT_c \times 365 \frac{days}{year}} + \frac{AF_c \times SA_c}{BW_c}\right]\right\}$$

Noncancer Hazard:

$$Hazard = \frac{1}{RfD_d} \times \left[C_{soil} \times \left(\frac{AF_c \times ABS_d \times ED_{nc,c} \times EF_r \times EV \times EC \times SA_c \times CF_d}{BW_c \times AT_{nc,c} \times 365 \frac{day}{year}}\right)\right]$$

Analyte	Mutagen?	C_{soil} (mg/kg)	ABS_d (unitless)	SF_d $(mg/kg\text{-}day)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfD_d (mg/kg-day)	Noncancer Hazard (Child) (dimensionless)	% of Total	Noncancer Hazard (Adult) (dimensionless)
Semivolatile Organic Compounds (SVOCs)										
DEHP		7.71E+01	1.00E-01	1.40E-02	2.58E-08	< 1%	2.00E-02	1.02E-03	5%	1.21E-04
Polycyclic Aromatic Hydrocarbons (PAHs)										
Benzo[a]anthracene	M	2.45E+00	1.30E-01	7.30E-01	3.22E-07	6%	--	--	--	--
Benzo[a]pyrene	M	2.39E+00	1.30E-01	7.30E+00	3.14E-06	61%	--	--	--	--
Benzo[b]fluoranthene	M	2.21E+00	1.30E-01	7.30E-01	2.90E-07	6%	--	--	--	--
Benzo[g,h,i]perylene		1.05E+00	1.30E-01	--	--	--	3.00E-02	1.20E-05	< 1%	1.43E-06
Benzofluoranthenes, Total	M	6.36E+00	1.30E-01	7.30E-01	8.35E-07	16%	--	--	--	--
Dibenz[a,h]anthracene	M	2.38E-01	1.30E-01	7.30E+00	3.13E-07	6%	--	--	--	--
Indeno[1,2,3-cd]pyrene	M	1.16E+00	1.30E-01	7.30E-01	1.52E-07	3%	--	--	--	--

	Cancer Risk		Hazard Index (Child)	Hazard Index (Adult
Pathway Sum:	5.2E-06	Pathway Sum:	0.019	0.0023

Table A-14.1

Risk and Hazard Estimates - Ingestion of Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definitions	Variable	Value	
Averaging Time, carcinogens	AT_c	70	yrs
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs
Body Weight, adult	BW_a	80	kg
Conversion Factor, ingestion	CF_o	1.0E-03	mg/µg
COPC Concentration in Water	C_{water}	chemical-specific	µg/L
Exposure Duration, worker	ED_w	1	yrs
Exposure Frequency, worker	EF_w	9	days/yr
Fraction Contaminated Water Ingested, worker	FI_w	1.0	unitless
Water Ingestion Rate, worker	IRW_w	0.02	L/day
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$

Equations

Carcinogenic:

$$Risk = SF_o \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365 day/year} \right) \right]$$

Noncarcinogenic:

$$Hazard = \frac{1}{RfD_o} \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,w} \times 365 day/year} \right) \right]$$

Analyte	C_{water} (*µg/L*)	SF_o (*mg/kg-day*)$^{-1}$	Cancer Risk (*dimensionless*)	% of Total	RfD_o (*mg/kg-day*)	Noncancer Hazard (*dimensionless*)	% of Total
Inorganic Constituents							
Vanadium	2.23E-01	No Toxicity Value	--	--	5.00E-03	2.75E-07	< 1%
Volatile Organic Compounds (VOCs)							
Acetone	3.88E+00	No Toxicity Value	--	--	9.00E-01	2.66E-08	< 1%
Benzene	1.37E-01	5.50E-02	6.64E-13	< 1%	4.00E-03	2.11E-07	< 1%
Carbon disulfide	2.55E-01	No Toxicity Value	--	--	1.00E-01	1.57E-08	< 1%
Chloroform	1.74E-01	3.10E-02	4.75E-13	< 1%	1.00E-02	1.07E-07	< 1%
1,1-Dichloroethane	5.00E+00	5.70E-03	2.51E-12	< 1%	2.00E-01	1.54E-07	< 1%
1,1-Dichloroethene	1.16E+00	No Toxicity Value	--	--	5.00E-02	1.43E-07	< 1%
cis-1,2-Dichloroethene	6.60E+02	No Toxicity Value	--	--	2.00E-03	2.03E-03	77%
trans-1,2-Dichloroethene	1.80E+00	No Toxicity Value	--	--	2.00E-02	5.55E-07	< 1%
1,2-Dichloropropane	1.79E-01	3.60E-02	5.67E-13	< 1%	9.00E-02	1.23E-08	< 1%
Ethylbenzene	4.47E-02	1.10E-02	4.33E-14	< 1%	1.00E-01	2.76E-09	< 1%
Tetrachloroethene	5.45E+01	2.10E-03	1.01E-11	2%	6.00E-03	5.60E-05	2%
Toluene	6.40E-01	No Toxicity Value	--	--	8.00E-02	4.93E-08	< 1%
1,1,1-Trichloroethane	2.22E+00	No Toxicity Value	--	--	2.00E+00	6.84E-09	< 1%
Trichloroethene	4.37E+01	4.60E-02	1.77E-10	39%	5.00E-04	5.39E-04	20%

Table A-14.1

Risk and Hazard Estimates - Ingestion of Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definitions	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Carcinogenic:
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs	
Body Weight, adult	BW_a	80	kg	$Risk = SF_o \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_c \times 365 day/year} \right) \right]$
Conversion Factor, ingestion	CF_o	1.0E-03	mg/µg	
COPC Concentration in Water	C_{water}	chemical-specific	µg/L	
Exposure Duration, worker	ED_w	1	yrs	
Exposure Frequency, worker	EF_w	9	days/yr	Noncarcinogenic:
Fraction Contaminated Water Ingested, worker	FI_w	1.0	unitless	
Water Ingestion Rate, worker	IRW_w	0.02	L/day	$Hazard = \frac{1}{RfD_o} \times \left[C_{water} \times \left(\frac{IRW_w \times EF_w \times ED_w \times FI_w \times CF_o}{BW_a \times AT_{nc,w} \times 365 day/year} \right) \right]$
Oral Reference Dose	RfD_O	chemical-specific	mg/kg-day	
Oral Slope Factor	SF_O	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	C_{water} (*µg/L*)	SF_o *(mg/kg-day)*$^{-1}$	Cancer Risk (*dimensionless*)	% of Total	RfD_o (*mg/kg-day*)	Noncancer Hazard (*dimensionless*)	% of Total
Vinyl Chloride	4.10E+00	7.20E-01	2.60E-10	58%	3.00E-03	8.42E-06	< 1%
Xylenes	1.32E-01	No Toxicity Value	--	--	2.00E-01	4.07E-09	< 1%
1,2,4-trimethylbenzene	4.85E-02	No Toxicity Value	--	--	No Toxicity Value	--	--
o-xylene	7.35E-02	No Toxicity Value	--	--	2.00E-01	2.27E-09	< 1%
Naphthalene	4.52E-02	No Toxicity Value	--	--	2.00E-02	1.39E-08	< 1%

	Cancer Risk	Hazard Index
Pathway Sum:	4.5E-10	2.6E-03

Table A-14.2

k and Hazard Estimates - Inhalation of Volatile Compounds from Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AC

Definition	Variable	Value		Risk and Hazard Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs	$Risk = URF \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365\ days/year \times 24} \right) \right]$
Body Weight, adult	BW_a	80	kg	
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$	
COPC Concentration in water	C_{water}	chemical-specific	µg/L	Noncancer Hazard:
Exposure Duration, worker	ED_w	1	yrs	
Exposure Frequency, worker	EF_w	9	days/yr	$Hazard = \frac{1}{RfC} \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365\ days/year \times 24 hours/day} \right) \right]$
Exposure Time, worker	ET_w	4.00	hours	
Air Inhalation Rate, worker	IRA_w	20	m^3/workday	
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$	
Inhalation Unit-Risk Factor	URF	chemical-specific	$(\mu g/m^3)^{-1}$	where: $C_{air} = C_{water} \times VF$
Volatilization Factor	VF	chemical-specific	L/m^3	

Analyte	C_{water} (µg/L)	VF (L/m^3)	C_{air} ($\mu g/m^3$)	URF_i $(\mu g/m^3)^{-1}$	Cancer Risk (dimensionless)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (dimensionless)	% of Total
Inorganic Constituents									
Vanadium	2.23E-01	non-VOC	--	No Toxicity Value	--	--	1.00E-01	--	--
Volatile Organic Compounds (VOCs)									
Acetone	3.88E+00	4.12E+00	1.60E+01	No Toxicity Value	--	--	3.10E+04	2.12E-06	< 1%
Benzene	1.37E-01	9.35E+00	1.28E+00	7.80E-06	5.86E-10	< 1%	3.00E+01	1.75E-04	< 1%
Carbon disulfide	2.55E-01	9.55E+00	2.44E+00	No Toxicity Value	--	--	7.00E+02	1.43E-05	< 1%
Chloroform	1.74E-01	7.53E+00	1.31E+00	2.30E-05	1.77E-09	2%	9.80E+01	5.49E-05	< 1%
1,1-Dichloroethane	5.00E+00	8.31E+00	4.15E+01	1.60E-06	3.90E-09	4%	No Toxicity Value	--	--
1,1-Dichloroethene	1.16E+00	8.46E+00	9.82E+00	No Toxicity Value	--	--	2.00E+02	2.02E-04	< 1%
cis-1,2-Dichloroethene	6.60E+02	8.36E+00	5.52E+03	No Toxicity Value	--	--	No Toxicity Value	--	--
trans-1,2-Dichloroethene	1.80E+00	8.43E+00	1.52E+01	No Toxicity Value	--	--	6.00E+01	1.04E-03	< 1%
1,2-Dichloropropane	1.79E-01	7.70E+00	1.38E+00	1.00E-05	8.09E-10	< 1%	4.00E+00	1.42E-03	< 1%
Ethylbenzene	4.47E-02	8.05E+00	3.60E-01	2.50E-06	5.28E-11	< 1%	1.00E+03	1.48E-06	< 1%
Tetrachloroethene	5.45E+01	6.47E+00	3.52E+02	2.60E-07	5.38E-09	5%	4.00E+01	3.62E-02	5%
Toluene	6.40E-01	8.62E+00	5.52E+00	No Toxicity Value	--	--	5.00E+03	4.54E-06	< 1%
1,1,1-Trichloroethane	2.22E+00	7.21E+00	1.60E+01	No Toxicity Value	--	--	5.00E+03	1.32E-05	< 1%
Trichloroethene	4.37E+01	7.25E+00	3.17E+02	4.10E-06	7.62E-08	76%	2.00E+00	6.51E-01	94%
Vinyl Chloride	4.10E+00	1.05E+01	4.32E+01	4.40E-06	1.12E-08	11%	1.00E+02	1.78E-03	< 1%
Xylenes	1.32E-01	8.02E+00	1.06E+00	No Toxicity Value	--	--	1.00E+02	4.35E-05	< 1%

Table A-14.2

k and Hazard Estimates - Inhalation of Volatile Compounds from Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AC

Definition	Variable	Value		Risk and Hazard Equations
Averaging Time, carcinogens	AT_c	70	yrs	Cancer Risk:
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs	
Body Weight, adult	BW_a	80	kg	$Risk = URF \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_c \times 365\ days/year \times 24} \right) \right]$
COPC Concentration in air	C_{air}	chemical-specific	$\mu g/m^3$	
COPC Concentration in water	C_{water}	chemical-specific	µg/L	Noncancer Hazard:
Exposure Duration, worker	ED_w	1	yrs	
Exposure Frequency, worker	EF_w	9	days/yr	$Hazard = \frac{1}{RfC} \times \left[C_{air} \times \left(\frac{EF_w \times ED_w \times ET_w}{AT_{nc,w} \times 365\ days/year \times 24 hours/day} \right) \right]$
Exposure Time, worker	ET_w	4.00	hours	
Air Inhalation Rate, worker	IRA_w	20	m^3/workday	
Inhalation Reference Concentration	RfC	chemical-specific	$\mu g/m^3$	
Inhalation Unit-Risk Factor	URF	chemical-specific	$(\mu g/m^3)^{-1}$	where: $C_{air} = C_{water} \times VF$
Volatilization Factor	VF	chemical-specific	L/m^3	

Analyte	C_{water} ($\mu g/L$)	VF (L/m^3)	C_{air} ($\mu g/m^3$)	URF_i $(\mu g/m^3)^{-1}$	Cancer Risk (*dimensionless*)	% of Total	RfC ($\mu g/m^3$)	Hazard Quotient (*dimensionless*)	% of Total
1,2,4-trimethylbenzene	4.85E-02	7.55E+00	3.66E-01	No Toxicity Value	--	--	7.00E+00	2.15E-04	< 1%
o-xylene	7.35E-02	8.02E+00	5.89E-01	No Toxicity Value	--	--	1.00E+02	2.42E-05	< 1%
Naphthalene	4.52E-02	6.60E+00	2.98E-01	3.40E-05	5.96E-10	< 1%	3.00E+00	4.09E-04	< 1%
				Pathway Sums:	Cancer Risk 1.0E-07			Hazard Index 6.9E-01	

Table A-14.3

Estimation of Kp, Tau(event), B, and t* for Organic Compounds: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definition	Variable	Value	
Permeability coefficient from water	K_p	Calculated (Equation 1)	cm/hr
Octanol:water partition coefficient	K_{ow}	Chemical-specific	dimensionless
Molecular weight	MW	Chemical-specific	g/mole
Lag time per event	τ_{event}	Calculated (Equation 2)	hr/event
Thickness of the strateum corneum	l_{sc}	0.001	cm
Effective diffusion coefficient, through the stratum corneum	D_{sc}	Calculated (Equation 2)	cm^2/hr
Relative contribution of permeability coefficients in stratum corneum and viable epidermis	B	Calculated (Equation 3)	dimensionless
Time it takes to reach steady state	t*	Calculated (Equation 4)	hr
Correlation coefficient	b	Calculated (Equation 4)	dimensionless
Correlation coefficient	c	Calculated (Equation 4)	dimensionless

Equations

1) $$K_p = 10^{(-2.8 + 0.66\, LogK_{OW} - 0.0056\, MW)}$$

2) $$\tau_{event} = \frac{(l_{sc})^2}{6D_{sc}}$$

where: $$D_{sc} = l_{sc} \times 10^{(-2.8 - 0.0056\, MW)}$$

3) $$B = K_p \frac{\sqrt{MW}}{2.6}$$ (as an approximation)

4) $$If\ B \le 0.6: \quad t^* = 2.4\tau_{event}$$

$$If\ B > 0.6: \quad t^* = 6\tau_{event}\left(b - \sqrt{b^2 - c^2}\right)$$

where: $$c = \frac{1 + 3B + 3B^2}{3 \times (1 + B)}$$

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

Analyte	MW (*g/mole*)	$LogK_{OW}$ (*dimensionless*)	Kp[a] (*cm/hr*)	τ_{event} (*hr/event*)	B (*dimensionless*)	c (*dimensionless*)	b (*dimensionless*)	t* (*hr*)
Inorganic Constituents								
Vanadium	50.94	2.30E-01	1.00E-03	2.03E-01	2.75E-03	3.35E-01	3.05E-01	4.87E-01
Volatile Organic Compounds (VOCs)								
Acetone	58.08	-2.40E-01	5.20E-04	2.22E-01	1.53E-03	3.34E-01	3.04E-01	5.34E-01
Benzene	78.11	2.13E+00	1.47E-02	2.88E-01	5.01E-02	3.68E-01	3.34E-01	6.91E-01
Carbon disulfide	76.13	1.94E+00	1.13E-02	2.81E-01	3.80E-02	3.59E-01	3.27E-01	6.74E-01
Chloroform	119.38	1.97E+00	6.79E-03	4.90E-01	2.85E-02	3.53E-01	3.21E-01	1.18E+00
1,1-Dichloroethane	98.96	1.79E+00	6.72E-03	3.77E-01	2.57E-02	3.51E-01	3.19E-01	9.04E-01
1,1-Dichloroethene	96.94	2.13E+00	1.16E-02	3.67E-01	4.38E-02	3.63E-01	3.30E-01	8.81E-01
cis-1,2-Dichloroethene	96.94	1.86E+00	7.67E-03	3.67E-01	2.90E-02	3.53E-01	3.21E-01	8.81E-01
trans-1,2-Dichloroethene	96.94	2.09E+00	1.09E-02	3.67E-01	4.12E-02	3.61E-01	3.29E-01	8.81E-01
1,2-Dichloropropane	112.99	1.98E+00	7.48E-03	4.51E-01	3.06E-02	3.54E-01	3.22E-01	1.08E+00
Ethylbenzene	106.17	3.15E+00	4.84E-02	4.13E-01	1.92E-01	4.71E-01	4.33E-01	9.92E-01
Tetrachloroethene	165.83	3.40E+00	3.28E-02	8.92E-01	1.62E-01	4.49E-01	4.11E-01	2.14E+00
Toluene	92.14	2.73E+00	3.06E-02	3.45E-01	1.13E-01	4.12E-01	3.76E-01	8.28E-01
1,1,1-Trichloroethane	133.41	2.49E+00	1.25E-02	5.87E-01	5.55E-02	3.71E-01	3.38E-01	1.41E+00
Trichloroethene	131.39	2.42E+00	1.15E-02	5.72E-01	5.08E-02	3.68E-01	3.35E-01	1.37E+00
Vinyl Chloride	62.5	1.62E+00	8.30E-03	2.35E-01	2.52E-02	3.50E-01	3.19E-01	5.65E-01
Xylenes	106.17	3.16E+00	4.91E-02	4.13E-01	1.95E-01	4.74E-01	4.35E-01	9.92E-01
1,2,4-trimethylbenzene	120.2	3.63E+00	8.37E-02	4.95E-01	3.53E-01	5.99E-01	5.66E-01	1.19E+00
o-xylene	106.17	3.12E+00	4.62E-02	4.13E-01	1.83E-01	4.65E-01	4.26E-01	9.92E-01
Naphthalene	128.18	3.30E+00	4.57E-02	5.49E-01	1.99E-01	4.77E-01	4.38E-01	1.32E+00

Table A-14.3

Estimation of Kp, Tau(event), B, and t* for Organic Compounds: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definition	Variable	Value		Equations
Permeability coefficient from water	K_p	Calculated (Equation 1)	cm/hr	1) $K_p = 10^{(-2.8+0.66\,LogK_{OW}-0.0056\,MW)}$
Octanol:water partition coefficient	K_{ow}	Chemical-specific	dimensionless	
Molecular weight	MW	Chemical-specific	g/mole	2) $\tau_{event} = \frac{(l_{sc})^2}{6D_{sc}}$
Lag time per event	τ_{event}	Calculated (Equation 2)	hr/event	
Thickness of the strateum corneum	l_{sc}	0.001	cm	
Effective diffusion coefficient, through the stratum corneum	D_{sc}	Calculated (Equation 2)	cm^2/hr	where: $D_{sc} = l_{sc} \times 10^{(-2.8-0.0056\,MW)}$
Relative contribution of permeability coefficients in stratum corneum and viable epidermis	B	Calculated (Equation 3)	dimensionless	
Time it takes to reach steady state	t*	Calculated (Equation 4)	hr	3) $B = K_p \frac{\sqrt{MW}}{2.6}$ (as an approximation)
Correlation coefficient	b	Calculated (Equation 4)	dimensionless	
Correlation coefficient	c	Calculated (Equation 4)	dimensionless	
				4) $If\ B \le 0.6:\ t^* = 2.4\tau_{event}$
				$If\ B > 0.6:\ t^* = 6\tau_{event}\left(b - \sqrt{b^2 - c^2}\right)$
				where: $c = \frac{1+3B+3B^2}{3\times(1+B)}$
				$b = \frac{2\times(1+B)^2}{\pi} - c$

Analyte	MW (*g/mole*)	$LogK_{OW}$ (*dimensionless*)	Kp[a] (*cm/hr*)	τ_{event} (*hr/event*)	B (*dimensionless*)	c (*dimensionless*)	b (*dimensionless*)	t* (*hr*)

[a] NRP = Not reliably predicted; the compound's chemical properties fall outside the Effective Prediction Domain for Kp (Equations 3.9 and 3.10; USEPA 2004a).

Table A-14.4

Calculation of Dose Absorbed Per Unit Area Per Event: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definition	Variable	Value		Equations
Relative contribution of permeability coefficients in stratum corneum and viable epidermis	B	Chemical-specific	dimensionless	*Organics:* If $t_{event} \leq t^*$, then:
Concentration of chemical in water	C_{water}	Measured	µg/L	$DA_{event} = 2FA_w \times K_p \times (C_{water} \times CF_d) \times \left(\sqrt{\frac{6\tau_{event} t_{event}}{\pi}}\right)$
Conversion Factor	CF_d	1.0E-06	(mg L) / (µg cm^3)	
Dose absorbed per unit area per event	DA_{event}	Calculated	mg/cm^2-event	If $t_{event} > t^*$, then:
Fraction Absorbed, worker	FA_w	Chemical-specific	dimensionless	$DA_{event} = FA_w \times K_p \times (C_{water} \times CF_d) \times \left[\frac{t_{event}}{1+B} + 2\tau_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$
Permeability coefficient from water	K_p	Chemical-specific	cm/hr	
Lag time per event	τ_{event}	Chemical-specific	hr/event	
Duration of event	t_{event}	2	hr/event	*Inorganics:*
Time it takes to reach steady state	t*	Chemical-specific	hr	$DA_{event} = K_p \times (C_{water} \times CF_d) \times t_{event}$

Analyte	FA_W [a] (*dimensionless*)	K_p [b] (*cm/hr*)	C_{water} [c] (*µg/L*)	τ_{event} [d] (*hr/event*)	t* [d] (*hr*)	B [d] (*dimensionless*)	DA_{event} (*mg/cm^2-event*)
Inorganic Constituents							
Vanadium	--	1.00E-03	2.23E-01	2.03E-01	4.87E-01	2.75E-03	4.46E-10
Volatile Organic Compounds (VOCs)							
Acetone	1	5.20E-04	3.88E+00	2.22E-01	5.34E-01	1.53E-03	4.93E-09
Benzene	1	1.47E-02	1.37E-01	2.88E-01	6.91E-01	5.01E-02	5.07E-09
Carbon disulfide	1	1.13E-02	2.55E-01	2.81E-01	6.74E-01	3.80E-02	7.25E-09
Chloroform	1	6.79E-03	1.74E-01	4.90E-01	1.18E+00	2.85E-02	3.49E-09
1,1-Dichloroethane	1	6.72E-03	5.00E+00	3.77E-01	9.04E-01	2.57E-02	9.15E-08
1,1-Dichloroethene	1	1.16E-02	1.16E+00	3.67E-01	8.81E-01	4.38E-02	3.60E-08
cis-1,2-Dichloroethene	1	7.67E-03	6.60E+02	3.67E-01	8.81E-01	2.90E-02	1.37E-05
trans-1,2-Dichloroethene	1	1.09E-02	1.80E+00	3.67E-01	8.81E-01	4.12E-02	5.26E-08
1,2-Dichloropropane	1	7.48E-03	1.79E-01	4.51E-01	1.08E+00	3.06E-02	3.85E-09
Ethylbenzene	1	4.84E-02	4.47E-02	4.13E-01	9.92E-01	1.92E-01	5.75E-09
Tetrachloroethene	1	3.28E-02	5.45E+01	8.92E-01	2.14E+00	1.62E-01	6.59E-06
Toluene	1	3.06E-02	6.40E-01	3.45E-01	8.28E-01	1.13E-01	5.02E-08
1,1,1-Trichloroethane	1	1.25E-02	2.22E+00	5.87E-01	1.41E+00	5.55E-02	8.69E-08
Trichloroethene	1	1.15E-02	4.37E+01	5.72E-01	1.37E+00	5.08E-02	1.56E-06
Vinyl Chloride	1	8.30E-03	4.10E+00	2.35E-01	5.65E-01	2.52E-02	8.28E-08
Xylenes	1	4.91E-02	1.32E-01	4.13E-01	9.92E-01	1.95E-01	1.72E-08
1,2,4-trimethylbenzene	1	8.37E-02	4.85E-02	4.95E-01	1.19E+00	3.53E-01	1.13E-08
o-xylene	1	4.62E-02	7.35E-02	4.13E-01	9.92E-01	1.83E-01	9.05E-09
Naphthalene	1	4.57E-02	4.52E-02	5.49E-01	1.32E+00	1.99E-01	6.16E-09

Table A-14.4

Calculation of Dose Absorbed Per Unit Area Per Event: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

[a] FA_r for organic chemicals is from Exhibit B-3, USEPA (2004. RAGS Part E. EPA/540/R/99/005); for chemicals not listed in Exhibit B-3, a default value of 1.0 was used.

[b] K_p for inorganics is from USEPA (2004. RAGS Part E. EPA/540/R/99/005).

K_p for organics is from Table A-18.3

NRP = Not Reliably Predicted (see Table A-18.3).

[c] from Table A-18.3

[d] from Table A-18.3.

Table A-14.5

Risk and Hazard Estimates: Dermal Contact with Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Carcinogenic:
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs	$Risk = SF_d \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_c \times 365\ day/year} \right) \right]$
Body Weight, adult	BW_a	80	kg	
COPC Absorbed Dose per Event	DA_{event}	chemical-specific	mg/cm^2-event	
Exposure Duration, worker	ED_w	1	yrs	Noncarcinogenic:
Exposure Frequency, worker	EF_w	9	days/yr	$Hazard = \frac{1}{RfD_d} \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_{nc,w} \times 365\ day/year} \right) \right]$
Event Frequency, worker	EV_w	2	events/day	
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	(mg/kg-day)	
Exposed Body Surface Area, worker	SA_a	5700	cm^2	
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	**DA_{event}** *(mg/cm^2-event)*	**SF_D** *($(mg/kg\text{-}day)^{-1}$)*	**Cancer Risk** *(dimensionless)*	**% of Total**	**RfD_D** (mg/kg-day)	**Hazard Quotient** *(dimensionless)*	**% of Total**
Inorganic Constituents							
Vanadium	4.46E-10		--		1.30E-04	1.21E-05	< 1%
Volatile Organic Compounds (VOCs)							
Acetone	4.93E-09		--		9.00E-01	1.93E-08	< 1%
Benzene	5.07E-09	5.50E-02	1.40E-11	< 1%	4.00E-03	4.45E-06	< 1%
Carbon disulfide	7.25E-09		--		1.00E-01	2.55E-07	< 1%
Chloroform	3.49E-09	3.10E-02	5.43E-12	< 1%	1.00E-02	1.23E-06	< 1%
1,1-Dichloroethane	9.15E-08	5.70E-03	2.62E-11	< 1%	2.00E-01	1.61E-06	< 1%
1,1-Dichloroethene	3.60E-08		--		5.00E-02	2.53E-06	< 1%
cis-1,2-Dichloroethene	1.37E-05		--		2.00E-03	2.40E-02	62%
trans-1,2-Dichloroethene	5.26E-08		--		2.00E-02	9.24E-06	< 1%
1,2-Dichloropropane	3.85E-09	3.60E-02	6.95E-12	< 1%	9.00E-02	1.50E-07	< 1%
Ethylbenzene	5.75E-09	1.10E-02	3.17E-12	< 1%	1.00E-01	2.02E-07	< 1%
Tetrachloroethene	6.59E-06	2.10E-03	6.95E-10	9%	6.00E-03	3.86E-03	10%
Toluene	5.02E-08		--		8.00E-02	2.21E-06	< 1%
1,1,1-Trichloroethane	8.69E-08		--		2.00E+00	1.53E-07	< 1%
Trichloroethene	1.56E-06	4.60E-02	3.61E-09	49%	5.00E-04	1.10E-02	28%
Vinyl Chloride	8.28E-08	7.20E-01	2.99E-09	41%	3.00E-03	9.70E-05	< 1%
Xylenes	1.72E-08		--		2.00E-01	3.03E-07	< 1%

Table A-14.5

Risk and Hazard Estimates: Dermal Contact with Water: Excavation/Trench Worker, Exposure to Groundwater - RME, Sandblast Area AOPC

Definition	Variable	Value		Equations
Averaging Time, carcinogens	AT_c	70	yrs	Carcinogenic:
Averaging Time, noncarcinogens, worker	$AT_{nc,w}$	1	yrs	$Risk = SF_d \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_c \times 365\ day/year} \right) \right]$
Body Weight, adult	BW_a	80	kg	
COPC Absorbed Dose per Event	DA_{event}	chemical-specific	mg/cm^2-event	
Exposure Duration, worker	ED_w	1	yrs	Noncarcinogenic:
Exposure Frequency, worker	EF_w	9	days/yr	$Hazard = \frac{1}{RfD_d} \times \left[DA_{event} \times \left(\frac{EF_w \times ED_w \times EV_w \times SA_w}{BW_a \times AT_{nc,w} \times 365\ day/year} \right) \right]$
Event Frequency, worker	EV_w	2	events/day	
Oral Reference Dose Adjusted for GI Absorption	RfD_d	chemical-specific	(mg/kg-day)	
Exposed Body Surface Area, worker	SA_a	5700	cm^2	
Oral Slope Factor Adjusted for GI Absorption	SF_d	chemical-specific	$(mg/kg\text{-}day)^{-1}$	

Analyte	**DA_{event}** *(mg/cm^2-event)*	**SF_D** *$(mg/kg\text{-}day)^{-1}$*	**Cancer Risk** *(dimensionless)*	**% of Total**	**RfD_D** (mg/kg-day)	**Hazard Quotient** *(dimensionless)*	**% of Total**
1,2,4-trimethylbenzene	1.13E-08		--			--	
o-xylene	9.05E-09		--		2.00E-01	1.59E-07	< 1%
Naphthalene	6.16E-09		--		2.00E-02	1.08E-06	< 1%

	Cancer Risk	Hazard Index
Pathway Sums:	7.4E-09	3.9E-02

APPENDIX B

Models Used in the BHHRA

Appendix B
Models Used in the BHHRA

GENERAL ABBREVIATIONS

(Additional Model-Specific Abbreviations Defined in Individual Sub-Appendices)

% = percent
-- = data not available or not calculated
µg= microgram
atm = atom
ACH = air changes per hour
bgs = below ground surface
CF = Conversion Factor
CF_i = unit conversion factor
Cg = concentration gas
Cgw = concentration of contaminant in groundwater
Ctrench = concentration of contaminant in trench
cm = centimeter
cm^3 = cubic centimeter
cm^2 = square centimeter
COPC = chemical of potential concern
dL = deciliter
EE/CA = Engineering Evaluation/Cost Analysis
F = fraction of floor through which contaminant can enter
ft = feet
g = gram
GI = gastrointestinal
GSD = geometric standard deviation
H2O = hydrogen peroxide
Hi = Henry's law constant for contaminant
hr = hour
IEUBK = Integrated Exposure Uptake Biokinetic
K = Kelvin (temperature unit)

kg = kilogram
Ki = overall mass transfer coefficient of contaminant
KiG = gas-phase mass transfer coefficient of i
KiL = liquid-phase mass transfer coefficient of I
L = liter
m = meter
m^2 = square meter
m^3 = cubic meter
mg = milligram
mol = mole
MW = molecular weight
Mwi = molecular weight inhaled
O2 = dioxide
Pb = lead
PbB = blood lead concentration
ppm = parts per million
R = ideal gas constant
s = second
T = average temperature
VF = volatilization factor
yr = year

SOURCES

Appendix B-1

Virginia Department of Environmental Quality (VDEQ) Trench Model. Website Accessed May 13, 2014: http://deq.state.va.us/Programs/LandProtectionRevitalization/RemediationProgram/VoluntaryRemediationProgram/VRPRiskAssessmentGuidance/Guidance.aspx

EPA Adult Lead Model (ALM) and integrated exposure uptake biokinetic (IEUBK) model for lead in children. Both models available from the following EPA Website: http://www2.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

Appendix B-2:

USEPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Appendix B-3:

USEPA. 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Washington, DC: Office of Emergency and Remedial Response. July. OSWER Directive #9355.4-12. July.

USEPA. 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil [EPA-540-R-03-001, OSWER Dir #9285.7-54. January.

USEPA. 2010. Integrated Exposure Uptake Biokinetic Model for Lead in Children, IEUBKwin32 V1.1 Build 11, Software Program. Developed by USEPA. February.

Appendix B-4

USEPA. 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) November 2002. EPA530-D-02-004.

USEPA. 2004. Johnson and Ettinger Model. The USEPA SG-ADV Version 3.1 (dated 02/04) modified for multiple chemicals. The original model is available at the EPA website: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm

USEPA. 2013. Oswer Final Guidance for Assessing And Mitigating The Vapor Intrusion Pathway From Subsurface Sources To Indoor Air. April.

Appendix B-1 Virginia DEQ Trench Model

INDEX OF TABLES

TRENCH MODEL INPUT DERIVATION EVALUATION

Virginia Department of Environmental Quality (VDEQ) Trench Model

- The Virginia Department of Environmental Quality (VDEQ) Trench Model
- Accessed May 13, 2014: http://deq.state.va.us/Programs/LandProtectionRevitalization/RemediationProgram/VoluntaryRemediationProgram/VRPRiskAssessmentGuidance/Guidance.aspx
- Recommend using the maximum detected VOCs concentration in groundwater (GW)
- **Landfill:** the maximum detected VOCs in monitoring well (MW) were used.
- **Sandblast:** the higher of the maximum VOC detected in either MW or temporary monitoring well (i.e., direct push wells) were used.
- Surrogate: 1,2-dichloroprpane used for 2,2-dichloropropane
- Surrogate: total xylenes used for m,p-xylenes
- VOC analysis for naphthalene used
- Depth to GW at both Landfill and Sandblast Area AOPCs met the criteria of potentially pooling in trenches 8 ft deep;
  - Landfill: shallowest GW elevation listed as **7.3 ft below top of casing**
    - (Appendix D of RI; Table D-1; MW-1; 10/24/2001),
  - Sandblast: **6.41 ft BTC** (MW-11; 4/15/2008)
- The depth to width ratio (trench shape) is the most significant parameter to affect the attenuation factor (AF) as a width greater than depth changes the Air Exchange Rate (ACH) from 2 per hour (similar to an indoor room) to 360/hr. This means the overall volume of the trench does not make a difference.
- The VDEQ model defaults were used in calculating the chemical specific AFs.
  Key ones listed (See Attachment C for complete list)
  - Temperature = 77 f
  - (F) Fraction of Floor through which contaminant can enter (unitless) = 1
  - Length = 8 ft
  - Width = 3 ft
  - Depth = 8 ft
  - Model Calculated width/depth ratio is 0.38
  - Model Calculated ACH = 2/hr

Table B-1.1
VDEQ Trench Model Settings

For Mass-Transfer Coefficients			For Emission Flux and Concentration in Trench			Trench dimensions		
Kg,H2O	0.833	cm/s	CF1	1.00E-03	L/cm3	Length	**8**	ft
MWH2O	18		CF2	1.00E+04	cm2/m2		2.44	m
Kl,O2	0.002	cm/s	CF3	3600	s/hr	Width	**3**	ft
MWO2	32		F	**1**			0.91	m
T	**77**	F	ACH	2	hr-1	Depth	**8**	ft
T	298	K					2.44	m
R	8.20E-05	atm-m3/mol-K				Width/Depth	0.38	

Table B-1.2

VDEQ Results for Landfill AOPC

(Accessed 02/05/2014)

Table 3.8 Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
Acetone	67-64-1	58.08	3.88E-05	5.63E-01	1.48E-03	5.58E-04	1.54E+01	4.12E+00	6.34E+01	6.34E-02
Chloroform	67-66-3	119.38	3.67E-03	4.42E-01	1.04E-03	1.02E-03	3.70E+00	7.53E+00	2.78E+01	2.78E-02
Isopropylbenzene	98-82-8	120.19	1.16E+00	4.41E-01	1.03E-03	1.03E-03	4.60E+00	7.62E+00	3.50E+01	3.50E-02
Tetrachloroethene	127-18-4	165.83	1.84E-02	3.96E-01	8.79E-04	8.76E-04	8.78E+00	6.47E+00	5.68E+01	5.68E-02
Vinyl Chloride	75-01-4	62.50	2.70E-02	5.49E-01	1.43E-03	1.43E-03	9.55E-01	1.05E+01	1.01E+01	1.01E-02
n-propylbenzene	103-65-1	120.19	1.05E-02	4.41E-01	1.03E-03	1.03E-03	2.00E+00	7.58E+00	1.52E+01	1.52E-02
1,2,4-trimethylbenzene	95-63-6	120.19	6.16E-03	4.41E-01	1.03E-03	1.02E-03	5.20E+00	7.55E+00	3.92E+01	3.92E-02

Table B-1.3
VDEQ Results for Sandblast Area AOPC

(Accessed 02/05/2014)

Table 3.8 Exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
TAL Inorganics										
Acetone	67-64-1	58.08	3.88E-05	5.63E-01	1.48E-03	5.58E-04	3.88E+00	4.12E+00	1.60E+01	1.60E-02
Benzene	71-43-2	78.11	5.55E-03	5.09E-01	1.28E-03	1.27E-03	1.37E-01	9.35E+00	1.28E+00	1.28E-03
Carbon disulfide	75-15-0	76.14	3.03E-02	5.14E-01	1.30E-03	1.29E-03	2.55E-01	9.55E+00	2.44E+00	2.44E-03
Chloroform	67-66-3	119.38	3.67E-03	4.42E-01	1.04E-03	1.02E-03	1.74E-01	7.53E+00	1.31E+00	1.31E-03
1,1-Dichloroethane	75-34-3	98.96	5.62E-03	4.71E-01	1.14E-03	1.13E-03	5.00E+00	8.31E+00	4.15E+01	4.15E-02
1,1-Dichloroethene	75-35-4	96.94	2.61E-02	4.74E-01	1.15E-03	1.15E-03	1.16E+00	8.46E+00	9.82E+00	9.82E-03
cis-1,2-Dichloroethene	156-59-2	96.94	4.08E-03	4.74E-01	1.15E-03	1.13E-03	6.60E+02	8.36E+00	5.52E+03	5.52E+00
trans-1,2-Dichloroethene	156-60-5	96.94	9.38E-03	4.74E-01	1.15E-03	1.14E-03	1.80E+00	8.43E+00	1.52E+01	1.52E-02
1,2-Dichloropropane	78-87-5	112.99	2.80E-03	4.50E-01	1.06E-03	1.04E-03	1.79E-01	7.70E+00	1.38E+00	1.38E-03
Ethylbenzene	100-41-4	106.17	7.88E-03	4.60E-01	1.10E-03	1.09E-03	4.47E-02	8.05E+00	3.60E-01	3.60E-04
Tetrachloroethene	127-18-4	165.83	1.84E-02	3.96E-01	8.79E-04	8.76E-04	5.45E+01	6.47E+00	3.52E+02	3.52E-01
Toluene	108-88-3	92.14	6.64E-03	4.82E-01	1.18E-03	1.17E-03	6.40E-01	8.62E+00	5.52E+00	5.52E-03
1,1,1-Trichloroethane	71-55-6	133.40	1.72E-02	4.26E-01	9.80E-04	9.76E-04	2.22E+00	7.21E+00	1.60E+01	1.60E-02
Trichloroethene	79-01-6	131.39	1.03E-02	4.28E-01	9.87E-04	9.82E-04	4.37E+01	7.25E+00	3.17E+02	3.17E-01
Vinyl Chloride	75-01-4	62.50	2.70E-02	5.49E-01	1.43E-03	1.43E-03	4.10E+00	1.05E+01	4.32E+01	4.32E-02
Total Xylenes	1330-20-7	106.16	5.18E-03	4.60E-01	1.10E-03	1.09E-03	1.32E-01	8.02E+00	1.06E+00	1.06E-03
1,2,4-trimethylbenzene	95-63-6	120.19	6.16E-03	4.41E-01	1.03E-03	1.02E-03	4.85E-02	7.55E+00	3.66E-01	3.66E-04
o-xylene	95-47-6	106.17	5.19E-03	4.60E-01	1.10E-03	1.09E-03	7.35E-02	8.02E+00	5.89E-01	5.89E-04
Naphthalene	91-20-3	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	4.52E-02	6.60E+00	2.98E-01	2.98E-04

Appendix B-2 USEPA Adult Lead Model (ALM)

Index of Tables

Table B-2.1 Landfill AOPC

Soil - unsieved (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	211
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.3**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.1
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.013%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table B-2.2 Landfill AOPC

Soil - unsieved (0-3 feet bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	342
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.032%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table B-2.3 Sandblast AOPC

Soil - sieved <250 um (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	300
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.4**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.4
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.025%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table B-2.4 Sandblast AOPC

Soil - sieved <250 um (0-3 feet bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	202
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.3**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.1
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.013%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table B-2.5 Landfill AOPC

Soil - unsieved (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs): Target 5ug/L
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	211
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.3**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.1
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.68%**

Table B-2.6 Landfill AOPC

Soil - unsieved (0-3 feet bgs)
Calculations of Blood Lead Concentrations (PbBs): Target 5 ug/L
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	342
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.3%**

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Table B-2.7 Sandblast AOPC

Soil - sieved <250 um (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs): Target 5 ug/L
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	300
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.4**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.4
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**1.1%**

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Table B-2.8 Sandblast AOPC

Soil - sieved <250 um (0-3 feet bgs)
Calculations of Blood Lead Concentrations (PbBs): Target 5 ug/L
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	202
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	219
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.3**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	ug/dL	3.1
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.65%**

Appendix B-3 ALM and IUEBK: Residential (Hypothetical Fishing Platform User)

Table B-3. Summary of Lead Evaluations

ALM Output

- Landfill AOPC Soil – Unsieved (0-1 foot bgs)
- Sandblast Area AOPC – Sieved <250 um (0-1 foot bgs)
- Pistol Range AOPC Soil – Unsieved
- Pistol Range AOPC Sediment – Unsieved
- Bulb Slope AOPC – Unsieved

IEUBK Model Input / Output

- Input Parameters
- Output: Landfill AOPC, Unsieved (0-1 foot bgs)
- Output: Sandblast Area AOPC, Sieved (0-1 foot bgs)
- Output: Pistol Range AOPC, Unsieved Soil
- Output: Pistol Range AOPC, Unsieved Sediment
- Output: Bulb Slope AOPC, Unsieved

Table B-3
Summary of Lead Evaluation
Fishing Platform Receptors
Predicted Blood Lead Levels (PbB) in Child Receptors and Fetuses of Adult Receptors

AOPC	Medium	EPC (mg/kg)	Receptor	Probability [(a)]	Probability Exceeds 5% [(b)]
Landfill	Unsieved soil (0-1 ft bgs)	211	Fetus of Adult	0.034%	No
			Child	0.36%	No
Sandblast Area	Soil - sieved <250 um (0-1 ft bgs)	300	Fetus of Adult	0.075%	No
			Child	1.52%	No
Pistol Range	Unsieved soil	208	Fetus of Adult	0.033%	No
			Child	0.34%	No
Pistol Range	Unsieved sediment	27.1	Fetus of Adult	0.0033%	No
			Child	<0.075%	No
Bulb Slope	Unsieved soil	222	Fetus of Adult	0.038%	No
			Child	0.45%	No

Notes
(a) Probability that the receptor would have a PbB exceeding the 10 µg/dL level of concern.
(b) USEPA's target is to limit the risk to a typical child or fetus of an adult exposed at a site to no more than a 5% chance of exceeding the 10 µg/dL PbB of concern (USEPA 1994, 2003).
PbB was also evaluated for probability of exceeding the CDC recommended level of concern of 5 ug/dl, and all results were less than 5% (CDC 2012, USEPA 2010).

% = percent
µg/dL = micrograms of lead per deciliter of blood
AOPC = area of potential concern
bgs = below ground surface
EPC = exposure point concentration
ft = foot
mg/kg = milligrams per kilogram
PbB = blood lead level
um = micrometers

Sources

CDC. 2012. Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention. January.

USEPA. 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Washington, DC: Office of Emergency and Remedial Response. July. OSWER Directive #9355.4-12. July.

USEPA. 2003. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil [EPA-540-R-03-001, OSWER Dir #9285.7-54. January.

USEPA. 2010. Integrated Exposure Uptake Biokinetic Model for Lead in Children, IEUBK win v1.1 Build 11, Software Program. Developed by U.S. EPA. February.

Landfill AOPC

Soil - unsieved (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	211
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal,\ 0.95}$	95th percentile PbB among fetuses of adult residents	ug/dL	3.6
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.034%**

Sandblast AOPC

Soil - sieved <250 um (0-1 foot bgs)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	300
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.7**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult residents	ug/dL	4.1
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.075%**

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ALM: Pistol Range AOPC (Soil)

Soil - unsieved
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	208
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult residents	ug/dL	3.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.033%**

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ALM: Piston Range AOPC (Sediment)

Sediment - unsieved
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	27.1
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S,\,D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S,\,D}$	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S,\,D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.1**
$PbB_{fetal,\,0.95}$	95th percentile PbB among fetuses of adult residents	ug/dL	2.5
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.003%**

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ALM: Bulb Slope AOPC

Soil - unsieved
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Version date 6/21/09

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 1999-2004
PbS	Soil lead concentration	ug/g or ppm	222
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	ug/dL per ug/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	ug/dL	1.0
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--
K_{SD}	Mass fraction of soil in dust	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	365
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PbB_{adult}	**PbB of adult worker, geometric mean**	**ug/dL**	**1.5**
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult residents	ug/dL	3.6
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.038%**

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IEUBK Exposure Parameters

IEUBK Model Parameters Used to Predict Blood Lead Levels
Child Residents
Soil and Sediments

Medium/Parameter	Default Parameters and Values (1)			Varied Values
Air Data at the Home:				Default values not varied
Vary Air Concentration By Year?	No			
Outdoor Air Lead Concentration:	0.1 µg Pb/m^3			
Indoor Air Lead Concentration				
(Percentage of Outdoor Air):	30%			
Lung Absorption:	32%			
Age-Specific Data	Age	Ventilation Rate	Time Spent Outdoors	
	0-1	2.0 m^3/day	1 hour/day	
	1-2	3.0 m^3/day	2 hour/day	
	2-3	5.0 m^3/day	3 hour/day	
	3-4	5.0 m^3/day	4 hour/day	
	4-5	5.0 m^3/day	4 hour/day	
	5-6	7.0 m^3/day	4 hour/day	
	6-7	7.0 m^3/day	4 hour/day	
Drinking Water Data at the Home:				Default values not varied
Lead Concentration in Drinking Water				
Constant:	4 µg/L			
Drinking Water Intake:	Age	Water Consumption		
	0-1	0.20 L/day		
	1-2	0.50 L/day		
	2-3	0.52 L/day		
	3-4	0.53 L/day		
	4-5	0.55 L/day		
	5-6	0.58 L/day		
	6-7	0.59 L/day		
Use Alternative Water Values?	No			
Absorption Fraction Percent	50%			
GI Method/Bioavailability	Non-Linear Active Passive Method:			
	Fraction Passive/Total Accessible		0.20	
	Half-Saturation Level (µg/day)		100	

IEUBK Exposure Parameters

IEUBK Model Parameters Used to Predict Blood Lead Levels
Child Residents
Soil and Sediments

Medium/Parameter	Default Parameters and Values [1]			Varied Values
Diet Data at the Home:				
Dietary Lead Intake	Age	Diet Intake		Default values not varied
	0-1	2.26 µg Pb/day		
	1-2	1.96 µg Pb/day		
	2-3	2.13 µg Pb/day		
	3-4	2.04 µg Pb/day		
	4-5	1.95 µg Pb/day		
	5-6	2.05 µg Pb/day		
	6-7	2.22 µg Pb/day		
Absorption Fraction Percent	50%			
GI Method/Bioavailability	Non-Linear Active Passive Method:			Default values not varied
	Fraction Passive/Total Accessible		0.20	
	Half-Saturation Level (µg/day)		100	
Alternate Diet Data:	Not used			
Yard Soil and Indoor House Dust Data (soil and dust at the home) :				Default values not varied
Yard Soil Lead Level:				
Constant -	Not used			
Variable -	AOPC-specific exposure point concentrations			
Indoor House Dust Lead Level:				
Constant -	Not used			
Variable -	Not used			
Multiple Indoor Source Analysis - Conversation factor for contribution of yard soil lead to lead in indoor household dust (0.7)				
Contribution of outdoor airborne lead to lead in indoor household dust (10 mg/kg)				
Soil/Dust Ingestion Weighting Factor (percent soil):	45%			

IEUBK Exposure Parameters

IEUBK Model Parameters Used to Predict Blood Lead Levels

Child Residents

Soil and Sediments

Medium/Parameter	Default Parameters and Values [1]			Varied Values
Amount Ingested Daily:	Age	Total House Dust & Yard Soil Intake (default values)		
	0-1	0.085		
	1-2	0.135		
	2-3	0.135		
	3-4	0.135		
	4-5	0.100		
	5-6	0.090		
	6-7	0.085		
Absorption Fraction Percent, Yard Soil	30%			
Absorption Fraction Percent, House Dust	30%			
GI Method/Bioavailability: Yard Soil	Non-Linear Active Passive Method:			
	Fraction Passive/Total Accessible		0.20	
	Half-Saturation Level (µg/day)		100	
GI Method/Bioavailability: House Dust	Non-Linear Active Passive Method:			
	Fraction Passive/Total Accessible		0.20	
	Half-Saturation Level (µg/day)		100	
<u>Maternal Data</u>				
Mother's blood lead concentration at childbirth	1.0 µg/dL			Default value not varied
<u>Alternate Source Data - non used</u>				
GI Method/Bioavailability: Soil/Tai	Non-Linear Active Passive Method:			
	Fraction Passive/Total Accessible		0.20	Default values not varied
	Half-Saturation Level (µg/day)		100	
GSD	1.6			Default values not varied
Cutoff	10 µg Pb/dL			Default values not varied

IEUBK Exposure Parameters

IEUBK Model Parameters Used to Predict Blood Lead Levels

Child Residents

Soil and Sediments

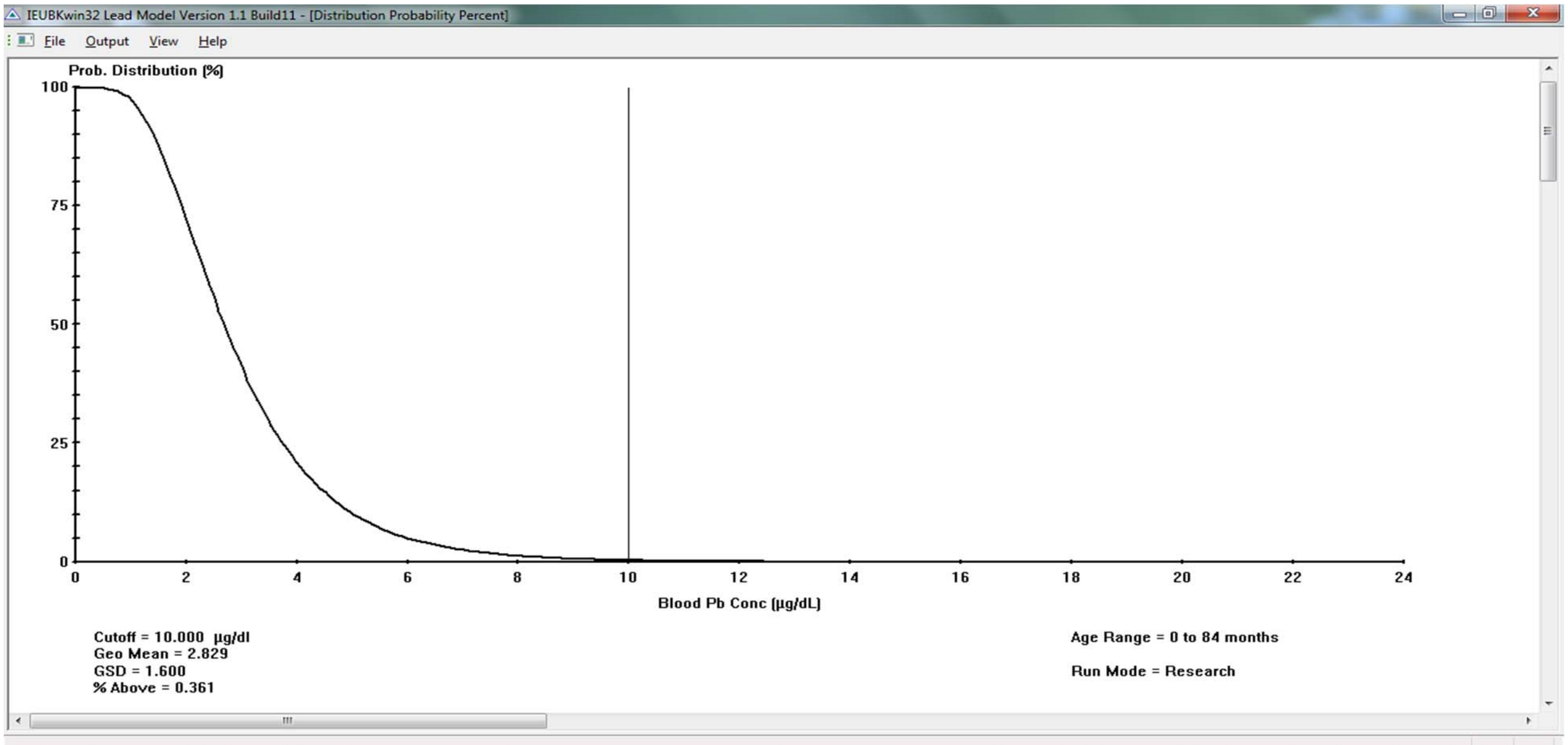
Notes:

EE/CA = Engineering Evaluation/Cost Analysis
g = gram
GI = gastrointestinal
GSD = geometric standard deviation
IEUBK = Integrated Exposure Uptake Biokinetic
kg = kilograms
L/day = liter per day
m^3/day = meters cubed per day
mg = milligram
mg/kg = milligram per kilogram
µg = microgram
µg Pb/day = microgram lead per day
µg Pb/dL = microgram lead per deciliter
µg Pb/m^3 = microgram lead per meter cubed
µg/day = microgram per day
µg/dL = microgram per deciliter
µg/L = micrograms per liter

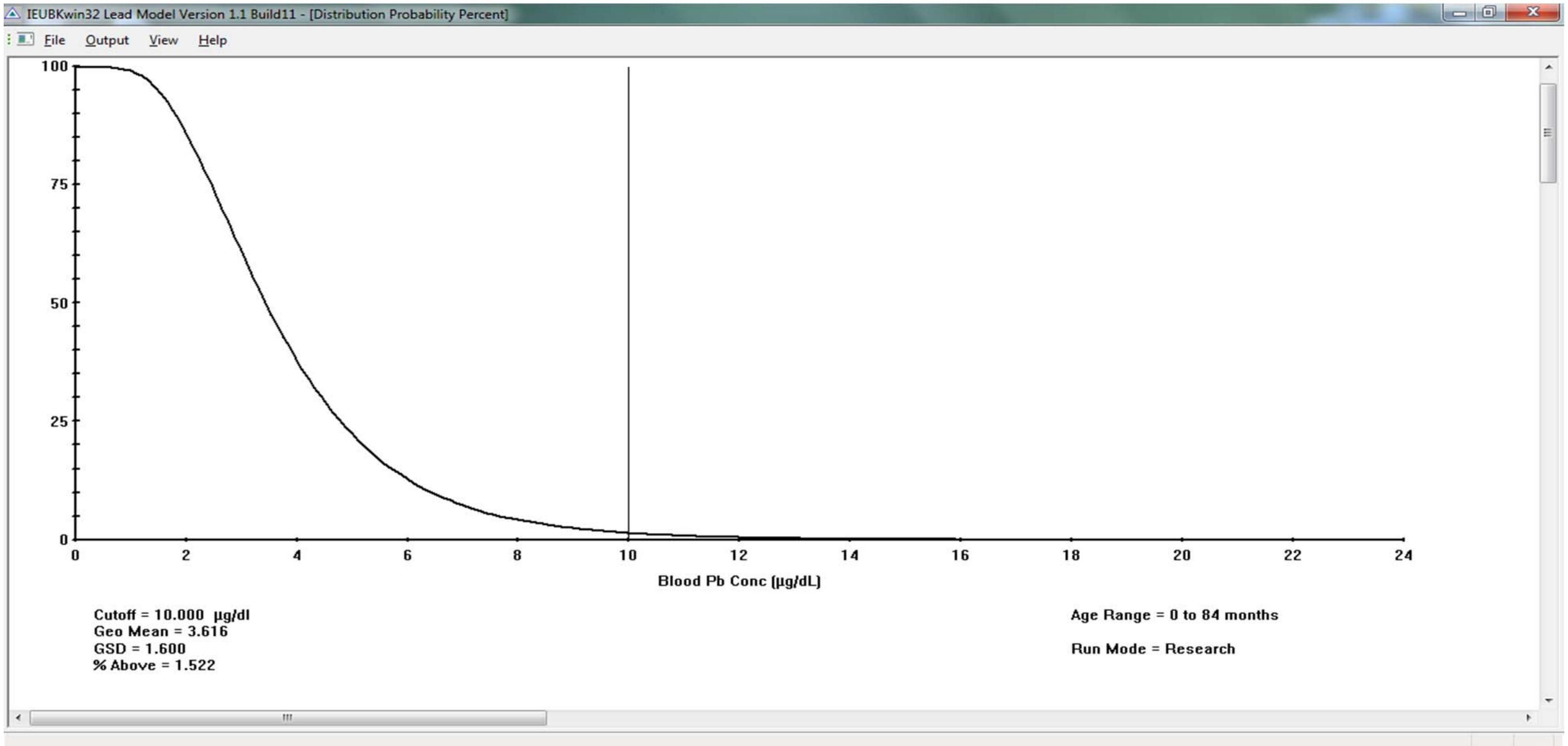
(1) Parameters and values were used in the IEUBK Lead Model (USEPA 2010) Version IEUBKWin32 Version 1.1 Build 11 to estimate blood lead levels and risks.

References:

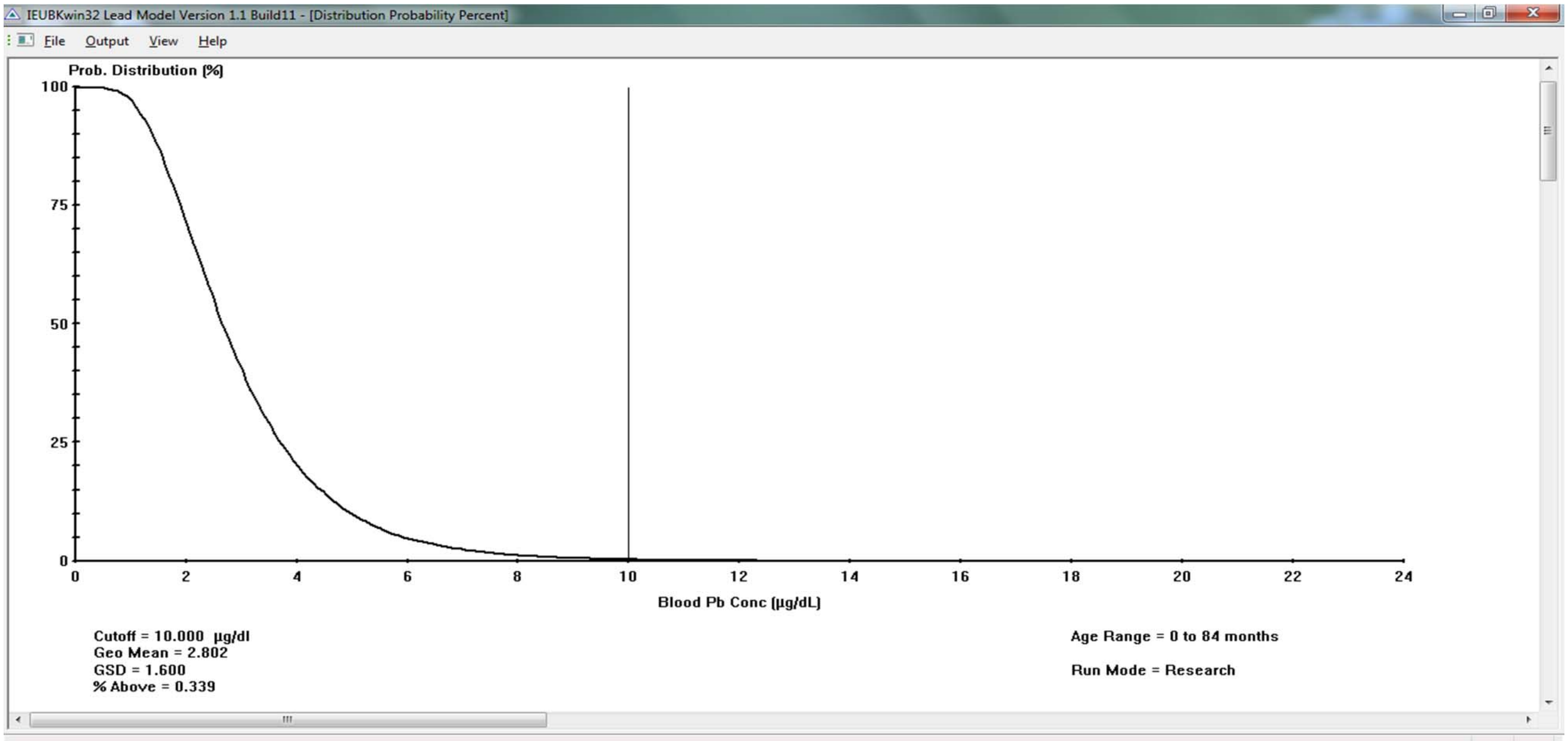
IEUBK Output Graph: Landfill AOPC, Unsieved Soil (0-1 ft bgs)



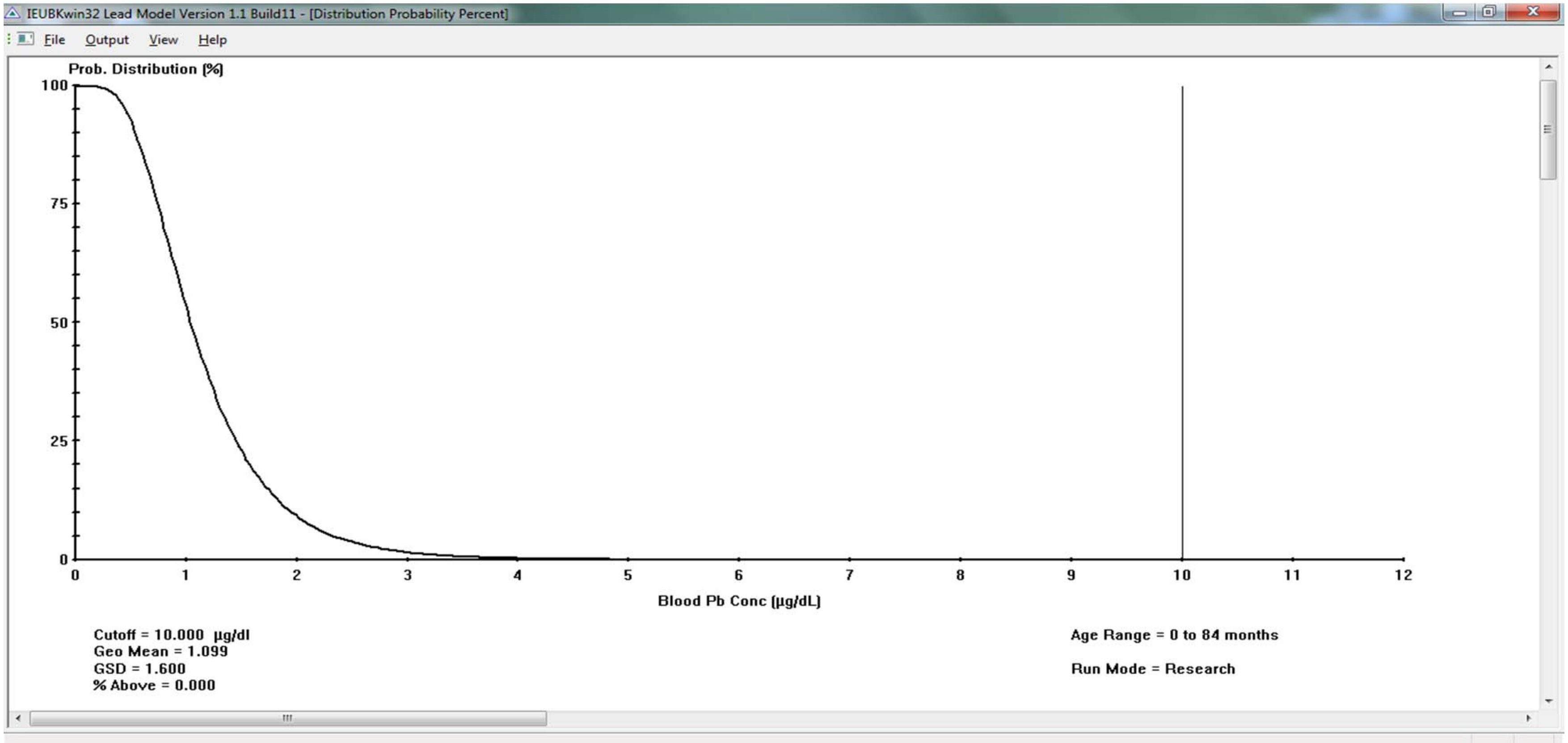
IEUBK Output Graph: Sandblast Area AOPC, Sieved Soil (0-1 ft bgs)



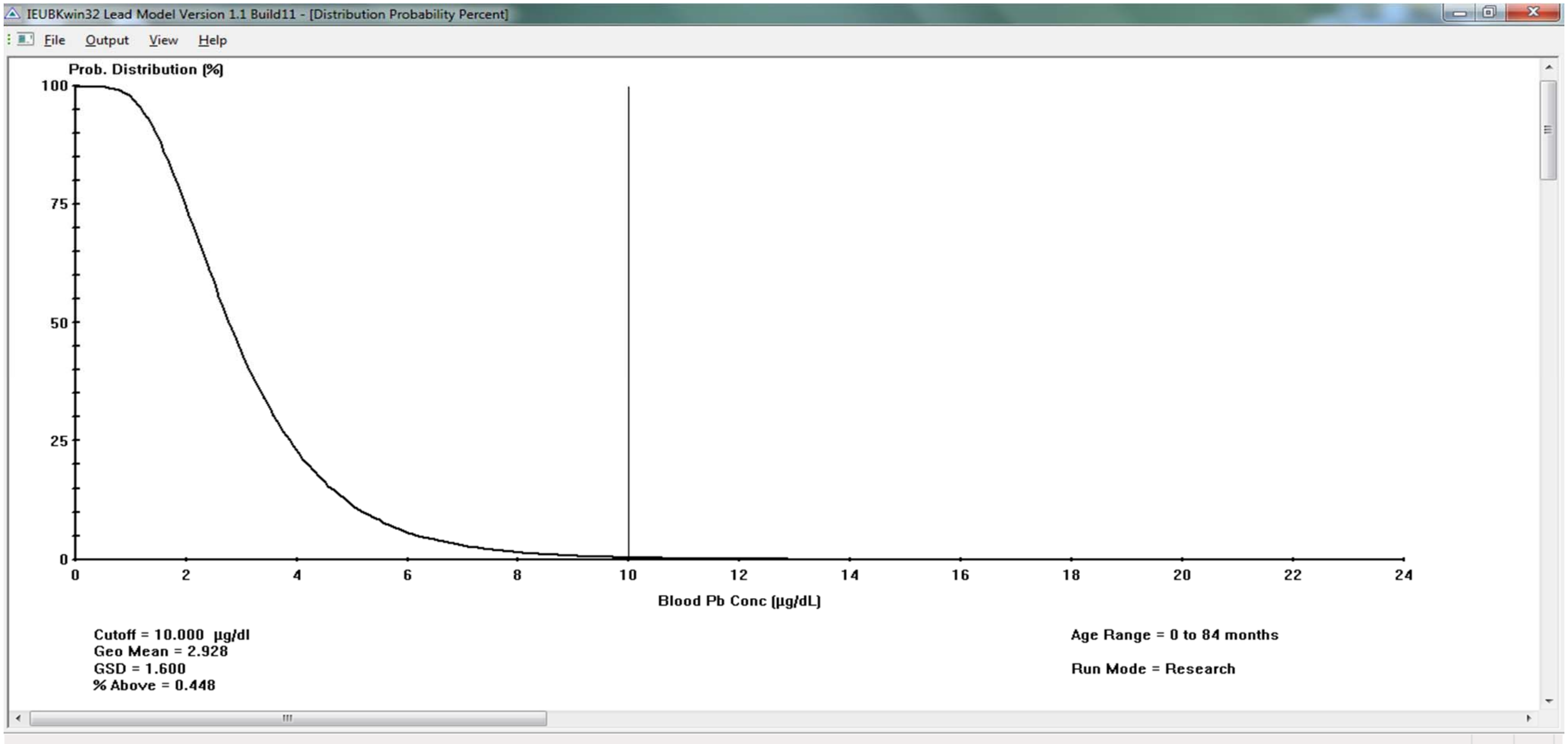
IEUBK Output Graph: Pistol Range AOPC, Unsieved Soil



IEUBK Output Graph: Pistol Range AOPC, Unsieved Sediment



IEUBK Output Graph: Bulb Slope AOPC, Unsieved Soil



Appendix B-4 USEPA Johnson and Ettinger Vapor Intrusion Model (JEM)

USEPA Johnson and Ettinger Model Input Derivations

- The USEPA SG-ADV Version 3.1 (dated 02/04) modified for multiple chemicals. The original model is available at the EPA website: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm
- Soil Gas concentrations (ug/m^3) were taken from Table 1-6
- Based on USEPA (2013), buildings within 100 ft of the VI source (either lateral or vertical) are considered “near” or within the “buffer zone”
- Based on (email) communications by the USACE, the Sandblast Building (outline shown on figures for Sandblast Area AOPC) has been demolished with no other structures or plans in its place. The occupied portion of the Equipment Building is a portable trailer that is approximately 12 ft x 30 ft. The Bradford Island Service Building sits just outside the Sandblast AOPC boundary but is also included due to being within the ‘buffer zone”.
- Current Scenario: Using current building dimensions for existing office space and floor/building descriptions and closest soil gas sampling locations.
  - Current scenario Bradford Island Service Building (RME, CTE)
  - Current Scenario Equipment Building (RME, CTE)
  - The JEM uses a Qsoil default value of 5 L/m. The derivation of Qsoil utilizes the building perimeter; therefore a scaling factor was applied to account for the difference in the BISB building perimeter from the default for the current scenario. The scaling factor derived for the Equipment Building was less than the default value of 5 L/min and therefore the default value was used to maintain the conservative estimates for the Qsoil parameter, which is identified as having “high uncertainty” and “sensitive” parameter (USEPA, 2002). The following equation was used for scaling the model default Qsoil:

Building Perimeter Scaling Equation for Qsoil:

- Qsoil (L/min)= 5 L/min x Perimeter (cm)/4000 cm

- Qsoil = average vapor flow rate into building (default of 5 L/min)
- L/min = liters per minute

    - Cm = centimeter

- Hypothetical Future Scenario: Using the maximum detected concentrations from the Sandblast Area AOPC and using JEM building dimension defaults (USEPA recommended). This is done for the RME and CTE.

B-4.1 Inputs for Current Scenario: Equipment Building

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (mg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical	
71556				1,1,1-Trichloroethane	
95636				1,2,4-Trimethylbenzene	
108678				1,3,5-Trimethylbenzene	
106990				1,3-Butadiene	
78933				Methylethylketone (2-butanone)	
67641				Acetone	
71432				Benzene	
75150				Carbon disulfide	
156592	2.10E+01			cis-1,2-Dichloroethylene	
75718				Dichlorodifluoromethane	
100414				Ethylbenzene	
110543				Hexane	
98828				Cumene	
103651				n-Propylbenzene	
95476				o-Xylene	
127184	7.30E+02			Tetrachloroethylene	SB-14
108883				Toluene	
79016	4.10E+01			Trichloroethylene	SB-14
75354	2.70E+00			1,1-Dichloroethylene	
156605	5.80E+00			trans-1,2-Dichloroethylene	
75014	3.00E+00			Vinyl chloride (chloroethene)	

Enter soil gas concentration above.

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ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	106.7	10	106.7			S		
	(3.5 ft)							

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ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, r_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, q_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, r_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, q_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, r_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, q_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

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ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, DP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	914.4	365.76	366	0.1	1	5
		30 ft	12 ft	default		0.25 Resident	
						1.0 Commercial	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

Scaling for building Perimeter
0.64008
Scaled Qsoil based on 5 L/min default
3.2004
Less than the default; therefore use 5 L/min

END

B-4.2 Intercalculations for Current Scenario: Equipment Building

Exposure duration, t (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, q_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, q_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, q_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. (mg/m^3)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	2.10E+01	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	7.30E+02	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	0.00E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	4.10E+01	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	2.70E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	5.80E+00	3.40E+04
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	2,560	3.00E+00	3.40E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, h (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $DH_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, m_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
3.73E+05	6.87E-04	15	7,885	8.48E-03	3.65E-01	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	91.7
3.73E+05	6.87E-04	15	11,692	2.16E-03	9.30E-02	1.75E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	91.7
3.73E+05	6.87E-04	15	11,678	2.07E-03	8.89E-02	1.75E-04	9.73E-03	0.00E+00	0.00E+00	9.73E-03	91.7
3.73E+05	6.87E-04	15	5,189	4.62E-02	1.99E+00	1.75E-04	4.03E-02	0.00E+00	0.00E+00	4.03E-02	91.7
3.73E+05	6.87E-04	15	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	91.7
3.73E+05	6.87E-04	15	7,559	1.97E-05	8.47E-04	1.75E-04	2.01E-02	0.00E+00	0.00E+00	2.01E-02	91.7
3.73E+05	6.87E-04	15	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	91.7
3.73E+05	6.87E-04	15	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	91.7
3.73E+05	6.87E-04	15	7,734	2.04E-03	8.77E-02	1.75E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	91.7
3.73E+05	6.87E-04	15	8,386	1.62E-01	6.96E+00	1.75E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	91.7
3.73E+05	6.87E-04	15	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	91.7
3.73E+05	6.87E-04	15	7,737	8.32E-01	3.58E+01	1.75E-04	3.23E-02	0.00E+00	0.00E+00	3.23E-02	91.7
3.73E+05	6.87E-04	15	12,644	3.74E-01	1.61E+01	1.75E-04	1.05E-02	0.00E+00	0.00E+00	1.05E-02	91.7
3.73E+05	6.87E-04	15	11,368	3.86E-03	1.66E-01	1.75E-04	9.72E-03	0.00E+00	0.00E+00	9.72E-03	91.7
3.73E+05	6.87E-04	15	10,404	2.04E-03	8.79E-02	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
3.73E+05	6.87E-04	15	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	91.7
3.73E+05	6.87E-04	15	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
3.73E+05	6.87E-04	15	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	91.7
3.73E+05	6.87E-04	15	6,392	1.47E-02	6.33E-01	1.75E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	91.7
3.73E+05	6.87E-04	15	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	91.7
3.73E+05	6.87E-04	15	5,000	1.72E-02	7.41E-01	1.75E-04	1.71E-02	0.00E+00	0.00E+00	1.71E-02	91.7

Convection path length, L_p (cm)	Source vapor conc., C_{source} (mg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, a (unitless)	Infinite source bldg. conc., $C_{building}$ (mg/m^3)	Unit risk factor, URF $(mg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	0.00E+00	0.10	8.33E+01	1.26E-02	2.56E+02	1.27E+112	9.34E-04	0.00E+00	NA	2.2E+00	1,1,1-Trichloroethane
15	0.00E+00	0.10	8.33E+01	9.80E-03	2.56E+02	1.95E+144	7.93E-04	0.00E+00	NA	6.0E-03	1,2,4-Trimethylbenzene
15	0.00E+00	0.10	8.33E+01	9.73E-03	2.56E+02	1.77E+145	7.89E-04	0.00E+00	NA	6.0E-03	1,3,5-Trimethylbenzene
15	0.00E+00	0.10	8.33E+01	4.03E-02	2.56E+02	1.31E+35	1.62E-03	0.00E+00	3.0E-02	2.0E-03	1,3-Butadiene
15	0.00E+00	0.10	8.33E+01	1.31E-02	2.56E+02	1.54E+108	9.54E-04	0.00E+00	NA	5.0E+00	Methylethylketone (2-butanone
15	0.00E+00	0.10	8.33E+01	2.01E-02	2.56E+02	3.13E+70	1.21E-03	0.00E+00	NA	3.5E-01	Acetone
15	0.00E+00	0.10	8.33E+01	1.42E-02	2.56E+02	2.31E+99	1.00E-03	0.00E+00	7.8E-06	3.0E-02	Benzene
15	0.00E+00	0.10	8.33E+01	1.68E-02	2.56E+02	1.19E+84	1.10E-03	0.00E+00	NA	7.0E-01	Carbon disulfide
15	2.10E+01	0.10	8.33E+01	1.19E-02	2.56E+02	6.36E+118	9.00E-04	1.89E-02	NA	3.5E-02	cis-1,2-Dichloroethylene
15	0.00E+00	0.10	8.33E+01	1.08E-02	2.56E+02	3.08E+131	8.43E-04	0.00E+00	NA	2.0E-01	Dichlorodifluoromethane
15	0.00E+00	0.10	8.33E+01	1.21E-02	2.56E+02	3.86E+116	9.11E-04	0.00E+00	2.5E-06	1.0E+00	Ethylbenzene
15	0.00E+00	0.10	8.33E+01	3.23E-02	2.56E+02	5.25E+43	1.50E-03	0.00E+00	NA	2.0E-01	Hexane
15	0.00E+00	0.10	8.33E+01	1.05E-02	2.56E+02	3.33E+134	8.31E-04	0.00E+00	NA	4.0E-01	Cumene
15	0.00E+00	0.10	8.33E+01	9.72E-03	2.56E+02	3.09E+145	7.88E-04	0.00E+00	NA	1.4E-01	n-Propylbenzene
15	0.00E+00	0.10	8.33E+01	1.41E-02	2.56E+02	3.20E+100	9.97E-04	0.00E+00	NA	1.0E-01	o-Xylene
15	7.30E+02	0.10	8.33E+01	1.16E-02	2.56E+02	2.78E+121	8.88E-04	6.48E-01	5.9E-06	6.0E-01	Tetrachloroethylene
15	0.00E+00	0.10	8.33E+01	1.41E-02	2.56E+02	3.20E+100	9.97E-04	0.00E+00	NA	4.0E-01	Toluene
15	4.10E+01	0.10	8.33E+01	1.28E-02	2.56E+02	4.82E+110	9.41E-04	3.86E-02	1.1E-04	4.0E-02	Trichloroethylene
15	2.70E+00	0.10	8.33E+01	1.45E-02	2.56E+02	1.43E+97	1.02E-03	2.75E-03	NA	2.0E-01	1,1-Dichloroethylene
15	5.80E+00	0.10	8.33E+01	1.14E-02	2.56E+02	4.75E+123	8.77E-04	5.09E-03	NA	7.0E-02	trans-1,2-Dichloroethylene
15	3.00E+00	0.10	8.33E+01	1.71E-02	2.56E+02	3.09E+82	1.12E-03	3.35E-03	8.8E-06	1.0E-01	Vinyl chloride (chloroethene
END											

B-4.3 Inputs for Current Scenario: Service Building

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (mg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical	
71556				1,1,1-Trichloroethane	
95636				1,2,4-Trimethylbenzene	
108678				1,3,5-Trimethylbenzene	
106990				1,3-Butadiene	
78933				Methylethylketone (2-butanone)	
67641				Acetone	
71432				Benzene	
75150				Carbon disulfide	
156592	8.60E+00			cis-1,2-Dichloroethylene	
75718				Dichlorodifluoromethane	
100414				Ethylbenzene	
110543				Hexane	
98828				Cumene	
103651				n-Propylbenzene	
95476				o-Xylene	
127184	1.80E+03			Tetrachloroethylene	SB-13
108883				Toluene	
79016	2.70E+01			Trichloroethylene	SB-13
75354	2.60E+00			1,1-Dichloroethylene	
156605	5.60E+00			trans-1,2-Dichloroethylene	
75014	2.90E+00			Vinyl chloride (chloroethene)	

Enter soil gas concentration above.

MORE ê

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^oC)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	106.7	10	106.7			S		
	(3.5 ft)							

Totals must add up to value of Ls (cell F24)

MORE ê

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, r_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, q_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, r_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, q_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, r_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, q_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ê

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, DP ($g/cm-s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	3810	2286	366	0.1	1	15.24
		125 ft	75 ft	default		0.25 Resident 1.0 Commercial	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

Scaling for building Perimeter
3.048

Scaled Qsoil based on 5 L/min default
15.24

END

B-4.4 Inter-Calculations for Current Scenario: Service Building

Exposure duration, t (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, q_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, q_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, q_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. (mg/m^3)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	8.60E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	1.80E+03	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	0.00E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	2.70E+01	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	2.60E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	5.60E+00	8.85E+05
9.46E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	12,192	2.90E+00	8.85E+05

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, h (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $DH_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, m_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
8.89E+06	1.37E-04	15	7,885	8.48E-03	3.65E-01	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	91.7
8.89E+06	1.37E-04	15	11,692	2.16E-03	9.30E-02	1.75E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	91.7
8.89E+06	1.37E-04	15	11,678	2.07E-03	8.89E-02	1.75E-04	9.73E-03	0.00E+00	0.00E+00	9.73E-03	91.7
8.89E+06	1.37E-04	15	5,189	4.62E-02	1.99E+00	1.75E-04	4.03E-02	0.00E+00	0.00E+00	4.03E-02	91.7
8.89E+06	1.37E-04	15	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	91.7
8.89E+06	1.37E-04	15	7,559	1.97E-05	8.47E-04	1.75E-04	2.01E-02	0.00E+00	0.00E+00	2.01E-02	91.7
8.89E+06	1.37E-04	15	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	91.7
8.89E+06	1.37E-04	15	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	91.7
8.89E+06	1.37E-04	15	7,734	2.04E-03	8.77E-02	1.75E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	91.7
8.89E+06	1.37E-04	15	8,386	1.62E-01	6.96E+00	1.75E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	91.7
8.89E+06	1.37E-04	15	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	91.7
8.89E+06	1.37E-04	15	7,737	8.32E-01	3.58E+01	1.75E-04	3.23E-02	0.00E+00	0.00E+00	3.23E-02	91.7
8.89E+06	1.37E-04	15	12,644	3.74E-01	1.61E+01	1.75E-04	1.05E-02	0.00E+00	0.00E+00	1.05E-02	91.7
8.89E+06	1.37E-04	15	11,368	3.86E-03	1.66E-01	1.75E-04	9.72E-03	0.00E+00	0.00E+00	9.72E-03	91.7
8.89E+06	1.37E-04	15	10,404	2.04E-03	8.79E-02	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
8.89E+06	1.37E-04	15	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	91.7
8.89E+06	1.37E-04	15	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
8.89E+06	1.37E-04	15	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	91.7
8.89E+06	1.37E-04	15	6,392	1.47E-02	6.33E-01	1.75E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	91.7
8.89E+06	1.37E-04	15	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	91.7
8.89E+06	1.37E-04	15	5,000	1.72E-02	7.41E-01	1.75E-04	1.71E-02	0.00E+00	0.00E+00	1.71E-02	91.7

Convection path length, L_p (cm)	Source vapor conc., C_{source} (mg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, a (unitless)	Infinite source bldg. conc., $C_{building}$ (mg/m^3)	Unit risk factor, URF $(mg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	0.00E+00	0.10	2.54E+02	1.26E-02	1.22E+03	5.68E+71	2.38E-04	0.00E+00	NA	2.2E+00	1,1,1-Trichloroethane
15	0.00E+00	0.10	2.54E+02	9.80E-03	1.22E+03	2.27E+92	2.26E-04	0.00E+00	NA	6.0E-03	1,2,4-Trimethylbenzene
15	0.00E+00	0.10	2.54E+02	9.73E-03	1.22E+03	9.34E+92	2.26E-04	0.00E+00	NA	6.0E-03	1,3,5-Trimethylbenzene
15	0.00E+00	0.10	2.54E+02	4.03E-02	1.22E+03	3.00E+22	2.69E-04	0.00E+00	3.0E-02	2.0E-03	1,3-Butadiene
15	0.00E+00	0.10	2.54E+02	1.31E-02	1.22E+03	1.77E+69	2.39E-04	0.00E+00	NA	5.0E+00	Methylethylketone (2-butanone
15	0.00E+00	0.10	2.54E+02	2.01E-02	1.22E+03	1.33E+45	2.54E-04	0.00E+00	NA	3.5E-01	Acetone
15	0.00E+00	0.10	2.54E+02	1.42E-02	1.22E+03	3.99E+63	2.42E-04	0.00E+00	7.8E-06	3.0E-02	Benzene
15	0.00E+00	0.10	2.54E+02	1.68E-02	1.22E+03	6.54E+53	2.48E-04	0.00E+00	NA	7.0E-01	Carbon disulfide
15	8.60E+00	0.10	2.54E+02	1.19E-02	1.22E+03	1.11E+76	2.35E-04	2.02E-03	NA	3.5E-02	cis-1,2-Dichloroethylene
15	0.00E+00	0.10	2.54E+02	1.08E-02	1.22E+03	1.46E+84	2.31E-04	0.00E+00	NA	2.0E-01	Dichlorodifluoromethane
15	0.00E+00	0.10	2.54E+02	1.21E-02	1.22E+03	4.21E+74	2.36E-04	0.00E+00	2.5E-06	1.0E+00	Ethylbenzene
15	0.00E+00	0.10	2.54E+02	3.23E-02	1.22E+03	9.64E+27	2.65E-04	0.00E+00	NA	2.0E-01	Hexane
15	0.00E+00	0.10	2.54E+02	1.05E-02	1.22E+03	1.27E+86	2.30E-04	0.00E+00	NA	4.0E-01	Cumene
15	0.00E+00	0.10	2.54E+02	9.72E-03	1.22E+03	1.33E+93	2.26E-04	0.00E+00	NA	1.4E-01	n-Propylbenzene
15	0.00E+00	0.10	2.54E+02	1.41E-02	1.22E+03	2.14E+64	2.42E-04	0.00E+00	NA	1.0E-01	o-Xylene
15	1.80E+03	0.10	2.54E+02	1.16E-02	1.22E+03	5.42E+77	2.34E-04	4.21E-01	5.9E-06	6.0E-01	Tetrachloroethylene
15	0.00E+00	0.10	2.54E+02	1.41E-02	1.22E+03	2.15E+64	2.42E-04	0.00E+00	NA	4.0E-01	Toluene
15	2.70E+01	0.10	2.54E+02	1.28E-02	1.22E+03	7.02E+70	2.38E-04	6.43E-03	1.1E-04	4.0E-02	Trichloroethylene
15	2.60E+00	0.10	2.54E+02	1.45E-02	1.22E+03	1.54E+62	2.43E-04	6.32E-04	NA	2.0E-01	1,1-Dichloroethylene
15	5.60E+00	0.10	2.54E+02	1.14E-02	1.22E+03	1.46E+79	2.33E-04	1.31E-03	NA	7.0E-02	trans-1,2-Dichloroethylene
15	2.90E+00	0.10	2.54E+02	1.71E-02	1.22E+03	6.32E+52	2.49E-04	7.22E-04	8.8E-06	1.0E-01	Vinyl chloride (chloroethene

END

B-4.5 Inputs for Future Scenario Sandblast Area AOPC

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (mg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
75354	9.80E+01			1,1-Dichloroethylene
156592	1.85E+04			cis-1,2-Dichloroethylene
156605	6.25E+03			trans-1,2-Dichloroethylene
75014	2.10E+02			Vinyl chloride (chloroethene)
78933	3.10E+01			Methylethylketone (2-butanone)
67641	9.70E+01			Acetone
71432	8.50E+01			Benzene
75150	4.20E+01			Carbon disulfide
156592	3.30E+02			cis-1,2-Dichloroethylene
75718	3.20E+00			Dichlorodifluoromethane
100414	1.55E+03			Ethylbenzene
110543	1.10E+02			Hexane
98828	1.10E+02			Cumene
103651	2.30E+03			n-Propylbenzene
95476	2.80E+03			o-Xylene
127184	3.40E+04			Tetrachloroethylene
108883	4.75E+04			Toluene
79016	6.10E+02			Trichloroethylene

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ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (^{o}C)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	106.7	10	106.7			S		
default for Slab	3.5 ft Table 6-3j	default	3.5 ft			Based on boring logs (2004)		

MORE
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ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, r_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, q_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, r_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, q_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, r_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, q_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE
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ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, DP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)		ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	1		5
Default	defaut	default	default	default	default	0.25 Resident 1.0 Commercial		

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	25	25	250

END

B-4.6 Inter-Calculations for Future Scenario Sandblast Area AOPC

Exposure duration, t (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, q_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, q_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, q_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. (mg/m^3)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	9.80E+01	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	1.85E+04	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	6.25E+03	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	2.10E+02	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	3.10E+01	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	9.70E+01	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	8.50E+01	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	4.20E+01	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	3.30E+02	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	3.20E+00	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	1.55E+03	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	1.10E+02	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	1.10E+02	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	2.30E+03	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	2.80E+03	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	3.40E+04	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	4.75E+04	1.02E+05
7.88E+08	91.7	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	4,000	6.10E+02	1.02E+05

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, h (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $DH_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, m_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	3.77E-04	15	6,392	1.47E-02	6.33E-01	1.75E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	91.7
1.06E+06	3.77E-04	15	7,734	2.04E-03	8.77E-02	1.75E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	91.7
1.06E+06	3.77E-04	15	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	91.7
1.06E+06	3.77E-04	15	5,000	1.72E-02	7.41E-01	1.75E-04	1.71E-02	0.00E+00	0.00E+00	1.71E-02	91.7
1.06E+06	3.77E-04	15	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	91.7
1.06E+06	3.77E-04	15	7,559	1.97E-05	8.47E-04	1.75E-04	2.01E-02	0.00E+00	0.00E+00	2.01E-02	91.7
1.06E+06	3.77E-04	15	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	91.7
1.06E+06	3.77E-04	15	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	91.7
1.06E+06	3.77E-04	15	7,734	2.04E-03	8.77E-02	1.75E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	91.7
1.06E+06	3.77E-04	15	8,386	1.62E-01	6.96E+00	1.75E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	91.7
1.06E+06	3.77E-04	15	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	91.7
1.06E+06	3.77E-04	15	7,737	8.32E-01	3.58E+01	1.75E-04	3.23E-02	0.00E+00	0.00E+00	3.23E-02	91.7
1.06E+06	3.77E-04	15	12,644	3.74E-01	1.61E+01	1.75E-04	1.05E-02	0.00E+00	0.00E+00	1.05E-02	91.7
1.06E+06	3.77E-04	15	11,368	3.86E-03	1.66E-01	1.75E-04	9.72E-03	0.00E+00	0.00E+00	9.72E-03	91.7
1.06E+06	3.77E-04	15	10,404	2.04E-03	8.79E-02	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
1.06E+06	3.77E-04	15	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	91.7
1.06E+06	3.77E-04	15	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	91.7
1.06E+06	3.77E-04	15	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	91.7

Convection path length, L_p (cm)	Source vapor conc., C_{source} (mg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, a (unitless)	Infinite source bldg. conc., $C_{building}$ (mg/m^3)	Unit risk factor, URF $(mg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	9.80E+01	0.10	8.33E+01	1.45E-02	4.00E+02	1.54E+62	5.48E-04	5.37E-02	NA	2.0E-01	1,1-Dichloroethylene
15	1.85E+04	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	5.10E-04	9.44E+00	NA	3.5E-02	cis-1,2-Dichloroethylene
15	6.25E+03	0.10	8.33E+01	1.14E-02	4.00E+02	1.46E+79	5.03E-04	3.14E+00	NA	7.0E-02	trans-1,2-Dichloroethylene
15	2.10E+02	0.10	8.33E+01	1.71E-02	4.00E+02	6.32E+52	5.77E-04	1.21E-01	8.8E-06	1.0E-01	Vinyl chloride (chloroethene
15	3.10E+01	0.10	8.33E+01	1.31E-02	4.00E+02	1.77E+69	5.28E-04	1.64E-02	NA	5.0E+00	Methylethylketone (2-butanone
15	9.70E+01	0.10	8.33E+01	2.01E-02	4.00E+02	1.33E+45	6.03E-04	5.85E-02	NA	3.5E-01	Acetone
15	8.50E+01	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	5.44E-04	4.62E-02	7.8E-06	3.0E-02	Benzene
15	4.20E+01	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	5.74E-04	2.41E-02	NA	7.0E-01	Carbon disulfide
15	3.30E+02	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	5.10E-04	1.68E-01	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.20E+00	0.10	8.33E+01	1.08E-02	4.00E+02	1.46E+84	4.91E-04	1.57E-03	NA	2.0E-01	Dichlorodifluoromethane
15	1.55E+03	0.10	8.33E+01	1.21E-02	4.00E+02	4.21E+74	5.14E-04	7.97E-01	2.5E-06	1.0E+00	Ethylbenzene
15	1.10E+02	0.10	8.33E+01	3.23E-02	4.00E+02	9.64E+27	6.70E-04	7.37E-02	NA	2.0E-01	Hexane
15	1.10E+02	0.10	8.33E+01	1.05E-02	4.00E+02	1.27E+86	4.86E-04	5.35E-02	NA	4.0E-01	Cumene
15	2.30E+03	0.10	8.33E+01	9.72E-03	4.00E+02	1.33E+93	4.71E-04	1.08E+00	NA	1.4E-01	n-Propylbenzene
15	2.80E+03	0.10	8.33E+01	1.41E-02	4.00E+02	2.14E+64	5.42E-04	1.52E+00	NA	1.0E-01	o-Xylene
15	3.40E+04	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	5.06E-04	1.72E+01	2.6E-07	6.0E-01	Tetrachloroethylene
15	4.75E+04	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	5.42E-04	2.57E+01	NA	4.0E-01	Toluene
15	6.10E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	5.24E-04	3.20E-01	4.1E-06	4.0E-02	Trichloroethylene

END

APPENDIX C

Work Plan Updates

Technical Memorandum

UPDATE TO RISK ASSESSMENT WORK PLAN, UPLAND OPERABLE UNIT

Bradford Island
Cascade Locks, Oregon

March 6, 2014

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ABBREVIATIONS

%	percent
Ah-R	aryl hydrocarbon
AOPC	area of potential concern
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
BHHRA	baseline human health risk assessment
BERA	baseline ecological risk assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfs	cubic feet per second
COI	contaminant of interest
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPEC	contaminant of potential ecological concern
CSM	conceptual site model
CTE	central tendency exposure
CVOC	chlorinated volatile organic compound
DEQ	(Oregon) Department of Environmental Quality
DQO	data quality objective
DRO	diesel range organics
EcoSSLs	Ecological Soil Screening Levels
ECSI	Environmental Cleanup Site Information
EPA	Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
GRO	gasoline range organics
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HMSA	hazardous material storage area
HPAH	high molecular weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
IRIS	Integrated Risk Information System
JEM	Johnson and Ettinger (Vapor Intrusion) Model
kg	kilogram(s)
L	liter(s)
LOAEL	lowest-observable-adverse-effect-level
LOEC	lowest-observable-effect-concentration
log K_{ow}	octanol-water partition coefficient
LPAH	low molecular weight polycyclic aromatic hydrocarbon
µg	microgram(s)
m^3	cubic meter
mg	milligram(s)
MP	Management Plan
NOAEL	no-observable-adverse-effect-level
NOEC	no-observable-effect-concentration

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OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PM	project manager
PPRTV	provisional peer-reviewed toxicity value
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBC	Risk-Based Concentrations
RI	remedial investigation
RI/FS	remedial investigation/ feasibility study
RM	river mile
RME	Reasonable Maximum Exposure
RRO	residual range organics
RSL	Regional Screening Levels
SLV	screening level value
SVOC	semivolatile organic compound
TAG	technical advisory group
TCE	trichloroethene
TEF	toxicity equivalence factors
TPH	total petroleum hydrocarbons
TRV	Toxicity Reference Value
UCL	upper confidence limit
URS	URS Corporation
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VCP	Voluntary Cleanup Program
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
WP	Work Plan

1.0 INTRODUCTION

This report documents proposed updates to methodologies to conduct risk assessments at Bradford Island, Bonneville Dam. The Portland District of the United States Army Corps of Engineers (USACE) has characterized and evaluated the contamination arising from historical practices at Bradford Island in Oregon. Bradford Island is part of the Bonneville Dam complex, which is located on the Columbia River at river mile (RM) 146.1, approximately 40 miles east of Portland, Oregon (Figure 1-1). The site is a multipurpose facility that consists of the First and Second Powerhouses, the old and new navigation locks, and a spillway with a capacity of 1.6 million cubic feet per second (cfs) (USACE 2000). Figure 1-2 shows features of the Bonneville Dam complex.

Site investigations on Bradford Island began with the Landfill. The Landfill was used from the early 1940s until the early 1980s. The USACE informed the U.S. Environmental Protection Agency (USEPA) and the Oregon Department of Environmental Quality (DEQ) of the presence of the Landfill in 1996. The Landfill was added to the DEQ Environmental Cleanup Site Information (ECSI) database in April 1997, and the Bonneville Dam Project Manager (PM) signed a DEQ Voluntary Cleanup Agreement letter for the Landfill in February 18, 1998 under the DEQ Voluntary Cleanup Program (VCP). In 2014, USACE will continue investigation of Bradford Island under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The USACE is currently working with the DEQ to address the state’s concerns regarding this investigation and any associated cleanup.

Numerous investigations have been performed by the USACE and their contractors since 1997, focusing on two Operable Units (OUs), the Upland OU, and the River OU (Figure 1-3). A review of site records for the Upland OU, including employee interviews, site environmental audits, and environmental investigations resulted in the identification of four areas of potential concern (AOPCs): the Landfill, Sandblast Area, Pistol Range, and the Bulb Slope (Figure 1-4). The primary contaminants of interest (COIs) that have been identified in soil and/or groundwater in the four AOPCs include certain metals; polychlorinated biphenyl (PCBs); semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbon (PAHs); butyltins; volatile organic compounds (VOCs); and a few pesticides and herbicides.

In 2007, the USACE submitted a Remedial Investigation/Feasibility Study (RI/FS) Management Plan (MP) (URS 2007), which defined the objectives of the remedial investigation (RI) and described the work to be performed to meet the project objectives. Using the Data Quality Objectives (DQO) approach (USEPA 2006), the RI/FS MP identified data gaps and described plans for extensive data collection to fill the identified data gaps for the site soils and groundwater (Upland OU) and for the offshore sediments, surface water, and tissues of various aquatic species (River OU). The RI/FS MP also described how the collected data would be used to delineate the nature and extent of contamination, evaluate the potential risks to human and ecological receptors, and support decision-making. The USACE and the external stakeholders for the project, which are collectively referred to as the Technical Advisory Group (TAG) and include the DEQ, conducted extensive internal and external review of the RI/FS MP, and the document was finalized in September 2007.

The Final RI report (URS 2012) documented the investigation, identified source areas at Bradford Island, defined the nature and extent of the environmental contamination, and identified the contaminants of potential concern (COPCs) for human health and contaminants of potential ecological concern (CPECs) in the media from the two OUs. Based on the screening level risk assessments (RAs) completed for each of the AOPCs, the RI report made the following recommendations:

Landfill AOPC

- Perform a site-specific baseline human health risk assessment (BHHRA) and a baseline ecological risk assessment (BERA) to determine if risks to human and ecological receptors are unacceptable.

Sandblast Area AOPC

- Perform a site-specific BHHRA and a BERA to determine if risks to human and ecological receptors are unacceptable.
- Evaluate the feasibility of a using a vapor extraction system or other remedial techniques to achieve acceptable soil gas VOC concentrations.

Pistol Range AOPC

- Perform a site-specific BERA to determine if exposure to lead in soil poses unacceptable risk to ecological receptors.

Bulb Slope AOPC

- Perform a site-specific BERA to determine if exposure to lead and mercury in soil poses unacceptable risk to ecological receptors.

The BHHRA and BERA will build on the data and findings of the Final RI (URS 2012). Only upland exposure pathways will be addressed in the Upland OU baseline RAs. The Upland OU to River OU pathways (i.e., potential mass wasting, soil erosion, and groundwater discharge) will not be addressed in the Upland OU baseline RAs. These possible pathways will be considered in the Upland Feasibility Study (FS), the River FS, or a Separate Source Control Document.

1.1 Objectives and Organization

This RA Work Plan (WP) Update Technical Memorandum provides updates and changes to the methodologies for conducting the BHHRAs and BERAs at the Upland OU since the RI/FS MP (URS 2007). Most of the updates to the RA procedures are driven by the following:

- USACE's adopting the USEPA/CERCLA approach for the baseline RAs.
- DEQ comments on the Bradford Island RI (Appendix P of URS 2012) that are to be addressed in the baseline RAs.
- Regulatory (USEPA and DEQ) updates to guidances.
- Other technical updates.

1.2 Project Schedule

The following table presents the expected current and potential future Upland OU project milestones with expected completion dates.

Project Milestones	Estimated Date
Data Evaluation Technical Meeting	March 2014
Technical Advisory Group (TAG) Meeting	March-April 2014
Draft Upland OU Baseline RAs	May 2014
TAG Meeting	May-June 2014
TAG Meeting	July 2014
Final Upland OU Baseline RAs	July 2014
Draft Upland FS for Review	October-November 2014
TAG Meeting	November 2014
Final FS Published	January-February 2015
Upland OU Record of Decision	To Be Determined

2.0 BASELINE HUMAN HEALTH RISK ASSESSMENT APPROACH

This section presents the updates to the BHHRA methodology that will be performed for the Upland OU. Most of the BHHRA process is described in the RI/FS MP (URS 2007), with only subsequent procedural updates described herein. The two main reasons for adjusting the approach for the BHHRA described in the RI/FS MP are to:

1. Reflect updates to HHRA guidance documents, and
2. Incorporate responses to DEQ’s comments on the Final RI in which the USACE agreed to certain elements of the approach to the BHHRA (see the responses to DEQ’s comments presented in Appendix P of the Final RI, URS 2012).
3. One additional potential receptor who was identified after the completion of the RI report has been added to the BHHRA.

2.1 Outstanding DEQ Comments to Be Addressed in BHHRA

Most of the comments related to the HHRA in the draft RI Report were addressed in the Final RI Report. There were two comments from DEQ that significantly affected the HHRA. One was DEQ’s general comment regarding data management (e.g., censoring limits, inclusion of historic data). This comment was accepted and addressed in the Final RI Report and requires no further effort in the BHHRA.

The second major comment (Specific Comment #12) related to the process to identify the COPCs to be included in the BHHRA. In response to DEQ’s comments, the COPC selection process was limited only to the mechanical process outlined in DEQ’s HHRA guidance (DEQ 2010a), and nuances related to site-specific considerations were omitted. This resulted in a slightly longer list of COPCs for each environmental medium at the Landfill AOPC and the Sandblast AOPC (Tables 11-1 and 11-2 in the Final RI, based on Tables M-12 and M-20).

Addressing the two types of comments above did not change the recommendation to conduct a BHHRA for the Landfill and Sandblast AOPCs.

Addressing Specific Comment #12—Inclusion of PAHs as COPCs in groundwater for the hypothetical potable use exposure pathway at the Sandblast Area AOPC—was deferred to the BHHRA. There is low confidence in the PAH data since they were collected from direct-push groundwater samples. The DEQ has since agreed that the potable use pathway is incomplete for Bradford Island and does not need to be included in the BHHRA (e-mail communication from Bob Schwarz, January 16, 2014). Therefore, this comment is no longer relevant to the BHHRA.

The screening Assessment in the RI identified COPCs in Upland OU groundwater potentially discharging to the River OU, and COPCs in Upland OU soil that could migrate to the River OU through soil erosion and/or mass wasting were identified as warranting additional evaluation for human receptors in the River OU. Further assessment of these migration pathways will be conducted in the Upland FS, River FS, or a separate Source Control Document.

2.2 Regulatory Updates

The RI/FS MP (URS 2007) detailed the proposed approach to the BHHRA (Appendix B of the RI/FS MP). Since then, several regulatory updates that are relevant to the HHRA have been published. Since USACE has elected to follow a CERCLA model for the execution of the BHHRA but Oregon DEQ remains the reviewing agency, updates from both agencies need to be considered with primary consideration given to USEPA guidance.

Relevant updates from USEPA and Oregon DEQ which may require some modifications to the approach for the BHHRA include the following:

<u>USEPA</u>

- *Regional Screening Levels* (USEPA 2013a)
- *Updated Toxicity Values* (USEPA IRIS and other sources, current)
- *Final Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air – External Review Draft.* (USEPA 2013b)
- *EPA National Risk Management Research Laboratory - Engineering Issue: Indoor Air Vapor Intrusion Mitigation Approaches* (USEPA 2008)

<u>DEQ</u>

- *Human Health Risk Assessment Guidance* (DEQ 2010a)
- *Guidance for Assessing and Remediating Vapor Intrusion in Buildings* (DEQ 2010b)

Modifications to the BHHRA methodology based on these updates are included in the section below.

2.3 Summary of BHHRA Approach

The approach for the BHHRA will follow the methodology presented in Appendix B of the RI/FS MP (URS 2007) with updates and changes discussed in this section.

2.3.1 AOPCs, Media, and COPCs

The Final RI (URS 2012) recommended the Landfill and Sandblast Area AOPCs for further evaluation in a BHHRA. The contaminated media are soil and groundwater with soil gas being an issue for the buildings on the Sandblast Area. The media-specific chemical groups of COPCs are as follows:

<u>Media and COPCs for Landfill AOPC</u>

- Soil: Metals, PAHs, Chlorinated VOCs (CVOCs)
- Groundwater (incidental exposure in trench setting for construction workers only): Metals, phthalates

<u>Media and COPCs for Sandblast Area AOPC</u>

- Soil: Metals, PAHs, chlorinated VOCs (CVOCs)
- Groundwater (incidental exposure in trench setting for Construction Workers only): Metals
- Soil Gas: CVOCs

Tables 2-1 and 2-2 list the individual COPCs recommended for further evaluation in the BHHRA by receptors and media for the Landfill and Sandblast Area AOPCs, respectively.

2.3.2 Receptors and Pathways

The eastern portion of Bradford Island continues to be a restricted access area that is managed by USACE. Due to the industrial nature of land use at the site, residential receptors are absent. On-site groundwater is not used for any purpose at Bradford Island. Along the shore of the Bradford Island, tribal fishermen may fish from fishing platforms erected along the shoreline.

Activities that are typically carried out by employees on the eastern side of the Island include grounds maintenance, vegetation clearing, painting, building maintenance and administrative activities. The grounds crew typically works up to three days per week during peak season. The building crews typically work up to 40 hours per week. The workers are supplied with drinking water. Construction activities (less than one-year duration) and short-term excavation involving utility repair or other types of soil-disturbing activities in a trench setting may be present.

The conceptual site models (CSMs) depicted in Figures 2-1 and 2-2 present potential exposures of humans to various media (i.e., soil gas, soil, and groundwater). Potential exposures by human receptors who may be exposed to COPCs at the upland AOPCs are described below.

Landfill AOPC

The landfill continues to be a fully vegetated area with no bare soils. Vegetation clearing occurs along a 3-4 foot-wide strip along roadsides when needed. There are no built or occupied structures at the landfill or in its vicinity. There are no plans at this time for construction of enclosed structures at this AOPC nor is it considered feasible from an engineering standpoint. Therefore, vapor intrusion pathways for indoor inhalation are incomplete and will remain incomplete.

Receptors who may be exposed to COPCs in soil and groundwater (incidental exposure in trench setting only) at the Landfill AOPC and will be evaluated in the BHHRA include the following:

- Adult outdoor site maintenance worker engaged in activities that do not involve a significant degree of soil disturbance (e.g., landscape workers). These receptors at Bradford Island may be exposed to COPCs in surface soil (0-3 feet below the ground surface [bgs]) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil.
- Construction workers may be exposed to COPCs in surface and subsurface soil (0-10 feet bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Occasionally, construction workers and short-term excavation workers also may be exposed to COPCs in shallow groundwater by incidental ingestion and dermal contact, if they undertake activities at depths that may bring them in contact with shallow groundwater.

Sandblast AOPC

The Sandblast AOPC is a mixture of vegetated and unvegetated areas. The former Sandblast building has been demolished and the former Hazardous Material Storage Area (HMSA) exists only as a lean-to area that is open to the outdoors. The two remaining buildings in the vicinity are the Service Building and the Equipment Building and both are in active occupational use. The Service Building provides work space for approximately 27 people and may support additional full-time employees in the future. The Equipment Building includes office space for two people.

- Adult outdoor site maintenance worker engaged in activities that do not involve a significant degree of soil disturbance (e.g., landscape workers). These receptors at Bradford Island may be exposed to COPCs in surface soil (0-3 feet bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil.
- Construction workers and short-term excavation workers may be exposed to COPCs in surface and subsurface soil (0-10 feet bgs) by incidental ingestion, inhalation (dusts and vapors), or dermal uptake of contaminants from soil. Occasionally, they also may be exposed to COPCs in shallow groundwater by incidental ingestion and dermal contact.
- Adult indoor workers may be exposed to VOCs emanating from soil gas and entering the indoor environment by vapor intrusion.

Fishing from Shore Platforms

Fishing on platforms used by tribal fishermen and their children is evaluated within the Upland OU. Tribal fishers and their children may utilize fishing platforms along the shoreline of the Island to fish for species that may be consumed or sold. The fishing platforms are typically accessed by boat and the actual fishing activity may include overnight stays at the platforms or in the Upland OU portion of Island itself.

Each of the four Upland AOPCs (Landfill, Sandblast Area, Pistol Range, Bub Slope) will be considered. Exposure pathways will include adult and child exposures to shallow soil (0-3 feet bgs) at each AOPC, for incidental ingestion, dermal contact, and inhalation of dusts and vapors. A screening step will be followed by forward risk assessment only for COIs that exceed the screening level values (SLVs) for the fishing platform exposure scenarios.

USACE has provided some general information regarding the nature of the receptor activity. The key assumptions used to characterize these receptors are as follows:

- There are two types of users of the fishing platforms:

  1) Tribal fishers who are allowed to sell their catch and use platforms for only 2 months a year. They may be there in excess of 24 hours during this period.
  2) Sustenance fishers who cannot sell their catch but are allowed to fish any time throughout the year.

- The tribal fishermen target salmon in the salmon migration path along the south shore of the dam complex.

- For purposes of the risk assessment of fishing platforms only, it is assumed that fishing platforms could be constructed and fishers should occupy any area of Bradford Island, including any of the four AOPCs. The tribal fishermen and their children will arrive and depart by small boat.
- Only direct exposure to contaminants in soil or sediment are evaluated (i.e., subsistence or fish consumption is not evaluated since that will be included in the River OU assessment).

To further refine assessment of the fishing platform exposure, an additional screening step will be conducted in a two-level process to assess possible exposures by commercial or sustenance fishers on Bradford Island. In Level 1 of the screening, the soil data for COIs at each AOPC will be compared to the DEQ Residential Risk-Based Concentrations (RBCs) and USEPA's Residential RSLs. Those AOPCs where all COIs are lower than the screening values will be dropped from further evaluation. AOPCs where there are exceedences will be carried to a second screening level. For the Pistol Range AOPC, sediment data and soil data will be grouped separately.

In the Level 2 screening, residential RBCs and RSLs will be multiplied by a factor that represents an exposure duration as a fraction of default residential exposure duration. For example, it may be assumed conservatively that an adult or child will spend several days a week for 8 months of the year for 30 years at the Upland AOPCs.

If any COIs from any AOPC fail the residential screening in Level 1, they will be compared to the Platform Fishing SLVs developed in Level 2. If all values are below the Level 1 and/or Level 2 SLVs, there will be no need for further evaluation and the screening exercise will be documented in the Baseline HHRA.

If any COIs exceed the fishing platform SLVs, they will be recommended for site-specific forward risk assessment calculations, similar to the other receptors already included in the BHHRA.

Minor Pathways

Since the DEQ RBCs only consider dermal contact in their groundwater exposure in a trench setting, potential inhalation of VOCs in a trench setting may be a complete but minor pathway for the construction worker at the Landfill and Sandblast Area AOPC**s.** The uncertainty assessment will include an evaluation of inhalation of VOCs from groundwater in a trench setting even though they were not identified as dermal COPCs in groundwater for the trench setting (Section 2.3.1).

2.3.3 Exposure Assessment

Quantifying exposure involves estimating chemical intake rates based on the evaluation of chemical releases from the site and estimation of exposure point concentrations (EPCs) for specific pathways.

The methods for calculating potential chemical intakes from soil, groundwater, and soil gas (vapor intrusion into indoor air) for the populations and exposure pathways selected for quantitative evaluation will primarily follow USEPA guidance and will also consider Oregon DEQ guidance, as appropriate. Exposure factor values are drawn from the Risk Assessment

Guidance for Superfund (RAGS) Part A (USEPA 1989) and all succeeding guidance documents as listed in Appendix B of the RI/FS MP (URS 2007) and in Section 2.2 above. In addition, Oregon DEQ's HHRA guidance, Vapor Intrusion guidance and current tables for Calculating Risk-Based Concentrations for Individual Chemicals were also consulted (DEQ 2010a,b, 2012).

There is generally close agreement between USEPA and DEQ for the exposure factor values. Where exposure factor values are not available from USEPA, DEQ's recommended values will be used.

The EPC is a chemical-specific and media-specific value that represents a central tendency exposure (CTE) or Reasonable Maximum Exposure (RME) estimate of the concentration to which a receptor is exposed. In accordance with USEPA guidance (USEPA 1989), and to address comments received on the Final RI (URS 2012), both RME and CTE estimates will be used in the BHHRA. As described in Appendix A of the Remedial Investigation Management Plan (URS 2007) and in accordance with the most recent USEPA guidance regarding statistical methodology to be used in EPC estimation (USEPA 2002), the 95th percentile (%) upper confidence limit (UCL) on the mean of values in a medium (95% UCL) (soil, groundwater for trench setting, soil gas) will be used as the EPC representing the RME. Where samples sizes are less than eight, the maximum or single location data may be used, as appropriate. As previously agreed, the 95% UCL is also acceptable to DEQ and is more conservative than DEQ's suggested 90% UCL. The EPC representing the CTE scenario will be based on the mean value. The RME and CTE EPCs will represent a single AOPC and will be estimated using statistical methods and values recommended by USEPA's ProUCL software (USEPA 2013c). EPCs for soil will be based on 0- to 3- foot bgs depth interval for outdoor workers, and 0- to 10-foot-bgs depth interval for construction workers and excavation workers.

Table 2-3 lists the exposure factors that will be used in the BHHRA for each of the receptors noted above. The selection of RME and CTE values generally exceeds the likely exposures of on-island personnel with respect to exposure duration, exposure frequency, and other uptake parameters. For example, although there are both part-time and full-time employees at Bradford Island, it is doubtful that they will have an exposure duration of 25 years. If warranted, the proposed exposure factors may be modified as part of the uncertainty assessment to provide context to the findings of the BHHRA.

Soil – Outdoor Maintenance Worker, Construction Worker

Soil-related pathways for the outdoor worker (0-3 feet bgs) and construction worker (0-10 feet bgs) are common to the Landfill and Sandblast Area AOPCs. The equations for estimating direct contact with soil are presented in the RI/FS MP and are not repeated here.

Soil Gas – Indoor Office Worker

The vapor intrusion pathway for the indoor office worker at the Sandblast Area AOPC will be evaluated by using soil gas data. USEPA's current versions of the Johnson and Ettinger Model (JEM) for soil gas data may be used to estimate site-specific risks for the vapor intrusion pathway (USEPA 2004a,b, 2013c). The current two buildings at the Sandblast Area AOPC and a hypothetical future building may be modeled using JEM. A combination of USEPA default and site-specific values (i.e., dimensions of existing inhabited buildings and available site specific soil parameters) will be used to represent building and soil properties. It is recognized that

DEQ's Vapor Intrusion guidance (DEQ 2010) de-emphasizes the use of site-specific modeling. The uncertainty assessment will include a discussion of the soil, groundwater and soil gas data in comparison to DEQ RBCs, the magnitude of exceedances, and other lines of evidence such as spatial distributions and proximity to source areas.

Groundwater – Construction Worker (Incidental exposures only)

There is no consumption of groundwater on the Island. Occasionally, construction workers and excavation workers may be exposed to groundwater within an excavation due to the occurrence of groundwater at depths as shallow as 5 feet bgs (as noted in the Final RI Appendix B logs and D tables [URS 2012]).

At the Landfill AOPC, construction workers in a trench setting may come into dermal contact with metals and phthalate COPCs in groundwater and may experience some minimal incidental ingestion of groundwater. These pathways will be evaluated by assuming that a portion of the overall exposure duration of construction workers (e.g., 25 of 250 days) may be spent in a trench setting where incidental contact with groundwater may occur.

At the Sandblast Area AOPC, the risk assessment will evaluate incidental contact with groundwater within a trench scenario for the construction worker.

As noted in Section 2.3.2, the DEQ RBCs only consider dermal contact in their groundwater exposure in a trench setting. The uncertainty assessment for the construction worker at the Landfill and Sandblast AOPC**s** will include an evaluation of inhalation of VOCs from groundwater in a trench setting even though they were not identified as dermal COPCs in groundwater for the trench setting. The Virginia Department of Environmental Quality (VDEQ 2014) trench model may be used to model trench air concentrations for VOCs in groundwater.

2.3.4 Toxicity Values

The selection of toxicity values will follow the hierarchy of sources that is currently recommended by USEPA (2013a), as follows:

- Integrated Risk Information System (IRIS) (USEPA)
- Provisional Peer-Reviewed Toxicity Values (PPRTVs) (USEPA)
- Minimal Risk Levels (Agency for Toxic Substances Disease Registry [ATSDR])
- Chronic Reference Exposure Levels (California Environmental Protection Agency [EPA])
- Appendices to PPRTVs (USEPA)
- Health Effects Assessment Summary Tables (HEAST)

This hierarchy is generally similar to Oregon DEQ's hierarchy with some minor variations. Toxicity values for the majority of the COPCs are available from IRIS or as PPRTVs. A few selected COPCs are discussed in more detail below.

2.3.4.1 Lead

Exposure to lead in Sandblast AOPC soils will be evaluated using the most current version of the Adult Lead Model, as recommended by USEPA (2014).

2.3.4.2 Polycyclic Aromatic Hydrocarbons

cPAHs will be evaluated by the use of Toxicity Equivalence Factors (TEFs) relative to benzo(a)pyrene, as listed below from USEPA (2013a).

Compound	TEF
Benzo(a)pyrene	1.0
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-c,d)pyrene	0.1

2.3.4.3 Trichloroethylene (TCE)

Toxicity values for TCE will be based on USEPA's current recommendations as listed in IRIS and USEPA (2013a). These include the following:

- Oral Slope Factor – 4.6E-02 (milligrams per kilogram [mg/kg]-day)-1
- Inhalation Unit Risk – 4.1E-06 (micrograms per cubic meter [$\mu g/m^3$])-1
- Oral Reference Dose – 5.0E-04 mg/kg/day
- Inhalation Reference Concentration – 2.0E-03 mg/m^3

2.3.5 Risk Characterization

As noted in in the RI/FS MP (URS 2007), both excess lifetime cancer risk and non-cancer hazard will be estimated for all carcinogenic COPCs, for each combination of receptor, exposure medium and exposure scenario. For non-carcinogenic chemicals, only non-cancer hazards will be estimated. The results will be summed to provide quantitative estimates of multi-pathway and multi-media risks and hazards for each receptor. If initial hazard indices are greater than 1, then segregation of hazard quotients by target organ or system specific analysis will also be performed. The estimated risks, hazard quotients, and hazard indices will be presented in the context of USEPA's acceptable risk range of 1E-06 to 1E-04 for cancer and hazard quotient or hazard index of 1.0 for noncancer COPCs (USEPA 1991).

An Uncertainty Assessment section describing the sources of uncertainty in the BHHRA and their potential effect on the underestimation or overestimation of risk and hazard will be included.

3.0 BASELINE ECOLOGICAL RISK ASSESSMENT APPROACH

This section presents the BERA methodology that will be implemented for the Upland OU. Most of the BERA process is described in the RI/FS MP (URS 2007), with only subsequent procedural updates described herein. The two main reasons for adjusting the approach for the BERA described in the RI/FS MP are to:

1. Reflect updates to ERA guidance documents, and
2. Incorporate responses to DEQ's comments on the Final RI (URS 2012) in which the USACE agreed to certain elements of the approach going forward with the BERA (see the responses to DEQ's comments presented in Appendix P of the Final RI, URS 2012).

The only relevant guidance update is the latest USEPA Ecological Soil Screening Levels (EcoSSLs) and associated methodology (USEPA 2005-2008). As described in the following subsections, USEPA's EcoSSL document now has priority in the hierarchy of toxicity reference values (TRVs) and bioaccumulation factors (BAFs) that will be used to assess risk.

Two responses to DEQ's comments on the Final RI require incorporation into the BERA: responses to Specific Comments 22 (add American mink, *Neovison vison*, as an Upland receptor) and 42 (consider Region 5 TRVs for birds and mammals). Both of these responses have been implemented into the updated approach for the BERA, as presented below.

3.1 AOPCs, Media, and CPECs

All four AOPCs in the Upland OU are retained for evaluation in the BERA. Only soil was identified as a medium of concern for terrestrial ecological receptors. Table 3-1 provides the list of CPECs that will be evaluated for each AOPC in the BERA. These CPECs include metals, total high-molecular-weight PAHs (HPAHs), tributyltin, organochlorine pesticides, VOCs, and SVOCs for the Landfill and Sandblast Area AOPCs, lead for the Pistol Range AOPC, and lead and mercury for the Bulb Slope AOPC. Risk estimates will be calculated for each CPEC for all receptors potential present at a given AOPC. For the receptors with large home ranges that will be assumed to forage in the combined four AOPCs (discussed in Section 3.3.1), all CPECs shown in Table 3-1 will be evaluated for this "combined AOPC" exposure unit.

3.2 Receptors and Exposure Pathways

The terrestrial receptors and exposure pathways identified in the RI/FS MP (URS 2007) will be evaluated in the BERA, and the American mink will be added to represent a hypothetical upland large mammal, as requested by the DEQ (Specific Comments 22 on the Final RI). The assessment and measurement endpoints originally presented in the RI/FS MP (URS 2007) are shown in Table 3-2, and an assessment endpoint associated with the mink was added.

The following list of receptors and exposure pathways will be included in the Upland BERA:

- Terrestrial plants and soil invertebrates exposed through direct contact with surface and shallow soil.
- Vagrant shrew (*Sorex vagrans*) exposed through incidental ingestion of surface and shallow soil, prey (100% soil invertebrates), and water.

- American mink exposed through incidental ingestion of surface soil, Upland prey (15% small mammals, and water.
- American robin (*Turdus migratorius*) exposed through incidental ingestion of surface soil, prey (100% soil invertebrates), and water.
- Canada goose (*Branta canadensis*) exposed through incidental ingestion of surface soil, prey (100% plants), and water.
- American kestrel (*Falco sparverius*) exposed through incidental ingestion of surface soil, prey (100% small mammals), and water.

Based on the available data, surface soil is defined as 0 to 1 foot bgs for all AOPCs with the exception of the Pistol Range, for which surface soil is defined as 0 to 1.5 feet bgs. Shallow soil is defined as 0 to 3 feet bgs, and this depth interval only applies to the Landfill and Sandblast Area AOPCs.

As described in detail in the response to DEQ's Specific Comment #22 on the Final RI (URS 2012), the mink was selected to represent large mammals in the Upland OU due to the absence of mammals on the island with the exception of rodents and feral cats. Mink are also known to be sensitive to environmental contaminants. The minimal amount of available habitat (approximately 12 acres) makes the island unsuitable for supporting viable populations of wildlife species with larger home ranges (URS 2002). Mink are present in the area and could feasibly access the island and forage there on rodents. Several sources of information on the mink's diet were consulted while developing the response to DEQ's comment, and the consensus is that mink's diet primarily consists of crayfish, fish, and other aquatic-related prey. Typically, 10% or less of their diet is comprised of terrestrial prey (e.g., birds and small mammals) (USEPA 1993, 1995).

To be conservative, a dietary composition of 15% small mammals from the Upland OU will be assumed as a first step in the evaluation for the mink, even though a lower proportion may actually be more realistic for site conditions (i.e., permanent water source; riverine habitat). The remaining 85% of the mink's diet is assumed to be comprised of prey from the River OU (i.e., fish and crayfish), which will be evaluated in the BERA for the River OU.

For the water ingestion pathway, highly mobile wildlife receptors (i.e., kestrel and mink) will be assumed to ingest water from the river, while less mobile receptors (i.e., robin and shrew) and the Canada goose will be assumed to ingest water that puddles in the Upland OU (via a simple equilibrium partitioning calculation).

3.3 Exposure Assessment

The foodweb model for the Upland OU and the ecological CSMs for each AOPC are provided on Figures 3-1 through 3-5, which were most recently presented in the Final RI (URS 2012). Minor updates to the foodweb model and CSMs presented in the Final RI (URS 2012) were made for purposes of the Upland OU BERA. These figures illustrate the potentially complete and significant ecological exposure pathways for the Upland OU, including those associated with transport to the River OU. In the Screening Assessment that was conducted in the RI, CPECs in Upland OU groundwater potentially discharging to the River OU did not pose a risk to aquatic receptors. CPECs in Upland OU soil that could migrate to the River OU through soil erosion and/or mass wasting did pose an unacceptable risk to aquatic receptors. Further assessment of this migration pathway will be conducted in the Upland FS, River FS, or a Separate Source Control Document.

3.3.1 Exposure Factors

No updates to the life history parameters developed in the RI/FS MP (URS 2007) were needed with the exception of the dietary composition adjustment for the mink described in Section 3.2 and the home range for the mink discussed below. Table 3-3 presents the life history parameters for each terrestrial receptor that will be evaluated in the Upland BERA.

For the animal receptors with small home ranges (i.e., shrew and robin), it is feasible for an individual to forage within one specific AOPC. Although the Canada goose has a potentially large home range (Table 3-3), part of Bradford Island is managed as goose habitat, and therefore this receptor could spend most of its time on the island. For the animal receptors with large home ranges (i.e., kestrel and mink), it was assumed that these receptors could forage at each individual AOPC (albeit unlikely) and within all four AOPCs combined. Receptor-specific area use factors will be calculated in the BERA as the AOPC (and/or combined AOPC) site size divided by the size of the home range.

The home range size of 1.85 km for the mink that was originally developed in the RI/FS MP (URS 2007) for the River OU was developed based on the idea that this receptor would be foraging along the river banks on and near Bradford Island. The shape of mink home ranges depends on the type of habitat available. In riverine environments, home ranges are linear, whereas those in marsh habitats tend to be more circular (USEPA 1993). In addition, home ranges for adult males are generally larger than adult female home ranges, especially during the mating season. Because the purpose of selecting the mink as a receptor in the Upland OU is to address the portion of the daily dose attributed to Upland prey, the smallest home range for an adult female in riverine habitat expressed as an area (7.8 hectare, or approximately19 acres) was selected for use in the Upland BERA (USEPA 1993). This home range will be used to calculate AOPC-specific area use factors for the mink.

3.3.2 Exposure Point Concentrations

The 95% UCLs calculated for soil in the RI will be used as the EPCs for all terrestrial receptors. In the Screening ERA presented in the Final RI Report (URS 2012), maximum detected concentrations were used for terrestrial plants and invertebrates, and the 95% UCLs were used for birds and mammals. Given that the objective of the BERA is to provide more realistic, site-specific estimates of risk, the 95% UCL will be used for plants and invertebrates as well as birds and mammals. This is due to the lack of protected plant and invertebrate species in the Upland OU and the goal of estimating risk to these receptor groups at the community level.

3.3.3 Bioaccumulation Factors

As described in the RI/FS MP (URS 2007), a combination of regression-derived BAFs, median BAFs, and octanol-water partition coefficient ($\log K_{ow}$) based BAFs from the literature will be used to predict tissue concentrations in the BERA. The regression-based approach is typically preferred because it provides a more site-specific prediction of a CPEC concentration in a certain dietary tissue, as it incorporates the site EPC.

The following two sources of BAFs are the primary documents that will be consulted for the BERA:

- USEPA's Eco-SSLs guidance document, Attachment 4-1 (2005a, last updated 2007)
- Oak Ridge National Laboratory's Risk Assessment Information System (RAIS) database

Other sources in the literature may also be reviewed in the absence of BAFs in the Eco-SSLs guidance or, secondarily, the RAIS database. In the absence of empirically-derived BAFs, equations to estimate BAFs for organic chemicals are typically based on the $\log K_{ow}$ of the chemical and the organic carbon content of the soil. For soil invertebrates, estimated lipid content (e.g., earthworms) is also incorporated into the BAF development.

3.4 Toxicity Values

Screening levels, or SLVs, are expressed as concentrations in media (i.e., mg of chemical/kg of soil). Although "screening levels" are typically associated with exposure via direct contact, and are commonly referred to as direct toxicity benchmarks, limited sources of generic media-based screening levels address both direct contact and dietary exposure for birds and mammals. In contrast, diet-based TRVs protective of birds and mammals are expressed as a daily dose normalized to body weight (mg of chemical/kg of body weight/day).

Both no-observable-adverse-effect-levels (NOAELs)/no-observable-effect-concentrations (NOECs) and lowest-observable-adverse-effect-levels (LOAELs)/lowest-observable-effect-concentrations (LOECs) will be selected for each receptor group in order to develop a range of hazard quotients (HQs) for consideration by risk managers. An uncertainty factor of 5 will be used to adjust chronic LOAELs/LOECs to NOAELs/NOECs and vice-versa, when necessary. Ideally, NOAELs and LOAELs from the same dose-response studies will be selected. As noted in Section 3.0, the TRV selection process was changed based on guidance updates and DEQ comments on the Final RI (URS 2012).

3.4.1 Screening Levels for Terrestrial Plants and Soil Invertebrates

The following hierarchy of sources of terrestrial plant and soil invertebrate SLVs will be consulted for the BERA:

- USEPA's Eco-SSLs guidance document, Attachment 4-1 (2005a, last updated 2007)
- DEQ's Level II SLVs (DEQ 2001)
- Oak Ridge National Laboratory's Risk Assessment Information System (RAIS) database

Other sources of the literature may also be review in the absence of SLVs from the hierarchy listed above.

3.4.2 Toxicity Reference Values for Birds and Mammals

The following hierarchy of sources of TRVs for birds and mammals will be consulted for the BERA:

- USEPA's Eco-SSLs (USEPA 2005-2008)
- Draft Portland Harbor RI/FS (Lower Willamette Group 2011)

- Oak Ridge National Laboratory's Risk Assessment Information System (RAIS) database
- USEPA Region 5 Ecological Screening Levels (USEPA 2003)
- USEPA's IRIS database

Other sources in the literature may also be reviewed in the absence of TRVs from the hierarchy listed above. To avoid the need to consider allometric scaling factors, TRVs based on large mammal studies will be selected for the mink. This is the primary reason for reviewing the mammalian TRVs provided in the Draft Portland Harbor RI/FS report (Lower Willamette Group 2011).

To address DEQ's Specific Comment 42 on the RI, USEPA Region 5 Ecological Screening Levels will be reviewed to identify the TRVs that were used to develop these screening levels. These TRVs would be considered in the absence of TRVs from the first few sources listed in the hierarchy above.

3.5 Risk Characterization

The two types of TRVs listed in Section 3.4 will be incorporated into the analysis: one based on a NOAEL/NOEC and a second based on an observed adverse effect in a test species (LOAEL/LOEC). If the HQ based on the NOAEL TRV is less than 1, adverse effects are unlikely because of the inherent conservatism (protectiveness) built into the exposure and effects assessments. If the HQ derived using the LOAEL TRV is greater than 1, it indicates that exposure exceeds a known effect concentration for a test organism; such exposure pathways may warrant attention with respect to potential risk management measures.

If the estimated exposure exceeds the NOAEL TRV (i.e., the NOAEL TRV-based HQ is >1.0) but is less than the LOAEL TRV, (i.e., the LOAEL TRV-based HQ is <1.0), then that complete exposure pathway will be considered in greater detail before conclusions about the likelihood that a risk or hazard is present is made. For non-listed (common) terrestrial species known to be present on Bradford Island, more emphasis will be placed on CPECs that have LOAEL TRV-based HQs above 1. However, the range of HQs developed for each receptor and CPEC will be considered in the risk characterization.

Hazard indices (HIs) are ideally calculated for the appropriate CPEC groups identified as those chemicals demonstrating similar modes of toxicity, or those that affect the same target organ. HIs are estimated by calculating the summation of HQs for COI groups that meet these criteria. The implications of HQs greater than or less than 1.0 discussed above, will also be applied to HIs.

Due to a lack of data regarding additive effects associated with exposure to multiple chemicals for nonhuman receptors, professional judgment will be used in the development of HIs. For the BERA, HIs will be calculated based on the following chemical groupings in an effort to derive more meaningful HIs than by simply adding all HQs (as cited in the RI/FS MP, URS 2007):

- Inorganics (including butyltins) - Adequate avian and mammalian toxicity data may be available for several inorganics detected at the site, and literature citations will support development of the HI for inorganics. If no information is available for a particular inorganic, it will automatically be included in the HI for this chemical class.
- Low-molecular-weight PAHs (LPAHs) – The toxicity of PAHs is highly variable and is driven by the number of ring structures and molecular weight (Eisler 1987). LPAHs

consist of fewer than four fused benzene rings and have molecular weights less than 200. LPAHs are more soluble and bioavailable in aqueous solution than HPAHs and are associated with acute toxicological effects on biota. LPAHs are much less persistent in the environment, are not considered bioaccumulative, and are readily metabolized by birds and mammals. For these reasons, it is not likely that they will affect reproduction and development. Although they may act through different mechanisms of toxicity, the HQs for LPAHs will be added separately from the HPAHs to generate an HI.

- HPAHs – These PAHs consist of four or more fused benzene rings and have a molecular weight greater than 200. HPAHs are more persistent than LPAHs, which is attributed to their higher hydrophobicity. Due to their size, HPAHs are relatively immobile and exhibit extremely low volatility and solubility (Eisler 1987). Bioaccumulation potential tends to increase as the molecular weight of PAHs increases and HPAHs are generally associated with carcinogenic effects. Chronic exposure to these cPAHs may also produce non-carcinogenic effects by destroying hematopoietic, lymphoid, and reproductive tissues (Eisler 1987). Generating separate risk estimates for HPAHs and LPAHs is further supported by the recently (2007) published USEPA Eco-SSL for PAHs (USEPA 2005-2008). The HQs for HPAHs will be added separately from the LPAHs to generate an HI.
- Organochlorine pesticides and herbicides and PCBs – Persistent, lipophilic chlorinated compounds such as chlorinated pesticides, herbicides, and PCBs are associated with a variety of ecotoxicological effects. Effects include mortality and neurotoxicity at high doses. At lower doses, effects include endocrine disruption and impairment of reproductive, developmental and neurological functions. Dioxin-like PCBs can alter gene expression by the activation of the aryl hydrocarbon (Ah-R) receptor. Both dioxin-like and non-dioxin-like PCBs may also act through many other modes of toxicity, the most common of which as characterized as narcosis (a non-specific mechanism of toxicity associated with organic compounds). Chlorinated pesticides such as DDTs can interfere with the nervous system and may impair the endocrine system by exerting estrogenic effects. PCBs and chlorinated pesticides are highly persistent, have the potential to biomagnify in the food web, and are known to cause similar developmental and reproductive effects in birds and mammals. Although they may act through different mechanisms of toxicity, their HQs will be added to generate an HI for persistent and bioaccumulative chlorinated compounds.
- Non-PAH SVOCs – These compounds are known to exist in soils of the Upland OU and will be included in the food web evaluation if they demonstrate a potential for bioaccumulation. Phthalates are known to be present in Upland OU soils and have the potential to bioaccumulate in terrestrial ecosystems. Phthalates tend to have low water solubility, adsorb to sediments, and dissolve easily in oils. Phthalate esters metabolize to monoesters, which deregulate cellular activity by mimicking endogenous ligands (Wexler 1998). Experiments with fish have not found extensive bioaccumulation of these compounds, although rat studies have found fetotoxcity and teratogenic effects. Increased incidences of carcinomas and adenomas observed in rats caused USEPA to label bis(2-ethylhexyl)phthalate a probable human carcinogen. The HQs for phthalates will be added to generate an HI for total phthalates. The decision to include the HQs for other SVOCs in HI summations will be evaluated on a case by case basis.

- VOCs – Those VOCs with the potential to bioaccumulate, as defined in the Final RI (URS 2012) (log Kow exceeding 3.5, with an optimum range between 3.5 and 5.5; Suter 1993) will also be considered in the evaluation of dietary exposure by wildlife. For those VOCs that are not potentially bioaccumulative, direct exposure by birds and mammals through evaluation of the incidental soil ingestion pathway. The HQs for VOCs will be added to generate an HI for this chemical class.

If the HIs generated for the chemical classes discussed above exceed 1.0, then further assessment of the appropriateness to add the HQs for individual chemicals may be conducted for the specific receptor.

4.0 SUMMARY

The BHHRA and BERA will build on the findings of the Final RI (URS 2012). Only Upland OU exposure pathways will be addressed in the baseline RAs. The Upland OU to River OU pathways (i.e., potential mass wasting and erodible soils and groundwater discharge) will not be addressed in the Upland OU baseline RAs. These pathways will be considered in the Upland FS, in the River FS, or in a Separate Source Control Document.

This Technical Memorandum documents the BHHRA and BERA methodology and highlights updates subsequent to the RI/FS MP (URS 2007). These BHHRA and BERA procedural updates were driven by the USACE adopting the USEPA/CERCLA approach for the baseline RAs, DEQ comments on the Bradford Island RI (URS 2012) that are to be addressed in the baseline RAs, regulatory (USEPA and DEQ) updates to guidances, and other technical updates.

The RI/FS MP (URS 2007) and this Technical Memorandum, with the methodology updates, will be used to conduct the Upland OU BHHRAs and BERAs.

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Table 2-1
Summary of COPCs - Landfill AOPC
Bradford Island -Upland Operable Unit

Media	Receptor	COPCs
Soil	Adult Outdoor Worker	Arsenic Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzofluoranthenes, Total Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene Lead #
	Construction Worker	Benzo(a)pyrene Tetrachloroethene (PCE) 1,1-Dichloroethene # cis-1,2-Dichloroethene # trans-1,2-Dichloroethene # Trichloroethene (TCE) Vinyl Chloride
Groundwater (Incidental Contact in Trench Setting Only)	Construction/Excavation Worker	Antimony Iron Mercury Thallium # Zinc Di-n-octyl Phthalate

# = non-carcinogenic COPC
COPC = chemicals of potential concern
Shaded indicates COPC selection is not based on a direct exceedance of the screening level (SL) but other factors (i.e., multi-media, C/SL>0.1, degradation product, or No SL)

Table 2-2
Summary of COPCs - Sandblast Area AOPC
Bradford Island -Upland Operable Unit

Media	Receptor	COPCs
Soil	Occupational Outdoor Worker	Arsenic Benzo(a)pyrene Benzofluoranthenes, Total Chromium Lead # Tetrachloroethene (PCE) 1,1-Dichloroethene # cis-1,2-Dichloroethene # Dibenz(a,h)anthracene trans-1,2-Dichloroethene # Trichloroethene (TCE) Vinyl Chloride
	Construction Worker	Benzo(a)pyrene Tetrachloroethene (PCE) 1,1-Dichloroethene # cis-1,2-Dichloroethene # trans-1,2-Dichloroethene # Trichloroethene (TCE) Vinyl Chloride
Soil Gas	Indoor Worker	Tetrachloroethene (PCE) Trichloroethene (TCE) 1,1-Dichloroethene # cis-1,2-Dichloroethene # trans-1,2-Dichloroethene # Vinyl Chloride
Groundwater (Incidental Contact in Trench Setting Only)	Construction/Excavation Worker	Vanadium #

= non-carcinogenic COPC

COPC = chemicals of potential concern

Shaded indicates COPC selection is not based on a direct exceedance of the screening level (SL) but other factors (i.e., multi-media, C/SL>0.1, degradation product, or No SL)

Table 2-3
Exposure Factors for Human Health
Bradford Island - Upland Operable Unit

Reasonable Maximum Exposure (RME)

Definitions	Variable	Units	Indoor Worker (IW)		Outdoor Worker		Construction Worker (CW)		Excavation Worker	
			USEPA, 2013	DEQ, 2010, 2013	**USEPA, 2013**	DEQ, 2010, 2013	**USEPA, 2013**	DEQ, 2010, 2013	USEPA 2013	**DEQ, 2010, 2013**
Averaging Time, Carcinogens	ATc	yrs	**70**	--	**70**	--	**70**	--	--	**70**
Averaging Time, Noncarcinogens, adult	ATnc,a	yrs	**25**	--	**25**	--	**1**	--	--	**1a**
Body Weight, adult	BW_{adult}	kg	**70**	--	**70**	--	**70**	--	--	**70**
Exposure Duration	ED_w	yrs	**25**	--	**25**	--	**1**	--	--	**1**
Exposure Frequency	EF_w	days/yr	**250**	--	**225**	250	**250**	--	NA	**9b**
Exposure Time	ET_w	hours/day	**8**	--	**8**	--	**8**	--	Not Available	**Not Available**
Event Frequency (contact with groundwater)	EV_w	events/day	**NA**	NA	**NA**	NA	**NA**	**2c**	Not Available	**2c**
Event Time (contact with groundwater)	t_{event}	hr/event	**NA**	NA	**NA**	NA	**NA**	**2**	NA	**2**
Soil Ingestion Rate	$IR_{soil,w}$	mg/day	**50**	NA	**100**	--	**330**	--	Not Available	**330**
Particulate Emission Factor (non-VOCs), default	PEF	m^3/kg	**NA**	NA	**1.360E+09**	1.320E+09	**1.360E+06**	Not Available	Not Available	**1.320E+09**
Soil Adherence Factor	AF_w	mg/cm^2-event	**0.1d**	--	**0.2**	0.1	**0.3**	--	Not Available	**0.3e**
Exposed Body Surface Area (soil)	SAs	cm^2	**3300**	--	**3300**	--	**3300**	--	--	**3300**
Exposed Body Surface Area (groundwater/seep)	SA_w	cm^2	**NA**	NA	**NA**	NA	**NA**	**5700**	Not Available	**5700**
Duration of event	t_{event}	hr/event	**NA**	NA	**NA**	NA	**NA**	**2g**	Not Available	**2g**
Conversion Factor - dermal	CF_d	kg/mg	**1.0E-06**	--	**1.0E-06**	--	**1.0E-06**	--	NA	**1.0E-06**
Conversion Factor - inhalation	CF_i	m^2/cm^2	**1.0E-04**	--	**1.0E-04**	--	**1.0E-04**	--	NA	**1.0E-04**
Conversion Factor - ingestion	CF_o	kg/mg	**1.0E-06**	--	**1.0E-06**	--	**1.0E-06**	--	NA	**1.0E-06**

Central Tendency Exposure (CTE)

Definitions	Variable	Units	Indoor Worker (IW)	Outdoor Worker	Construction Worker (CW)	Trench Worker
			DEQ, 2010	DEQ, 2010	DEQ, 2010	DEQ, 2010
Averaging Time, Carcinogens	ATc	yrs	70	70	70	70
Averaging Time, Noncarcinogens, adult	ATnc,a	yrs	6	6	0.5	1
Body Weight, adult	BW_{adult}	kg	70	70	70	70
Exposure Duration	ED_w	yrs	6	6	0.5	1
Exposure Frequency	EF_w	days/yr	250	250	250	9
Event Frequency (contact soil/groundwater)	EV_w	events/day	NA	NA	2	2
Event Time (contact with groundwater)	t_{event}	hr/event	NA	NA	2	2
Soil Ingestion Rate	$IR_{soil,w}$	mg/day	NA	50a	100a	100a
Particulate Emission Factor (non-VOCs), default	PEF	m^3/kg	NA	1.320E+09	1.360E+06	1.360E+06
Soil Adherence Factor	AF_w	mg/cm^2-event	NA	0.02	0.1i	0.1i
Exposed Body Surface Area (soil)	SAs	cm^2	NA	3300	3300	3300
Exposed Body Surface Area (groundwater/seep)	SAw	cm^2	NA	NA	5700	5700

Bolded values are values selected for use in BHHRA
-- = Same
NA = Not Applicable

a = EPA 2002

b = The value of 9 days per year was based on standard dimensions for a residential excavation site from DEQ (1997a) and construction worker excavation statistics from EPA and Means Heavy Construction Cost Data, 8th Annual Edition, R.S. Means Company, Inc., Kingston, MA.
c = Assumes that direct soil contact or groundwater contact activities occur twice a day (morning, afternoon) for a total of four hours per day.
d = EPA 2004: Exhibit 3-3, mean for commercial gardener used to represent upper end commercial exposure.
e = EPA 2004: Exhibit 3-3, 95th percentile construction worker
f = EPA 1997, adjusted for time spent at work (8 hours / 24 hours)
g = Assumes that direct soil contact or groundwater contact activities occur twice a day (morning, afternoon) for a total of four hours per day.
h = EPA 2004: Exhibit 3-3, mean for commercial groundskeeper
i = EPA 2004: Exhibit 3-3, mean for construction worker

DEQ, 2010: Human Health Risk Assessment Guidance
DEQ, 2013. Risk-Based Concnetrations for Individual Chemicals - Exposure Factors
USEPA Regional Screening Values (RSL) : http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

Table 3-1
CPECs to be Evaluated in the BERA
Bradford Island - Upland Operable Unit

AOPC	Media	Inorganic CPECs	Organic CPECs	Boiaccumulative COIs without SLVs or SLVs not Bioaccumulation-based
Landfill	Soil	Antimony, chromium, copper, lead, mercury, and nickel	Total HPAHs	Tributyltin, chlordane-technical, heptachlor, 1,2,4-trimethylbenzene, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, carbazole, dibenzofuran, and di-n-butylphthalate
Sandblast	Soil	Antimony, cadmium, chromium, lead, mercury, and nickel	Bis(2-ethylhexyl)phthalate and total HPAHs	Tributyltin, BHC-delta, BHC-gamma, chlordane-alpha, chlordane-gamma, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, methoxychlor, 1,2,4-trumethylbenzene, 4-isopropyltoluene, n-propylbenzene, butylbenzylphthalate, carbazole, dibenzofuran, di-n-butylphthalate, and di-n-octylphthalate
Pistol Range	Soil	Lead		
Bulb Slope	Soil	Lead and mercury		

AOPC = area of potential concern
BERA = baseline ecological risk assessment
BHC = hexachlorocyclohexane
COI = contaminant of interest
CPEC = contaminant of potential ecological concern
HPAH = high molecular weight PAH
PAH = polycyclic aromatic hydrocarbons
SLV = screening level value

Table 3-2
Assessment and Measurement Endpoints for the BERA
Bradford Island - Upland Operable Unit

Assessment Endpoints	Measurement Endpoints	
	Measures of Exposure	**Measures of Effect**
Protection of the **terrestrial plant community** and **soil invertebrate** populations that may be exposed to COIs in soil to maintain species diversity, abundance, and nutrient cycling.	Measured concentrations in surface and shallow soils that reduce survival, growth, and/or productivity of the plant or soil invertebrate communities.	Potential toxicity due to exceedances of screening values related to maintenance of the terrestrial plant community, based on a 20% reduction (or greater) in growth or yield (DEQ 2001; Efroymson et al. 1997a).
		Potential toxicity due to exceedances of screening values related to maintenance of the soil-dwelling invertebrate community, based on a 20% reduction (or greater) in growth, reproduction, or activity (DEQ 2001; Efroymson et al. 1997b).
Protection of herbivorous birds (trophic level 1), represented by the **Canada goose**, with no unacceptable effects on reproduction, growth, or development on a population level due to COIs in soil and terrestrial plants.	Measured concentrations in surface soils, estimated water concentrations in upland puddles, and estimated concentrations in terrestrial plant tissues that reduce reproduction, health, and/or survival of populations of avian herbivores.	Potential or observed toxicity due to exceedances of screening values and/or acceptable hazard quotients related to survival, growth, and reproduction of resident populations of Canada geese (DEQ 2001; Efroymson et al. 1997c; USEPA 2005b; Sample et al. 1996).
Protection of invertivorous birds (trophic level 2), represented by the **robin,** with no unacceptable effects on reproduction, growth, or development on a population level due to COIs in soil and invertebrates.	Measured concentrations in surface soils, estimated water concentrations in upland puddles, and estimated concentrations in soil invertebrate tissues that reduce reproduction, health, and/or survival of populations of avian invertivores.	Potential or observed toxicity due to exceedances of screening values and/or acceptable hazard quotients related to survival, growth, and reproduction of resident populations of robins (DEQ 2001; Efroymson et al. 1997c; USEPA 2005b; Sample et al. 1996).
Protection of carnivorous small mammals (trophic level 2-3), represented by the **vagrant shrew,** with no unacceptable effects on reproduction, growth, or development on a population level due to COIs in soil and invertebrates.	Measured concentrations in surface and shallow soils, estimated concentrations in water from upland puddles, and estimated concentrations in soil invertebrate tissues that reduce reproduction, health, and/or survival of populations of carnivorous small mammals.	Potential or observed toxicity due to exceedances of screening values and/or acceptable hazard quotients related to survival, growth, and reproduction of resident populations of vagrant shrews (DEQ 2001; Efroymson et al. 1997c; USEPA 2005b; Sample et al. 1996).
Protection of top-level predatory birds (trophic level 3-4), represented by the **American kestrel**, with no unacceptable effects on reproduction, growth, or development on a population level due to COIs in soil and small mammals.	Measured concentrations in surface soils, measured concentrations in river water, and estimated concentrations in small mammal tissues that reduce reproduction, health, and/or survival of populations of top-level predatory birds.	Potential or observed toxicity due to exceedances of screening values and/or acceptable hazard quotients related to survival, growth, and reproduction of resident populations of American kestrels (DEQ 2001; Efroymson et al. 1997c; USEPA 2005b; Sample et al. 1996).

Table 3-2
Assessment and Measurement Endpoints for the BERA
Bradford Island - Upland Operable Unit

Assessment Endpoints	Measurement Endpoints	
	Measures of Exposure	**Measures of Effect**
Protection of large carnivorous mammals (trophic level 3-4), represented by the **mink**, with no unacceptable effects on reproduction, growth, or development on a population level due to COIs in Upland OU soil and Upland OU small mammals (15% of diet).	Measured concentrations in surface soils, measured concentrations in river water, and estimated concentrations in small mammal tissues that reduce reproduction, health, and/or survival of populations of carnivorous large mammals.	Potential or observed toxicity due to exceedances of screening values and/or acceptable hazard quotients related to survival, growth, and reproduction of resident populations of mink (DEQ 2001; DEQ 2007; LWG 2007; USEPA 2005b; Sample et al. 1996).

Notes:
Surface soil = 0 to 1 foot bgs for all AOPCs, with the exception of the Pistol Range for which surface soil is defined as 0 to 1.5 feet bgs.
Shallow soil = 0 to 3 feet bgs (only applies to Landfill and Sandblast Area AOPCs).
USEPA = United States Environmental Protection Agency
DEQ = (Oregon) Department of Environmental Quality
LWG = Lower Willamette Group

Table 3-3
Exposure Factors for Ecological Receptors
Bradford Island - Upland Operable Unit

Parameter	Symbol	Units	American Robin	Vagrant Shrew	Canada Goose	American Kestrel	Mink	Reference/Comment
Habitat	--	--	Terrestrial	Terrestrial	Terrestrial	Terrestrial	Aquatic-dependent	(A)
Operable Unit	OU	--	Upland	Upland	Upland	Upland	River	--
Trophic Level	--	--	Level 3	Level 3	Level 2	Level 4	Level 2-4	(A)
Occurrence	--	--	Resident	Resident	Resident	Resident	Resident	--
Status	--	--	None	None	None	None	None	(B)
Home Range	--	acres or km	0.37 acres (C)	0.26 acres (A)	2,430 acres (C)	270 acres (D)	19 acres (C)	--
Area Use Factor	AUF	fraction of site	Receptor- and AOPC-specific	Receptor- and AOPC-specific	Receptor- and AOPC-specific	Receptor- and AOPC-specific	Receptor- and AOPC-specific	General equation (1)
Seasonality Factor	SF	fraction of one year	1	1	1	1	1	All are resident species
Body Weight	BW	kg	0.0773	0.007	3.0	0.116	0.974	(C)
Dietary Composition	--	--	Soil-dwelling invertebrates	Soil-dwelling invertebrates	Aboveground vegetation	Small mammals	Small mammals, benthic invertebrates, and fish	(A,C) Professional judgment also used
Diet - Plant material	df_i	fraction of diet	0	0	1	0	0	(A,C) Professional judgment also used
Diet - Soil-dwelling invertebrates	df_i	fraction of diet	1	1	0	0	0	(A,C) Professional judgment also used
Diet - Small mammals	df_i	fraction of diet	0	0	0	1	0.15	(A,C) Professional judgment also used
Food Ingestion Rate	IR_{food}	kg/day dw	0.013	0.0014	0.15	0.017	0.054	(E)
		kg/day ww	NA	NA	NA	NA	0.16	(E)
Fraction of Soil or Sediment in Diet	--	fraction of diet	0.104	0.04	0.082	0.02	0.094	(F) (2)
Incidental Soil or Sediment Ingestion Rate	IR_{soil}	kg/day dw	0.0013	0.000055	0.013	0.00033	0.0051	General equation (3)
Incidental Surface Water Ingestion Rate	IR_{water}	L/day	0.011	0.0011	0.12	0.014	0.097	(C)
Concentration in Food - type *i*	$C_{food\ i}$	mg/kg dw	Food-specific chemical concentration	Food-specific chemical concentration	Food-specific chemical concentration	Food-specific chemical concentration	Food-specific chemical concentration	Measured/modeled concentration
Concentration in Soil/Sediment	$C_{soil/sed}$	mg/kg dw	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Measured concentration
Concentration in Surface Water	C_{water}	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Measured concentration

Notes:

AOPC = area of potential concern

BW = body weight

dw = dry weight

kg = kilogram

km = kilometer

L = liter

mg = milligram

NA = not applicable

SF = seasonality factor

ww = wet weight

(1) Area Use Factor (AUF) = area of the site divided by the area of home range

Because part of Bradford Island is managed as Canadian goose habitat, an AUF of 1.0 will be used for the goose regardless of its home range.

(2) The remaining 85% of the mink's diet is assumed to be comprised of prey from the River OU (i.e., fish and crayfish), which will be evaluated in the River OU Baseline ERA.

(3) Percent soil or sediment in diet reported for species with similar feeding habits used to develop soil and sediment ingestion rates (Beyer et al. 1994). For species without an adequate surrogate, the default percent soil in diet of 2% was used (Beyer et al., 1994).

For the vagrant shrew, the percent soil in diet for a white-footed mouse (2%) was doubled to account for a higher soil ingestion rate expected for a shrew.

(4) $IR_{soil} = IR_{food\_dw}$ * fraction of soil/sediment in diet

(A) Zeiner, D.C., W.F. Laudenslayer, K.E. Mayer, and M. White (eds) 1990. California's Wildlife. Volumes I-III. Department of Fish and Game, The Resources Agency, State of California, Sacramento, CA. April., and Lower Willamette Group. 2007. Round 2 Ecological Risk Assessment for the Portland Harbor (Appendix G of the Portland Harbor Remedial Investigation/Feasibility Study).

(B) Oregon Department of Fish and Wildlife, Oregon List of Threatened and Endangered Fish and Wildlife Species: http://www.dfw.state.or.us/threatened_endangered/t_e.html

(C) United States Environmental Protection Agency (USEPA). (1993). Wildlife Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/R-93/187a. December, 1993.

(D) California Wildlife Biology, Exposure Factor, and Toxicity Database (Cal/ECOTOX). 2002. Created by the California Office of Environmental Health Hazard Assessment and the University of California at Davis.

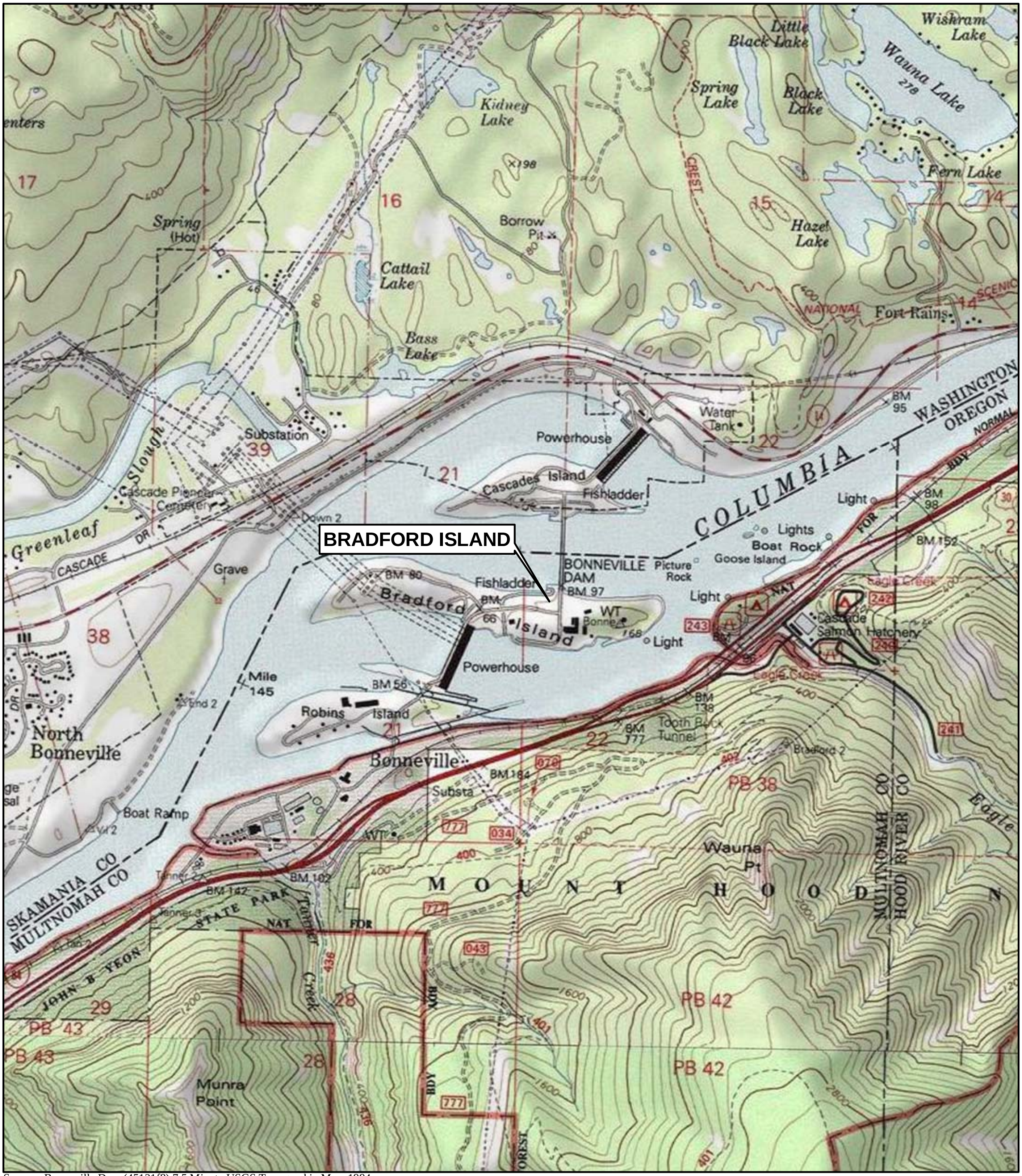
http://www.oehha.ca.gov/cal_ecotox/default.htm

(E) Nagy KA. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B 71, 21R-31R.

If species-specific empirical data not available, then the generic equations for "all mammals" or "all birds" used to estimate IR_{food}.

(F) Beyer, W.N., Connor, E.E. and Gerould, S. 1994. Estimates of soil ingestion by wildlife. Journal of Wildlife Management. 58:375-82.

FIGURES



Source: Bonneville Dam (45121f8) 7.5 Minute USGS Topographic Map, 1994.

0 1,000 2,000 Feet

VICINITY MAP

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25696528

BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 1-1

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BONNEVILLE DAM COMPLEX

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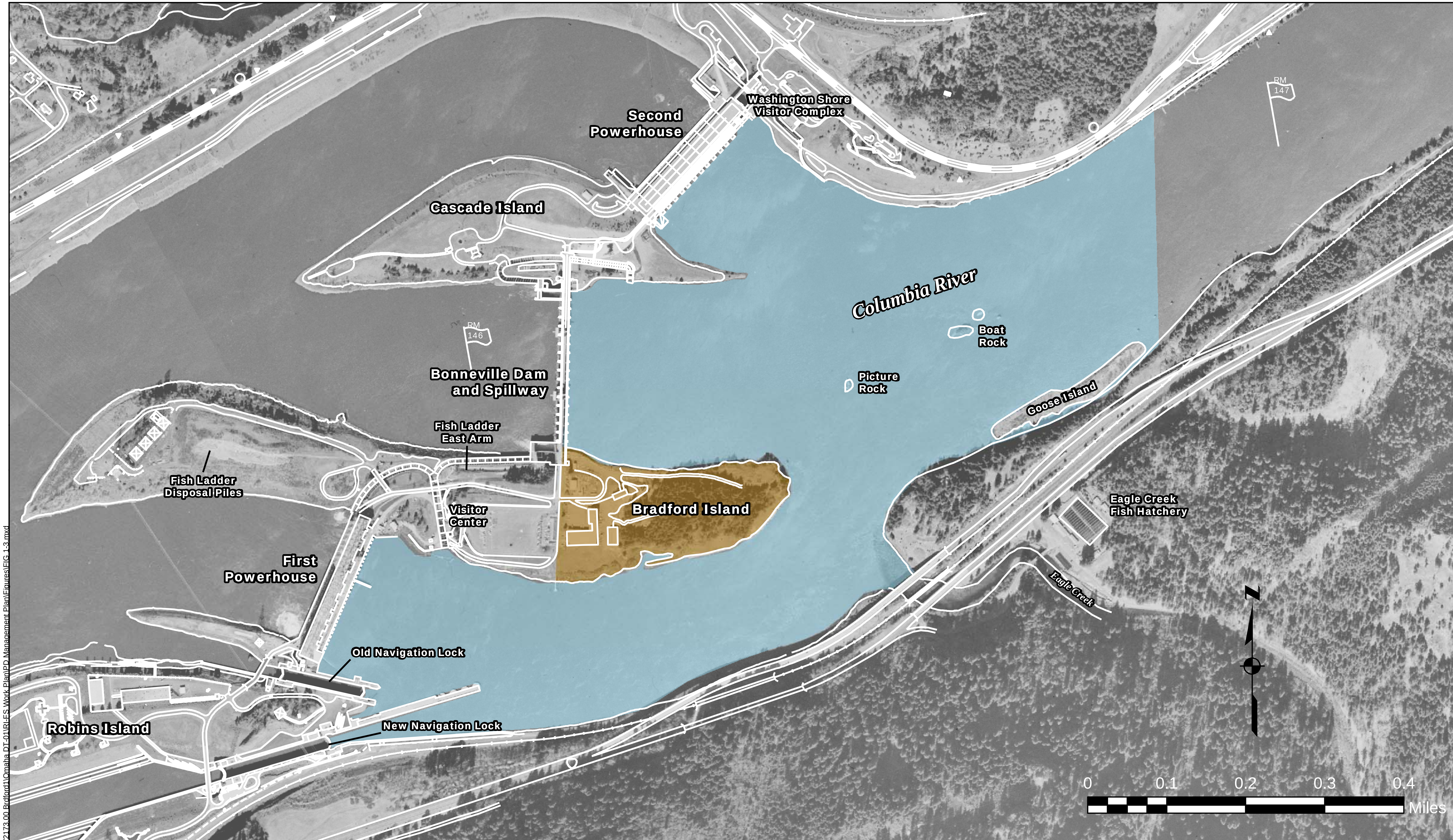

Legend

Upland OU

River OU

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LOCATION OF OPERABLE UNITS

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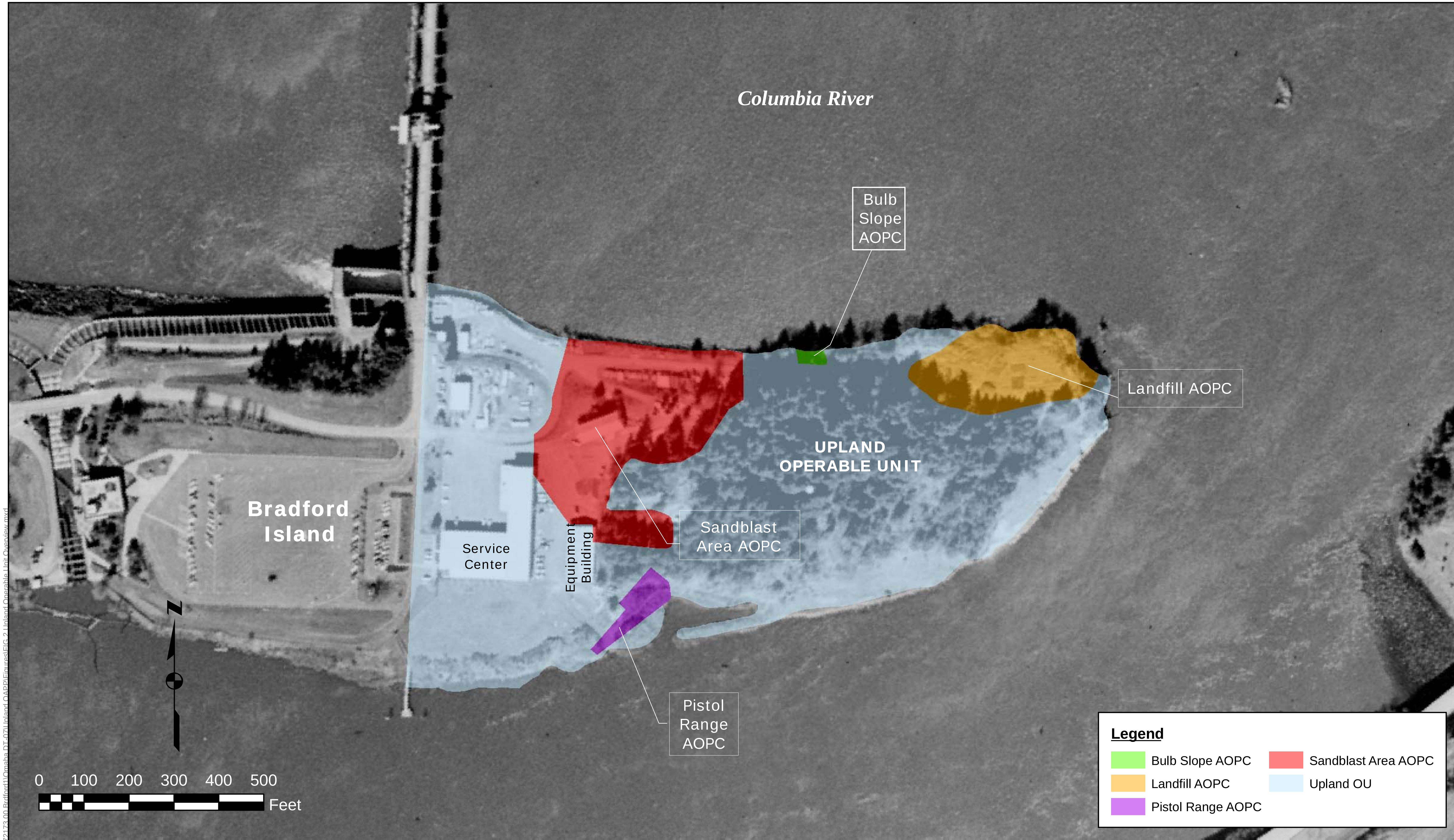

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UPLAND OPERABLE UNIT OVERVIEW

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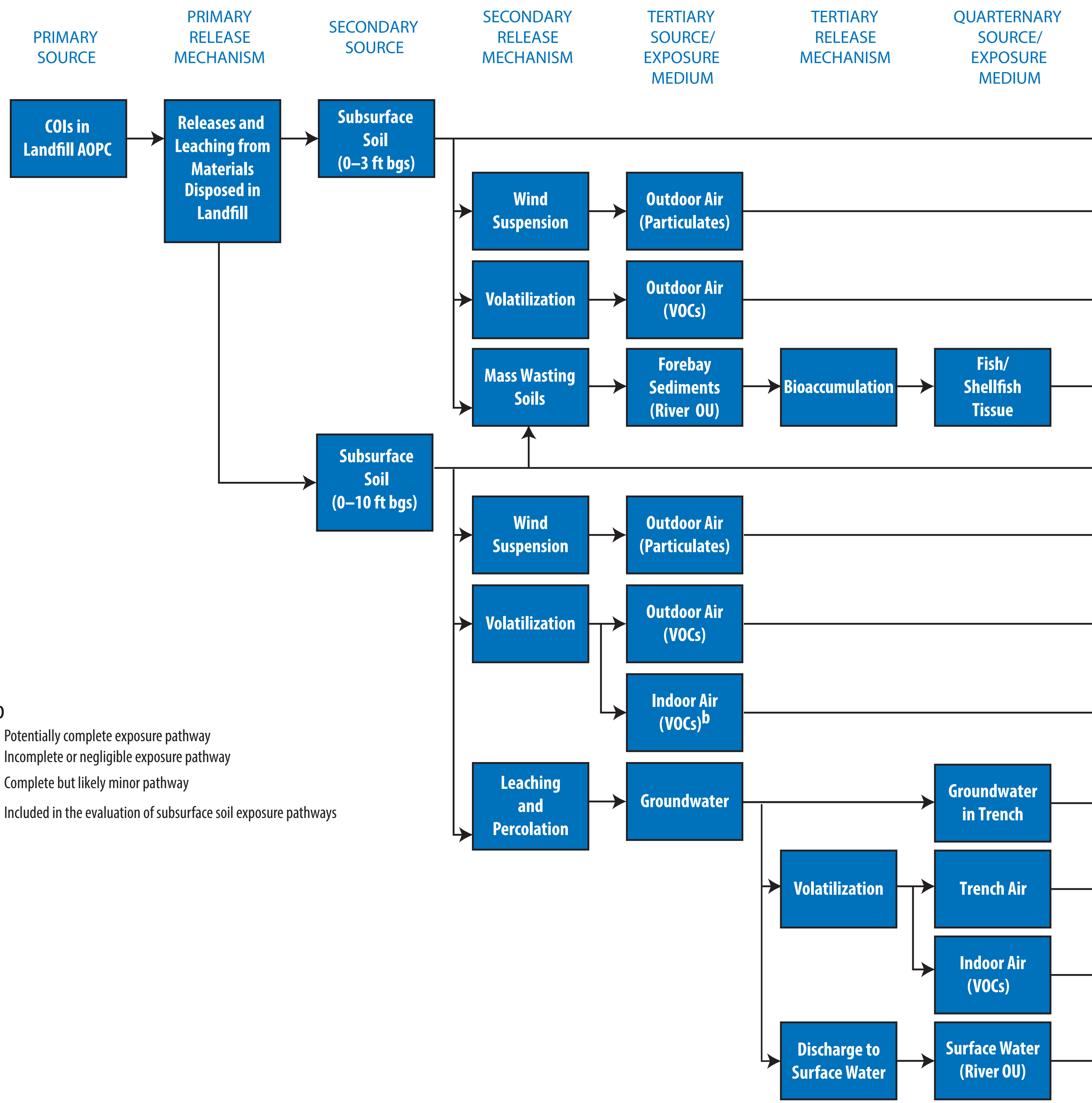

EXPOSURE ROUTE	UPLAND OU RECEPTORS: OUTDOOR WORKER	CONSTRUCTION/ EXCAVATION WORKER	INDOOR OFFICE WORKER	RIVER OU RECEPTORS: SUBSISTENCE FISHER	RECREATIONAL FISHER/WADER	DOWNSTREAM POTABLE WATER USER
Incidental Ingestion	●	● (a)	I	I	I	I
Dermal Contact	●	● (a)	I	I	I	I
Dust Inhalation	●	● (a)	I	I	I	I
Vapor Inhalation	●	● (a)	I	I	I	I
Fish Consumption	I	I	I	●	●	I
Incidental Ingestion	I	●	I	I	I	I
Dermal Contact	I	●	I	I	I	I
Dust Inhalation	I	●	I	I	I	I
Vapor Inhalation	I	●	I	I	I	I
Inhalation	I	I	I	I	I	I
Dermal Contact	I	●	I	I	I	I
Incidental Ingestion	I	○	I	I	I	I
Inhalation	I	○	I	I	I	I
Inhalation	I	I	I	I	I	I
Ingestion	I	I	I	I	I	●
Dermal Contact	I	I	I	●	●	●
Fish Consumption	I	I	I	●	●	I

LEGEND

- ● Potentially complete exposure pathway
- I Incomplete or negligible exposure pathway
- ○ Complete but likely minor pathway
- a Included in the evaluation of subsurface soil exposure pathways

O:\25692709 USACE\53-F0072173.00 Bradford\1\Ft.Worth DT-02\RI Report_Working Folder\RI Text\Figures\FIG 11-1.ai

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LANDFILL AOPC

HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

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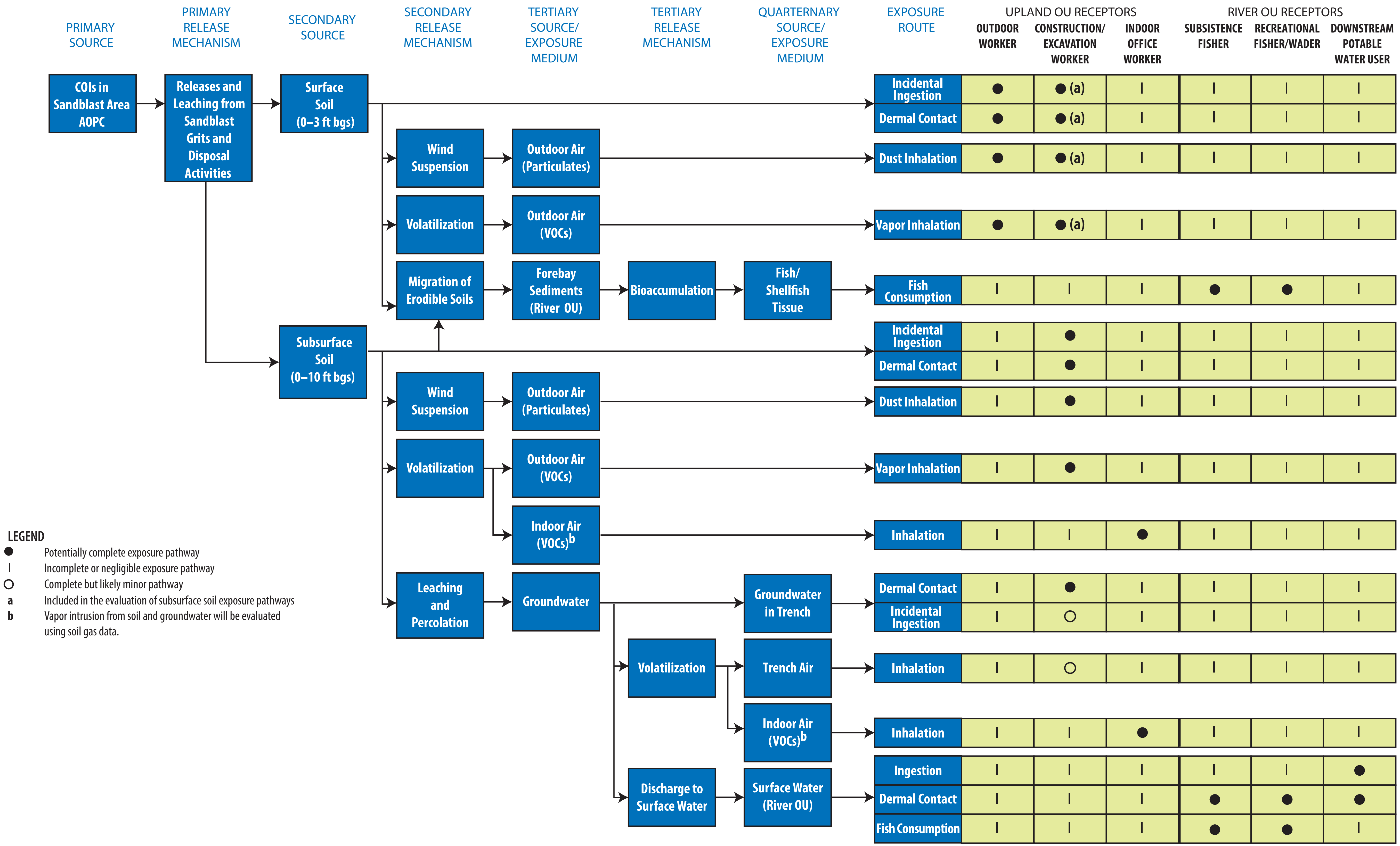

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SANDBLAST AREA AOPC

HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

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GIS FILE NUMBER: FIG 2-2
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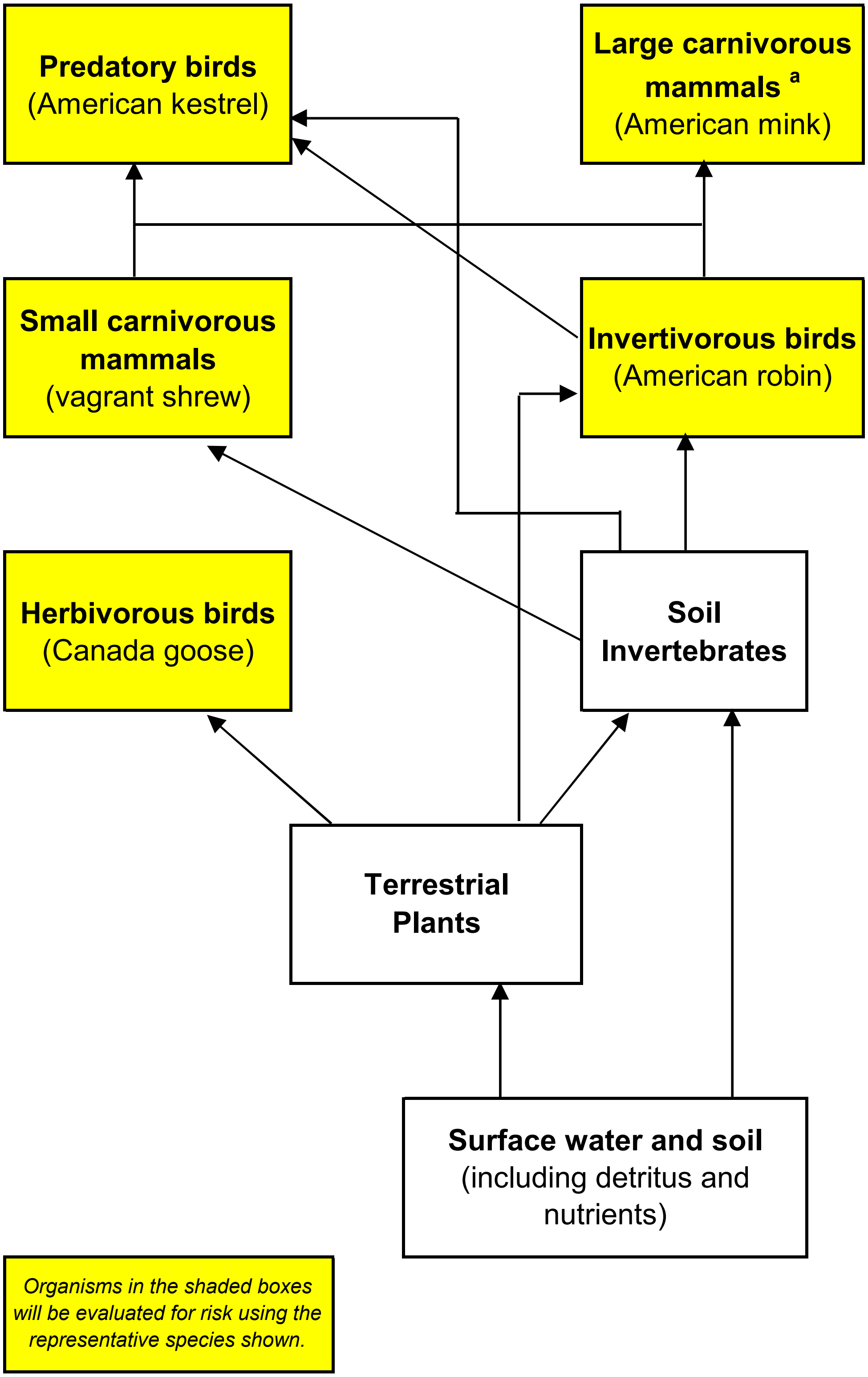

[a] The American mink would primarily forage in the riverine habitat adjacent to the Upland OU, but could also forage in the Upland OU when aquatic prey are scarce.

UPLAND OU FOODWEB

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25698014

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CASCADE LOCKS, OREGON

FIGURE 3-1

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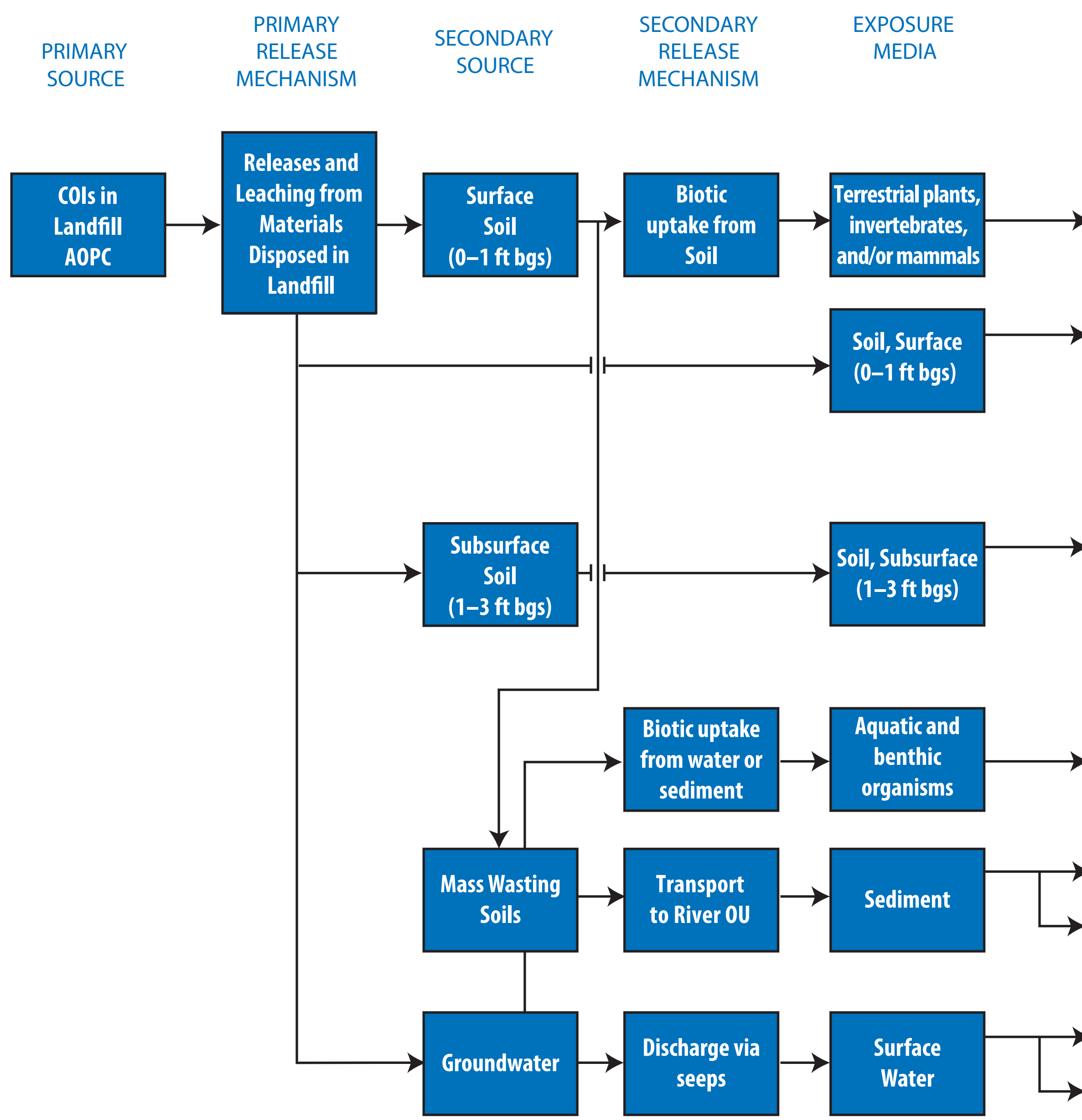

EXPOSURE MEDIA	EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Terrestrial plants, invertebrates, and/or mammals	Ingestion	NA	NA	NA	●	●	●
Soil, Surface (0–1 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●
	Root Uptake/Dermal[a]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Soil, Subsurface (1–3 ft bgs)	Incidental Ingestion	-	-	NA	●	○	●
	Root Uptake/Dermal[a]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-
Sediment	Ingestion	●	●	-	-	-	-
	Uptake/Dermal[a]	●	●	-	-	-	-
Surface Water	Ingestion[b]	●	●	-	-	●	●
	Uptake/Dermal[a]	●	●	-	-	○	○

LEGEND

- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.

a. The dermal exposure pathway for wildlife is expected to be minor due to the barrier offered by fur and feathers.

b. Highly mobile birds and mammals could ingest water from the river, while less mobile species would likely ingest water from puddles in the Upland OU.

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BRADFORD ISLAND

CASCADE LOCKS, OREGON

LANDFILL AOPC

ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

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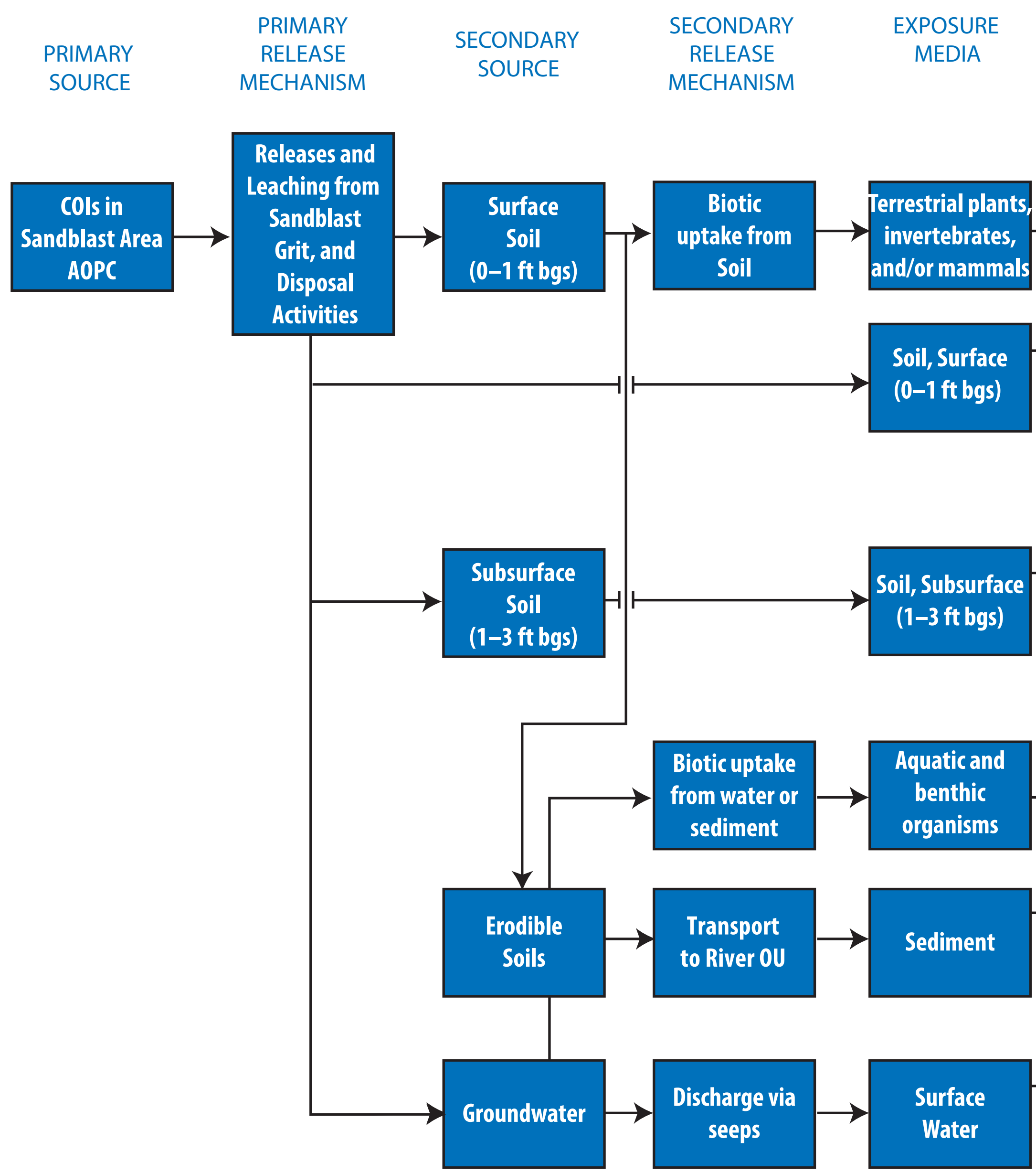

EXPOSURE MEDIA	EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Terrestrial plants, invertebrates, and/or mammals	Ingestion	NA	NA	NA	●	●	●
Soil, Surface (0–1 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●
	Root Uptake/ Dermal[a]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Soil, Subsurface (1–3 ft bgs)	Incidental Ingestion	-	-	NA	●	○	●
	Root Uptake/ Dermal[a]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-
Sediment	Ingestion	●	●	-	-	-	-
	Uptake/Dermal[a]	●	●	-	-	-	-
Surface Water	Ingestion[b]	●	●	-	-	●	●
	Uptake/Dermal[a]	●	●	-	-	○	○

LEGEND
- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.
a. The dermal exposure pathway for wildlife is expected to be minor due to the barrier offered by fur and feathers.
b. Highly mobile birds and mammals could ingest water from the river, while less mobile species would likely ingest water from puddles in the Upland OU.

JOB No. 25696528	DESIGNED: LSM	PROJ. ENGINEER: LSM
	DRAWN BY: MS	APPROVED BY: MP
	CHECKED BY: HP	DATE: JULY 2010

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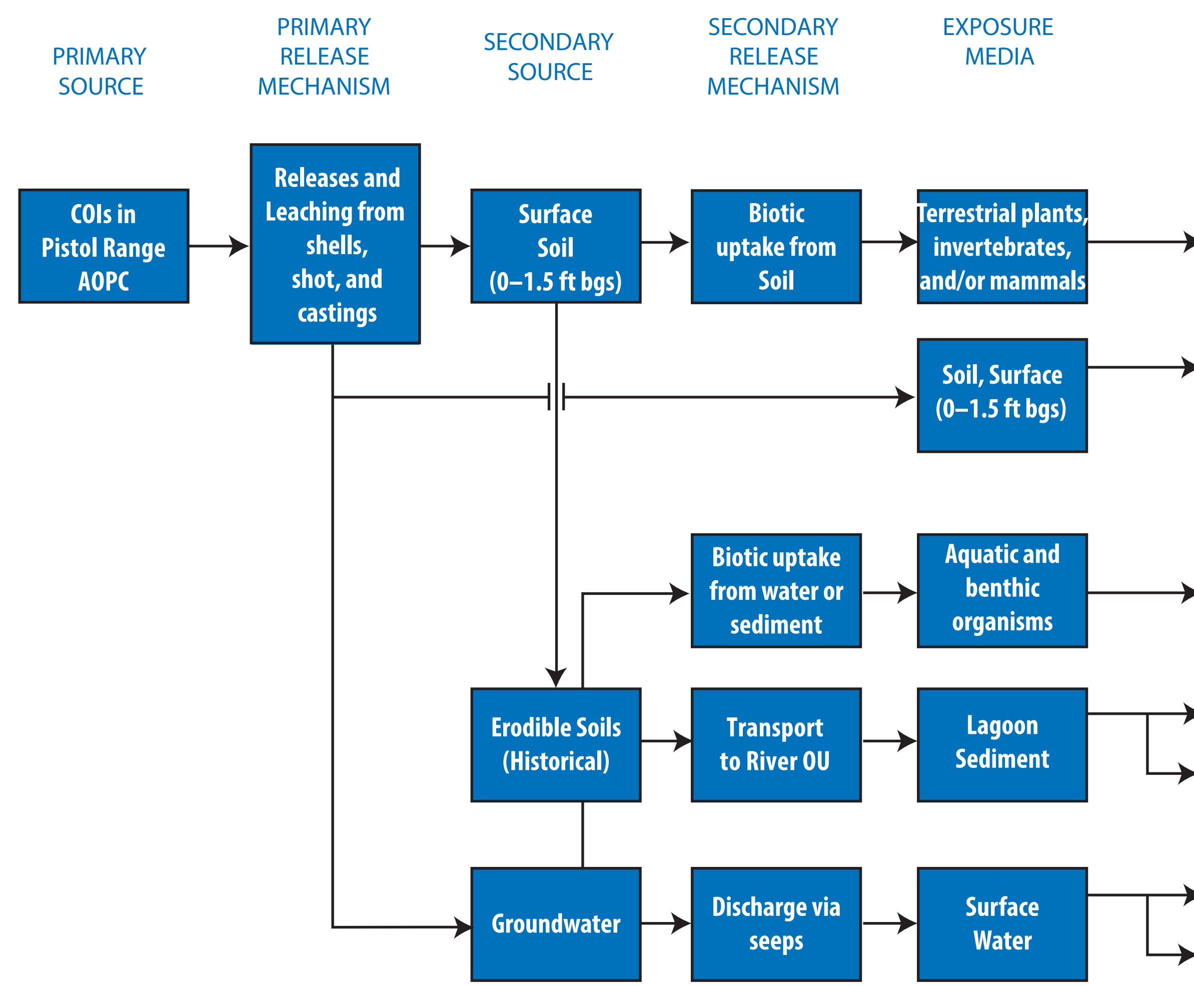
BRADFORD ISLAND
CASCADE LOCKS, OREGON

SANDBLAST AREA AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-3
GIS FILE NUMBER: FIG 3-3
SHEET: REV.

O:\25692709 USACE\53-F0072173.00 Brdford1\F\Worth DT-02\RI Report_Working Folder\RI Text\Figures\FIG 12-3.ai



EXPOSURE MEDIA	EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Terrestrial plants, invertebrates, and/or mammals	Ingestion	NA	NA	NA	●	●	●
Soil, Surface (0–1.5 ft bgs)	Incidental Ingestion	-	-	NA	●	●	●
	Root Uptake/ Dermal[a]	-	-	●	●	○	○
	Inhalation	-	-	NA	NA	○	○
Aquatic and benthic organisms	Ingestion	●	●	-	-	-	-
Lagoon Sediment	Ingestion	●	●	-	-	-	-
	Uptake/Dermal[a]	●	●	-	-	-	-
Surface Water	Ingestion[b]	●	●	-	-	●	●
	Uptake/Dermal[a]	●	●	-	-	○	○

LEGEND

- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.

a. The dermal exposure pathway for wildlife is expected to be minor due to the barrier offered by fur and feathers.

b. Highly mobile birds and mammals could ingest water from the river, while less mobile species would likely ingest water from puddles in the Upland OU.

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BRADFORD ISLAND

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PISTOL RANGE AOPC

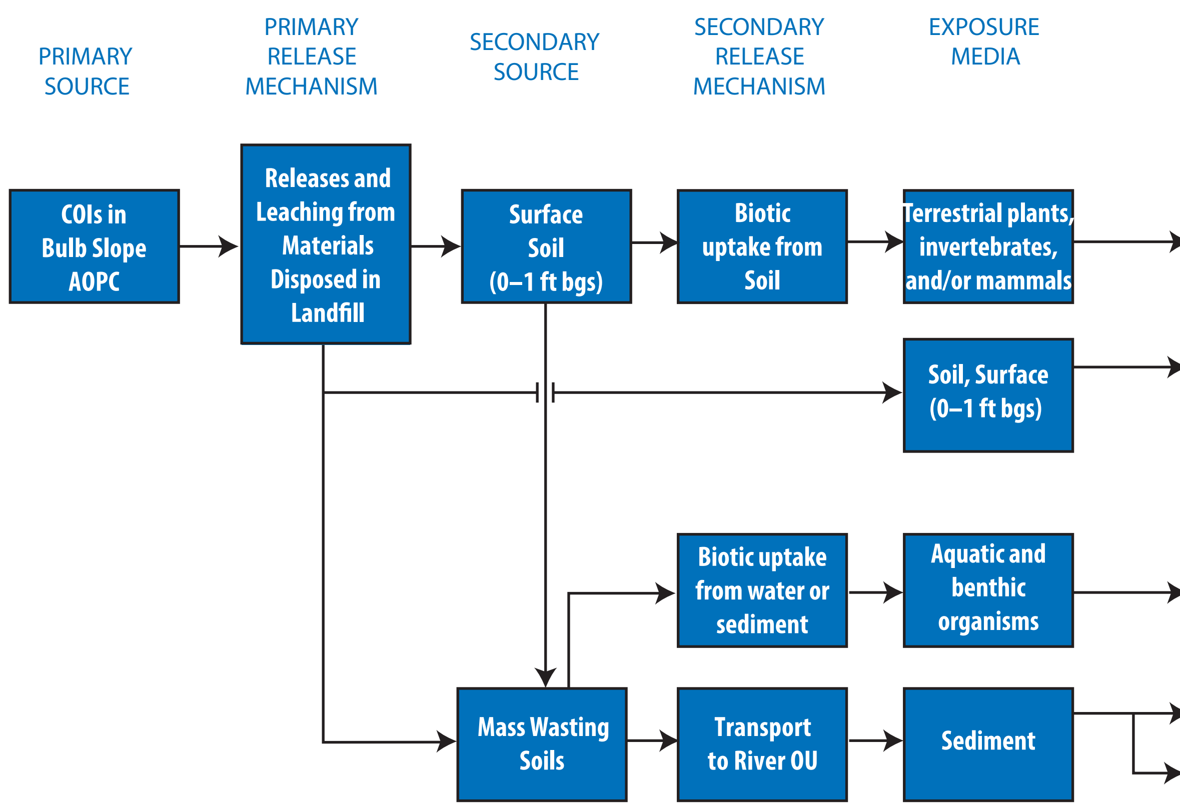
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-4

GIS FILE NUMBER: FIG 3-4

SHEET: REV.

O:\25692709 USACE\53-F0072173.00 Bradford1\Ft.Worth DT-02\RI Report_Working Folder\RI Text\Figures\FIG 12-4.ai



EXPOSURE ROUTE	AQUATIC RECEPTORS: AQUATIC BIOTA	AQUATIC RECEPTORS: BENTHIC ORGANISMS	TERRESTRIAL RECEPTORS: TERRESTRIAL PLANTS	TERRESTRIAL RECEPTORS: SOIL INVERTEBRATES	TERRESTRIAL RECEPTORS: BIRDS	TERRESTRIAL RECEPTORS: MAMMALS
Ingestion	NA	NA	NA	●	●	●
Incidental Ingestion	-	-	NA	●	●	●
Root Uptake/ Dermal[a]	-	-	●	●	○	○
Inhalation	-	-	NA	NA	○	○
Ingestion	●	●	-	-	-	-
Ingestion[b]	●	●	-	-	●	●
Uptake/Dermal[a]	●	●	-	-	○	○

LEGEND
- ● Complete and potentially significant pathway
- ○ Complete but likely minor pathway
- \- Incomplete pathway
- NA Pathway not applicable to receptor

Aquatic Biota defined as aquatic plants, plankton, invertebrates, fish and aquatic-dependent wildlife.
a. The dermal exposure pathway for wildlife is expected to be minor due to the barrier offered by fur and feathers.
b. Highly mobile birds and mammals could ingest water from the river, while less mobile species would likely ingest water from puddles in the Upland OU.

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BULB SLOPE AOPC
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

DRAWING NUMBER: FIGURE 3-5
GIS FILE NUMBER: FIG 3-5
SHEET: REV.

O:\25692709 USACE\53-F0072173.00 Brdford1\FL Worth DT-02\RI Report_Working Folder\RI Text\Figures\FIG 12-5.ai

APPENDIX D

USACE Responses to ODEQ Comments on Draft Upland OU BHHERA

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
General Human Health Comments		
1.	**State Rules and Guidance**. The report emphasizes federal risk assessment requirements and guidance over state rules and guidance. This includes use of acceptable risk levels and evaluations of total petroleum hydrocarbons. DEQ will be making final decisions based on state rules.	Comment noted. The US Army Corps of Engineers (USACE) will be making final decisions based on Comprehensive Environmental Response, Compensation & Liability Act (CERCLA). Please see Section 1.3 of the Remedial Investigation (RI) Report (URS, 2012) for a detailed description of regulatory initiative and authority. Please also see response to Comment #4 regarding petroleum hydrocarbons. No revisions to the Baseline Human Health Risk Assessment (BHHRA) are necessary.
2.	**Fishing Platform User Exposure.** The USACE agreed to include fishing platform users as a potential future exposure scenario. In the report there is an inappropriate distinction made between this exposure scenario and the other ones. The fishing platform scenario should be included in the conceptual site model with the other potential scenarios. It is appropriate to acknowledge the uncertainty associated with this potential future scenario.	Fishing platform scenario will be added to the conceptual exposure models (CEMs) for the Landfill and Sandblast AOPCs, Figures 2-1 and 2-2. The human health CEMs for Bulb Slope and Pistol Range AOPCs will be added to the BHHERA, and will also include the fishing platform scenario. USACE will retain the distinction that the Fishing Platform User scenario is a hypothetical future scenario.
Specific Human Health Comments		
3.	**Page 2-3**. DEQ uses 5 percent frequency of detection only as an indication that there may be an error in the measured concentration of a chemical. If data are found to be invalid, they should not be used in the risk assessment. For valid data, it is entirely reasonable to evaluate risks from chemicals that may be present (at potentially high concentrations) in a small area and are not detected elsewhere.	Comment noted. The detection frequency step of the screening process (used in the Remedial Investigation [RI] Report; URS 2012) was described in the RI/Feasibility (FS) Management Plan (MP) (URS 2007) and follows precedent established in risk assessments for other sites led by the Oregon Department of Environmental Quality (ODEQ), including the Level II Ecological Screening Assessment previously performed for the Landfill Area of Potential Concern (AOPC). The detection frequency topic was previously addressed in the Remedial Investigation (RI) Report (URS 2012). The potential for underestimation of human health risk based on detection frequency status was discussed in chemical-specific and AOPC-specific detail in Appendix O.2.1.3 in the RI Report. The results of the detection frequency evaluation provided in Appendix O.2.1.3 indicate that none of the contaminants of interest (COIs) eliminated as contaminants of potential concern (COPCs) in the Landfill and Sandblast AOPCs on the basis of frequency of detection represent a significant uncertainty in the HHRA. No revisions to the BHHRA are necessary.

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
4.	**Page 2-4**. TPH was excluded from evaluation because there is a petroleum exclusion in CERCLA. TPH is a hazardous substance in Oregon, and should be evaluated accordingly.	Comment noted. USACE plans to continue to follow CERCLA. However, the total petroleum hydrocarbons (TPH) were not ignored in the BHHRA. TPH are included in the initial screening for the HHRA in the RI Report (Tables 2-1 to 2-4, URS 2012). The only TPH fraction exceeding the screening level was TPH-RRO. Although it was not retained as a COPC in the risk calculations due to the CERCLA exclusion, the potential risk associated with TPH-RRO is discussed in the Uncertainty Section, in Section 2.6.4. No revisions to BHHRA are necessary.
5.	**Page 2-9**. Using the 90% UCL as the exposure point concentration is a requirement of rule, although DEQ can accept other methods. We consider the 95% UCL to be similar and an acceptable basis for an EPC. No action is required.	Comment noted. No revisions to the BHHRA are necessary.
6.	**Page 2-19 and page 4-2**. The Corps states that "… exceedance of the ODEQ risk thresholds or USEPA acceptable risk range does not automatically mean that adverse effects may have occurred or will occur (e.g., does not automatically mean that the COC will be recommended for further evaluation in the FS)." If the risk assessment shows unacceptable risk from exposure to chemicals, DEQ will require consideration of those chemicals in the feasibility study.	Comment noted. The BHHRA uses multiple lines of evidence to derive recommendations for further evaluation in the FS. No revisions to the BHHRA are necessary.
7.	**Pages 2-20 to 2-23.** For naturally-occurring chemicals present above background levels, DEQ requires the evaluation of risk. If the excess cancer risk is greater than 1 x 10-6, that is unacceptable. DEQ does not consider the exceedance above background risk. However, both EPA and DEQ will not require remediation to below naturally occurring background concentrations. The difference is that DEQ allows chemicals to be screened out prior to conducting a risk assessment if the concentrations are below background levels. But both agencies require evaluating risk at the EPC concentration, not after subtracting out the background concentration or risk. DEQ considers background levels for hazardous substances that occur naturally. Typically this evaluation is limited to inorganic chemicals. Although we acknowledge that cPAHs may occur naturally, we are not confident that the cPAHs measured in the reference area are naturally occurring.	Consistent with USEPA and ODEQ requirements, risk <u>was</u> evaluated at the total exposure point concentration (EPC). In addition, the contributions from background levels of arsenic and incremental site-related arsenic to total risk were also presented, in compliance with U.S. Environmental Protection Agency's (USEPA) guidance regarding the role of background in risk assessment (USEPA 2002b,c) and to illustrate the magnitude of the contributions to risk from the two types of sources. The comparison was useful in indicating that the site-related contribution to arsenic risk was very minor for the occupational exposures. For the Fishing Platform user, the site-related contribution to arsenic risk was higher, and therefore, it was retained as a chemical of concern and included in Table 2-27. The Reference Area background carcinogenic polycyclic aromatic hydrocarbon (cPAH) upper prediction level (UPL) was used only for concentration comparison purposes, but was not used to screen out cPAHs. As shown in Table 2-27, cPAHs were retained as contaminants

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
		of concern (COCs) and receptor-specific risk based concentrations (RBCs) were developed. No revisions to the BHHRA are necessary.
8.	**Page 2-30, Section 2.6.3.2.** The fishing platform exposure scenario is a potential future exposure, and one the Corps agreed to evaluate. The assumptions in the risk assessment should incorporate reasonable maximum exposure, not "impossible" or worst-case conditions. The likelihood of future exposure can be discussed in the uncertainty section.	Text in Section 2.6.3.2 will be changed from "impossible" to *"highly unlikely."* Please note, Section 2.6.3.2 is already part of the Uncertainty Section (Section 2.6).
9.	**Page 2-31.** To the extent that chemicals are detected in soil or groundwater, regardless of whether they are degradation products of PCE, their risks should be evaluated.	Clarification provided. As stated in Section 2.1 of the BHHERA, risks from tetrachloroethylene (PCE) and its degradation products, including both detections and non-detections, <u>were</u> evaluated in the BHHRA to meet ODEQ recommendations. See Section 2.5 and Tables 2-1, 2-2, 2-11, 2-12, and 2-16 through 2-24 for quantitative risk evaluations of detected concentrations of PCE and its degradation products. For an evaluation of the non-detect concentrations of PCE degradation products see Section 2.6.3.4 and Tables A-3.1 to A11.4 of Appendix A. No revisions to the BHHRA are necessary.
10.	**Page 2-33 and Table 2-1 (notes for Tables 2-1 to 2-4) footnote *****. Petroleum hydrocarbons are hazardous substances in Oregon, and risks from exposure to TPH should be evaluated accordingly.	Comment noted. Please see response to Comment #4. No revisions to the BHHRA are necessary.
11.	**Page 2-35.** The Corps states that "This would imply that risk levels for individual chemicals that exceed 1 x 10-6 are acceptable as long as the cumulative multi-chemical risk level does not exceed 1 x 10-5." As stated, this is incorrect; both criteria are used. Excess cancer risk exceeding 1 x 10-6 for an individual carcinogen is unacceptable, regardless of the cumulative risk. However, it appears that results shown in tables are interpreted correctly.	The text will be revised to state: *"Cumulative risks and hazards are also presented in the context of ODEQ's acceptable multi-carcinogen risk level of 1 x 10^{-5}. However, even if the cumulative multi-chemical risk level does not exceed 1 x 10^{-5}, individual chemicals are still identified as a COC if they exceed the individual risk level of 1 x 10^{-6} (i.e., the RME Construction Worker at both the Landfill and Sandblast Area AOPCs have cumulative cancer risks less than ODEQ's threshold of 1 x 10^{-5} but benzo(a)pyrene is identified as a COC at both AOPCs due to exceeding the individual risk level of 1 x 10^{-6})."*

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
12.	**Table 2-7a.** Three values are shown for PEF. The correct value should be 1.36 x 10+9 or 1.32 x 10+9, not 1.36 x 10+6, m3/kg. DEQ uses the inverse value of 7.58 x 10-10 kg/m3 (which corresponds to 1.32 x 10+9 m3/kg). The CTE body weight for the indoor worker should be 80 kg, not 70 kg.	The following revisions will be made to Table 2-7a: 1) Outdoor Maintenance Worker - The particulate emission factor (PEF) value of $1.36E^{+09}$ will be revised to arithmetic notation as $1.36 \times 10^{+9}$ for the outdoor maintenance worker. This value ($1.36E^{+09}$) will be used because it is consistent with USEPA guidance and practice (USEPA 2002a, 2015a,b). 2) Excavation/Trench Worker - The excavation/ trench worker is assumed to be only exposed incidentally to groundwater at the bottom of a trench. The PEF value of 1.32E+09, which was shown for the Excavation/ Trench Worker, will be deleted. The soil ingestion rate of 330 mg/day will also be deleted. Neither was used in the risk calculations. 3) Construction Worker - The construction worker is assumed to be exposed only to soils. For the construction worker scenario, USEPA's Soil Screening guidance (USEPA 2002a) recommends that PEFs should reflect exposure to the higher levels of dust that would typically be expected for a construction scenario. However, USEPA does not provide default PEFs for construction activities. Neither does ODEQ guidance. Therefore, the default PEF ($1.0 \times 10^{+06}$ m^3/kg) recommended by the California Department of Toxic Substances Control (DTSC) for construction workers was used (DTSC, HHRA Note 2, 2014). The DTSC value is more conservative than ODEQ's current practice of using the same PEF for all types of receptors, and therefore assumed to be acceptable for the purposes of the BHHRA. 4) CTE body weight will be changed to 80 kg in the table; it was used in the risk calculations (not 70 kg).
13.	**Table 2-8.** We could not confirm the OAF value of 0.013 for lead.	The oral absorption factor (OAF) value of 0.013 for lead will be deleted from Table 2-8 and replaced with a dash notation "--". Because lead was evaluated separately, using the procedures described in Appendix B-2, the following footnote will be added to Table 2-8: *"Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B."*

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
14.	**Table 2-9.** Rather than leave the evaluation of lead risk as a dash, it would be helpful to explain the risk evaluation, possibly in a footnote. This also applies to subsequent tables.	Agreed. The following footnote will be added to Tables 2-9, 2-10, 2-13, 2-14, 2-16, 2-17, 2-20 and 2-21: *"Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B."*
15.	**Table 2-13.** The excess cancer risks for lead should not be presented as 0.00. Instead, provide a footnote stating that although lead is a carcinogen, the excess cancer risk was not quantitatively evaluated.	Agreed. The excess cancer risk value of "0.00" will be deleted from Table 2-13 and replaced with a dash notation "--". Because lead was evaluated separately, the following footnote will be added to Table 2-13: *"Lead is evaluated independently using adult and child lead models because a linear adjustment of the RSL may not be appropriate, see Table 2-25 and Appendix B."*
16.	**Figures 2-1 and 2-2.** Fishing platform users should be included in the CSM. Also, CSMs for the Firing Range and Bulb Slope should also be provided. It is important to identify relevant exposure pathways and receptors to select appropriate screening values, even if all chemicals are screened out.	The fishing platform scenario will be added to the CEMs and all four Upland OU human health CEMs will be included with the BHHRA.
General ERA Comments		
17.	**Scope of BERA, Groundwater Seeps, Source control, Upland Soil:** Groundwater to Surface Water, storm water and erosional soil / material pathways and associated data should be evaluated and discussed in the risk assessment. These pathways are presented in Figure 3-3, ERA CSM with the exception of storm water, which should be added to the figures where storm water outfalls are present. a. Groundwater, total, dissolved and seep water (some of the data presented in Table 1-7 and 1-8): i. Identify areas where groundwater and seep water are higher than reference, as was done in previous risk assessments ii. Identify areas where groundwater and seep water are above risk based levels using surface water criteria b. All contaminants of interest above risk based criteria (COPCs) in soil or water media need to be identified in the risk assessment. For example, in landfill soil, previous screening identified barium, iron, manganese, zinc, and BEHP above risk based criteria in landfill soil. Arsenic, lead, tributyltin, pentachlorophenol, 1,2,4-trimethylbenzene, isopropylbenzene, n-propylbenzene, di-n-octyl phthalate, 2-methylnapthalene, acenapthalene, phenantharene were detected and identified based on the bioaccumulation pathway with no SLV. COIs below background criteria, and therefore not included in the risk	The stormwater pathway will be added to the CEM (Figure 3-3). The upland-to-river pathways were evaluated at the screening level in the RI Report (URS 2012). As stated in Section 1.0 of the BHHERA (page 1-3), these pathways were not evaluated in the Upland OU Baseline Human Health and Ecological Risk Assessment (BHHERA) report but will be considered in the Upland FS or River FS. a. The groundwater to surface discharge scenario (part of the upland-to-river pathway) was evaluated in the screening level ecological risk assessment (SLERA) presented in the RI Report (URS, 2012). As stated in Section 1.0 of the BHHERA (page 1-3), further evaluation of the pathway will be considered in the Upland FS or River FS. b. As stated in Section 1 of the BHHERA, the baseline RAs build upon the findings of the RI Report and screening level RAs (URS 2012). All contaminants of potential ecological concern (CPECs) identified in the SLERA as warranting further evaluation were evaluated in the Baseline Ecological Risk Assessment (BERA), see responses to specific Questions 26-30. Contaminants of interest (COIs) below background criteria, and therefore not included in the BERA, were identified in the SLERA.

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
	estimates, should also be identified on this basis. c. Soil PCBs risk estimates are not made in the upland risk assessment, although there are known detections in landfill soil. As noted in (b) of this comment, the reason for PCB exclusion should be clear. This comment should be extended to all detected COIs.	c. As stated in Section 1 of the BHHERA, the baseline RAs builds upon the findings of the RI Report and screening level RAs (URS 2012). All CPECs identified in the SLERA as warranting further evaluation were evaluated in the BERA (see responses to specific Questions 26-30). Polychlorinated biphenyls (PCBs) were evaluated in the SLERA and were not found to be CPECs for upland receptors (see RI Report Table 12-1, and RI Report Appendix N Tables N-1 to N-4, N-5 to N-9, N-11 to N-14, N-16 to N-19, N-35 to N-42, and N-43 to N-46).
18.	**Scope of BERA**, **Landfill:** The heterogeneity of the landfill composition should be discussed relative to the risk identified in this document. PCBs need to be evaluated in upland soil, including the landfill.	The following discussion on the heterogeneity of the Landfill AOPC composition will be added to the BHHERA uncertainty sections (as new Sections 2.6.6 and 3.5.2.7): *"For approximately 40 years (early 1940s until the early 1980s), USACE managed, stored and disposed of waste materials at the landfill in excavated pits or existing depressions. By 1982, the surface of the Landfill AOPC had been capped with soil cover. In 1989, approximately 8-inches of additional soil cover was placed on the Landfill site by the USACE (Hibbs, personnel comm. 2001). Because the waste was buried in separate pits, rather than one continuous pit, the heterogeneity of the landfill composition makes contamination characterize difficult. Although sampling targeted areas known (via historical aerial review or previously exposed areas) or suspected (via electrical resistivity data and seismic refraction data) as having the greatest landfilling activity, risk may be underestimated due to the heterogeneous nature of the landfill."* PCBs were evaluated in the RI Report and SLERA (URS 2012) and were not found to be CPECs for upland receptors (see RI Report Table 12-1, and RI Report Appendix N Tables N-1 to N-4, N-5 to N-9, N-11 to N-14, N-16 to N-19, N-35 to N-42, and N-43 to N-46)

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
Specific ERA Comments		
19.	**Page ES-5 – ES-6:** Pesticides: The landfill and sandblast area should be evaluated relative to pesticides and PCBs. Limited data should be presented relative to the in water fish tissue detections. Data gaps should be discussed. The heterogeneity of the landfill in particular should be discussed.	PCBs were evaluated in the screening level RAs presented in the RI Report (URS 2012) and were not identified as CPECs or contaminants of potential concern (COPCs) for human health. Detected pesticides in the Landfill and Sandblast Area AOPCs were evaluated in the BERA. As stated in Section 1.0 of the BHHERA (page 1-3), the upland-to-river pathways evaluation will be part of the Upland or River FS; therefore, an evaluation of Upland concentrations relative to fish tissue detections will not be presented in the Upland OU BHHERA. The discussion provided in the response to comment #18 on the heterogeneity of the Landfill AOPC composition will be added to the BHHERA uncertainty sections (as new Sections 2.6.6 and 3.5.2.7).
20.	**Section 3.2, Receptors and Exposure Pathways and Section 3.5.2.4:** A carnivorous mammal should be represented in the risk assessment, assuming a diet of primarily terrestrial species. While a mink receptor is included, this species does not represent a relevant surrogate receptor for this measurement endpoint given that the risk assessment assumes the mink is primarily feeding in the river and not the terrestrial uplands. In order to represent the terrestrial mammalian guild, the mink should be assumed to consume terrestrial species. Alternatively, a weasel or other similar carnivorous mammals should be included instead of the mink. While the two species are similar in chemical sensitivity, specifying the weasel as the representative upland receptor eliminates confusion regarding the assumed percentage of terrestrial dietary consumption.	The American mink was added to represent a hypothetical upland large mammal, as requested by the ODEQ (Specific Comments 22 on the Final RI), due to the absence of mammals on the island with the exception of rodents and feral cats. The upland receptors and their dietary assumptions, including a conservative percent diet of upland prey for mink (15%), was presented in the Update to Risk Assessment (RA) Work Plan (URS 2014, provided as Appendix C to the Upland OU BHHERA). The weasel was not previously requested by the ODEQ, nor is it part of the Update to RA Work Plan. No revisions to the BERA are necessary.
21.	**Section 3.2, Page 3-1:** It is unclear what is meant between surface soil, defined as 0 to 1 ft bgs (all AOPCs), and shallow soil, defined as 0 to 3 ft bgs (Landfill and Sandblast Area). It does not appear that "shallow soil", which would incorporate a deeper exposure interval, was included in the risk assessment.	Soil deeper than 3 feet was not evaluated in the SLERA or the BERA. The 0 to 3 foot soil depth interval was established as the ecologically relevant depth for evaluations in Appendix C of the RI/FS MP (URS 2007a) and was evaluated in both the SLERA (see Section 12.3.2.3, page 12-10, of the RI Report; URS 2012) and BERA (see Section 3.2, page 3-1 and 3-2, of the BHHERA). No revisions to the BERA are necessary.
22.	**Section 3.2, Receptors and Exposure Pathways, Figure 3-1:** Terrestrial plants and invertebrates should be included in the risk assessment. This particularly true given the metals and other contaminants present in the landfill and sandblast grit area.	As stated in Section 3.2, terrestrial plants and invertebrates were included in the risk assessment (and are shaded in Figure 3-1 indicating their assessment). The shaded note in Figure 3-1 will be revised to say *"Organisms in the shaded boxes will be evaluated for risk (representative species are shown for birds and mammals)."*

Comment Number	Comments by Jennifer Peterson, Mike Poulsen and Bob Schwarz, DEQ Cleanup Program March 2, 2016	US Army Corps of Engineers Response/Action Taken
23.	**Section 3.3.3: Bioaccumulation Factors:** EPA Estimation Programs Interface (EPI) should be used to select Kow and Koc values for the calculation of partitioning-based BAF values. EPI values for Kow and Koc are used in EPA's Regional Screening Level Tables, and the supporting documentation for these Tables also provides recommendations for selection of experimental or estimated values. Parameters from the Regional Screening Level Tables also form the basis of the calculation of DEQ's human health risk based concentrations.	The logK_{ow}s used in the BERA are presented in Table J-6 in the Final RI (URS 2012), for which USEPA EPI Suite was used as the primary source. No revisions to the BERA are necessary.
24.	**Section 3.3, Exposure Assessment, Groundwater to Surface Water:** Is the conclusion that groundwater pathways to the river do not pose a risk to aquatic receptors?	As stated in Section 1.0 of the BHHERA (page 1-3), the upland-to-river pathways evaluation was not part of the Upland OU BHHERA and no conclusions regarding it were made in the BERA. The upland-to-river potential pathway will be further evaluated in the FS. No revisions to the BERA are necessary.
25.	**Section 3.4.2 and Table 3-17, Toxicity Reference Values for Birds and Mammals:** TRVs used in DEQ's guidance, from ORNL (cited last in the hierarchy here) should be selected second after EPA Eco SSLs. It is unclear why Portland Harbor TRVs would be selected. Out of the CPECs listed in Table 3-17 this will impact TRVs selected for mercury, tributyltin, and BHP.	The toxicity reference value (TRV) selection hierarchy was presented in the Update to RA Work Plan (URS 2014, provided as Appendix C to the Upland OU BHHERA). The BERA was consistent with the work plan. No revisions to the BERA are necessary.
26.	**Section 3.5.1.1, Landfill AOPC and Table 3-21 Summary:** a. Terrestrial Plants: Zinc and lead should have been identified based on the previous risk assessment. b. Birds: Antimony, cadmium , MCPP, dichlorprop and BEHP should have been identified based on the previous risk assessment c. Mammals: Antimony, lead, dichlorprop, MCPP and dibenzofuran should have been identified based on the previous risk assessment d. Terrestrial Plants: Zinc and PCE based on the previous risk assessment e. Soil Invertebrates: Zinc based on the previous risk assessment f. Birds: Antimony and BEHP based on the previous risk assessment g. Mammals: Cadmium and dibenzofuran based on the previous risk assessment	Several of the CPECs (i.e., lead, antimony, BEHP, cadmium, dibenzofuran) were evaluated in the BERA. A few CPECS (i.e., zinc, MCPP, dichlorprop, and PCE) were not retained for further evaluation in the SLERA based upon the weight of evidence evaluation presented in the SLERA risk interpretation section (see Section 12.3.4.3 in the RI Report, URS 2012). No revisions to the BERA are necessary.
27.	**Section 3.5.1 and Table 3-21, AOPC Table Summaries:** All COIs above risk based criteria should be identified in the risk assessment and added to the receptor specific tables and summaries.	Not all COIs above risk based criteria were recommended for further evaluation based upon the weight of evidence evaluation presented in the risk interpretation section of the SLERA (see Section 12.3.4.3 in the RI Report, URS 2012) or BERA (see Section 3.5.4 in the BHHERA). No revisions to the BERA are necessary.

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28.	**Section 3.5.1.2, Sandblast Area AOPC Table 3-21 Summary.** Please add additional COCs to the receptor specific summaries based on the previous risk assessment, including antimony, zinc, PCE, BEHP, dibenzofuran and cadmium.	See responses to Questions 26 and 27. No revisions to the BERA are necessary.
29.	**Section 3.5.1.3, Pistol Range AOPC Table 3-21 Summary:** a. Birds: Zinc should be identified based on the previous risk assessment	As discussed in Section 12.3.4.3.3 of the SLERA (URS 2012), "due to the low toxicity ratio for zinc (hazard quotient [HQ] of 2), absence of protected species of terrestrial birds, and because zinc is an essential nutrient for birds (metabolically regulated), no further evaluation is recommended for zinc for birds." In the SLERA, only lead at the Pistol Range AOPC was recommended for further evaluation in the BERA. See responses to Questions 26 and 27. No revisions to the BERA are necessary.
30.	**Section 3.5.1.4, Bulb Slope AOPC Table 3-21 Summary:** a. Mammals: Lead should be identified based on the previous risk assessment	The no observable adverse effect level (NOAEL) and lowest observable adverse effect level (LOAEL) HQs were less than 1.0 for lead at the Bulb Slope AOPC for exposure to mammals (see Tables 3-14d and 3-14e in the BERA). No revisions to the BERA are necessary.
31.	**Section 3.5.3, Calculation of Site Specific Risk Based Concentrations:** a. Reference Area UPLs should not be used in place of risk based concentrations, and the term reference should be replaced with background. According to DEQ guidance, metals should be eliminated if present at background (naturally occurring levels). The full risk should be analyzed if Site concentrations are above background values. Each Site sample should be compared to DEQ's background UPLs for this comparison (http://www.deq.state.or.us/lq/pubs/docs/cu/DebORbackgroundMetal.pdf). If any detection on the Site is above the UPL, the contaminant should be included in the risk assessment. b. Table 1-9 should be replaced with DEQ's background UPL values.	a. The term "background" is used throughout the BHHERA to describe the Reference Area. To be consistent, the term "reference area" in Section 3.5.3 will be changed to "background". Table 3-20 will be revised to show RBCs and Reference Area background UPLs separately, replacing the background values in the RBC columns with *"< bkg"* and a new column will be added to the right side of the table that shows the Reference Area background UPLs. Screening out of COIs below background was done in the RI and was based on a statistical population-to-population evaluation (see Section 8 of the RI Report, URS 2012). The BERA evaluated the risk to all CPECs carried forward from the SLERA and did not screen out CPECs based on comparison to Reference Area background UPLs prior to the Level III assessment. b. As stated in Section 6.1.5 of the RI Report (URS 2012), the objective of the upland Reference Area was to provide site-specific background concentrations of inorganic COIs in soil and groundwater (URS 2008a). The samples were also analyzed for selected organic analytes to evaluate the potential contribution, if any, of non-site-specific sources of organic COIs to site risk. USACE will continue to use the site-specific background UPLs established in the upland Reference Area (Table 1-9).

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32.	**Section 3.5.4.1, Landfill AOPC:** Zinc, antimony, MCPP, dibenzofuran should be added to this list. It would also be helpful to indicate if detections of these additional CPECs are co-located with the areas identified in this section.	See response to Questions 26-27. No revisions to the BERA are necessary.
33.	**Section 3.5.4.2, Sandblast Area AOPC:** Antimony, Zinc, BEHP and dibenzofuran should be added. It would also be helpful to indicate if detections of these additional CPECs are co-located with the areas identified in this section.	See response to Questions 26-28. No revisions to the BERA are necessary.
34.	**Section 3.5.4.4, Bulb Slop AOPC:** Zinc should be added based on the previous risk assessment.	See response to Question 29. No revisions to the BERA are necessary.
35.	**Table 1-1 through 1-5, Statistical Summary for AOPC data:** Please show all COIs and not just the COPCs identified in the 2012 RI Report. Plant and invertebrate exceedances of RBCs should also be added to the Figure set, similar to the wildlife CEC locations above RBCs (e.g., Figures 3-6 through 3-9).	Statistical summaries for all COIs in each AOPC are presented in the RI Report (URS 2012). Only the COPCs and CPECs carried forward from the screening level RAs for risk evaluation in the BHHERA are presented in the Section 1 Tables of the BHHERA in order to be clear what specific COIs were further evaluated. Contaminants of ecological concern (CEC) locations above plant and invertebrate exceedances of RBCs are not depicted in Figures 3-6 through 3-8 because their RBCs (High screening level values [SLVs]) are lower than the wildlife RBCs, with the exception of chromium for plants at the Landfill and Sandblast Area AOPCs (as noted on Figures 3-6 and 3-7). The chromium RBC for plants is less than the site-specific Reference Area background UPL (28.1 mg/kg), and rather than show background chromium exceedances in the figures, the figures show the wildlife chromium RBC (177 mg/kg) exceedances. The notes on Figures 3-6 and 3-7 will be clarified to say, “**Wildlife RBCs are depicted because all plant and invertebrate High SLVs are lower than wildlife RBCs except chromium. Plant/invert chromium risk is evaluated at background levels and therefore not shown.”* Figure 3-8 does not depict plant and soil invertebrate RBCs because they were not derived (see Table 3-20). As noted on Figure 3-8, “*Plant and invertebrate High SLV HQs < 1.” Figure 3-9 does depict soil invertebrate RBC exceedances. As noted on Figure 3-9, “*Wildlife and plant RBCs were not derived because LOAEL/High SLV HQs < 1.” No revisions to the BHHERA are necessary.

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36.	**Table 3-4, Exposure Assumptions for Shrew, Food and Soil Ingestion Rates:** Please use those food and soil ingestion rates calculated for shrew by EPA in the Ecological Soil Screening Level Values instead of using the white footed mouse. Mice and shrew have very different ingestion rates based on metabolism.	The food and soil ingestion rates for the shrew were calculated and established in the Update to RA Work Plan (provided as Appendix C to the Upland OU BHHERA). The food ingestion rate was based on the 'all mammal' equation in Nagy 2001 using the vagrant shrew body weight. As noted in Table 3-4, the white-footed mouse incidental soil ingestion rate was doubled in the absence of a shrew-specific value. USACE will continue to use the established exposure parameters from the work plan. No revisions to the BERA are necessary.
37.	**Table 3-16, Terrestrial Plant and Soil Invertebrate Toxicity Benchmarks:** a. The low and high terrestrial SLVs are based multiplying soil screening levels by a factor of 5 (note b). This does not have any basis in toxicology (dose response). The original SLVs ("low SLVs) should be used to assess risk. This issue was also included in DEQ's Sept. 2011 comments (Specific Comment 24 and 25) *"A Q=5 should not be used for plant and invertebrate SLVs based on MATCs (Maximum Acceptable Toxicant Concentrations). A Q of 5 can be used for SLVs served with a no observed adverse effect level (NOAEL) where threatened and endangered species are not present"*. b. Additionally, invertebrates and plants are not mobile, and therefore the 95% UCL should not be used as an exposure point concentration. This issue was also included in DEQ's Sept. 2011 comments (Specific Comment 23 and 25). Specific Comment 23: *"The appropriate exposure point concentration for plants and invertebrates is point by point and therefore frequency of detection over a larger area does not apply."* Specific Comment 25: *"For plants, aquatic, and soil invertebrates that are immobile or nearly immobile, the maximum*	a. In the SLERA (URS 2012), risk to soil invertebrates and plants was evaluated at the individual level and conservatively based on Q=1, as per ODEQ's request. Evaluating risk to soil invertebrates and plants at the individual level was not warranted for the BERA, as there are no threatened and endangered (T&E) plant or invertebrate species in the Upland OU. As stated in the Update to RA Work Plan (Appendix C in the Upland OU BHHERA), the goal of the BERA is estimating risk to soil invertebrate and terrestrial plants at the community level (i.e., it is appropriate to assess risk at Q=5). In the BERA, the original SLV from the SLERA was conservatively used as the low TRV. In the absence of a high TRV, in some cases the low TRV was multiplied by 5, which results in a high TRV based on Q=5 in order to assess risk at the community level. The BERA was conservative by presenting risk at both Q=1 AND Q=5. Although many of the USEPA ecological soil screening levels (Eco-SSLs) for plants and invertebrates are derived from maximum acceptable threshold concentrations (MATCs), the Eco-SSLs are still considered to be conservative screening levels and "Eco-SSLs are not designed to be used as cleanup levels" (USEPA 2005). Therefore, use of both Q values is appropriate for a BERA that is being conducted to support an FS. b. In the SLERA (URS 2012), the maximum detection as the EPC (and subsequent sample by sample analysis) was used for evaluation of the community receptors. Based on the results of the evaluation, specific CPECs were carried forward into the BERA. However, as stated in the Update to RA Work Plan, the 95% UCLs calculated for soil in the RI were used as the EPCs for all terrestrial receptors in the BERA, including plants and invertebrates due to the lack of protected plant and invertebrate species in the Upland OU and the goal of estimating

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	detected concentration (MDC) in soil or sediment is the appropriate value for comparison" to the screening level value". It is recommended instead to show maps exceeding criteria for each sample location. >20% of the AOPC exposure area exceeding SLVs may be one way to indicate an unacceptable risk. c. Background UPLs are shown here, whereas the footnote states "reference area 95% UPL concentrations are shown". See previous comments regarding the use of appropriate <u>DEQ background UPLs</u>.	risk to these receptor groups at the community level. Protection of the individual (i.e., use of maximum detection or sample by sample analysis) is not the goal of the BERA phase. c. See response to Question 31. No revisions to the BERA are necessary.
38.	**Table 3-17, Toxicity Reference Values for Birds and Mammals:** The LWG-derived TRVs (footnote b) should be placed last in the hierarchy of sources. For example, this impacts TRVs selected for mercury and BEHP where the primary TRV source can be found in Sample 1996 (note "c" in the footnotes).	See response to Question 25. No revisions to the BERA are necessary.
39.	**Table 3-18a-d, Terrestrial and Invertebrate HQ:** EPCs should be sample by sample. Summary statistics on how many samples are above HQs along and HQ magnitude should be presented. Risk displayed as an average concentration over the "low SLV" should be interpreted as significant exceedances given the large exposure area.	See responses to Question 37. No revisions to the BERA are necessary.
40.	**Figure 1-4, Upland Operable Unit Overview:** The Sandblast Area, Bulb Slope, Landfill and Pistol Range AOPCs are shown as a subset of the larger Upland Operable Unit. Is the rest of the upland operable unit considered outside the locality of the facility?	The rest of the Upland OU is considered outside the locality of the risk assessments, but not outside the locality of the Bonneville Dam complex facility. The four AOPCs were evaluated based on previous site investigations and, as such, were the focus of the upland evaluations in the RI (including screening level RAs) and the BHHERA. See Section 3.0 of the RI (URS 2012) for further details on the site background, previous investigations, and establishment of the upland AOPCs.
41.	**Figure 3-2, Landfill AOPC CSM:** Root/Dermal uptake for soil invertebrates should be complete at 1-3 ft, similar to 0-1ft.	The CEM (Figure 3-2) will be revised to indicate that the root/dermal updated for soil invertebrates is a complete pathway for the shallow soil. It was evaluated in the BERA.
42.	**Figure 3-3, Sandblast Area AOPC:** Exposure to sandblast grit itself, not just soil, should be complete to all receptors.	As stated in Section 1 of the BHHERA, both Sandblast Area AOPC soil subgroups (one noted as having higher soil and the other as higher sandblast grit) were utilized as soil in the screening-level RAs in the Final RI and in these baseline RAs. In Figure 3-3, the box for soil at 0-1 ft bgs will be revised to *"soil and sandblast grit."*
43.	**Figures 3-6 through 3-8**. Please revise AOPC figures that are inclusive of all locations above risk levels. Risk levels for all COPCs (as indicated by above comments) should be used. For example, the Figure 3-8 AOPC boundary of the pistol range shows two samples high in lead outside the boundary.	See response to Question 35. The AOPC boundary of the pistol range will be revised in Figure 3-8 to include the two locations north of the backstop that exceed RBCs.

References:

DTSC, 2014. Human Health Risk Assessment (HHRA) Note 2. Available at https://www.dtsc.ca.gov/assessingrisk/humanrisk2.cfm.

USEPA. 2002a. Supplemental Guidance for Developing Soil Screening levels for Superfund Sites. OSWER 9355.4-24. Solid Waste and Emergency Response. December.

USEPA. 2002b. Guidance for Comparing Background and Chemical Concentrations in Soil at CERCLA Sites. USEPA 540-R-1-003. OSWER 9285.7-41. September.

USEPA. 2002c. Role of Background in the CERCLA Cleanup Program. OSWER 9285.6-07P.

USEPA. 2005. Guidance for Developing Ecological Soil Screening Levels – Revised Draft. OSWER Directive 9285.7-55, USEPA, OSWER, February.

USEPA. 2015a. Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites. RSL Table Update. May.

USEPA. 2015b. RSLs-User's Guide (webpage). USEPA website available at: https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-november-2015 (accessed 03-22-2016). November.

URS. 2007. Remedial Investigation/Feasibility Study (RI/FS) Management Plan (MP), Bradford Island, Bonneville Lock and Dam Project, Cascade Locks, Oregon. September.

URS. 2008a. QAPP, Upland Operable Unit Remedial Investigation, Bradford Island, Bonneville Lock and Dam Project, Cascade Locks, Oregon. October.

URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.

URS. 2014. Update to Risk Assessment Work Plan for the Upland OU. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. April.

Hibbs, Don. 2001. USACE. Personal communication.

APPENDIX E

Yakima Nation Comments on Draft Upland/River OU BHHERAs

Responses to Yakama Nation Comments on the Draft Upland / River OU BHHERA Reports (Submittal Date January 2016)
Bradford Island, Oregon

Comment Number	Comments by Yakama Nation as forwarded to the US Army Corps of Engineers by letter, dated 28 January 2016	US Army Corps of Engineers Response/Action Taken
Concerns about the Remedial Investigation		
1.	1. Contaminant Sources a. The RI does not adequately evaluate historic PCB use with respect to potential releases. The Yakama Nation requests the following information: i. The history of PCBs use at the Bonneville Dam complex that may have led to releases, besides in-water disposal of transformers. For example, historically many dams' power generating equipment was designed to slowly leak (PCB-containing) hydraulic oil; PCBs have also been used in the past as a component of paints at fish hatcheries, dust control oils, etc.	Early work on this project included record searches, review of aerial photographs, interviews of employees, etc. We are confident that any historical releases to the Bonneville Dam forebay have been identified. No attempt was made to broaden the investigation to include the Bonneville Dam project, as a whole (see Note 1, below). The downstream sediment samples, collected in 2008, do not indicate that historic or unknown releases of PCBs are impacting resources below the dam; see 3.b.viii, below). No revisions to the Baseline Human Health or Ecological Risk Assessments (BHHRAs) are necessary.
2.	1. Contaminant Sources a. The RI does not adequately evaluate historic PCB use with respect to potential releases. The Yakama Nation requests the following information: ii. Efforts made to eliminate PCB use in Bonneville Dam power-generating equipment and any other sources.	Efforts made to eliminate PCB usage or impacts from legacy PCB usage at Bonneville Dam are not a part of the scope of this CERCLA project; however, contact information for the offices that are actively working this can be provided (see Note 1, below). No revisions to the BHHRAs are necessary.
3.	1. Contaminant Sources b. Upland: In general, the information supports the delineation of upland contamination in the former disposal areas. However, it is unclear how the areas of concern were initially identified to begin delineating the site uplands. It appears upland investigations may have been limited to a decision unit (i.e. the area surrounding the landfill) rather than a comprehensive site investigation. Outside of the eastern portion of the Bradford Island Upland OU, please provide a summary of evaluations conducted to identify recognized environmental conditions on the remaining Bonneville Dam complex and surrounding nearshore mainland.	In 1992, Portland District conducted its first Environmental Review of Government Operations (ERGO) assessment at Bonneville Dam. The intent of the assessment was to make sure that all applicable environmental laws were being followed and to identify any instances of non-compliance. In that 1992 report, the landfill on the eastern tip of the island was noted. A recommendation to take samples of soil in the landfill (completed in 1996) led to a determination that contaminants were present. Work was then initiated to determine the nature and extent of any release of contaminants at/from the landfill. As the investigation moved forward, additional sites were identified, including the in-water location where disposal of capacitors had occurred, the bulb slope, the sandblast area and the pistol range (see 1.a.i., above; some of these additional sites were identified during the literature searches, some by interviews, some by our contractors during the course of working at the site, etc.). A decision was made to complete one Remedial Investigation for all of the sites as opposed to conducting distinct investigations for each one.

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		Once it was known that the release associated with the in-water disposal of capacitors had crossed state lines (PCBs in sediments on the north side of the forebay in Washington state), the decision was made to move under CERCLA (as opposed to working under the State of Oregon's Voluntary Cleanup Program.) No revisions to the BHHRAs are necessary.
4.	1. Contaminant Sources c. River: There appears to be a data gap regarding the location or source of PCBs, which will make remedy selection difficult. The older data (in Appendix G of the RI) include samples that show very high PCB concentrations in sediment samples from the forebay prior to any removal actions. The highest PCB concentrations tended to be associated with coarse sediments, with high fractions of gravel and coarse sand. High concentrations of PCBs in coarser sediments indicates the release of product directly to the sediments, rather than through upland releases. The data are inconclusive as to whether additional sources exist and further evaluation is needed. For example, no samples were collected in the deeper forebay in front of the dam or farther upstream.	We agree that the high concentrations of PCBs in coarse sediment indicate a direct release of product. We attribute this to the release of PCB laden oils from the capacitors. Each of the 6 inerteen capacitors were capable of holding 2-3 gallons of oil. And, PCBs were present in the oil at a 20% concentration. Also, oil with PCB residue was released through the sandblast area outfalls (a known oil spill). We could find no record of any other direct release of product (see 1.a.i, above). And, the grid systems devised for the equipment removal in 2002 and the sediment removal in 2007 give us confidence that no additional equipment was missed on the river bottom. So, while we agree with your assessment that the high PCB levels are consistent with a release of product, as opposed to run off, we believe that the current condition of the site is consistent with the sources already identified. To summarize, we do not believe there is another, as yet, unidentified PCB source. No revisions to the BHHRAs are necessary.
5.	2. Contaminant transport and migration: a. If PCB-laden product was released directly to sediment, it would be much denser than the river water and would flow into porous (coarse) sediments, cracks in bedrock, and down slope along any retaining barrier such as bedrock. The data analysis presented in the 2014 River OU Data Evaluation Tech Memo (Figure 3-1) shows a number of locations associated with the debris piles where the PCB concentrations exceeded 1,000 micrograms per kilogram (ug/kg) in the most riverward sample, indicating that contaminants have likely migrated farther beyond the area delineated.	In 2003, seventeen depositional samples were collected from several areas around the forebay. A few of these are in deep water and in front of the powerhouses and spillway (as close as we could safely get). The samples in deep water were difficult to obtain (two locations were unsuccessful due to depth and strong currents). The majority of samples were non-detect for PCBs (Aroclor 1254). Three of the samples had low detections (the highest is 2.9 ug/kg). Our earlier discreet sampling efforts did not find a bright line for the extent of the release. Detection of PCBs at low levels is found in front of the spillway (on both the north and south sides), on the south side of Bradford Island, and near the west end of Goose Island. Levels of contamination are lower as you move away (following the currents) from the original sources of the release. In 2012, it was determined that

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		enough information was already available (see Remedial Investigation report, June 2012) to determine that risks to the environment and human health were present and that further sampling would not further inform the remedial options that would be considered in the Feasibility Study. (Note: sampling and analysis takes approximately 2 years to complete from start to finish.) We agree that further sampling may be warranted, or even preferred (to delineate the exact footprint for the remedial action.) But, additional samples would not further inform the risk assessments or feasibility study alternatives. No revisions to the BHHRAs are necessary.
6.	2. Contaminant transport and migration: b. The Yakama Nation still requires hydraulic model information requested December 15 and 28, 2015. The most recent data, indicate higher concentrations of PCBs are located toward the eastern end of Bradford Island, possibly residual contamination deposits, but also possibly contributions of contaminated sediments carried along shore.	We are working to provide all requested materials. We agree that the eastern tip of Bradford Island, where Debris Pile #1 was located, is the most impacted location. No revisions to the BHHRAs are necessary.
7.	3. Site delineation: a. The adequacy of the sampling to define the extent of contamination, both in space and over time, is a major concern. Without adequate site characterization and delineation, the effectiveness of any remedy is uncertain.	We believe that enough sampling has been done to determine that the forebay is the 'extent' of the release. And, that the north side and eastern tip of Bradford Island are the most impacted areas within the forebay. No other sources were found after 15 years of direct sampling and investigation. Also, the most contaminated locations are consistent with the location of the debris piles and the outfall. Therefore, the data we currently have is adequate for the purposes of conducting a baseline risk assessment and to select a remedial alternative. No revisions to the BHHRAs are necessary.
8.	3. Site delineation: b. River: i. It is unclear how the River OU eastern delineation line was drawn, since there are no data upriver of this line besides the reference area (approximately 2 miles upstream). Based on RI information and the more recent River OU RA, Figure 2-7, sediment and tissue samples indicate HH risk extends across the entire unit, including locations at upriver boundary.	The eastern boundary for the In Water OU was determined with hydraulic models. Currents can flow upstream under certain operational scenarios (spillways closed). The western end of Goose Island is the most upstream point that the hydraulic model shows currents extending. The eastern end of Goose Island was chosen for the upstream boundary to be conservative. Although a few bass have been caught along Goose Island with high PCB concentrations, sediment and clam data from the 2008 sampling event are consistent with the setting of this eastern boundary (i.e. no elevated levels of contaminants east of the western tip

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		of the island). No revisions to the BHHRAs are necessary.
9.	3. Site delineation: b. River: ii. Goose Island Slough was constructed in 1989-1993 by removing a portion of the southeastern tip of Bradford Island. One of the most heavily impacted sediment locations is at the eastern tip of Bradford Island. At the time of construction this material was not evaluated for the presence of contamination; however, limited sampling of slough sediments and fish tissue post-construction has been completed. This data are inconclusive about whether or not contaminated sediments were re-located into this area. The Yakama Nation requests discussion of the hydrodynamic model and any older data that indicate the potential for borrowed sediments to have become contaminated.	To place material in water in the state of Oregon requires a 404(b) permit and a 401 permit. These permits would only have been issued if the soils / sediments met State and EPA guidelines for in-water placement. We can look for and share those records. No revisions to the BHHRAs are necessary.
10.	3. Site delineation: b. River: iii. The information available to date are not adequate to narrow down the focus area for cleanup decisions in the FS. The highest PCBs concentration in fish tissue are found in the forebay and Goose Island areas. In addition, very highPCB concentrations were observed at the upriver site boundary (e.g., 69,276 µg/kg PCB, equivalent to 7% PCBs in fish tissue sample 68), again leaving questions as to whether high or higher concentrations might be observed if fish from farther upstream were sampled. The higher concentration at Goose Island should be further considered to determine whether there is a proximate or upstream source of PCBs.	See Note 2, below. Also, sampling at Goose Island was completed in 2009 at the request of the TAG, after some Goose Island bass (fish caught in the slough in 2008) were found to have high PCB levels. No new source areas were found. It is our opinion that fish are an inadequate media for tracking down new sources of contamination. No revisions to the BHHRAs are necessary.
11.	3. Site delineation: b. River: iv. In the recent data (2011), the concentrations of PCBs in fish, clams, and sediments were still high along the north side of Bradford Island, with concentrations in all media increasing toward the eastern end of the island. The sampling at Bradford Island was limited to the north side of the island; however, it did not bound the extent of the high concentration area to the south around the end of the island, nor riverward. One of the debris piles was located near the eastern end of the island and river current flow is around the tip of the island at least some of the time (per conversation with USACE, December 15, 2015), providing a reasonable basis for residual high concentrations of PCBs to be found in this location. Considered together with the potential for heterogeneity in the PCB distributions, these data are simply too limited to confidently delineate the present distribution of PCB contamination.	The 2011 sampling event was done to supplement the 2008 sampling results. In 2008, samples were not taken in the removal areas (at the time, we did not believe there would be enough sediment present to obtain samples because the sediment removal action had just taken place a few months earlier). Taken together, the 2008 and 2011 sampling data adequately describes the forebay in the shallower shoreline areas (within 150 feet of the shoreline). Deeper areas, beyond 150 feet, were not sampled during this timeframe. Some samples were taken in 2003 (see 2.a., above). These samples were non-detect or had very low detections for PCBs. Also, these areas present a safety risk to divers and they are not normal habitat for bass, sculpin, etc. For these reasons, no additional deep water samples were taken in 2008 and 2011.

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		No revisions to the BHHRAs are necessary.
12.	3. Site delineation: b. River: v. USACE assumes the primary source of residual PCBs is located in cracks of the river bottom disposal areas. The Yakama Nation requests information on direct support exists for this assumption.	We can provide the diver logs from the 2011 sampling event. They note that surface sediment was not available for collection and that they had to get sediment material from the cracks and crevices in the rocky river bottom. No revisions to the BHHRAs are necessary.
13.	3. Site delineation: b. River: vi. The use of organisms with smaller home ranges (sculpin, crayfish, clams, periphyton and macroinvertebrates) for evaluation of ecological receptors might be more conclusive.	We prepared a comprehensive Work Plan (2007) for sampling, including media to be utilized. We agree that smaller home range organisms are desirable, but media at all levels of the food chain are required for a complete risk assessment. No revisions to the BHHRAs are necessary.
14.	3. Site delineation: b. River: vii. The Yakama Nation requests information to support USACE's conclusion that sediments in general, and especially contaminated sediments, do not accumulate behind the Bonneville Dam in the forebay.	High velocity areas are not depositional. Hydraulic models will show that the area in front of the spillway is a high velocity area. Samples do exist on the Oregon side of powerhouse 1. These samples show non-detect for PCBs. No sampling was ever contemplated in front of powerhouse 2. Hydraulic modeling does not support the idea that sediments could reach this area. No revisions to the BHHRAs are necessary.
15.	3. Site delineation: b. River: viii. We are concerned about the adequacy of the sediment investigation downstream of the Bonneville Dam. The Yakama Nation requests information on how the 4 downstream sediment samples listed in the RI were selected to evaluate downstream sediment impacts. In addition, we request all historic downstream data not used in the RI.	Hydraulic modeling was utilized to determine the most likely depositional areas downstream of the dam. Six locations (not 4) were sampled (see RI, page 8-10) for more on this topic. No other sampling events have occurred below Bonneville Dam. No revisions to the BHHRAs are necessary.
16.	3. Site delineation: b. River: ix. Older data: 1. Older data should be considered. The Yakama Nation disagrees with USACE that including historic data will add uncertainty to the RI (USACE response to Oregon Department of Environmental Quality comments, 2011). Because the forebay is a dynamic environment, understanding where contamination has come to be located over time will inform a cleanup selection and design. Not considering this information in the conceptual site model adds greater uncertainty.	At the request of ODEQ, most of the older data was included in the In Water baseline risk assessment. Please see the In Water OU Technical Memo (June 2014) for a full explanation of what data was added to the risk assessment data set. No revisions to the BHHRAs are necessary.

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17.	3. Site delineation: b. River: ix. Older data: 2. For example, these older data show that the PCB contamination was heterogeneously distributed in the sediments (e.g., Figure 3-1 of 2014 Data Evaluation Technical Memorandum, River OU), indicating that a high frequency sampling was necessary to identify the “hot spots” at that time. There is no reason to assume that the same heterogeneity is not present today, leaving the possibility that areas with higher contamination have just been missed in the limited recent sampling.	All sampling done after 2003 uses a compositing method. Up to 10 discreet samples are collected within a 50 foot gridded area and combined for analysis. We agree that discreet samples would give wildly varied results, which is why we started using the compositing method. No amount of sampling will be enough to locate every hot spot on the river bottom. But, we believe enough sampling has already been done to tie the hot spots to the debris piles and the outfalls (our PCB sources). No revisions to the BHHRAs are necessary.
18.	3. Site delineation: b. River: ix. Older data: 3. RI, appendix G (historical data not used) does not include a map or adequate location information. We request location information for this data.	See 3.b.ix.1, above. The RI, Appendix G no longer reflects the data used in the RA. Please refer to the In Water OU Technical Memo (June 2014) for more up to date information. No revisions to the BHHRAs are necessary.
19.	3. Site delineation: b. River: ix. Older data: 4. We understand that past efforts were made to sample clam tissue in the forebay close to the dam (early 2000s). We request information on this sampling event.	In 2003, sediment and clam tissue was collected (over 120 locations). However, the clam tissue samples were never analyzed. After 3 years, they were discarded. No revisions to the BHHRAs are necessary.
20.	3. Site delineation: c. Upland: i. The groundwater VOC plume needs further evaluation. Fairly high concentrations of volatile organic compounds (VOCs) were observed, as were apparent groundwater plumes of those substances. In general, VOCs do not accumulate in sediments or biota and are not highly toxic to aquatic biota. However, the VOC plumes could provide a vector (solvent) for the transport of other organic contaminants.	While groundwater data from borings delineated a PCE plume in 2004 with concentrations greater than 10 times the SLV, subsequent sampling in 2008 suggested that the mass of VOCs available to leach to groundwater is decreasing over time. The breakdown products of PCE (1,1-DCA , cis-1,2-DCE, and vinyl chloride) were also present in groundwater but at generally lower concentrations and with fewer SLV exceedances. The hypothesis that the groundwater VOC plume can function as a vector for transport of other organic contaminants is legitimate but is not reflected in other groundwater and seep data. From data collected in support of the RI, limited or no detection of contaminants, including butyltins, herbicides, pesticides, PCBs, PAHs, and SVOCs, were identified in groundwater and seep water. No revisions to the BHHRAs are necessary.
21.	3. Site delineation: c. Upland: ii. The Yakama Nation requests information on how the FS will address	Surface water was evaluated in the screening level ecological risk assessment and was not found to pose unacceptable risk. Surface water

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	groundwater to surface water contaminant contributions. This pathway was not carried forward into the RA for further evaluation, despite toxicity criteria exceedances.	was also evaluated as an exposure medium in the baseline human health risk assessment and was found to not pose unacceptable risk. Any contaminant contribution from groundwater to surface water is considered negligible given the results of the risk assessments. No revisions to the BHHRAs are necessary.
22.	3. Site delineation: c. Upland: iii. The FS cleanup alternatives should still include preventative measures to eliminate current and future transport of upland soil and groundwater contamination to the river. In general, upland risks are limited in comparison to river OU PCBs and the RI reasonably discussed the possible inputs from the upland sites to the river, but the quantitative impact of those inputs has been poorly characterized, e.g., associated with slope failure. It also seems very unlikely that the upland sites are the source of the high PCB concentrations observed in the river.	Quantitative characterization of a landfill is not possible. Mass wasting of soil has been confirmed by a recent geotechnical report. Agree that the Upland Landfill alternatives need to address upland soil. No revisions to the BHHRAs are necessary.
Comments on the Upland and River OUs Draft Risk Assessments		
23.	1. River and Upland Combined: a. With respect to these limited or focused RAs, observations are prefaced by noting that there are risks posed by a number of substances at this site including metals and a variety of organic chemicals. Although the risks posed by these substances are lower than the risks posed by the PCB contamination, the risks from all substances should be identified.	Risks, both cancer and non-cancer, for all identified COPCs and CEPCs were calculated in the baseline risk assessments. These calculated risks are presented in Tables 2-6.1 through 2-12 and 3-15 through 3-19 in the River OU baseline RA and Tables 2-9 through 2-25 and 3-11a through 3-19d in the Upland OU baseline RA. No revisions to the BHHRA are necessary.
24.	1. River and Upland Combined: b. Tribal exposure scenario: USACE made assumptions about future tribal use to estimate risk at Bradford Island and we appreciate effort to use conservative assumptions in its RA; however, Yakama Nation reiterates its request to have further dialogue on this issue.	We would welcome further dialogue. No revisions to the BHHRA are necessary.
25.	2. River OU: a. Lipid normalization should be done when comparing concentrations among species. Similarly, for the bass, age differences should be considered as well. It was not clear when the River OU Baseline Ecological Risk Assessment (BERA) states that the concentration in fish tissue were substantially greater than in clams or crayfish whether those measurements were lipid normalized. Lipid content has a major control over the concentrations and the fish have greater lipid content than the shellfish.	Lipid normalization was conducted for all calculations. As stated in the in River OU baseline RA, the median site-specific clam, crayfish, sculpin, and bass lipid contents are 2.6%, 0.73%, 4.1%, and 3%, respectively (page 3-5, River OU Baseline RA). These values were used calculate relevant tissue concentrations. No revisions to the BHHRA are necessary.

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26.	2. River OU: b. For the dietary uptake by mink it would be useful to discuss in the uncertainty section the effects of assuming the mink ate only the most contaminated food to demonstrate the possible upper limit of the risks.	The results for the mink are likely a conservative, over estimate of risk in both the River and Upland OU baseline RAs. Excerpts from the River OU baseline RA are provided below for reference. Based on the assumed dietary fractions identified in the baseline RA, the EPC (95% UCL on the mean) was used to calculate CPEC exposure. Use of the 95% UCL on the mean is in accordance with the most recent USEPA guidance regarding statistical methodology to be used in EPC estimation and more conservative than ODEQ's guidance. Because of this conservative methodology, USACE feels a discussion regarding the possible upper limit of risk is unwarranted. *Several sources of information on the mink's diet were consulted while developing the response to ODEQ's Specific Comment #22 to the Final RI (URS 2012), and the consensus is that mink's diet primarily consists of crayfish, fish, and other aquatic-related prey. Typically, 10% or less of their diet is comprised of terrestrial prey (e.g., birds and small mammals) (USEPA 1993b, 1995). Although the Upland OU BERA assumed 15% small mammals for the upland RA, mink were conservatively assumed to have a dietary composition of 100% prey from the River OU for this River OU BERA. This was done because it is likely that mink preferentially use the River OU (i.e., permanent water source, riverine habitat) rather than the Upland OU to forage. Therefore, the uncertainty that risk may have been underestimated in the River OU BERA is minimal and unlikely to impact risk management decisions in the FS.* *In addition, although the mink was assumed to consume more the one type of riverine food item (i.e., crayfish, sculpin, and bass), the mink's diet was assumed to be comprised of each equally (i.e., 33.3% each). In actuality, mink dietary composition is likely to fluctuate with availability, season, and, potentially, animal preference. Additionally, in instances when an CPEC was not analyzed in all three tissues, the dietary composition was adjusted for that particular analyte based on available tissue analysis (e.g., 50% each if only analyzed in two tissues, or 100% if analyzed in a single tissue type). Both of these uncertainties may over- or underestimate risk to the mink; the direction and magnitude of this uncertainty is difficult to quantify.* No revisions to the BHHRA are necessary.

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27.	2. River OU: c. Similarly, since there is uncertainty in the biomagnification factor (BMF) it would be helpful to discuss the range of possible BMF values compared to the resulting risk estimate. We request calculations using these BMF values to determine if there's a change in risk, both cancerous and non-cancerous.	The BMF values selected for the baseline RA were ODEQ's default values. As stated in the baseline RA, the study for which the default eagle BMFs are from (Buck 2004) noted that the PCB BMFs varied "quite markedly" among the Columbia River segments evaluated (i.e., ranged from 90 to 155) and used prey fish tissue from a wider range of prey items than the assumed dietary assumptions for this BERA (i.e., 100% bass). The use of the default BMFs, which showed variations among the study river segments from studies on which they are based, introduces a level of uncertainty that is hard to quantify and may over- or underestimate risk. However, combined with the dietary assumption of 100% bass (with highest detected CPEC concentrations), this likely conservatively skews the uncertainty toward overestimation. Given that the risk results provide a likely overestimation of risk, USACE feels a discussion regarding the possible upper limit of risk is unwarranted No revisions to the BHHRA are necessary.
28.	2. River OU: d. Table 3-13. It would be helpful to include the maximum concentrations observed in the reference areas in the table since the upper prediction limit (UPL) can exceed the maximum if the sample size is small and variable.	It is generally believed that the UPL is a more statistically reliable value and a better representation of the data set, as compared to the maximum detected value. However, maximum concentrations can be found in the risk assessments, Tables 1-1 through 1-8 for the River OU baseline RA and Tables 1-1 through 1-9 for the Upland OU baseline RA. The tables relevant to the reference area samples present both the UPL and maximum detected value. No revisions to the BHHRA are necessary.
29.	2. River OU: e. In comparison to data from the Portland Harbor BERA, the fish tissue no-observed-adverse-effect concentrations (NOAELs) used in the Bradford Island BERA are similar, but the Portland Harbor lowest-observed-adverse-effect levels (LOAELs) are usually less than 3 times the NOELs, rather than the 5 times used as the default in the BI BERA. For PCBs, the NOELs are virtually the same (Portland Harbor -0.42 milligrams/kilogram wet weight (mg/kg ww) versus Bradford Island -0.43 mg/kg ww), but the Portland Harbor LOEL is 0.93 mg/kg ww verses 2.2 mg/kg ww. For PCBs and other substances using the lower LOELs from Portland Harbor would increase some of the LOEL-based HQs, better characterizing the risks posed by those substances.	During a May 20, 2015 meeting between USACE and ODEQ, it was agreed ODEQ toxicity reference values (TRVs) would be the first choice in the hierarchy of TRV selection. This was done in response to some of ODEQ's expressed concerns regarding the TRVs utilized in the Portland Harbor RA. As a result, some TRVs results in both higher and lower characterized risks. Ultimately, PCBs are still identified as a COC/CEC with unacceptable risk warranting remedial action. No revisions to the BHHRA are necessary.

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30.	2. River OU: f. USACE needs a better data set to determine fish tissue contaminant concentration trends. Yakama Nation does not agree that PCB concentrations are decreasing in post-removal (2011) fish tissue. The river OU RA presents information that the highest concentrations were found in young fish and that the sampling efforts had a low sample size and low sample frequency.	Monitoring fish tissue concentrations will almost certainly be part of the recommended alternative. But, additional sampling is unnecessary to complete the In Water FS. No revisions to the BHHRA are necessary.
31.	3. Upland OU BERA: Erosion of the landfill at the north bank shoreline of Bradford Island, as identified in the 2015 slope stability analysis, is an ongoing concern and should be addressed in FS cleanup alternatives.	Agreed. This is being addressed in the Upland FS. No revisions to the BHHRA are necessary.
Global Comments		
32.	1. Reference Area: a. The appropriateness of the reference area data is a concern and should be re-evaluated. It is close to the site (i.e., within small mouth bass home range of approximately 0.7 to 1 mile) and under the direct influence of multiple releases from waterfront cleanup sites with confirmed and suspected contaminant sources also found at Bradford Island, including: i. Herman Creek PCBs, Cascade Locks, OR – confirmed PCBs in sediments ii. Cascade Locks Wastewater & Storage Facility, Cascade Locks, OR - PCBs suspected due to illegal dumping and storage of transformers (along Herman Creek) iii. Cascade Locks Lumber, Cascade Locks, OR – PCBs, TPH, metals, PAHs (along Herman Creek) iv. Pyramid Metals, Cascade Locks, OR – metals (along Herman Creek) v. Stevenson CoPly Mill, Stevenson, WA – Awaiting Cleanup Status (WA, Department of Ecology). Confirmed or suspected contaminants of concern for this facility include PCP, dioxins/furans, creosote, petroleum, PAHs, metals, corrosive wastes. vi. Multiple petroleum bulk storage facilities in both Stevenson, WA and Cascade Locks, OR that are in various stages of investigation and cleanup. Confirmed or suspected contaminants of concern include cPAHs and petroleum. vii. Multiple municipal and industrial wastewater outfalls in Stevenson, WA and Cascade, OR. These facilities have existing discharge permits to pollute the Columbia River.	Sample results from all reference area samples are statistically similar, no matter how close or how far from the cited locations of concern. Also, please note that approximately 8 of the reference area bass were actually caught several miles upstream (because they could not catch enough in the actual reference area). The results in these bass are comparable, if not slightly elevated, in PCBs, when compared to the other bass. We do understand the concern, but the sample data from the reference area does not indicate a problem. No revisions to the BHHRAs are necessary.
33.	1. Reference Area: b. It is inappropriate to eliminate COCs and CECs due to similar reference area (background) concentration ranges when the reference area is located in an	For the River OU reference area, the upstream reference area was selected based on modeling results characterizing the upstream extent of the river flow reversal caused by the powerhouses and the spillway that

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	industrial area directly influenced by releases from similar contaminant sources. Specifically mercury and arsenic (mentioned in Section 2 text) are of concern. Evaluation of these contaminants for elimination as a COC or CEC should be risk-based only.	could transport impacted sediment back upstream. The reference area was found to be statistically different from the source area. This reference area was subsequently used for comparative analyses in the Remedial Investigation and baseline RAs. For the Upland OU reference area, the location was selected because it was upgradient of and unaffected by the site related waste handling activities. The reference site was also found to have samples that generally reflected background or ambient concentrations of all COIs. Lastly, the reference area exhibited similar physical soil characteristics relative to the soil sampled in the four AOPCs in the Upland OU. Because the reference area exhibits these characteristics, USACE believes it is appropriate to use the reference area as site background concentrations and apply these concentrations when determining COCs and CECs. CERCLA guidance states that it is generally not feasible to set cleanup levels below background and thus can be used for helping to screen contaminants for risk management purposes. For mercury and arsenic, the 95% reference UPL (0.06 and 5.5 mg/kg, respectively) are either in line or much lower the Oregon DEQ's regional background values for inorganics in soil. No revisions to the BHHRAs are necessary.
34.	1. Reference Area: c. Yakama Nation is concerned about USACE's stated intentions to use reference area data as background values. It is inappropriate to set cleanup levels to a background value that is directly influenced by releases from contaminant sources.	As stated in response to Global Comment 1.b., the reference areas for the River and Upland OU were identified and justified with empirical information identifying the reference areas as statistically different from the source areas and justifiable as reference locations. There is no information supporting the idea that the reference areas are directly influenced by releases from contaminated sources. Further, the baseline RAs followed CERCLA guidance when developing and applying background concentrations to risk management decisions. "Under CERCLA, cleanup levels are not set at concentrations below natural background levels. Similarly, for anthropogenic contaminant concentrations, the CERCLA program normally does not set cleanup levels below anthropogenic background concentrations" (Reference: US EPA, 2002. Role of Background in the CERCLA Cleanup Program. OSWER 9285.6-07P). As such, USACE believes it is appropriate and in line with guidance to use the reference area to represent anthropogenic

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		background. No revisions to the BHHRAs are necessary.
35.	1. Reference Area: d. Comparisons of site data to those from reference area is principally a risk management issue. The presence of similar concentrations elsewhere does not reduce the risks at the site.	USACE agrees that in some cases deferring to background concentrations for select contaminants will not reduce risks to *de minimus* levels. This is because *de minimus* concentrations fall below background concentrations. It is infeasible to set preliminary remedial goals below background. This strategy is in line with both current CERCLA and ODEQ guidance regarding the consideration of background contamination concentrations. No revisions to the BHHRAs are necessary.
36.	2. CEPCs and COPCs not retained: Yakama Nation wants to make it clear that monitoring and evaluation of the broader CEPCs and COPCs list of contaminants exceeding toxicity levels should be continued in future response action stages.	Comment noted. This issue will be given full consideration when developing strategies for post construction confirmation sampling and long term monitoring. Risk driver contaminants, as well as the full set of identified COCs and CECs will be sampled for in post construction and long term monitoring sampling. CPECs and COPCs will be given consideration as warranted. No revisions to the BHHRAs are necessary.

Note 1: We understand the concern that the entire Bonneville Dam complex is not a part of the scope of this project. However, please note that the Bradford Island project is not the primary vehicle for managing waste at Bonneville Dam. In fact, most actions are managed by an Environmental Compliance Team following Resource Conservation and Recovery Act (**RCRA**) processes and protocols. This is a fully staffed team that is integral to the routine operation and maintenance of the project. Their mission manages the majority of actions related to the generation, transportation, treatment, storage, and disposal of hazardous waste at the project. Their process begins with ERGO assessments, which are now conducted on an annual basis (the first ERGO assessment was completed in 1992) and ends when an item of non-compliance is corrected. Some past actions have included removal of underground storage tanks and removal of soils associated with known localized spills.

The sites that have become the 'Bradford Island' project, are being managed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). These sites are either too large to be managed as part of a routine program or fit the definition of a 'legacy' site.

Note 2: After the sediment removal work was completed in 2007, the sediments in the barges were sampled for final disposition. PCBs could not be detected in the samples. This is relevant because it shows that PCBs in sediments that were removed from the hottest locations could not be detected once handled by the removal contractor. In the case of Goose Island millions of tons of material was removed and placed to form Goose Island. It is highly unlikely that any contamination could be detected after the material went through such a removal and placement action, given the results in 2007.