FINAL

RISK ASSESSMENT REPORT

OPERABLE UNIT B, POLELINE ROAD DISPOSAL AREA FORT RICHARDSON, ALASKA

Contract No. DACA-85-94-D-0005
Delivery Order No. 013

Prepared For

U.S. ARMY CORPS OF ENGINEERS
ALASKA DISTRICT
Anchorage, Alaska

SEPTEMBER 1996

Prepared By

Woodward-Clyde

3501 Denali Street, Suite 101
Anchorage, Alaska 99503

RECEIVED
OCT 03 1996
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

TABLE OF CONTENTS

LIST OF APPENDIXES

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ADEC	Alaska Department of Environmental Conservation
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	Bioaccumulation Factor
BCC	Bioaccumulative Chemical of Concern
bgs	Below Ground Surface
bw	Body Weight
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CI	Confidence Interval
COC	Chemical of Concern
CSM	Conceptual Site Model
CT	Central Tendency
CWA	Chemical Warfare Agents
CWM	Chemical Warfare Materials
DNAPL	Dense Non-aqueous Phase Liquid
EI	Ecotox Index
EPA	United States Environmental Protection Agency
EQ	Ecotoxicological (ecotox) Quotient
EqP	Equilibrium Partitioning
ERA	Ecological Risk Assessment
ESCM	Ecological Site Conceptual Model
ESE	Environmental Science and Engineering, Inc.
FAC	Facultative
FACW	Facultative Wetland
f_{oc}	Fraction of Organic Carbon Content in Sediment
FOD	Frequency of Detection
GC	Gas Chromatograph
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
kg	kilogram
K_{oc}	Equilibrium Partition Coefficient or Water to Sediment Partition Coefficient
K_{ow}	Octanol/Water Partition Coefficient

L	Liter
LC_{50}	Median Lethal Concentration
LD_{50}	Median Lethal Dose
LOAEL	Lowest Observable Adverse Effect
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observed Effect Level
m^3	cubic meter
MCL	Maximum Contaminant Level
mg	milligram
MW	Monitoring Well
ND	Non-detect or Not Detected
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
OBL	Obligate
OHM	OHM Remediation Services Corporation
ORNL	Oak Ridge National laboratory
OSWER	Office of Solid Waste and Emergency Response
OUB	Operable Unit B
PCE	Tetrachloroethene
ppb	parts per billion
ppm	parts per million
PRDA	Poleline Road Disposal Area
QM	Quotient Method
RAGS II	Risk Assessment Guidance for Superfund, Volume II
RBC	Risk-based Concentration
RBCA	Risk-based Corrective Action
RDX	Royal Demolition Explosive
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
SF	Slope Factor
SOW	Statement of Work
SQL	Sample Quantitation Limit
SRC	Sediment Quality Criteria

SSL	Soil Screening Level
SVOC	Semi-volatile Organic Compound
TCE	Trichloroethene
UCL	Upper Confidence Limit
µg	microgram
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WC	Woodward-Clyde Federal Services
WQC	Water Quality Criteria

This Risk Assessment Report contains baseline human health and ecological risk assessments for the Poleline Road Disposal Area (PRDA), which is Operable Unit B at Fort Richardson Army Installation in Anchorage, Alaska. This report accompanies the Remedial Investigation Report, which describes the conduct and results of field investigations conducted for soil, groundwater, and an adjacent wetland at the PRDA by Woodward-Clyde Federal Services (WC) in 1995 (WC 1996). The report was prepared for the United States Army Corps of Engineers, Alaska District, in compliance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Federal Facilities Agreement negotiated among the Army, the United States Environmental Protection Agency (EPA), and the Alaska Department of Environmental Conservation (ADEC).

Soil and groundwater at the PRDA are contaminated with chlorinated solvents that were used to denature munitions and chemical warfare materials (CWM) prior to disposal in trenches at the site. The disposal site was active from about 1950 to 1972, and has been used since then for various field training exercises. The site is now inactive, except for investigation and remedial activities. The risk assessments were performed in order to evaluate potential human health and ecological risk associated with potential exposure to chemicals at the site. The risk assessments will be used to help support remedial action decisions for the PRDA.

SITE BACKGROUND

The PRDA is a small site (about 3 acres) located about 10 miles northeast of Anchorage in a wooded area on the Fort Richardson property. The main disposal area occupies only about 1.5 acres. The PRDA is adjacent to Poleline Road, 1 mile south of the Eagle River and 0.6 miles north of the Anchorage regional landfill. When it was used for disposal, most of the waste materials were placed in trenches in two disposal areas (called A-3 and A-4) on the west side of PRDA. Areas A-3 and A-4 were the subject of a removal action conducted in 1993 and 1994 by OHM Remediation Services, which removed all solid waste and soil above the perched water table that was contaminated with chlorinated solvents above health-risk based removal action levels approved by ADEC. Contaminant concentrations above action levels are still present in soil beneath the perched zone in Areas A-3 and A-4. Areas A-3 and A-4 appear to be the source of soil and groundwater contamination at the site.

Geophysical surveys suggest that Areas A-1 and A-2 on the east side of PRDA may also have been used to a lesser extent for waste disposal; the surveys also indicate the possible presence of small metallic items in the wetland southwest of the PRDA These areas have not been excavated, but in 1994 an 18-inch soil cover was placed by OHM on Areas A-1 and A-2. The cover was placed on top of approximately 18 inches of existing soil that was on top of the apparent disposal horizon, resulting in a total cover of 3 feet. The RI showed little contamination of soil adjacent to and surrounding Areas A-1 and A-2.

SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

During the RI, numerous soil borings were placed in and around the disposal areas A-1 through A-4, groundwater samples (from well points) were collected from each boring, groundwater monitoring well samples were collected from 11 existing and 6 new wells, and surface water and sediment were sampled in the adjacent wetland. No sampling was performed within Areas A-1 and A-2 because of the possible presence of unexploded ordnance. The nature and extent of contamination as evaluated in the RI is summarized briefly below.

Soil: Chlorinated solvents were detected in numerous soil samples, ranging in concentration from less than 0.001 mg/kg to over 2,000 mg/kg. 1,1,2,2-Tetrachloroethane and trichloroethene (TCE) were detected most often and in the highest concentrations, but many other chlorinated compounds were detected in lower concentrations. The highest levels of contamination were found at depths greater than 15 feet below ground surface (bgs) in and near Areas A-3 and A-4. Little contamination was found around Areas A-1 and A-2. CWM and explosives were not detected in soil samples collected during the RI. Metals were not significant contaminants. Although a few metals were identified as statistically exceeding background levels (see Section 4.4), they did not contribute significantly to human health or ecological risk.

Groundwater: Three main water-bearing zones are present: perched at about 8 feet bgs, shallow at about 20 to 25 feet bgs, and deep at 80 to 160 feet bgs (all depths are top of water table). Additional "intermediate" water-bearing zones were observed between the shallow and deep zones. Solvents were detected in each zone. Maximum concentrations decreased with depth. Maximum concentrations of 1,1,2,2-tetrachloroethane and TCE in each zone were 1,900 and 220 mg/L (perched); 93 and 46 mg/L (shallow); and 3.1 and 1 mg/L (deep). Several other chlorinated solvents (including 1,2-dichloroethene, and 1,1-dichloroethene, which are breakdown products of TCE and 1,1,2,2-tetrachloroethane) were also detected at lower concentrations. TCE and 1,1,2,2 tetrachloroethane are practically insoluble in water and are heavier than water. The high concentrations of these compounds are indicative but not conclusive evidence of the presence of dense non-aqueous phase liquid (DNAPL). However, no evidence of DNAPL was found in any monitoring well. The perched zone is not continuous across the site. The shallow and deep zones flow north-northeast locally at the PRDA but trend northwest regionally and probably discharge to the Eagle River.

Metals and explosive residue were not significant contaminants in groundwater. Metals detected in monitoring well samples were below Alaska Maximum Contaminant Levels (MCLs) for drinking water, and only one explosive residue was detected (2,4-dinitrotoluene at 0.003 mg/L) (see Sections 3.2.4 and 3.2.5). CWM was not detected.

Wetland: Low concentrations (< 1 mg/kg and less than 0.005 mg/L) of explosive residues were detected in wetland sediment and surface water samples. Metals detected in surface water are probably not site-related contaminants (see discussion in Section 6.3.3.4). Solvents and CWM were not detected in the wetland samples.

SUMMARY OF GROUNDWATER FATE AND TRANSPORT MODELING

Groundwater fate and transport modeling was performed to simulate contaminant transport in the shallow and deep zones to the Eagle River. The perched zone was included as a source of contamination to the shallow and deep zones. Three indicator chemicals were modeled: 1,1,2,2-tetrachloroethane, TCE, and 1,1,2-trichloroethane. Biodegradation was not included in the base case fate and transport modeling; however, Appendix XIII of the RI Report contains a sensitivity analysis evaluating biodegradation rates. The base case model results indicated a travel time of 120 years or more (depending on the contaminant) for the leading edge of simulated contaminant plumes in the shallow and deep water-bearing zones to reach the Eagle River. The leading edge of the plume was defined by a contaminant concentration of 0.005 mg/L. Groundwater fate and transport modeling indicates that contaminants at PRDA do not pose a threat to the Eagle River in the imminent or near future.

SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

The health risk assessment was performed assuming long-term residential and industrial use of the site, although future development of the site is unlikely. This conservative approach was taken in order to support decisions for no further action, if warranted, for media or exposure areas at PRDA. Risk estimates would be lower if site-specific exposure assumptions were used.

Data Used: Data used in the risk assessment included results from soil, sediment, surface water, and groundwater samples collected in the RI, results of previous groundwater sampling events, and results of confirmation sampling by OHM in excavation bottom and sidewalls in Areas A-3 and A-4. For evaluating direct exposure to soils, soil samples collected between 0 and 15 feet bgs were used, representing the depth interval that could be exposed if construction were to occur at the site. Samples from approximately 14 feet bgs or deeper were used to evaluate vapor migration into a building because most contamination in soil is at that depth.

Exposure Areas and Media: Potential risk from soil exposure was evaluated for two exposure areas: Areas A-1, A-2 and other surrounding areas (exposure area A-1, A-2, O), and Areas A-3, A-4 and toe of hill in Area A-3 (exposure area A-3, A-4, T). In addition, a separate "hot spot" evaluation was made for three saturated soil samples collected in the perched zone at about 14 feet bgs in the hillside at the southwest edge of Area A-3. Risk from use of groundwater as drinking water was evaluated for the shallow saturated zone (although its ability to support domestic use is unlikely) and the deep aquifer. Perched water was not evaluated for use as domestic water because it could not support a domestic supply. However, perched water was evaluated as a contaminant source to the shallow and deep saturated zones in groundwater fate and transport modeling and for vapor migration through a building foundation. Risk from exposure to sediment and surface water in the wetland was evaluated as if these media were equivalent to residential soil and drinking water.

Chemicals of Concern: Chemicals of concern evaluated in the risk assessment included all detected chlorinated solvents, explosive residues, and metals that appeared to be above background levels based on statistical comparisons to background data.

Exposure Pathways Evaluated: Exposure pathways quantified in the risk assessment were:

- Soil ingestion and inhalation
- Groundwater ingestion and inhalation of VOCs during domestic use
- Sediment ingestion
- Surface water ingestion
- Vapor intrusion through a building foundation

In addition, groundwater modeling results were compared to surface water quality criteria for protection of human health via a fish ingestion pathway.

Exposure pathways not quantified in the risk assessment (e.g., dermal contact) were shown not to affect the conclusions of the risk assessment.

Risk Characterization Method: Risks were estimated by comparing reasonable maximum exposure (RME) concentrations to EPA risk-based concentrations (RBCs) for residential and industrial soil and for residential tap water. RBCs for soil are based on the soil ingestion pathway; RBCs for tap water are based on ingestion and inhalation of volatile organic compounds (VOCs) during domestic use. To evaluate the outdoor inhalation pathway for soil, RME concentrations were also compared to draft EPA soil screening levels for soil-to-air transfer. Cumulative risk/hazard from exposure to multiple chemicals was calculated by summing ratios of chemical concentrations to RBCs. The potential for exposure to vapors migrating from soil and groundwater through a building foundation was evaluated by comparing representative site concentrations to modeled risk-based target levels for soil and groundwater.

Risk Results: Estimates of cancer risk and noncancer hazard indexes (HIs) are summarized in Table ES-1. Total cancer risk for residential and industrial exposure to unsaturated soil from 0 to 15 feet bgs in both exposure areas was 1E-05 (1 in 100,000) or less. Total HIs for noncancer effects were 0.1 or less. These values are within or below EPA's target acceptable cancer risk range of 1E-06 to 1E-04 (1 in 1,000,000 to 1 in 10,000) and the level of potential concern for noncancer effects represented by a HI of 1. Therefore, no unacceptable risks are associated with potential exposure to unsaturated soil 0 to 15 feet bgs at the PRDA, even using conservative residential exposure assumptions.

Likewise, no unacceptable risk was shown for exposure to wetland sediment and surface water (cancer risk of 2E-08 and HI of 0.9 or less, assuming long-term residential soil ingestion and use of wetland water as drinking water).

The "hot spot" evaluation of saturated soil in the perched zone at 14 feet bgs in the hillside southwest of Area A-3 indicated a cancer risk of 3E-04 for residential exposure and 4E-05 for industrial exposure. The estimated cancer risk for residential exposure exceeds EPA's target range. However, exposure to deep soil in this location is unlikely.

Estimated risk from hypothetical onsite use of groundwater for domestic purposes exceeded levels of concern. Cancer risk from hypothetical groundwater ingestion was 3E-01 (3 in 10) for the shallow zone and 4E-04 (4 in 100) for the deep aquifer. HIs were 200 for the shallow zone and 25 for the deep zone. Chemicals contributing most to the risk estimates were 1,1,2,2-tetrachloroethane and TCE. These risk/hazard estimates exceed EPA's acceptable levels. However, groundwater in the area is not used currently and is not likely to be used for drinking water in the future because development of the area is unlikely, and a drinking water source (the Eklutna waterline) exists just west of the site.

Based on groundwater fate and transport modeling of the two most prevalent contaminants (TCE and 1,1,2,2-tetrachloroethane) and assuming no source decay or biodegradation, detectable concentrations (0.005 mg/L) could reach the Eagle River in 120 and 170 years, respectively. Concentrations in the Eagle River would be much lower due to dilution. Even neglecting dilution, 0.005 mg/L is below water quality criteria for protection of human health by fish ingestion.

Vapor Intrusion: Representative site concentrations of selected solvents in soil and groundwater near Areas A-3 and A-4 exceeded conservative screening levels calculated using the American Society for Testing and Materials (ASTM) model for soil vapor migration into a building (ASTM 1995). Therefore, air or soil vapor measurements would be warranted prior to making remedial decisions based on the vapor migration to indoor air pathway.

Conclusion: The low levels of residual VOCs in unsaturated soil (0 to 15 feet) and in wetland surface water and sediment do not pose an unacceptable health risk under conservative residential exposure assumptions. Hypothetical use of groundwater onsite would pose unacceptable health risks, but groundwater is not currently used or expected to be used in the future in the vicinity of PRDA. Based on groundwater fate and transport modeling, assuming no biodegradation, detectable concentrations (0.005 mg/L) of TCE and 1,1,2,2-tetrachloroethane could reach the Eagle River in 120 and 170 years, respectively. Concentrations of 0.005 mg/L are well below levels of concern for protection of human health by fish ingestion. These results indicate no imminent or near-future threat to the Eagle River.

Higher concentrations of chemicals are found in soil deeper than 15 feet in and near Areas A-3 and A-4. The estimated cancer risk for residential exposure exceeds EPA's target range, but exposure to deep soil at this location is unlikely. These soil concentrations may be a continuing source of contamination to groundwater and could pose an indoor air inhalation hazard. Air or soil vapor measurements are recommended prior to making remedial decisions based on this pathway.

SUMMARY OF ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment evaluated potential exposure of key receptors to near-surface soil (0 to 3 feet bgs), to wetland sediment and surface water, and to concentrations of chlorinated solvents in the leading edge of groundwater plumes simulated to reach the Eagle River in 120 to 170 years.

Chemicals of Ecological Concern: Chemicals detected in soil 0 to 3 feet bgs in exposure areas A-1, A-2, O and A-3, A-4, T and in wetland surface water and sediment were screened using five criteria to identify chemicals of ecological concern (COECs): (1) detection in at least one sample; (2) frequency of detection; (3) RI background levels; (4) toxicity-based values: and (5) literature-based background data. As a result of the screen, five VOCs at exposure area A-1, A-2, O, seven VOCs at exposure area A-3, A-4, T, and two explosive residues in the wetland sediment were retained for further evaluation in the risk assessment.

Key Receptors: The northern red-backed vole and muskrat were selected as representative key receptors for the upland and wetland habitats, respectively, based on site-specific exposure pathway and ecological considerations. In addition, upland and wetland plant communities and aquatic invertebrates were also evaluated.

Risk Characterization Method: Benchmark toxicity values for COECs for each receptor were determined. The Quotient Method was used to quantitatively evaluate potential risk to the key receptors from exposure to COECs in soil and sediment. The Quotient Method is based on the comparison of estimated maximum and RME concentrations for on-site receptors with protective benchmark toxicity values derived from the toxicological literature.

Risk Results and Conclusion: Based on the risk analysis, COEC concentrations at the PRDA result in negligible risk to small mammal populations, aquatic invertebrates, emergent wetland vegetation, and upland plant vegetation. Groundwater concentrations simulated in the leading plume edge (0.005 mg/L) are below water quality criteria for protection of freshwater aquatic life. The overall potential for valued environmental resources at this site to be adversely affected is considered negligible.

TABLE ES-1
SUMMARY OF RME CANCER RISK AND NONCANCER HAZARD INDEX
HUMAN HEALTH RISK ASSESSMENT
FORT RICHARDSON PRDA

Receptor	Media		Total Excess Lifetime Cancer Risk	Noncarcinogenic Hazard Index
Resident	Soil 0 to 15 feet (A-3, A-4, T)			
	Ingestion		2E-06	7E-02
	Inhalation		1E-05	3E-02
		Total	1E-05	1E-01
	Soil 0 to 15 feet (at A-1, A-2, O)			
	Ingestion		2E-08	6E-03
	Inhalation		2E-07	2E-02
		Total	2E-07	3E-02
	Hot spot soil, 14 feet (hillside)		3E-04	--
	Groundwater (Shallow Zone)		3E-01	2E+02
	Groundwater (Deep Aquifer)		4E-02	2.5E+01
	Surface Water (Wetland)		-	9E-01
	Ingestion of Sediments (Wetland)		2E-08	2E-01
Industrial Worker	Soil Ingestion (A-3, A-4, T)		2E-07	2E-03
	Soil Ingestion (A-1, A-2, O)		2E-09	2E-04
	Hot spot soil (hillside)		4E-05	--
	Ingestion of Sediments (Wetland)		2E-09	8E-03

-- = Not evaluated.

1.0
INTRODUCTION

The United States Army Corps of Engineers (USACE), Alaska District, retained Woodward-Clyde Federal Services (WC) to perform a Remedial Investigation (RI) at Operable Unit B (OUB) at the Fort Richardson Army post near Anchorage, Alaska. Operable Unit B consists of one site, the Poleline Road Disposal Area (PRDA). In 1994 Fort Richardson was placed on the National Priority List under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and all RI work performed for the PRDA was in compliance with CERCLA. Work also was in compliance with the draft Federal Facilities Agreement negotiated among the Army, the United States Environmental Protection Agency (EPA), and the Alaska Department of Environmental Conservation (ADEC). The OUB RI project was assigned Delivery Order Number 013, under terms of USACE contract Number DACA85-94-D-0005. The scope of the RI was provided by the USACE in a Statement of Work (SOW) dated May 3, 1995, and a SOW for Delivery Order Modification No. 1 dated July 12, 1995. The SOW included a human health risk assessment (HHRA) and an ecological risk assessment (ERA).

This Risk Assessment Report includes baseline human health and ecological risk assessments for the PRDA. It accompanies the Remedial Investigation Report (WC 1996), which describes the conduct and results of field investigations conducted by WC in 1995 for soil, groundwater, and wetlands.

Previous investigations and a removal action conducted in 1994 at the PRDA had revealed the presence of unexploded ordnance, chemical warfare materials (CWM), other debris, and decontamination solutions (mainly chlorinated solvents) in subsurface soil at the site. Chlorinated solvents were detected in shallow and deep water-bearing zones at the site, as well as in discontinuous perched zones. The RI was conducted to obtain adequate data to characterize the nature and extent of contamination at the site, perform a risk assessment, and evaluate remedial alternatives.

1.1 HUMAN HEALTH RISK ASSESSMENT APPROACH

The risk assessments have been prepared in keeping with the approaches outlined in the Remedial Investigation Management Plan (WC 1995a), the Human Health Risk Assessment Approach Document (WC 1995b), and the Screening-Level Baseline Ecological Risk Assessment Approach Document (WC 1995c). However, the HHRA uses reasonable maximum exposure (RME) concentrations of chemicals to estimate risk, rather than maximum chemical concentrations as was described in the Management Plan and the HHRA Approach Document. This change was made following additional review of the final data set for risk assessment, which included RI data and historical data that are still characteristic of current conditions. It was concluded that maximum concentrations were not appropriate estimates of chemical concentrations in the exposure areas being evaluated. Using RME concentrations is consistent with EPA guidance for risk assessment (EPA 1989a). Otherwise, the HHRA was conducted as described in the HHRA Approach Document.

The HHRA compares RME concentrations to conservative health risk-based concentrations (RBCs) for residential and industrial exposure to estimate chemical-specific and cumulative risk from exposure to multiple chemicals and via multiple exposure pathways. Using conservative residential and industrial exposure assumptions will overestimate actual exposure and risk at the PRDA. This conservative approach was taken in order to support decisions for no further action, if appropriate, for environmental media sampled in the RI. The HHRA includes evaluation of data used in risk assessment, assessment of exposure pathways, toxicity assessment, chemical-specific and cumulative risk estimates, and discussion of uncertainties.

More detail on the HHRA approach is presented in Section 5.0 of this report.

1.2 ECOLOGICAL RISK ASSESSMENT APPROACH

The approach for a screening-level baseline ERA was detailed in the Management Plan for OUB and in the Screening-Level Baseline Ecological Risk Assessment Approach Document (WC 1995c). The objective of the ERA is to document whether or not there is potential for ecological impacts, based on available data. The ERA is screening level because (1) it uses available data and assumes values for parameters where data are lacking, and (2) it uses conservative assumptions regarding chemical toxicity and exposure to ensure that potential ecological threats are not overlooked. The risk characterization section of the ERA provides the screening calculations, risk characterization, uncertainty evaluation, and overall summary of potential risk in terms of extent, severity, and probable harm.

More detail on the ERA approach is provided in Section 6.0 of this report.

1.3 ORGANIZATION

The risk assessment report is organized into the following Sections and Appendixes:

1.0	Introduction
2.0	Site Background and Environmental Setting
3.0	Remedial Investigation Results
4.0	Data Evaluation
5.0	Human Health Risk Assessment
6.0	Ecological Risk Assessment
7.0	Summary and Conclusions
8.0	References

Appendix A	Calculation of Concentration Terms for Human Health Risk Assessment
Appendix B	Health Risk Calculations
Appendix C	Calculation of Concentration Terms for Ecological Risk Assessment
Appendix D	Analytical Results for Metals
Appendix E	Toxicity Assessment and RBC Tables
Appendix F	Vapor Intrusion into a Building

2.0
SITE BACKGROUND AND ENVIRONMENTAL SETTING

2.1 SITE BACKGROUND

This section provides a description of the PRDA site location and history, a summary of previous investigations, and a description of the environmental setting including site hydrogeology, demographics and land use, and ecology. This information appears in similar form in the Remedial Investigation Report for Operable Unit B (WC 1996) and is included here because of its relevance to the assessment of health and environmental risk at PRDA. Remedial investigation results and the adequacy of data for risk assessment are discussed in Section 3.0 and Section 4.3.4, respectively.

2.1.1 PRDA Description and Waste Disposal History

The PRDA is located on the Fort Richardson Army Installation, approximately 10 miles northeast of Anchorage, Alaska (Figure 2-1). Fort Richardson occupies 61,500 acres of land. The PRDA is located on about 3 acres approximately 1 mile south of the Eagle River and 0.6 miles north of the Anchorage regional landfill (Figure 2-2). The PRDA lies off of Poleline Road, a major gravel road that runs northeast-southwest along a power line route and the Eklutna Water Line. The PRDA is bisected by Barrs Boulevard, a gravel road extending from the Glenn Highway to Poleline Road.

The PRDA is low-lying and relatively flat and is bordered by two wooded hills on the northwest and southeast. The area where buried waste has been detected by geophysical surveys (the main disposal area) is approximately 1.5 acres in size. The investigation also included a wetland located directly south and southwest of the main disposal area. The remaining area bordering the PRDA is relatively flat and wooded. The main disposal area was cleared of vegetation during a 1994 removal action (OHM 1994a).

The PRDA was identified in 1990 through interviews conducted by the US Army with two ex-servicemen who were stationed at Fort Richardson in the 1950s. The PRDA was a disposal area for chemicals and other materials and was active from approximately 1950 to 1972. Disposed materials may have included chlorinated solvents and other decontaminants (such as bleach) that were used to neutralize chemical warfare agents, smoke bombs, and Japanese cluster bombs. Both types of bombs were detonated in pits prior to burial, but duds may have been dispersed over the area and not recovered. Disposal procedures for chemical warfare materials (CWM) consisted of placing a layer of "bleach/lime" in the bottom of the trench, placing the materials on a pallet in the trench, dousing with diesel fuel, and igniting with thermal grenades. After burning was complete, a mixture of either bleach or lime combined with chlorinated solvent carrier was poured over the remaining materials.

2.1.2 Previous Investigations and Remedial Actions

Several investigations and a removal action have been conducted at the PRDA since its discovery in 1990. Environmental Science and Engineering, Inc. (ESE) conducted site investigations between 1990 and 1992, which included a qualitative geophysical survey, soil sampling, a soil gas survey, installation of 11 monitoring wells, groundwater sampling and water level study, and aquifer (slug) tests (ESE 1990; 1991; 1992; 1993). OHM Remediation Services (OHM) began a removal action in 1993, which was halted when chemical agent identification sets and other materials related to chemical warfare training activities were unearthed. Following a geophysical survey conducted by the USACE's Cold Regions Research and Engineering Laboratory (CRREL), the removal action was completed by OHM in October 1994. The CRREL performed another geophysical survey in June 1995 to determine whether any suspicious material remained in the recently excavated areas and to define more accurately anomalous zones in areas not excavated in 1994. A brief summary of previous investigations is presented below.

The geophysical surveys conducted in 1990 and 1994 located four disposal areas within the PRDA (Areas A-1 through A-4, which are indicated in Figure 3-1). Areas A-3 and A-4, which showed the greatest evidence of buried waste, were the subject of the OHM removal action. Solid materials removed from Areas A-3 and A-4 included various munitions, small and large containers with chemical residues or labels, and other debris.

Chemical analyses of soil and groundwater samples (ESE 1991, 1992; OHM 1993, 1994a, 1994b) confirmed that chlorinated solvents, especially trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,2,2-tetrachloroethane, were disposed at the PRDA. Solvents were detected in soils and in groundwater samples from both the shallow (top of water is about 20 feet bgs) and deep (top of water is between 80 and 160 feet bgs) water-bearing zones. Concentrations of metals were within regional background levels as compiled by ESE in their previous investigations (ESE 1991). Semivolatile organics have not been detected at the site. The only CWM detected in soils was adamsite. Adamsite is an arsenic-based vomiting agent used in aerosol form for riot control. No CWM were detected in groundwater. Explosives and CWM breakdown products were not detected during the previous investigations (prior to the RI) except for one detection of RDX in a groundwater sample from monitoring well MW-5 (Figure 3-1).

During the removal action, soils excavated by OHM from Areas A-3 and A-4 were sampled and analyzed for TCE, PCE, and 1,1,2,2-tetrachloroethane. Sample results were compared to the removal action levels listed below. The removal action levels are based on a 10^{-5} (1 in 100,000) excess cancer risk level assuming residential soil ingestion and were approved by ADEC for purposes of the removal action:

TCE	600 mg/kg
PCE	100 mg/kg
1, 1, 2, 2-Tetrachloroethane	30 mg/kg

After buried debris was removed, confirmation soil sampling was performed in the excavations to confirm that soils exceeding the removal action levels had been removed. Soils were excavated to a maximum depth of 14 feet, where water was encountered.

Soils that met the removal action levels were mixed with borrow soil and returned to the excavations. No additional soil cover was placed in Areas A-3 and A-4. Soils that exceeded the action levels were stockpiled southeast of the site in lined, plastic-covered piles surrounded by berms. The stockpile area is currently fenced.

Areas A-1 and A-2 have not been excavated (Figure 3-1). However, an 18-inch soil cover was placed by OHM in 1994, resulting in approximately 3 feet of soil overlying the apparent disposal horizon (18 inches of soil originally overlying the disposal horizon, plus the 18-inch soil cover). Based on the geophysical survey, these areas are expected to contain less significant quantities of buried waste than found in Areas A-3 and A-4. Information from an ex-soldier indicated that undetonated bomblets from cluster bombs may be buried in Areas A-1 and A-2.

The condition of the wetland to the southwest of PRDA was largely unknown prior to the 1995 RI. Based on the geophysical survey conducted in 1994, the wetlands may contain small dispersed metallic objects.

2.2 ENVIRONMENTAL SETTING

2.2.1 Geology

The PRDA is located in the Susitna Lowland of south-central Alaska (ESE 1991). Local relief generally ranges from 50 to 250 feet above sea level. The region was glaciated repeatedly in Quaternary time and remains glaciated today. Discontinuous lenses of permafrost exist in the region but continuous permafrost is not present.

The surficial deposits of the region are fluvially reworked glacial sediments and glacial tills. These deposits appear to be up to 30 feet thick at the site and consist of unstratified to poorly stratified clays, silts, sands, gravels, and boulders. A somewhat denser basal till lies below the surficial deposits. The shallow ground water interval lies directly above the basal till. The basal till appears to be about 100 feet thick at the site and overlies an advance moraine/till complex. Individual stratigraphic units are discontinuous and are difficult to correlate between borings. This is typical of glacial deposits.

Underlying the glacial sediments is bedrock composed of a hard black fissile claystone with fine sandy siltstone interbeds (ESE 1991). Bedrock was encountered beneath the PRDA at between 80 and 160 feet below grade, according to boring logs produced from the previous and current investigations.

2.2.2 Hydrogeology

Groundwater in the Anchorage-Eagle River area occurs in both glacio-fluvial deposits and fractured bedrock zones (ADNR 1992). Individual water-bearing zones in the glacio-fluvial deposits are separated by silt and clay intervals, and some of the deeper water-bearing zones are semi-confined. Groundwater in the fractured bedrock is also semi-confined due to silts and clays overlying the bedrock.

Three distinct water-bearing units have been identified at PRDA and evidence of others has been observed. The three identified water-bearing units are a perched zone, a shallow zone, and a deep aquifer. These three units appear to be interconnected, but the degree of this interconnection is unknown. Other water-bearing units between the shallow zone and deep aquifer were observed while drilling MW-16, located about 600 feet northeast of PRDA (Figure 3-1).

The perched zone was observed in borings drilled between Areas A-2 and wetlands, and in Area A-3. The top of the perched zone was encountered at 4 to 10 feet below ground surface (bgs), and the bottom was found at 6 to 12 feet bgs. The perched zone appears to be recharged by infiltration of precipitation and surface water from the wetlands. The only well installed in the perched zone is MW-14, located at the northwest corner of Area A-3 (Figure 3-1).

The shallow zone was encountered in nearly all the soil borings drilled at the site and most of the wells at PRDA are installed in it. The shallow zone appears to be recharged by infiltration of precipitation and from the perched zone.

The hydraulic properties of the shallow water-bearing zone are variable (ESE 1991). Water-bearing deposits are localized and of limited extent, and groundwater may occur in many different units throughout the strata as perched water, confined zones, and unconfined zones. Shallow groundwater appears to flow locally in a north-northeast direction but trends northwest on a regional basis and probably discharges to the Eagle River. Because of the localized nature of water-bearing units, it is difficult to tell whether the water-bearing units are hydraulically connected between wells. The shallow water-bearing zone does not appear to meet the definition of an aquifer (saturated, and sufficiently permeable to transmit economic quantities of water).

There is no information on the depth and flow direction of groundwater beneath the wetlands, and it is possible that flow direction fluctuates seasonally in the area. The interaction between groundwater beneath the main disposal area and the wetlands is unknown.

Five monitoring wells at the PRDA penetrate bedrock, which was encountered from approximately 80 to 160 feet below surface. The deep wells are screened in both the bedrock and in an unconsolidated deposit that lies directly above the bedrock. Groundwater flow in the bedrock is at least partially controlled by the frequency of fractures. Solvents were detected in the deep aquifer, but the degree of interconnection between the shallow zone and the deep aquifer is not clear. The flow direction in the deep aquifer is locally to the northeast and regionally to the northwest.

2.2.3 Hydrology and Area Water Usage

There are no rivers or streams or obvious surface water drainages in the immediate vicinity of the PRDA; the closest are the Eagle River approximately 1 mile to the north and Fossil Creek about 0.4 mile to the southeast. The Eagle River has the largest drainage area of the nearby streams. Five smaller creeks (Clunie, Fossil, Ship, Chester, and North Fork of Campbell) traverse the post (USACE 1994a). Ship Creek, which is located south of PRDA and in a different drainage basin, provides industrial water for Anchorage, Fort Richardson, and the adjacent Elmendorf Air Force Base. Ship Creek also provides drinking water for Fort Richardson. Wetlands occupy small or large basins in the rolling to hummocky terrain and appear to be isolated from each other and from the closest rivers and streams. No flowing water was found in these closed basins.

The ultimate discharge of the shallow water-bearing zone at the PRDA is probably the Eagle River. The Eagle River flows into the Knik Arm of Cook Inlet approximately 5 miles northwest of the PRDA. The river is not used as a drinking water supply.

The cities of Anchorage and Eagle River obtain drinking water from groundwater and from Eklutna Lake, over 15 miles from the PRDA. Groundwater is obtained from several isolated glacio-fluvial and bedrock aquifers (ADNR 1992). Available data indicate that the drinking water aquifers are not hydraulically connected with groundwater beneath the PRDA.

2.2.4 Nearby Water Wells

A database owned by the State of Alaska Division of Water Management and the United States Geological Survey (USGS) Water Resources Division was used to locate nearby water wells.

However, records on wells in this area are incomplete. The closest wells with available location data were plotted on a USGS topographic map (Figure 2-3). According to the database, there are 12 wells within a 1-mile radius of the PRDA, 566 wells within 3 miles and 1083 wells within 5 miles. The database does not contain information on the present status of the wells, or whether the wells are used for municipal, industrial or residential purposes. The nearest known drinking water well is approximately 1.2 miles east of the site. The zone it is screened in is unknown. Several water wells were abandoned in the 1980s with the merging of water districts in the Eagle River area under the Anchorage Water and Wastewater Utility, and with the availability of treated water from Eklutna Lake.

The closest wells to the PRDA are to the south and were drilled for the Municipality of Anchorage as a part of the monitoring system for the Anchorage regional landfill. Other nearby wells were drilled for the Alaska Department of Corrections facility off Hiland Road and the Eagle River Campground (both over a mile east of the PRDA), and a subdivision west of the Glenn Highway and east of the Eagle River (northeast of and across the river from the PRDA). There are no wells located to the north, between the PRDA and the Eagle River.

2.2.5 Demographics and Land Use

Land use surrounding Fort Richardson is dominated by military, State of Alaska, and residential land holdings (ESE 1991). Elmendorf Air Force Base and Fort Richardson Army Installation surround the PRDA. The area is currently under the control of the Fort Richardson Range Control Office.

There are two major population centers within 10 miles of the PRDA. The city of Eagle River is approximately 2 miles northeast of the site, and the city of Anchorage is approximately 10 miles to the southwest. The combined population of the Eagle River-Anchorage area is approximately 225,000. The Eagle River area serves as a suburban community for Fort Richardson personnel and for Anchorage. Directly east of the site lies Chugach State Park, which borders the southern and eastern boundaries of Fort Richardson. The Alaska Railroad passes approximately 1 mile northwest of the PRDA.

The PRDA area has been used the last several years for outdoor field training by Army troops. The immediate area surrounding the PRDA is currently closed to training activities (Gardner, pers. comm.), but the site can be accessed by vehicle via Poleline Road. Hunting is not allowed in the area, but Fort Richardson allows the public to fish in the nearby Eagle River. Cross-country skiers also use the area.

Future land use includes the potential for closure of Fort Richardson. A pipeline carrying drinking water from Eklutna Lake (over 15 miles from the site) runs through the area. It is unlikely that groundwater would be used for a drinking water supply. The area is not suitable for agricultural purposes. The potential for future residential use of the area is remote, but was considered for screening purposes in the risk assessment.

2.2.6 Ecology

The general ecological setting is described briefly here. A more detailed discussion is provided in Section 6.0, Ecological Risk Assessment. The description of ecological conditions is based on a site visit on July 25, 1995, previous documents describing the site (USACE 1994a, ESE 1991), aerial photographs, and a review of available ecological literature.

The PRDA consists of a relatively small clearing of mostly unvegetated ground, surrounded by a large area of forested land with scattered wetlands. Four major habitat types are present at and near the site: spruce-hardwood forest, wetland, herbaceous vegetation, and unvegetated areas due to clearing of the site.

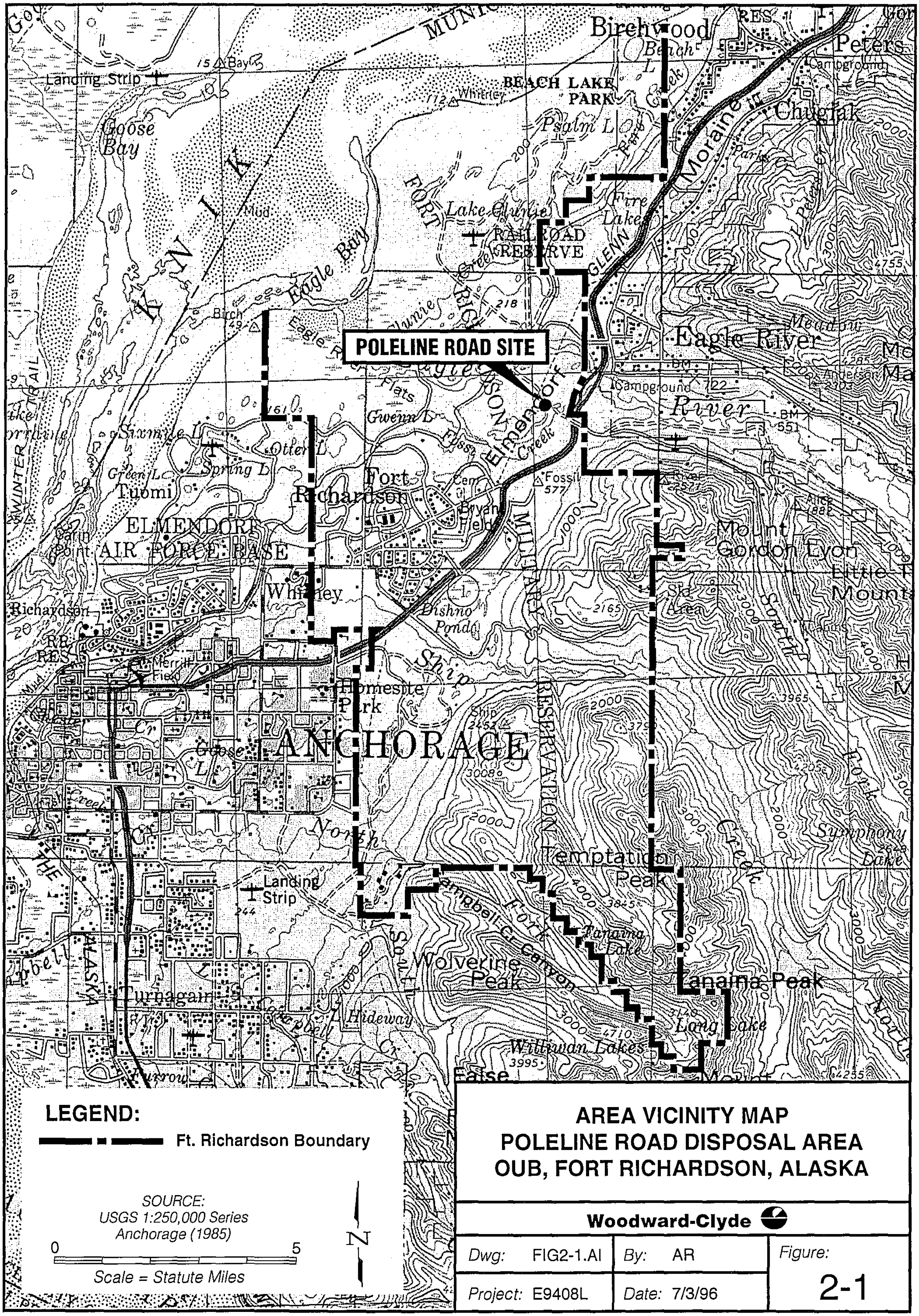
Spruce-hardwood forest, consisting of paper birch, aspen and white spruce, is the predominant vegetation type in upland areas surrounding the PRDA clearing. The understory is comprised of numerous shrubs.

Moose and black bear are common in the PRDA vicinity and grizzly bear may occur occasionally. Various small mammals and raptors are likely to be present; however, no raptor nests were observed at or near the PRDA. Relatively little wildlife or its sign was observed during the July 1995 site visit, but numerous wolf tracks were observed in February and March 1996.

A 4- to 5-acre wetland is present immediately south of the PRDA clearing, and several smaller wetlands (< 1 acre) also occur in the vicinity. They are isolated, are not nurseries for fish, and have a low diversity of vegetation. They probably function primarily for water collection and groundwater recharge. The wetlands provide potential habitat for a number of waterfowl and groundwater recharge. The wetlands provide potential habitat for a number of waterfowl and shorebird species, but they appear to be too shallow and densely vegetated to have significant waterfowl use or breeding. No waterfowl or shorebirds were observed during the field visit. Wildlife habitat values are also low. Muskrat trails were observed, and moose and bird use probably occurs.

No federally listed threatened or endangered species are known or expected to use the PRDA area or vicinity. Peregrine falcon could occasionally fly over the area, but no key habitat features are present at or near the PRDA site.

Two category 2 candidate species for listing may occur: North American lynx and northern goshawk. Category 2 species are those which for which listing as threatened or endangered may be appropriate, but for which further information on threats or rarity is needed to support listing. Based on habitat preference, lynx are likely to be present in the successional forests surrounding the PRDA. Northern goshawk inhabit a large part of Alaska, preferring dense forested areas, especially old growth. Suitable habitat was not observed near the PRDA and northern goshawk are not expected to occur except occasionally on migration.



LEGEND:

▬ ▪ ▬ Ft. Richardson Boundary

SOURCE:
USGS 1:250,000 Series
Anchorage (1985)

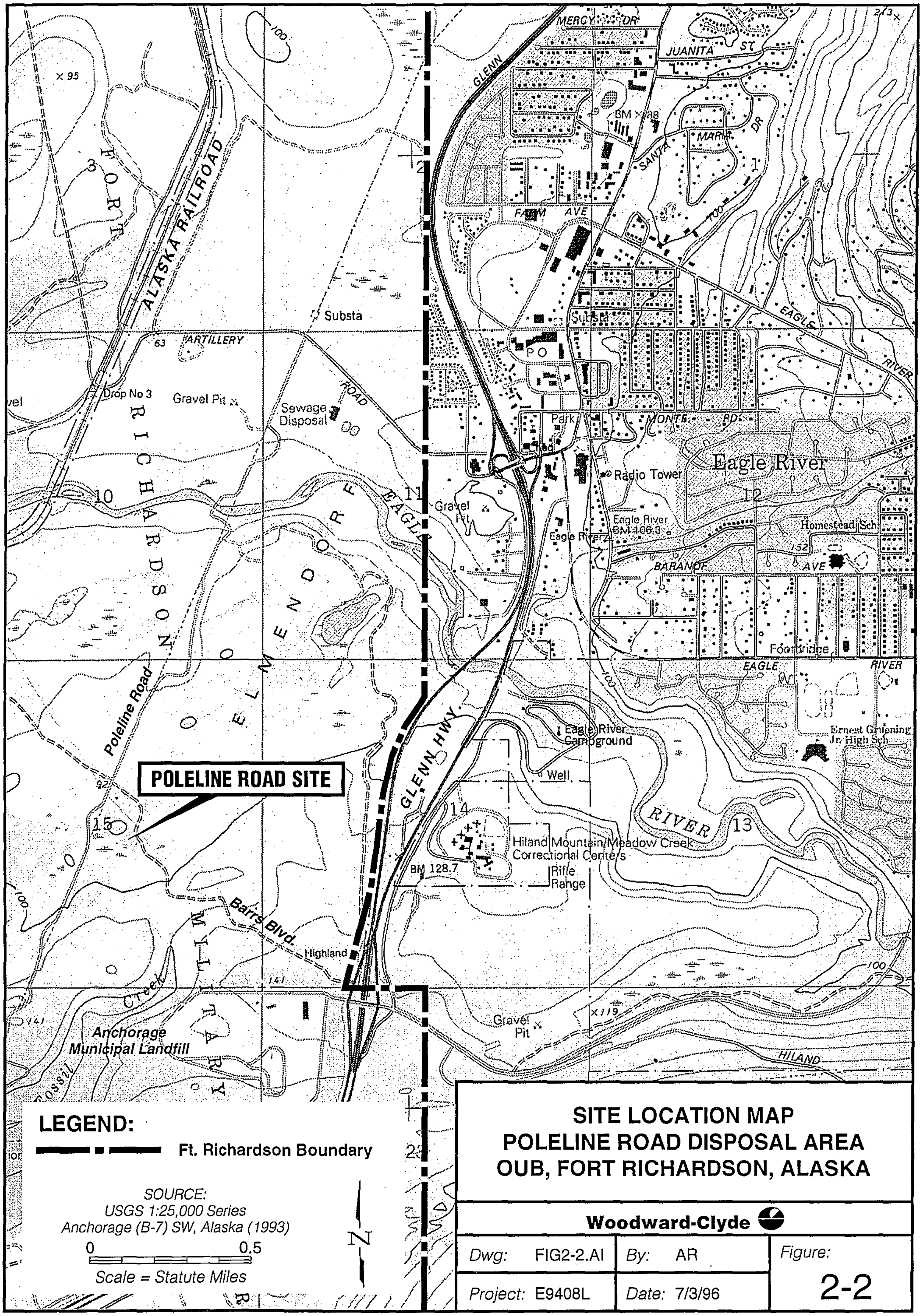
0 5
Scale = Statute Miles

N

AREA VICINITY MAP
POLELINE ROAD DISPOSAL AREA
OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIG2-1.AI	By: AR	Figure:
Project: E9408L	Date: 7/3/96	2-1



LEGEND:

▬ ▪ ▬ Ft. Richardson Boundary

SOURCE:
USGS 1:25,000 Series
Anchorage (B-7) SW, Alaska (1993)

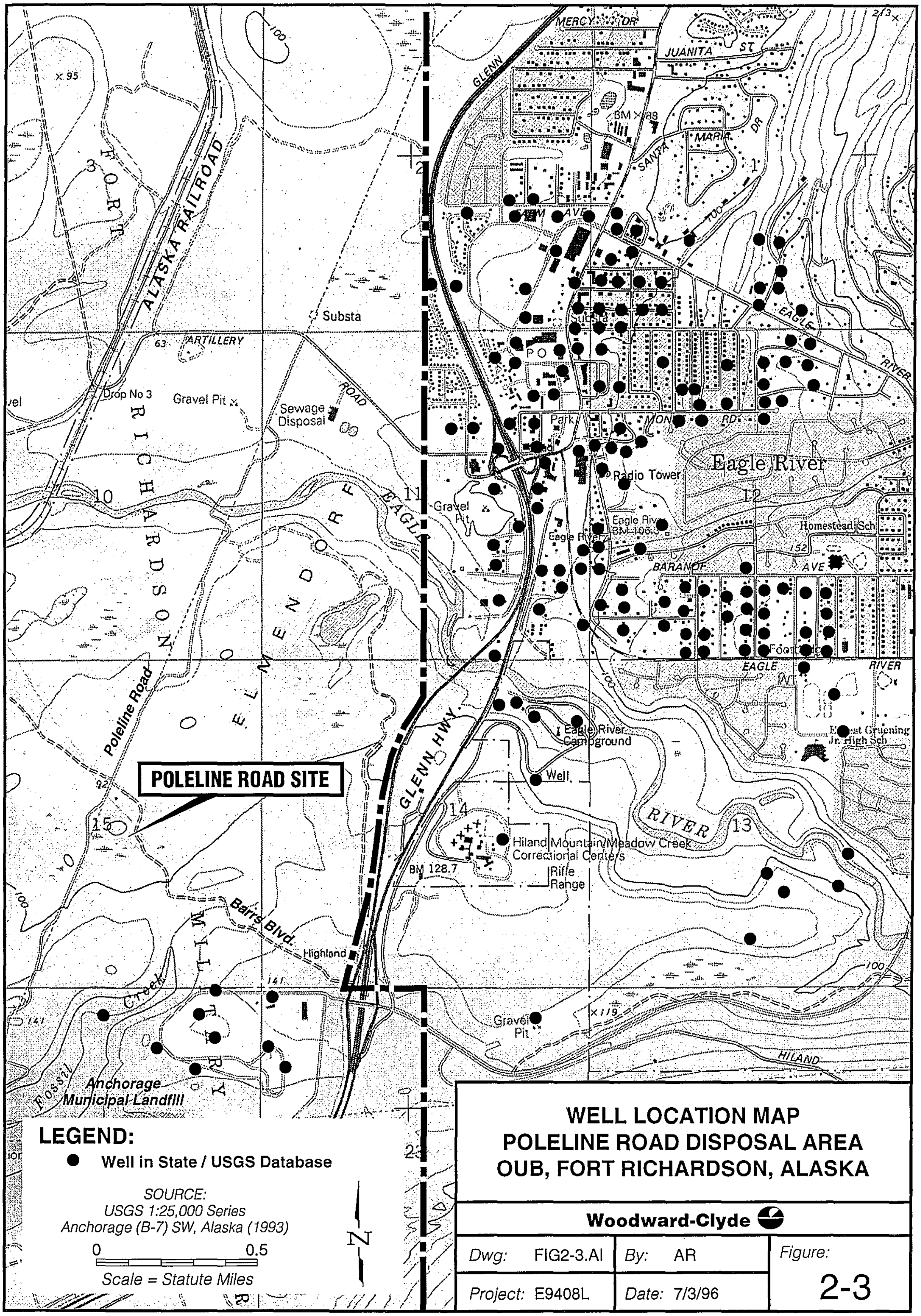
0 0.5

Scale = Statute Miles

SITE LOCATION MAP
POLELINE ROAD DISPOSAL AREA
OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIG2-2.AI	*By:* AR	*Figure:*
Project: E9408L	*Date:* 7/3/96	2-2



LEGEND:

● Well in State / USGS Database

SOURCE:
USGS 1:25,000 Series
Anchorage (B-7) SW, Alaska (1993)

0 0.5

Scale = Statute Miles

N

WELL LOCATION MAP
POLELINE ROAD DISPOSAL AREA
OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIG2-3.AI	*By:* AR	*Figure:*
Project: E9408L	*Date:* 7/3/96	2-3

3.0
REMEDIAL INVESTIGATION RESULTS

This section presents a brief summary of the nature and extent of contamination at the PRDA based on the results of the 1995 RI field investigation. The field activities, sampling and analysis plan, chemical analytical results, and quality assurance/quality control review are presented in detail in the Remedial Investigation Report, Operable Unit B (WC 1996).

The investigation included soil, groundwater, and sediment and surface water in the adjacent wetland.

3.1 SOIL SAMPLING RESULTS

Soil samples were collected from borings in the areas listed below. Areas A-1 through A-4 are indicated in Figure 3-1.

- The perimeter of Areas A-1 and A-2 (where geophysical surveys were completed but no excavation has occurred): to determine whether contaminant migration has occurred;
- Areas A-3 and A-4 (site of the 1994 removal action): to verify residual VOC concentrations in the backfill and below the excavation;
- Toe of the hill southwest of Area A-3: three borings to determine potential contaminant migration to the wetland; and
- Other areas outside the known or suspected disposal areas: to identify contaminant migration, if any.

Over 250 soil samples (collected continuously in 3-foot intervals from the surface to bottom of borehole) were analyzed in the field by gas chromatograph (GC) for chlorinated solvents and 198 samples were screened for mustard. Samples were collected at a rate of about 10 percent for off-site laboratory analysis of VOCs, priority pollutant metals, explosives, and CWM (37 samples). Mustard and CWM were not detected in any of the samples analyzed, and only minor detections of explosives were reported. Therefore, the following discussion focuses on analytical results for VOCs and metals.

3.1.1 Soil in Areas A-1 and A-2

Fifteen soil borings were drilled around Areas A-1 and A-2, and soil samples were collected continuously over 3-foot intervals. No borings were placed within Areas A-1 and A-2 because of the potential for unexploded ordnance. Boring locations are shown in Figure 3-1.

Relatively low levels of contamination by chlorinated solvents were found in this investigation area. Of 74 soil samples analyzed by field GC for chlorinated solvents, only 1,1,2,2-tetrachloroethane was detected in 6 samples, ranging in concentration from 0.12 mg/kg (at MW-13 at 26-28 feet bgs) to 1.7 mg/kg (at SB-B1 at 4-6 feet bgs). No other VOCs were detected by field screening (detection limit was 0.05 mg/kg).

In 7 split samples analyzed off-site for VOCs and priority pollutant metals, the only VOCs detected were chloroform (1 sample, 0.004 mg/kg) and trichloroethene (2 samples, 0.001 and 0.004 mg/kg). In a statistical background comparison performed for the risk assessment, only lead and mercury were found to be above background levels (see Section 4.4).

3.1.2 Soil in Areas A-3 and A-4

Areas A-3 and A-4 were the site of the 1994 removal action; the excavation pits were backfilled with soil meeting ADEC removal action levels described in Section 2.1. In the 1995 RI, three soil borings were drilled inside Area A-3 and two soil borings were drilled inside Area A-4 to verify the level of residual contamination in the backfilled soil and to evaluate contaminant levels below the backfill. In addition, samples were collected during the installation of MW-14. Boring locations are shown in Figure 3-1.

Twenty-four soil samples were collected and analyzed by field GC for halogenated solvents, and 14 split samples were collected for laboratory VOC analysis. Chlorinated solvents were found in most of the samples. TCE and 1,1,2,2-tetrachloroethane were the most frequently detected and had the highest concentrations, as summarized below for soil 0 to 15 feet bgs and soil deeper than 15 feet. The interval of 0 to 15 feet was selected to correspond to the soil depth evaluated in the HHRA, as discussed in Section 4.0.

Concentration Ranges in Soil (Areas A-3 and A-4), mg/kg

Chemical	0 - 15 ft	> 15 ft
TCE	[0.001] to [1.8]	[0.620] to 384
1,1,2,2-Tetrachloroethane	[0.002] to [8.1]	0.480 to 2,030

[1.4]	Result from laboratory analysis by Method 8260.
480	Result from field GC (no brackets).

The highest concentrations were found in the soil sample collected from MW-14 at 16 to 18 feet bgs. Cis-1,2-dichloroethane, trans-1,2-dichloroethene, tetrachloroethene, and other chlorinated hydrocarbons were also detected, generally in much lower concentrations.

The high concentrations of solvents detected at 16 to 18 feet bgs at MW-14 is consistent with solvent concentrations measured in a soil sample collected at a similar depth from the bottom of the excavation in Area A-3 (1,1,2,2-tetrachloroethane detected at 2,920 mg/kg). These data suggest that there may be a layer of soil with high concentrations of 1,1,2,2-tetrachloroethane starting at around 16 feet bgs. (Soil at MW-14 was not excavated in the removal action because excavation there would have destabilized the slope above the excavation.)

Fourteen soil samples were collected for metals analyses inside the boundaries of Areas A-3 and A-4, including a sample from the boring for MW-14. Several metals in Area A-4 exceeded background levels based on the statistical comparison discussed in Section 4.4. The metals and their maximum concentrations were copper (190 mg/kg), lead (160 mg/kg), silver (1.9 mg/kg), zinc (1000 mg/kg), and mercury (0.58 mg/kg).

3.1.3 Soil in Other Areas and Toe of Hill

Five soil borings were drilled south of Areas A-1 and A-2, and fifteen soil borings were drilled north of Areas A-1 and A-2, including 7 borings drilled in a road bulldozed through the woods northeast of Area A-1 (Figure 3-1). Samples were collected from soil borings and from monitoring well installations. In addition, three borings were drilled in the "toe of hill" between Area A-3 and the wetland. The purpose of these borings was to evaluate whether contaminants were migrating from Area A-3 toward the wetland.

Relatively little contamination was found at these sampling locations. For example, out of a total of 170 samples analyzed by field GC for chlorinated solvents, only TCE (2 samples) and 1,1,2,2-tetrachloroethane (11 samples) were detected. The highest levels were detected in SB-O3 at about 25 feet bgs, where TCE was detected at 0.76 mg/kg and 1,1,2,2-tetrachloroethane was detected at 5.75 mg/kg.

Sixteen split samples were submitted for laboratory analyses for VOCs and other analytes. A few chlorinated hydrocarbons were detected in 1 to 4 samples each at low concentrations ranging from less than 0.010 mg/kg to 0.24 mg/kg, confirming the relatively low concentrations of VOCs measured by field GC at these locations.

Metals concentrations in 17 soil samples were comparable to background levels, with the exception of mercury (maximum concentration = 0.2 mg/kg; background maximum = 0.1 mg/kg).

3.1.4 Soil Summary

Chlorinated solvents were detected frequently at the PRDA. Investigated areas in order of decreasing solvent concentrations are (1) unexcavated portions of Area A-3, (2) the backfilled soil in Areas A-3 and A-4, and (3) soils east of Areas A-3 and A-4 and south of Area A-2. No VOCs were detected in soil samples collected around the perimeter of Area A-1. This pattern suggests that Areas A-3 and A-4 were the source of VOCs at the site.

Based on the statistical background comparison discussed in Section 4.4, five metals were detected above background levels in samples from Area A-4 (copper, lead, mercury, silver, and zinc). Mercury and lead were found above background levels in Areas A-1 and A-2, and mercury was found above the background range in a few samples collected in areas outside Areas A-1 through A-4. CWM, explosives, and mustard were not detected in any soil samples.

3.2 GROUNDWATER

Groundwater samples were collected from nearly all of the soil borings (34 well point samples) and analyzed for chlorinated solvents by field GC. All well points were in the shallow saturated zone or in the perched zone. A total of 17 permanent monitoring wells have been installed, including 11 installed previously by ESE and 6 installed by WC. Two wells (MW-10 and MW-11) were dry and could not be sampled in the RI. Monitoring wells and well points and the zones in which they were screened are listed in Table 4-3.

The locations of monitoring wells installed in 1995 were selected after reviewing the well point data. The monitoring wells were located to be near the edge of the area of impacted groundwater and to be adequately distributed to permit the development of groundwater contour maps based on water level measurements. The location for MW-14 was selected to provide data in the area of suspected solvent release. (Monitoring well locations are shown in Figure 3-1.)

Fourteen samples (one sampling round) were collected from the permanent monitoring wells (MW-10 and MW-11 were dry and MW-17 is the background well). These samples and 10 percent of the well point samples were analyzed at an off-site laboratory for VOCs, priority pollutant metals, explosives, and CWM.

The discussion of investigation results for chlorinated solvents and other VOCs is divided into sections on the perched zone, shallow zone, and deep aquifer. Groundwater results for metals, explosives, and CWM, which were not significant contaminants, are addressed together for all saturated zones.

No evidence of dense non-aqueous phase liquid (DNAPL) was found in any monitoring well.

3.2.1 Perched Zone VOCs

Thirteen well points were located in the perched zone, as is MW-14. Chlorinated solvents were detected in 4 of the 13 well point samples analyzed by field GC. The four sampling points where VOCs were detected (SB-B1, -C1, -C2, and -C3) are located in and near Area A-3. Concentrations were highest in SB-B1. Detected concentrations of TCE ranged from 0.519 mg/L to 31 mg/L; 1,1,2,2-tetrachloroethane ranged from 0.122 mg/L to 68 mg/L, and cis-1,2-dichloroethene ranged from 0.182 mg/L to 3.1 mg/L. Other solvents were detected in lower concentrations.

In Area A-3, the levels of 1,1,2,2-tetrachloroethane are highest in the northern portion of the area (52 mg/L in SB-C1) and then decrease to the south (5.7 mg/L in SB-C2 and 0.122 mg/L in SB-C3). The other VOCs detected had concentrations in nearly the same pattern as 1,1,2,2-tetrachloroethane except at lower levels.

The sample from MW-14 contained the highest concentrations of solvents detected in any monitoring well. This well is located in the heart of the suspected source of solvent release. For example, TCE was detected at 220 mg/L, 1,1,2,2-tetrachloroethane at 1,900 mg/L, and cis-1,2-dichloroethene at 37 mg/L. Other chlorinated hydrocarbons were detected in concentrations ranging from 1.4 mg/L chloroform to 12 mg/L trans-1,2-dichloroethene. Benzene was also detected at a concentration of 2.9 mg/L.

3.2.2 Shallow Zone VOCs

A total of 21 samples were collected from well points in the shallow zone and were analyzed by field GC for chlorinated solvents. Concentrations measured in well points in the shallow zone samples were comparable to those measured in the perched zone well point samples. For example, concentrations of TCE (0.057 to 46 mg/L), 1,1,2,2-tetrachloroethane (0.071 to 93 mg/L), and cis-1,2-dichloroethene (0.062 to 1.7 mg/L) were detected in well point samples in the shallow zone. (However, higher concentrations were detected in the perched zone monitoring well MW-14).

Maximum concentrations of solvents in the shallow zone were detected in and near Area A-4 (at locations SB-D1, -D2, and -O13).

Four well point samples were also analyzed at an off-site laboratory for VOCs. The laboratory analysis confirmed high concentrations of solvents in the sample from location SB-O13 and nondetectable concentrations in other samples that were non-detect in field screening. Toluene and chloroform were also detected in low concentrations (0.0005 mg/L) in samples that were analyzed off-site.

Groundwater samples were collected from eight monitoring wells screened in the shallow zone (MW-2, 3, 4, 5, 8, 12, 13, and 15). Solvents were detected in all shallow zone wells except MW-2 and MW-8. Samples from MW-4 and MW-5 contained the highest concentrations of VOCs. For example, the sample from MW-4 contained TCE at 14 mg/L, 1,1,2,2-tetrachloroethane at 71 mg/L, and cis-1,2-dichloroethene at 1.6 mg/L. The sample from MW-5 contained TCE at 4.8 mg/L and 1,1,2,2-tetrachloroethane at 21 mg/L. In other shallow zones wells, concentrations of chlorinated hydrocarbons ranged from 0.0002 to 0.54 mg/L. Benzene (0.00034 mg/L) and chlorobenzene (0.00038 mg/L) also were detected in one well (MW-13).

3.2.3 Deep Aquifer VOCs

Five groundwater samples were collected from monitoring wells screened in the deep aquifer (MW-1, 6, 7, 9, and 16). Solvents were detected in all deep aquifer wells, but concentrations were much lower than detected in the shallow zones, ranging from 0.00031 mg/L trichloroethene in MW-16 to a high of 3.1 mg/L 1,1,2,2-tetrachloroethane in MW-7. Benzene (0.00073 mg/L) and chlorobenzene (0.00055 mg/L) were detected in MW-9.

3.2.4 Total Metals

Four well point samples and 14 monitoring well samples were analyzed for total metals. Results are shown in Appendix D, Tables D-4 and D-5. Bailers were used to collect water samples from well points, and pumps were used at monitoring wells. Well point samples had much higher concentrations of total metals than the samples from the monitoring wells, most likely due to different sampling techniques (bailing vs. dedicated pump) that affected the amount of suspended particulate matter. For example, maximum concentrations in the well point were 100 times or more higher than in the monitoring well samples. The well point results for metals are not considered characteristic of groundwater quality at PRDA because they almost certainly reflect artificially high suspended solids resulting from the sampling technique (i.e., bailer).

In samples from monitoring wells (including background well MW-17), arsenic, chromium, copper, lead, nickel, and zinc were detected, all at concentrations well below Alaska Maximum Contaminant Levels (MCLs) (see Appendix D, Table D-5). MW-17 is screened in the shallow zone. Analytical results for total metals do not suggest that metals are contaminants in groundwater. For example, metals in shallow zone wells were detected at concentrations lower than those measured in the background well (see Table D-5). Total metals concentrations in MW-6 and MW-7 (both in the deep aquifer) were somewhat higher than in the other wells, but the metals are probably related to aquifer characteristics, not contamination, since metals in the shallow zone wells do not exceed background levels.

Metals were rarely detected in filtered samples (Appendix D, Table D-6), suggesting that metals are not being mobilized into aqueous phase by the presence of organic solvents. However, the filtered background sample from MW-17 was non-detect for metals.

In conclusion, metals do not appear to be contaminants in groundwater.

3.2.5 Explosives and Chemical Warfare Materials

2,4-Dinitrotoluene (0.0003 mg/L at SB-B4) was the only explosive detected in well point groundwater samples. CWM was not detected. Only thiodiglycol (0.48 mg/L in MW-14), which is a breakdown product of mustard, was detected in groundwater samples from monitoring wells.

3.2.6 Groundwater Summary

Chlorinated solvents were detected in the perched, shallow, and deep water-bearing zones. The compounds 1,1,2,2-tetrachloroethane and TCE were detected most frequently and at the highest concentrations (up to 1,900 mg/L 1,1,2,2-tetrachloroethane in MW-14). The pattern of solvent detections suggests that the solvents are moving from Areas A-3 and A-4 to the northeast, in both the shallow and deep water-bearing zones. Only two wells did not have solvents detected in groundwater samples (MW-2 and MW-8).

3.3 WETLAND SURFACE WATER AND SEDIMENT

Four co-located surface water and sediment samples (SED-1 to SED-4) were collected from the wetland southwest of the disposal areas to determine if activities at the site have impacted the adjacent wetland. Sample locations (SED-1 through SED-4) are indicated in Figure 3-1. Surface water and sediment samples were analyzed for VOCs, 13 priority pollutant metals, explosives, and CWM. Six background samples for surface water and sediment were collected from three nearby wetlands. Background samples were analyzed for metals only.

In surface water, the only VOC detected was toluene (0.0045 mg/L). Copper (0.01 to 0.1 mg/L), lead (0.004 to 0.008 mg/L), and nickel (0.01 to 0.02 mg/L) were detected in site samples but not in background samples. An explosive, 1,3-dinitrobenzene, was detected in two surface water samples collected at locations SED-1 (0.0034 mg/L) and SED-2 (0.0048 mg/L). However, 1,3-dinitrobenzene was reported non-detect in the two duplicate samples from SED-1. Surface water samples were nondetect for CWM.

VOCs were not detected in the sediment samples. Arsenic, chromium, copper, nickel, and zinc were detected in the sediment samples, but all metals were within background concentrations measured in nearby wetlands (see Section 4.4). Three explosives were detected in one to four samples each. Maximum concentrations of explosives were 1,3,5-trinitrobenzene (0.78 mg/kg), 2,4,6-trinitrotoluene (0.48 mg/kg), and m-nitrotoluene (3.0 mg/kg). No CWM were detected in the sediment samples.

3.4 GROUNDWATER FATE AND TRANSPORT

Groundwater fate and transport modeling was performed to evaluate migration of contaminants in the shallow zone and deep aquifer. The purpose of the modeling was to estimate arrival times and chemical concentrations in groundwater when it discharges into the Eagle River. The groundwater fate and transport modeling is presented in detail in Section 5 and Appendix XIII of the Final Remedial Investigation Report, and a brief summary is provided here. The results of the modeling are considered in the HHRA and ERA.

First, a conceptual model based on the surrounding hydrogeologic characteristics and on physical and chemical processes that affect fate and transport of chemical compounds was developed. Numerical models were then used to simulate groundwater flow (MODFLOW) and chemical migration (MT3D) in the shallow and deep groundwater below the PRDA disposal area. Movement of the perched groundwater was not simulated in the groundwater model, because perched groundwater was not encountered away from the disposal area and is probably not laterally continuous beyond the disposal area. However, contaminants in the perched zones were included as contaminant sources to the shallow and deep aquifer in groundwater transport modeling (Appendix XIII of the RI Report WC 1996).

The numerical model is calibrated such that the computed potentiometric groundwater surface (elevations and hydraulic gradients) and chemical concentrations approximate the observed values. Calibration was achieved by varying the input parameters within a range of reasonable values until the computed values approximate the observed values.

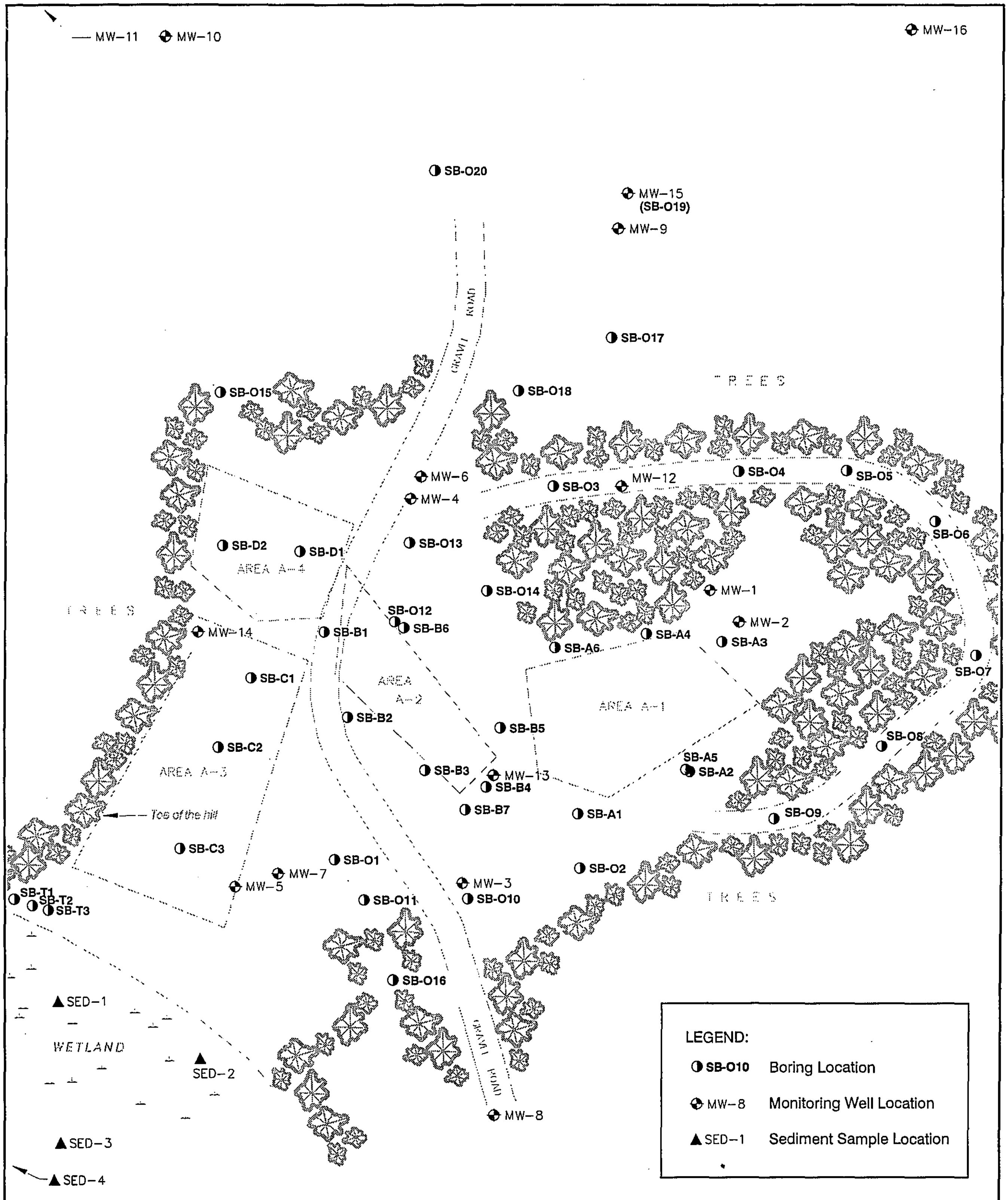
The groundwater transport model was calibrated to the observed concentrations of 1,1,2,2-tetrachloroethane. This constituent was selected because it is not a daughter product of the other compounds detected in groundwater, it has the highest concentrations detected in groundwater, and historical data are available to support calibration.

The PRDA was active from 1950 to 1972. No information characterizing the chemical mass loading from the disposal areas to groundwater is available. Soil samples representative of original contaminant concentrations within disposal Areas A-3 and A-4, the suspected source of contamination, are not available. Source loading (i.e., concentrations and recharge rates) was varied to calibrate the model and approximate the groundwater concentrations observed in 1995.

The calibrated model was used to estimate time for the leading edge of the plume of the shallow zone and deep aquifer to travel to the Eagle River. The leading edge of the plume is defined by 0.005 mg/L, the limit of the model's capability to estimate low concentrations given the uncertainties in the model. Travel times were estimated for three constituents: TCE, 1,1,2,2-tetrachloroethane, and 1,1,2-trichloroethane. The constituent TCE has the smallest retardation factor and as a result migrates through groundwater more quickly than 1,1,2,2-tetrachloroethane or 1,1,2-trichloroethane. Travel times were:

- Shallow zone - TCE (120 years); 1,1,2,2-tetrachloroethane (170 years); 1,1,2-trichloroethane (> 500 years)
- Deep aquifer - TCE (130 years); 1,1,2,2-tetrachloroethane (180 years); 1,1,2-trichloroethane (> 500 years)

The sensitivity of the model results to uncertainty in the model input parameters is presented in Appendix XIII of the Final Remedial Investigation Report. Chief sources of uncertainty in the model are limited information on source loading and the assumption of no source decay over time.



MW-17 (background well) is located southwest of the wetlands - See Figure 4-15 of RI Report.

GRAPHIC SCALE

50 0 50 100 200

(IN FEET)
1 inch = 100 ft.

BORING AND MONITORING WELL LOCATIONS
POLELINE ROAD DISPOSAL AREA
OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIG3-1.DWG	*By:* AR	*Figure:* 3-1
Project: E9408L	*Date:* 7-3-96	

4.0
DATA AGGREGATION AND EVALUATION

Chemical analytical data for the HHRA and ERA were aggregated based on exposure medium and exposure area (Section 4.1). Results from several previous investigations, as well as results of the current investigation, were considered for use in the risk assessment. Data sets included and excluded from the risk assessment are described in Section 4.2. Data qualifiers and detection limits are discussed in Section 4.3 and the comparison to background levels of metals is discussed in Section 4.4.

The chemical analytical results used in the HHRA and ERA are shown in Appendixes A and C. The following sections discuss how the data were selected for use.

4.1 ON-SITE EXPOSURE MEDIA AND EXPOSURE AREAS

Two exposure areas for soil were defined for purposes of assessing risk:

1. Soil in Area A-1 and Area A-2 and from borings in "Other" areas (described in Section 3.1.3). These were grouped as one exposure area (called "A-1, A-2, O") because the areas are adjacent to each other and have not been excavated in a removal action. Borings included are SB-A1 through SB-A6, SB-B1 through SB-B7, SB-O1 through SB-O20, MW-13, MW12, and MW16. Historical data from ESE (1991) were also included (see Section 4.2.1).

2. Soil from Areas A-3, A-4 and from borings at the toe of hill (Area T) adjacent to Area A-3. These were grouped as one exposure area (called "A-3, A-4, T") because Areas A-3 and A-4 appear to be the original source of contamination at PRDA and were previously excavated, and Area T was sampled to evaluate whether it had been affected by releases from Areas A-3 and A-4. Borings included are SB-C1 through SB-C3, SB-D1 and SB-D2, SB-T1 through SB-T3, and MW-14. Excavation sidewall and bottom samples from OHM (1994a) were also included (see Section 4.2.1).

The chemical analytical data for the HHRA were grouped based on exposure medium, exposure area, and soil depth as shown below:

- Soil in exposure area A-1, A-2, O (0-15 feet)
- Soil in exposure area A-3, A-4, T (0-15 feet)
- Groundwater in the shallow zone
- Groundwater in the deep aquifer
- Surface water in the wetland
- Sediments in the wetland

Fifteen feet is considered a typical depth of excavation and therefore soil 0 to 15 feet bgs is a potential exposure medium for humans, assuming hypothetically that excavation occurs prior to construction of residential or commercial buildings. Using sample results from 0 to 15 feet bgs is protective of current exposure to surface soil only because subsurface soil had higher contaminant concentrations than found in the 0 to 3 foot soil interval. Soil deeper than 15 feet is not considered a direct exposure medium for humans; however, soil at approximately 14 feet bgs and deeper, which are more contaminated than shallower soil, were evaluated for vapor intrusion into a building (Appendix F).

The chemical analytical data for the ERA were similarly grouped based on exposure medium., exposure area, and soil depth as shown below:

- Soil in exposure area A-1, A-2, O (0-3 feet)
- Soil in exposure area A-3, A-4, T (0-3 feet)
- Surface water in the wetland
- Sediments in the wetland

Soil to 3 feet is considered a potential exposure medium for plant roots and burrowing animals. Soil deeper than 3 feet is not considered an exposure medium for ecological risk assessment. Likewise, groundwater on-site is not an exposure medium for ecological receptors.

4.2 CHEMICAL ANALYTICAL DATA USED IN RISK ASSESSMENT

Chemical analytical data were available from environmental samples collected during the 1995 RI field investigation and from several previous sampling events. Some available data were eliminated from the data set for risk assessment because they were judged not to characterize current contamination at PRDA or because they were not relevant to human or ecological exposure conditions at the site. Table 4-1 lists sampling events at PRDA that were evaluated for possible use in the risk assessment.

Data sets retained or excluded from the risk assessment are discussed below.

4.2.1 Soil Samples

Analytical data for soil were available from the 1995 RI field investigation (WC 1996) and from three previous sampling events:

- ESE 1991: Samples from 10 soil borings in exposure area A-1, A-2, O analyzed for VOCs and metals.
- OHM 1993: Excavation and soil pile samples from the first removal action at Areas A-3 and A-4.
- OHM 1994a: Excavation and soil pile samples from the completed removal action at Areas A-3 and A-4.

Historical data used in the risk assessment were results from ESE 1991 and from OHM 1994a (excavation sidewall and bottom samples only). These data supplement locations sampled in the RI are considered recent enough to be used in characterizing soil concentrations.

Data from OHM (1993) were not included because most of the soil that was sampled was removed during the completion of the removal action in 1994. Likewise, data from soil pile samples collected during the completion of the removal action (OHM 1994a) were not used because the soil piles from this second excavation were stockpiled or mixed with clean soil prior to being used as backfill. The backfill itself was sampled in the RI (WC 1996).

In addition, three excavation bottom soil samples from Area A-3 collected at about 14 feet bgs in standing perched water by OHM (1995b) were excluded from the data set because construction would not be expected to occur below the water table. However, these samples were considered as a "hot spot" and evaluated separately in Section 5.4.2 and were included in the data set for soil vapor migration (Appendix F).

4.2.2 Groundwater Samples

Analytical data for groundwater were available from the RI field investigation (WC 1996) and from three previous investigations:

- ESE (1991): Two rounds of samples collected in September and October 1990 from 5 monitoring wells (4 in the shallow and 1 in the deep aquifer).

- OHM (1993): Samples from 6 monitoring wells, 3 each in the shallow zone and deep aquifer.

- OHM (1994a): Samples from 5 monitoring wells in the shallow zone.

Groundwater samples obtained by ESE (1991), OHM (1993, 1994a), and WC (1996) were analyzed for some or all of the following analyte groups: VOCs, SVOCs, metals, explosives, and CWM.

All groundwater samples were included in the data set for risk assessment, except for the following:

- Metals analyses of groundwater samples from ESE 1991, OHM 1993, and OHM 1994a.
- Metals analyses of groundwater samples from well points (WC 1996).
- Groundwater samples from the perched aquifer (WC 1996).

The results for metals from the previous investigations and from well points were excluded from the data set for risk assessment because the collection technique used (a bailer) as well as the difficulty of obtaining samples from the well points produces higher amounts of turbulence and suspended particulate matter (and associated metals) than occurs when a dedicated pump is used, as was done for monitoring wells sampled during the RI (WC 1996).

As shown in Table 4-2, analytical results for historical monitoring well samples and well point samples were always higher than results from monitoring wells sampled in the RI. Therefore, based on known sampling procedures and analytical results, the concentrations of metals in groundwater from historical samples and from well points were not considered characteristic of groundwater quality and were not used in the risk assessment.

Samples collected in the RI from the perched water zone were also excluded from the risk assessment. As discussed in Section 2.2.2, the perched zone is not a true aquifer capable of supporting a well. It consists of shallow, discontinuous pools of water that have collected as a result of precipitation and infiltration from the wetlands. Because receptors would not be directly exposed to perched water by ingestion or any other route, contaminants in perched water were not evaluated for direct exposure in the HHRA or ERA. However, perched water was included as a contaminant source in groundwater fate and transport modeling, described in detail in Section 5.0 and Appendix XIII of the RI report (WC 1996).

Table 4-3 lists the monitoring wells and well points sampled in the RI and the water-bearing zone in which they were installed.

4.2.3 Surface Water and Sediment Samples

Surface water and sediment samples were collected at four sampling locations in the wetland and at six background locations (WC 1996). Wetland samples were analyzed for VOCs, metals, explosives, and CWM, and background samples from nearby wetlands were analyzed for metals only. All samples were included in the data set for risk assessment..

4.2.4 Duplicate Samples

When field duplicate samples were collected, the maximum concentration of the duplicate results was used in the data set for risk assessment. Also, when a sample was analyzed by field GC and in the off-site laboratory for VOCs, the higher of the two results was used.

4.3 DATA USABILITY

This section discusses data qualifiers and sample detection limits and their effect on data use in risk assessment.

4.3.1 Data Qualifiers

Chemical data qualifiers are letter codes attached to analytical results by the laboratory or validator to indicate possible problems with chemical identification, quantification, or source. Qualifiers found in the chemical analytical data from the RI are listed below.

- ND qualifier: The analyte was not detected above the sample detection limit (SDL). ND-qualified results were considered non-detect.

- J qualifier: The analyte was positively identified below the SDL, or the sample was analyzed beyond the recommended holding time. The result is considered an estimate because of the uncertainty associated with quantifying the concentrations. Results were used as reported.

- ND, J qualifier: The analyte was not detected above the SDL; the SDL is estimated.

- B qualifier for organics: The chemical was detected in the associated laboratory blank.

- R qualifier for non-detected organics: Maximum holding times were missed. Non-detected results are rejected because of potential reduction in the chemical concentration during storage. R qualified data (all non-detect results) were not used to estimate site exposure concentrations.

In addition, dilution codes were attached to some sample results by the data validator to indicate the magnitude of sample dilution (e.g., D0 represents a 25-fold dilution for groundwater samples collected in the RI). Dilution codes in chemical data tables in Appendix A are explained in footnotes to the tables.

Qualified results were used as reported in the risk assessment with two exceptions. First, for non-detect (ND) results, one-half of the detection limit was used as the sample result in calculating the concentration term for risk assessment, following EPA guidance for risk assessment (EPA 1989a). Secondly, methylene chloride in soil, groundwater, surface water, and sediments was deemed to be a laboratory contaminant based on numerous B-qualified results and professional judgment and was excluded from the data set (see Section 3.4 of the RI Report).

4.3.2 Detection Limits

Sample detection limits varied with the analytical method and with any dilutions required to overcome matrix effects or to permit quantification of high analyte concentrations in some samples. Detection limits for chlorinated solvents in the OHM 1994 soil excavation confirmation samples were typically 5 mg/kg and detection limits for the GC field screening for chlorinated solvents in soils in the RI were typically 0.05 mg/kg. These detection limits are about 10 to 100 times higher than detection limits for chlorinated solvents using EPA Method 8260 in the off-site laboratory (typically 0.005 mg/kg or less) and are substantially higher than contaminant concentrations detected in some areas at the PRDA. Therefore, there is the possibility that the higher reporting limits for the less sensitive methods either conceal the presence of contaminants in samples reported as non-detect or overestimate contaminant concentrations if used at one-half their value to represent analyte concentrations in samples from areas of little or no contamination.

The same effects could occur with elevated reporting limits due to sample dilution, which occurred in some groundwater samples from the shallow zone and deep aquifer.

All sample results were retained in the data set regardless of detection limits; that is, no non-detect results were excluded on the basis of high detection limits associated with the analytical method or elevated detection limits due to dilution. This is a conservative approach that is likely to result in an overestimate of actual concentrations at the site, but evaluation of the analytical results and detection limits supported a conclusion that this would not unduly bias the results of the risk assessment.

For example, numerous chemical data sets shown in Appendix A have a large number of results that are non-detects with detection limits higher than detected concentrations in other samples. When the 95% upper confidence limit (UCL) of the mean is calculated for use as the concentration term in risk assessment, one-half of the detection limit is used for non-detects. For these chemical data sets, the 95% UCL usually significantly exceeded the maximum detected concentration, in which case the maximum detected concentration was used as the RME concentration term in the risk assessment (EPA 1989a). Using the maximum is conservative but did not bias the results of the risk assessment because these chemicals were not risk drivers. In other areas with high detected concentrations, one-half the value of the high or elevated reporting limits could reasonably be considered representative of concentrations in non-detect samples, and the concentration term was dependent upon the detected concentrations, not the detection limits for non-detect samples.

4.3.3 Metals in Groundwater

As discussed in Section 4.2, metals results from historical monitoring well samples (ESE 1991, OHM 1993, and OHM 1994a) and well point samples (WC 1996) were excluded from the data sets for risk assessment because the results are not considered characteristic of groundwater quality at the PRDA.

4.3.4 Sufficiency of Data for Risk Assessment

The data are considered sufficient for risk assessment on the basis of the following:

- Number of samples characterizing the various media (176 soil samples from exposure area A-1, A-2, O; 139 soil samples from exposure area A-3, A-4, T; 45 groundwater samples from the shallow zone; and 10 groundwater samples from the deep zone);

- Adequacy of data quality (described in the Data Quality Assessment in Section 3.0 of the RI Report); and

- Adequacy of detection limits (see Section 4.3.2).

4.4 BACKGROUND COMPARISON

Local background samples were collected for soil (16 samples), groundwater (1 sample from MW-17), and wetland surface water and sediment (6 samples each). To determine whether metals detected in these media at PRDA were naturally occurring or potentially site-related, background comparisons were performed using the methodologies described below.

4.4.1 Statistical Comparison for Soil, Surface Water, and Sediment Samples

Statistical background comparisons were performed for metals in soil, surface water, and sediment. Depending on the number of non-detects present and the distribution of the data, site soil, sediment, and surface water concentrations were compared to background concentrations using one of the following techniques:

- Comparison of 95 percent confidence intervals (95% CIs) around the site mean and background mean concentration (CIs are calculated using a t statistic, and this comparison is analogous to a t-test).
- Comparison of site range to background range.

If the detection frequency was greater than 50 percent for both the background and site data and both background and site data were normally or lognormally distributed, then the data were compared using 95% CIs around the means. Confidence intervals that overlap indicate that the site and background populations are not significantly different. If the lower CI of the site mean exceeds the upper CI of the background mean, then the site population is significantly higher than that of background. For example, a mean with a CI of 23 to 33 would be significantly higher than a mean with a CI of 13 to 18 but not significantly different from one with a CI of 19 to 25. Normality of the data was tested using the W test (Gilbert 1987). If the data were not found to be normal, the data were log transformed and the transformed data were tested.

If the detection frequency was less than or equal to 50 percent for either the background or site data or if either the background or site data were not normally or lognormally distributed (i.e., if the data cannot be compared using a t-test), then site and background populations were compared using ranges of the data. Site concentrations were considered comparable to background levels if the site range fell within the background range. If the maximum site concentration exceeded the background maximum, the metal was considered to be above the background level. These metals are noted in Tables 4-4 and 4-5.

Metals whose site concentrations were judged not to exceed background were not considered to be site-related contaminants and were excluded from the data sets for the HHRA and ERA.

4.4.2 Qualitative Comparison for Groundwater

Because there is only one groundwater background sample for the shallow zone and none for the deep aquifer, a statistical background comparison was not performed for groundwater. Instead, site concentrations of metals in groundwater were qualitatively compared to those in the background sample. As discussed in Section 3.2.4, the metals results do not suggest that metals are contaminants in groundwater, and they are not evaluated in the risk assessment.

4.4.3 Results of Background Comparison for HHRA

Soils: Background comparisons for the HHRA were performed for soil samples collected at depths up to 15 feet (the lowest depth of potential direct human exposure). Results for exposure area A-1, A-2, O and exposure area A-3, A-4, T are presented in Tables 4-4 and 4-5, respectively, and summarized below:

Metals Above Background in Soil 0 to 15 Feet

Exposure Area A-1, A-2, O	Exposure Area A-3, A-4, T
Lead	Copper
Mercury	Lead
	Mercury
	Silver
	Zinc

These metals were evaluated in the HHRA. Other metals were not statistically different than background levels and were eliminated from further evaluation.

Groundwater: As discussed in Sections 3.2.4 and 4.4.2, metals in groundwater at PRDA are not considered to be site-related contaminants and were not included in the HHRA data set.

Wetlands: Background comparison results for wetland surface water and sediment are presented in Tables 4-6 and 4-7, respectively. In surface water, copper, lead, and nickel were detected in site samples but not in background samples and were therefore retained for further evaluation in the HHRA. Zinc in surface water did not exceed background levels. Metals concentrations detected in sediment were not significantly different than background levels and were not evaluated further.

4.4.4 Results of Background Comparison for ERA

Soil: Background comparisons for the ERA were performed for surface soil at depths up to 3 feet, because ecological receptors are not expected to be significantly exposed to subsurface soil.

Metals Above Background in Soil 0 to 3 Feet

Exposure Area A-1, A-2, O	Exposure Area A-3, A-4, T
Chromium	Lead
Lead	Mercury
Nickel	Zinc
Zinc	

These metals were included in the ERA. Other metals detected in soil did not exceed background levels.

Groundwater: Groundwater is not a medium of concern for ecological receptors because they do not contact groundwater, which occurs at depths of 14 or more feet bgs. However, groundwater is evaluated as part of a potentially complete pathway to surface water.

Wetlands: The results of the background comparison for wetlands sediment and surface water for the ERA is the same as that for the HHRA, described above.

TABLE 4-1
SUMMARY OF SAMPLING EVENTS
FORT RICHARDSON PRDA

Medium	Reference	Description	Chemicals Analyzed For	Data Set Used in HHRA?
Soil	ESE 1991	Borehole samples (0-9 feet bgs) from 7 locations around Areas A-1 and A-2	VOCs, Metals	Yes
	OHM 1993	Excavation, side-wall and bottom confirmation, and disposal samples obtained during the first excavation at Areas A-3 and A-4	VOCs, CWM	No
	OHM 1994a	Excavation and side-wall and bottom confirmation samples obtained after the second excavation of Areas A-3 and A-4	VOCs	Yes (samples above perched water table)
	WC 1996	Borehole samples from 38 locations in Areas A 1, A-2, and "Other"; 9 locations in A-3, A-4, and toe of hill; and 3 background locations	VOCs, Metals, Explosives, CWM	Yes (0-15 feet bgs only)
Groundwater	ESE 1990	Samples from 4 monitoring wells in the shallow zone and 1 in the deep zone	VOCs, SVOCs, Pesticides, Metals, Explosives	Yes (except metals)
	ESE 1990	Samples from 4 monitoring wells in the shallow zone and 1 in the deep zone	VOCs, SVOCs, Pesticides, Metals, Explosives	Yes (except metals)
	OHM 1993	Samples from 6 monitoring wells, 3 each in the shallow and deep zones	VOCs, SVOCs, Pesticides, Metals, Explosives	Yes (except metals)
	OHM 1994a	Samples from 5 monitoring wells in the shallow zone	VOCs, Metals, Explosives	Yes (except metals)
	WC 1996	Samples from 8 monitoring wells and 21 well points in the shallow zone; 5 monitoring wells in the deep zone; 1 monitoring well and 13 well points in the perched water zone; and 1 background monitoring well (in the shallow zone)	VOCs, Metals, Explosives, CWM	Yes (except perched zone samples and metals in well points)
Surface Water	WC 1996	Samples from 4 locations in the wetlands and at 6 background locations	VOCs, Metals, Explosives, CWM	Yes
Sediment	WC 1996	Samples from 4 locations in the wetlands and at 6 background locations	VOCs, Metals, Explosives, CWM	Yes

CWM = Chemical warfare materials (and breakdown products)

TABLE 4-2
METALS CONCENTRATIONS IN MONITORING WELL AND WELL POINT SAMPLES (mg/L)
FORT RICHARDSON PRDA

	Analyte	1995 Maximum from Monitoring Wells(1)	1995 Maximum from Well Points (1)	Historical Maximum from Monitoring Wells(2)
Shallow Zone	Antimony	ND (<0.05)	2.5	ND (<0.038)
	Arsenic	ND (<0.005)	0.15	0.0509
	Beryllium	ND (<0.005)	0.093	0.0065
	Chromium	0.018	7.5	0.122
	Copper	ND (<0.01)	13	0.0797
	Lead	ND (<0.003)	0.89	0.0267
	Mercury	ND (<0.0002)	0.072	0.0005
	Nickel	0.021	19	0.0947
	Silver	ND (<0.005)	0.25	ND (<0.0046)
	Zinc	0.024	1.7	0.368
Deep Aquifer	Arsenic	0.005	-	0.027
	Beryllium	ND (<0.005)	-	0.02
	Chromium	0.086	-	0.369
	Copper	0.058	-	0.392
	Lead	0.012	-	0.0799
	Mercury	ND (<0.0002)	-	0.0005
	Nickel	0.057	-	0.337
	Silver	ND (<0.005)	-	ND (<0.0046)
	Zinc	0.095	-	0.754

(1) WC 1996. Monitoring well samples were collected with a dedicated pump. Well point samples were collected with a bailer.

(2) ESE 1991, OHM 1993, OHM 1994a. Samples were collected with a bailer.

\- No well points were in the deep aquifer.

TABLE 4-3
SUMMARY OF WATER ZONES SAMPLED IN THE REMEDIAL INVESTIGATION
FORT RICHARDSON PRDA

Well	Type	Water Zone
SB-A1	Well Point	Perched Zone (1)
SB-A2	Well Point	Perched Zone
SB-B1	Well Point	Perched Zone
SB-B3	Well Point	Perched Zone
SB-B4	Well Point	Perched Zone
SB-C1	Well Point	Perched Zone
SB-C2	Well Point	Perched Zone
SB-C3	Well Point	Perched Zone
SB-T1	Well Point	Perched Zone
SB-T2	Well Point	Perched Zone
SB-T3	Well Point	Perched Zone
SB-O8	Well Point	Perched Zone
SB-O9	Well Point	Perched Zone
MW-14	Monitoring Well	Perched Zone
SB-A3	Well Point	Shallow Zone (2)
SB-A4	Well Point	Shallow Zone
SB-A5	Well Point	Shallow Zone
SB-A6	Well Point	Shallow Zone
SB-B2	Well Point	Shallow Zone
SB-B5	Well Point	Shallow Zone
SB-B7	Well Point	Shallow Zone
SB-D1	Well Point	Shallow Zone
SB-D2	Well Point	Shallow Zone
SB-O1	Well Point	Shallow Zone
SB-O2	Well Point	Shallow Zone
SB-O3	Well Point	Shallow Zone
SB-O4	Well Point	Shallow Zone
SB-O6	Well Point	Shallow Zone
SB-O7	Well Point	Shallow Zone
SB-O11	Well Point	Shallow Zone
SB-O13	Well Point	Shallow Zone
SB-O14	Well Point	Shallow Zone
SB-O16	Well Point	Shallow Zone
SB-O17	Well Point	Shallow Zone
SB-O20	Well Point	Shallow Zone
MW-2	Monitoring Well	Shallow Zone

TABLE 4-3
SUMMARY OF WATER ZONES SAMPLED IN THE REMEDIAL INVESTIGATION
FORT RICHARDSON PRDA

Well	Type	Water Zone
MW-3	Monitoring Well	Shallow Zone
MW-4	Monitoring Well	Shallow Zone
MW-5	Monitoring Well	Shallow Zone
MW-8	Monitoring Well	Shallow Zone
MW-12	Monitoring Well	Shallow Zone
MW-13	Monitoring Well	Shallow Zone
MW-15	Monitoring Well	Shallow Zone
MW-17	Monitoring Well	Shallow Zone (Background)
MW-1	Monitoring Well	Deep Aquifer (2)
MW-6	Monitoring Well	Deep Aquifer
MW-7	Monitoring Well	Deep Aquifer
MW-9	Monitoring Well	Deep Aquifer
MW-16	Monitoring Well	Deep Aquifer

(1) Analytical results for samples in the perched zone were excluded from the HHRA data set.

(2) Analytical results for samples in the shallow zone and deep aquifer were included in the HHRA data set.

TABLE 4-4
BACKGROUND COMPARISON: EXPOSURE AREA A-1, A-2, AND O SOILS (mg/kg)
FORT RICHARDSON PRDA

Metal	Background n=16		A-1, A-2, and O (0-3') n=10		A-1, A-2, and O (0-15') n=24		Do 0-3 feet and 0-15 feet soil concentrations exceed background?
	Mean	95% CI[a]	Mean	95% CI[a]	Mean	95% CI[a]	
Antimony	Range[b]:	5.9 - 12.0	Range[b]:	<3.8 - 12.0	Range[e]:	<3.8 - 12.0	**No** -- Soil is at or below background range.
Arsenic[c]	2.183	1.919 - 2.446	2.293	2.176 - 2.410	2.293	2.186 - 2.400	**No**
Beryllium	Range[b]:	<0.28 - 0.39	Range[b]:	0.34 - 0.45	Range[e]:	<0.26 - 0.45	**No**[e,f]
Chromium[c]	3.474	3.401 - 3.548	3.877	3.664 - 4.090	3.615	3.483 - 3.748	**Yes** -- 0-3 feet **No** -- 0-15 feet
Copper	28	26 - 30			32	29.6 - 34.5	**No** -- 0-15 feet
	Range[b]:	22 - 33	Range[b]:	26 - 38			**No** -- 0-3 feet[e]
Lead	5.6	4.74 - 6.46	9.2	7.5 - 10.9	7.8	6.51 - 9.13	**Yes**
Mercury	Range[b]:	<0.099 - 0.12	Range[b]:	<0.05 - 0.20	Range[b]:	<0.056 - 0.21	**Yes** -- 0-15 feet soil has greater number of samples above detection limit than background. **No** -- 0-3 feet soil, except for a couple of values, is at or below the background upper range.
Nickel[c]	3.696	3.596 - 3.796	4.093	3.876 - 4.310	3.855	3.729 - 3.981	**Yes** -- 0-3 feet **No** -- 0-15 feet
Silver	Range[b]:	0.44 - 0.81	Range[b]:	<0.29 - 0.68	Range[e]:	0.34 - 0.86	**No**[f]
Zinc[c]	4.030	3.901 - 4.159	4.670	4.387 - 4.953	4.330	4.150 - 4.510	**Yes** -- 0-3 feet **Yes** -- 0-3 feet **No** -- 0-15 feet

[a] 95% confidence interval (CI) around the mean.

[b] Because ≥50% of the site and/or background results were non-detects, 95% CI are not appropriate and ranges are used as basis of comparison.

[c] Data were found to be lognormally distributed, therefore the mean and 95% CI values shown are for lognormal transformed data (ln mg/kg).

[d] Confidence intervals that overlap are not significantly different.

TABLE 4-4
BACKGROUND COMPARISON: EXPOSURE AREA A-1, A-2, AND O SOILS (mg/kg)
FORT RICHARDSON PRDA

	Background n=16		A-1, A-2, and O (0-3') n=10		A-1, A-2, and O (0-15') n=24		Do 0-3 feet and 0-15 feet soil concentrations exceed background?
Metal	Mean	95% CI[a]	Mean	95% CI[a]	Mean	95% CI[a]	

[c] Because site data are not normally or lognormally distributed, a 95% CI is not appropriate and ranges were used as the basis of comparison.

[f] Excluding 1990 samples which had higher detection limits than the 1995 background and site sampling effort.

TABLE 4-5
BACKGROUND COMPARISON: EXPOSURE AREA A-3, A-4, AND T SOILS (mg/kg)
FORT RICHARDSON PRDA

	Background n=16		A-3, A-4, and T (0-3') n=6		A-3, A-4, and T (0-15') n=13		Do 0-3 feet and 0-15 feet soil concentrations exceed background?[d]
Metal	**Mean**	**95% CI[a]**	**Mean**	**95% CI[a]**	**Mean**	**95% CI[a]**	
Antimony	8.9	7.9 - 9.9	8.1	6.9 - 9.3	8.7	7.5 - 9.9	**No**
Arsenic[c]	2.183	1.919 - 2.446	2.006	1.831 - 2.181	2.004	1.839 - 2.169	**No**
Beryllium[e]	Range[b]:	<0.28 - 0.36	Range[b]:	<0.28 - 0.39	Range[b]:	<0.28 - 0.39	**No** -- Site soils are at background range.
Chromium[c]	3.474	3.401 - 3.548	3.414	3.286 - 3.542	3.467	3.325 - 3.609	**No**
Copper	28	26 - 30	37	26 - 48			**No** -- 0-3 feet
	Range[e]:	22 - 38			Range[e]:	22 - 190	**Yes** -- 0-15 feet site soil has four results greater than background.
Lead	5.6	4.7 - 6.5	13	26 - 48	Range[e]:	4.6 160	**Yes** -- 0-3 feet
	Range[e]:	22 - 38					**Yes** -- 0-15 feet
Mercury	Range[b]:	<0.099 - 0.12	Range[b]:	<0.10 - 0.58	Range[b]:	<0.10 - 0.58	**Yes** -- One site result (0.17 mg/kg) is slightly above the detected value (0.12 mg/kg) in background, and one site result is about 5 times higher.
Nickel[e]	3.696	3.596 - 3.796	3.651	3.526 - 3.776	3.662	3.569 - 3.756	**No**
Silver	Range[b]:	0.44 - 0.81	Range[b]:	<0.28 - 0.40	Range[b]:	<0.28 - 1.9	**No** -- 0-3 feet below background range. **Yes** -- 0-15 feet has two values (1.7 and and 1.9 mg/kg) outside background range.

TABLE 4-5
BACKGROUND COMPARISON: EXPOSURE AREA A-3, A-4, AND T SOILS (mg/kg)
FORT RICHARDSON PRDA

	Background n=16		A-3, A-4, and T (0-3') n=6		A-3, A-4, and T (0-15') n=13		Do 0-3 feet and 0-15 feet soil concentrations exceed background?[d]
Metal	**Mean**	**95% CI[a]**	**Mean**	**95% CI[a]**	**Mean**	**95% CI[a]**	
Zinc[c]	4.030	3.901 - 4.159	4.700	3.931 - 5.469	4.81123	4.171 - 5.45123	**No** -- 0-3 feet **Yes** -- 0-15 feet

[a] 95% confidence interval (CI) around the mean.

[b] Because ≥50% of the site and/or background results were non-detect, 95% CI are not appropriate and ranges are used as basis of comparison.

[c] Data were found to be lognormally distributed, therefore the mean and 95% CI values shown are for lognormal transformed data (ln mg/kg).

[d] Confidence intervals that overlap are not significantly different.

[e] Because site data are not normally or lognormally distributed, 95% CI are not appropriate and ranges were used as the basis of comparison.

TABLE 4-6
BACKGROUND COMPARISON: WETLAND SURFACE WATER (mg/L)
FORT RICHARDSON PRDA

	Background n=6		Wetland n=4		
Metal	**Mean**	**95% CI[a]**	**Mean**	**95% CI[a]**	**Is site surface water concentration significantly higher than background?[c]**
Copper	Range[b]:	<0.010	Range[b]:	<0.010 - 0.013	**Yes** -- Half the site samples were above the detection limit whereas none of the background samples were above the detection limit.
Lead	Range[b]:	<0.003	Range[b]:	0.0040 - 0.0081	**Yes** -- All of the site samples were above the detection limit whereas none of the background samples were above the detection limit.
Nickel	Range[b]:	<0.010	Range[b]:	<0.010 - 0.0019	**Yes** -- Half the site samples were above the detection limit whereas none of the background samples were above the detection limit.
Zinc	0.132	0.031 - 0.233	0.041	0.0002 - 0.0818	**No** -- Not significantly different.

[a] 95% confidence interval (CI) around the mean.

[b] Because ≥50% of the site and/or background results were non-detect, 95% CI are not appropriate and ranges are used as basis of comparison.

[c] Confidence intervals that overlap are not significantly different.

TABLE 4-7
BACKGROUND COMPARISON: WETLAND SEDIMENT (mg/kg)
FORT RICHARDSON PRDA

Metal	Background n=6 Mean	Background n=6 95% CI[a]	Wetland n=4 Mean	Wetland n=4 95% CI[a]	Is wetland sediment concentration significantly higher than background?[d]
Arsenic[a]	1.450	0.440 - 2.460	0.564	-0.525 - 1.653	**No** -- Not significantly different.
Chromium	16	3.7 - 29	5.0	0.9 - 9.1	**No** -- Not significantly different.
Copper	19	12 - 26	13	3 - 24	**No** -- Not significantly different.
Nickel	9.35	2.7 - 16	4.3	1.2 - 7.4	**No** -- Not significantly different.
Zinc	32	5.3 - 59	16	2.2 - 29	**No** -- Not significantly different.

[a] Distribution of data was lognormal. Values shown are for natural log transformed data (in mg/kg).

5.1 RISK ASSESSMENT SCOPE AND METHODOLOGY

A baseline human health risk assessment (HHRA) was performed to evaluate potential health effects associated with exposure to organic contaminants and metals detected above background levels in the following media and areas at PRDA:

- Soil in exposure area A-1, A-2, O
- Soil in exposure area A-3, A-4, T
- Saturated soil in perched zone "hot spot"
- Groundwater in the shallow zone
- Groundwater in the deep aquifer
- Surface water in the wetland
- Sediments in the wetland

Groundwater migration to the Eagle River and vapor migration into a building were also evaluated.

The purpose of the HHRA is to assess whether existing levels of contaminants in media at PRDA could pose a threat to human health under conservative (health-protective) exposure assumptions. The risk assessment is conservative because it is based on long-term residential or occupational exposures (which are not likely at this site) and does not include site-specific exposure assumptions. Risks calculated using site-specific exposure assumptions would be lower than those estimated by this approach.

The health risk assessment was conducted following EPA guidance for evaluation of public health risks at Superfund sites. Specific EPA guidance documents include:

- Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual, Part A (EPA 1989a);

- Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors" (EPA 1991a);
- Guidelines for Exposure Assessment (EPA 1992a);
- EPA Region 3, Risk-Based Concentration Tables (EPA Region 3 1995);
- EPA Region 10, Supplemental Risk Assessment Guidance for Superfund (EPA Region 10, 1991).

Other EPA and ADEC guidance documents (such as the Interim Guidance for Surface and Groundwater Cleanup Levels [ADEC 1990] and Water Quality Standards [ADEC 1995]), were consulted when appropriate.

Potential human health impacts were evaluated by comparing reasonable maximum exposure (RME) concentrations in soil, groundwater, and wetland surface water and sediments at PRDA to EPA Region 3 risk-based concentrations (RBCs) (EPA Region 3 1995) for (1) residential soil ingestion, (2) residential ingestion of groundwater and inhalation of VOCs from groundwater, and (3) ingestion of soil by industrial workers. EPA Region 10 recommends using EPA Region 3 RBCs as screening values because they are based on standard EPA exposure and toxicity assumptions and are updated on a regular basis. In addition, EPA draft soil screening levels (SSLs) for transfer to air were used to evaluate outdoor inhalation risks (residential exposure); SSLs listed in EPA Region 3 (1995) were obtained from EPA OSWER's 1994 Soil Screening Guidance or were calculated by Region 3 using methods similar to those in the Soil Screening Guidance (EPA Region 3 1995; EPA 1994a). Indoor inhalation risks from vapor migration through a building foundation were evaluated in Appendix F using American Society for Testing and Materials (ASTM) Risk-Based Corrective Action (RBCA) model for vapor inhalation in enclosed spaces (ASTM 1995; GSI 1995). U.S. EPA Ambient Water Quality Criteria (AWQC) were used to evaluate potential impacts on human health from groundwater migration to the Eagle River (EPA 1991b).

To estimate cumulative noncancer effects from exposure to multiple chemicals and pathways, ratios of RME concentrations of COCs to RBCs and SSLs were summed to yield a total hazard index (HI). For cumulative cancer effects, ratios of RME concentrations of COCs were summed and multiplied by 10^{-6} to yield RME estimates of total lifetime excess cancer risk. RBCs and SSLs listed in EPA Region 3 (1995) are derived using EPA default exposure assumptions for long-term residential or industrial use, EPA-approved chemical toxicity factors, and a cancer target risk level of 10^{-6} (1 in 1 million) and a noncancer hazard quotient of 1. This approach to estimating health risks yields the same results as would be obtained by doing "forward" risk calculations using site concentrations, toxicity factors, and EPA standard default residential and industrial exposure assumptions.

EPA guidance recommends estimating hazard/risk for central tendency (CT) and for RME exposure conditions (EPA 1992a). The RME is estimated by selecting values for exposure variables (such as ingestion rate and exposure duration) so that the combination of all variables results in maximum exposure that can reasonably be expected to occur at the site. The CT is estimated by selecting average values for exposure variables. The HHRA at PRDA assesses hazard/risk using RME exposure assumptions for all pathways evaluated. The RME risk estimates were considered adequate for this site because, based on observed levels of contamination, risk from exposure to soil is expected to be relatively low and risk from exposure to groundwater onsite is expected to be relatively high under both RME and average residential and industrial conditions. (This expectation was confirmed by risk calculations performed in Section 5.4.) Therefore, only RME risks were calculated because the CT estimates would not provide useful additional information for this site.

It should be noted that RBCs and SSLs are not cleanup standards, but rather are a means of assessing potential health risks associated with default exposure conditions. The assumption of future residential use at the PRDA will overestimate actual site risk because residential development is not expected as long as the property is owned by the federal government. Cleanup goals are based on site-specific risk management decisions.

The human health risk assessment includes the subsections listed below. A toxicity assessment and RBC tables are presented in Appendix E.

5.2 Chemicals of Concern
5.3 Exposure Assessment
5.4 Risk Characterization
5.5 Uncertainties in the Assessment
5.6 Summary and Conclusions

5.2 CHEMICALS OF CONCERN

Chemicals of concern (COCs) (listed in Table 5-1) are site-related compounds evaluated in the HHRA. COCs were detected organic compounds not judged to be laboratory contaminants, detected explosives, and metals above background levels based on background comparisons (see Section 4.4). Detection frequency, regional background concentrations, and low chemical concentration or toxicity were not used to screen COCs for the HHRA.

5.2.1 Soil

COCs for the HHRA were identified from sampling data for soil at depths ranging from 0 to 15 feet bgs in two exposure areas at PRDA: (1) A-1, A-2, O and (2) A-3, A-4, T. The 15-foot depth is a conservative estimate of excavation depth if the site were developed for residential or commercial use. Samples from depths lower than 15 feet bgs or lower than the perched water table were not evaluated in the HHRA (except for the perched zone "hot spot," discussed in Section 5.4.2).

COCs in soil are listed in Table 5-1. Numerous organic COCs (primarily chlorinated solvents) were detected in soil. Methylene chloride was detected in both areas but was eliminated from further consideration in the risk assessment because it was judged to be a laboratory contaminant (see Section 3.4 of the RI Report, WC 1996). No explosives were detected in soil.

Lead and mercury in exposure area A-1, A-2, O and copper, lead, mercury, silver, and zinc in exposure area A-3, A-4, T were identified as COCs in soil at depths from 0 to 15 feet because their concentrations exceeded background levels in the background comparison (Section 4.4.2).

5.2.2 Groundwater

COCs for the HHRA were identified from sampling data for groundwater in the shallow zone and deep aquifer, but not in the perched zone. The perched zone is a shallow, discontinuous pool and is not a true aquifer capable of supporting a water supply well. Contaminants in the perched zone were not evaluated for direct human contact, but were included as a contaminant source to the shallow zone and deep aquifer in groundwater transport modeling (Appendix XIII of the RI Report, WC 1996) and as a source of vapor migration into a building (Appendix F).

COCs in groundwater are listed in Table 5-1. Numerous organic COCs (primarily chlorinated solvents) were detected in groundwater in both the shallow zone and deep aquifer. RDX, an explosive, was detected in one sample in the shallow zone. Metals in the shallow zone and deep aquifer were not identified as COCs because their concentrations were lower than or generally consistent with background levels (see Section 3.2.4).

5.2.3 Wetland

COCs in the wetland are toluene (the only detected VOC), explosives, and metals above background in sediments and surface water. COCs in the wetland are listed in Table 5-1.

Toluene was the only VOC detected in wetland surface water and no VOCs were detected in sediments. Trace levels of explosives were detected in wetland surface water and sediments. Concentrations of metals in sediments were not significantly different from background. Copper, lead, and nickel were identified as COCs in wetland surface water because they were detected in site samples but not in background samples.

5.3 EXPOSURE ASSESSMENT

This section discusses (1) current and future land use at PRDA; (2) site-specific exposure scenarios and exposure scenarios evaluated in this HHRA; (3) relevance of exposure pathways that are not evaluated quantitatively in the HHRA; and (4) exposure assumptions and target risk levels used to calculate RBCs and SSLs.

5.3.1 Current and Future Land Use

As described in Section 2.2.5, the PRDA is located at the Fort Richardson Army Installation, approximately 10 miles northeast of Anchorage, Alaska. The PRDA occupies approximately 1.5 acres and is located in a remote wooded area, surrounded by Fort Richardson and Elmendorf Air Force Base.

Current Onsite Land Use: Current use of PRDA is limited to periodic visits by authorized personnel, and by trespassers or open space recreational users. Groundwater at PRDA is not used as a source of water.

Current Offsite Land Use: The area immediately surrounding PRDA belongs to the Installation or to Elmendorf Air Force Base. Fort Richardson allows open space recreational uses (cross country skiing, fishing) in land surrounding PRDA.

Locally, groundwater moves northeast in the vicinity of PRDA, but regionally it trends northwest from PRDA and probably intersects the Eagle River about 1 mile from the site. The area north and northwest of PRDA is owned by the Army, including the Eagle River to the north and land beyond it (see Figure 2.1). Currently, there are no residents or wells downgradient (north) of PRDA. The closest populated area is the City of Eagle River, located across the Eagle River approximately 2 miles northeast of PRDA (see Figure 2-2).

Future Land Use: Future land use includes the potential for closure of Fort Richardson. The potential for future development for residential use is considered remote, but is considered for screening purposes in the HHRA. The area is not suitable for agricultural purposes. Instead the area is likely to remain Department of Defense property or open space accessible to recreational users.

Future use of perched and shallow groundwater at PRDA as a drinking water source is considered unlikely, because the perched and shallow zones appear to be discontinuous and are unlikely to provide adequate yields. Furthermore, a public drinking water supply is available via a pipeline from Eklutna Lake (over 15 miles from the site) that runs through the area.

5.3.2 Potential Receptors

Potential onsite receptors at PRDA are:

- Current and future authorized personnel who visit PRDA periodically
- Current and future recreational users who may traverse the PRDA
- Hypothetical future onsite residents
- Hypothetical future onsite industrial workers

Potential offsite receptors (outside of PRDA) include:

- Current and future offsite recreational users of the Eagle River (assumes complete groundwater to surface water pathway)
- Future residents downgradient of PRDA (assumes receptors reside on land currently owned by Fort Richardson)

The risk assessment was performed using a conservative approach assuming onsite residential or industrial use in order to support a conclusion of no further action if warranted. Risks to current personnel, to recreational users, and to future downgradient residents will be lower than those estimated using this conservative approach, because their exposure to contaminants would be much less than exposure of onsite residents or industrial workers.

5.3.3 Exposure Pathways

Potentially complete exposure pathways for various receptors are shown in the Conceptual Site Models (CSMs) in Figures 5-1 through 5-3. The most conservative onsite exposure scenarios are being evaluated in this HHRA (summarized in the table below). Potentially complete pathways shown in the CSM but not evaluated in the risk assessment are discussed in Section 5.3.4.

EXPOSURE PATHWAYS EVALUATED IN HHRA

Receptor	Exposure Pathway	Evaluated by Comparing COC Concentrations to:
Hypothetical Onsite Resident	• Ingestion and inhalation of COCs in groundwater from shallow and deep zones	Region 3 RBCs (tap water)
	• Incidental ingestion of soil in exposure areas A-1, A-2, O and A-3, A-4, T	Region 3 RBCs (residential soil ingestion)
	• Inhalation of airborne constituents from soil in exposure areas A-1, A-2, O and A-3, A-4, T	Region 3 SSLs (residential soil-to-outdoor-air transfer)
	• Ingestion and inhalation of COCs in wetland surface water	Region 3 RBCs (tap water)
	• Ingestion of wetland sediment	Region 3 RBCs (residential soil ingestion)
	• Inhalation of indoor vapors from soil and groundwater	ASTM RBCA target levels
Hypothetical Onsite Industrial Worker	• Incidental ingestion of soil in exposure areas A-1, A-2, O and A-3, A-4, T	Region 3 RBCs (industrial soil)
	• Inhalation of indoor vapors from soil and groundwater	ASTM RBCA target levels
Future Offsite Resident	• Ingestion and inhalation of COCs in leading edge of plumes in shallow and deep zones at the nearest downgradient point intersecting the Eagle River.	Region 3 RBCs (tap water)
Offsite Recreational User	• Ingestion of fish from Eagle River	Ambient Water Quality Criteria (ingestion of freshwater organisms)

Risk from potential exposure of current authorized personnel or trespassers to wetland surface water and sediments at PRDA was assessed by comparing wetland concentrations to residential tap water and soil ingestion RBCs, respectively. This conservative approach will significantly overestimate risk because incidental ingestion of surface water and sediment from intermittent contact by visitors at the wetland will be much less than residential ingestion of tap water (2 L/day) and soil (almost 100 mg/day).

5.3.4 Excluded Exposure Pathways

Several other potentially complete pathways shown in the CSMs were not included in the quantitative assessment of risk at PRDA:

1. dermal contact with soil and sediment
2. dermal contact with groundwater (during household use)
3. leaching from soil to groundwater
4. dermal contact with offsite surface water and sediments potentially affected by contaminant transport in groundwater

The elimination of these pathways from quantitative evaluation in the risk assessment will not affect the results of the risk evaluation because (1) they are negligible pathways or (2) they are potentially significant pathways but quantification would not affect the conclusions of the risk assessment. Each is discussed below.

1. Dermal contact with soil and sediment is a negligible pathway because surface soil at Fort Richardson is frozen and snow-covered much of the year and exposed skin surface area on receptors wearing clothing suited to the climate and terrain will be minimal. In addition, contamination in soil at depth (e.g., below 15 feet bgs) is not accessible for exposure via ingestion or dermal contact. Exclusion of the dermal soil pathway will not affect the conclusions of the risk assessment.

2. Dermal contact with groundwater (e.g., during showering) is not evaluated in the HHRA, and this could underestimate risk from exposure to groundwater. However, because of the high concentrations of COCs in groundwater at the site, the magnitude of potential health risks from hypothetical use of groundwater are adequately assessed via the ingestion and inhalation exposure routes, and further refinement of the risk estimates are not needed.

3. Potential leaching of contaminants from soil to groundwater is not evaluated in this risk assessment. Instead, concentrations measured in perched water and in shallow groundwater were used as source concentrations for estimating contaminant migration to and in the shallow zone and the deep aquifer. The reasons for not modeling leaching from soil are (1) with the exception of two soil samples collected in standing perched water at about 14 feet bgs at the hillside excavation at the southeast corner of Area A-3 (OHM 1995b), contaminant levels in the vadose zone to 15 feet bgs are relatively insignificant compared to concentrations measured in water in the perched and shallow saturated zones and (2) the highest concentrations measured in soil (e.g., the hillside excavation samples and soil samples collected from MW-14 at depths of about 18 feet bgs) are in contact with water, and therefore the water concentrations already represent contaminant migration through soil. Furthermore, because of the low solubility of the chief solvent contaminants (e.g., TCE and 1,1,2,2-tetrachloroethane), any estimate of leaching from soil based on octanol-water partition coefficients would probably be insignificant compared to the measured concentrations of these contaminants in perched and shallow water.

4. 4. Direct contact exposure to surface water and sediments in the Eagle River potentially impacted by migration of contaminants in groundwater is not evaluated in this assessment. Instead, a conservative estimate of potential risks at the Eagle River from groundwater transport was obtained by evaluating hypothetical residential exposure to modeled groundwater concentrations at the closest downgradient point intersecting the Eagle River.

5.3.5 Exposure Assumptions

This section discusses the exposure assumptions and target risk levels used by EPA Region 3 (1995) and EPA (1994a) to calculate RBCs and SSLs for soil and groundwater and the use of AWQC for evaluating potential human health impacts from ingestion of fish. EPA default exposure assumptions for inhalation of indoor air from vapor migration are presented in Appendix F.

Soil: Exposure factors used in deriving RBCs for soil are listed below.

Residential soil RBCs for carcinogens:

- Combined childhood (6 year) and adult (24 year) exposure duration
- Age-adjusted soil ingestion rate of 114 mg-year/kg-day (based on 200 mg/day for a 15 kg child and 100 mg/day for a 70-kg adult)
- Exposure frequency of 350 days/year
- Averaging time of 25,550 days (70 years)

Residential soil RBCs for noncarcinogens:

- Childhood only exposure duration of 6 years
- Soil ingestion rate of 200 mg/day
- Body weight of 15 kg
- Exposure frequency of 350 days/year
- Averaging time of 2,190 days (6 years)

Industrial soil RBCs for carcinogens:

- Occupational exposure duration of 25 years
- Ingestion rate of 100 mg/day
- Fraction from contaminated source is 50 percent
- Body weight of 70 kg
- Exposure frequency of 250 days/year
- Averaging time of 25,550 days (70 years)

Industrial soil RBCs for noncarcinogens:

- Same as for carcinogens, except averaging time of 9,125 days (25 years)

Soil-to-Outdoor-Air Pathway: The October 1995 EPA Region 3 RBC table includes generic SSLs based on reasonable maximum estimates of transfers of contaminants from soil to other media. SSLs for outdoor air quality are protective of residential inhalation of constituents from soil generated by volatilization of VOCs and fugitive dust emissions. SSLs in the Region 3 RBC Tables were obtained directly from U.S. EPA's proposed OSWER Soil Screening Guidance (EPA 1994a) or were calculated by EPA Region 3 using the proposed

SSL methodology. SSLs for soil were used to evaluate hazard/risk for residential inhalation exposure (outdoor air) to constituents in soil in exposure areas A-1, A-2, O and A-3, A-4, T.

The exposure factors used in deriving EPA OSWER and Region 3 SSLs for inhalation of outdoor air are listed below.

Inhalation SSLs for carcinogens:

- Combined childhood (6 year) and adult (24 year) exposure duration
- Age-adjusted inhalation rate of 11.6 m^3-year/kg-day (based on 12 m^3/day for a 15 kg child and 20 m^3/day for a 70-kg adult)
- Exposure frequency of 350 days/year
- Averaging time of 25,550 days (70 years)
- Volatilization factor (L/m^3, chemical specific)
- Particulate emission factor of 6.79E+08 m^3/kg

Inhalation SSLs for noncarcinogens:

- Adult only exposure duration of 30 years
- Inhalation rate of 20 m^3/day
- Body weight of 70 kg
- Exposure frequency of 350 days/year
- Averaging time of 10,500 days (30 years)
- Volatilization factor (L/m^3, chemical specific)
- Particulate emission factor of 6.79E+08 m^3/kg

The derivation of the SSLs also assumes a 30-acre contaminated source area, a constant contaminant source at the ground surface, and temperature and other parameters that do not reflect site-specific conditions at PRDA. Therefore, the SSLs are extremely conservative and will overestimate risk from airborne contaminants released from soil.

Groundwater: RBCs for groundwater were used to evaluate hazard/risk for exposure to groundwater in the shallow zone and deep aquifer and to wetland surface water. These RBCs are based on residential ingestion of groundwater and inhalation of indoor VOCs during household use of groundwater. The exposure factors used in deriving residential groundwater RBCs are listed below.

Residential groundwater RBCs for carcinogens:

- Combined childhood (6 year) and adult (24 year) exposure duration
- Age-adjusted water ingestion rate of 1.09 L-year/kg-day (based on 1 L/day for a 15 kg child and 2 L/day for a 70-kg adult)
- Age-adjusted inhalation rate of 11.6 m^3-year/kg-day (based on 12 m^3/day for a 15 kg child and 20 m^3/day for a 70-kg adult)
- Volatilization factor of 0.5 L/m^3
- Exposure frequency of 350 days/year
- Averaging time of 25,550 days (70 years)

Residential groundwater RBCs for noncarcinogens:

- Adult only exposure duration of 30 years
- Water ingestion rate of 2 L/day
- Inhalation rate of 20 m^3/day
- Volatilization factor of 0.5 L/m^3
- Body weight of 70 kg
- Exposure frequency of 350 days/year
- Averaging time of 10,950 days (30 years)

Surface Water (Eagle River): Federal ambient water quality criteria (AWQC) for carcinogens in surface water were used to evaluate human exposure to COCs in the Eagle River from ingestion of freshwater organisms (EPA 1991b). An AWQC for ingestion of freshwater organisms is the concentration in surface water that is estimated to result in lifetime excess cancer risk of 1E-06 (1 in 1,000,000) from consumption of 6.5 g of fish and shellfish per day. Chemical-specific cancer toxicity values and bioconcentration factors are also used in deriving the AWQC.

Target Cancer Risk and Hazard Quotients: The RBC for a carcinogen is the concentration in soil or water that is estimated to result in lifetime excess cancer risk of 1E-06 (1 in 1,000,000) to residential or occupational receptors. EPA's target lifetime excess cancer risk range for remediation under Superfund and RCRA is 1E-06 to 1E-04. Generally, remediation is not warranted for protection of public health if cumulative lifetime excess cancer risk does not exceed 1E-04 and if noncarcinogenic effects are not a concern (EPA 1991c).

Cancer risk is the estimated daily dose multiplied by the slope factor (SF), a dose-response factor used to relate carcinogenic response to chemical dose. SFs represent the upper bound probability that an individual will develop cancer as a result of exposure to the potential carcinogen. EPA acknowledges that SFs likely overestimate risk and that actual cancer risks are likely to be between zero and EPA's upper bound estimate (EPA 1989a).

The RBC for a noncarcinogen is the concentration in soil or water that is estimated to result in a Hazard Quotient (HQ) of 1. The HQ is the ratio of the estimated daily dose to the reference dose (RfD) for ingestion or inhalation exposures. The RfD is an intake or contaminant dose per unit of body weight per day that is unlikely to result in toxic effect to humans, including sensitive subgroups (e.g., the very young or old), even if exposure occurs every day for a lifetime. An HQ of 1 or less means that no toxic effects are likely to occur under the assumed exposure conditions. An HQ above 1 does not necessarily mean that toxic effects will occur, but that further evaluation of exposure or chemical toxicity is warranted.

Lead, a COC for HHRA in soil in exposure areas A-1, A-2, O and A-3, A-4, T and in wetland surface water does not have EPA-approved toxicity values, RBCs, or SSLs. Potential health hazards from exposure to lead at PRDA are discussed in Uncertainty in the Assessment (Section 5.5).

5.3.6 Exposure Point Concentrations

Exposure point concentrations for COCs at PRDA were estimated from sampling results for soil in two exposure areas (A-1, A-2, O and A-3, A-4, T), groundwater in shallow and deep aquifers, and surface water and sediment in the wetland. Following EPA guidance (EPA 1989a), the exposure point concentrations were the maximum detected concentration or the 95% UCL of the mean concentration (whichever was smaller). In calculating the 95% UCL of the mean, one-half the detection limit was used as the concentration for sample results that were non-detect.

Exposure point concentrations for groundwater in the shallow zone and deep aquifer at the nearest point intersecting the Eagle River were estimated via a groundwater model that incorporated information regarding source concentrations in groundwater at PRDA and aquifer characteristics (see Appendix XIII of the RI report).

Sampling results and exposure point concentration calculations are shown in Appendix A. Detection frequency and exposure point concentrations are summarized in Tables 5-2 to 5-7.

5.4 RISK CHARACTERIZATION

Chemical-specific hazards/risks were characterized by comparing RME concentrations of COCs at PRDA to medium-specific RBCs and SSLs derived by EPA Region 3 (1995) and EPA (1994a) using the methodology described in Section 5.3.4. Concentrations of carcinogens that exceed RBCs yield an estimated lifetime excess cancer risk greater than 1E-06; concentrations of noncarcinogens that exceed RBCs yield a hazard quotient greater than 1. Modeled concentrations of COCs in groundwater from the shallow zone and deep aquifer at the nearest downgradient point intersecting the Eagle River were compared to RBCs for domestic groundwater use and to AWQC for surface water concentrations protective of human ingestion of freshwater organisms.

Cumulative effects from exposure to multiple chemicals were addressed by (1) summing ratios of concentrations to RBCs to yield cumulative estimates of noncarcinogenic health hazards (hazard index) and (2) summing ratios then multiplying by 10^{-6} to yield estimates of total lifetime excess cancer risk. RBCs and SSLs for COCs at PRDA are provided in Table 5-8.

Risk characterization results for soil, groundwater, and wetland surface water and sediment are discussed in the following sections and summarized in Table 5-9. Risks for each medium are presented separately so that media that have low associated risk and that may not warrant further evaluation can be readily distinguished from contaminated media that may require further evaluation or action.

Chemical-specific hazard/risk calculations are shown in Appendix B.

5.4.1 Soil

The maximum cumulative lifetime excess cancer risk was 1E-05 and the maximum cumulative hazard index was 1E-01, for residential exposure to soil from 0 to 15 feet in exposure area A-3, A-4, T. Risks were lower for other exposure areas and receptors. These results are within EPA's target risk range of 1E-06 to 1E-04 and below the level of concern for noncancer effects (HI > 1) (EPA 1989a). These results indicate that soils at PRDA do not pose an unacceptable risk of cancer or noncarcinogenic health effects under conservative exposure assumptions of long-term residential use. Risk to actual receptors under site-specific exposure conditions would be lower than these estimates.

Hazard/risk results for COCs in soil at PRDA are discussed in detail in the following section and summarized in Table 5-9.

Cumulative Lifetime Excess Cancer Risk: In exposure area A-1, A-2, O, cumulative lifetime excess cancer risk was 2E-07 (2 in 10 million) for residential exposure to compounds in soil from 0 to 15 feet via ingestion and inhalation and 2E-09 (2 in 1 billion) for industrial exposure to compounds via soil ingestion. These estimates of lifetime excess cancer risk are below EPA's "point of departure" of 1E-06 (1 in 1 million) and are considered to be negligible.

In exposure area A-3, A-4, T, cumulative lifetime excess cancer risk from residential exposure to compounds in soil via ingestion and soil-to-air routes of exposure was 1E-05 (1 in 100,000), which is within EPA's target lifetime excess cancer risk range of 1E-06 to 1E-04 (EPA 1989a). Cumulative lifetime excess cancer risk for soil ingestion in exposure area A-3, A-4, T by industrial workers was negligible (2E-07). The results indicate that soils from 0 to 15 feet at PRDA do not pose an unacceptable risk of cancer under conservative exposure scenarios.

Cumulative Noncarcinogenic Hazard Index: In exposure area A-1, A-2, O, cumulative hazard indexes for noncarcinogenic effects were 3E-02 for residential exposure to compounds in soil via ingestion and inhalation and 2E-04 for soil ingestion by industrial workers. Noncarcinogenic hazard indexes for soils in exposure area A-3, A-4, T were 1E-01 for residential exposure and 2E-03 for soil ingestion by industrial workers. These results are well below 1 indicating that soils from 0 to 15 feet at PRDA do not pose a noncancer health threat.

5.4.2 Saturated Soil in Perched Zone "Hot Spot"

Three samples (MS-10, MS-11, and MS-12) that were collected by OHM in standing water at about 14 feet bgs in a small "hillside excavation" (OHM 1995b) located just north of the toe of hill were not included in the estimate of exposure concentrations and risk for soil at the

PRDA. (The sample locations are indicated on Figure F-1 in Appendix F.) These samples were not included in the exposure assessment for soil because the location sampled (saturated soil in the perched zone at 14 feet bgs in the side of a hillside) is an unlikely site for future construction (i.e., no direct contact by future installation personnel or future residents is likely) and because the concentrations of TCE and 1,1,2,2-tetrachloroethane in these samples of saturated soil are not characteristic of contaminant concentrations in the vadose zone in the rest of the PRDA.

However, because the sample depth technically falls within the 0 to 15 feet assumed for excavation prior to construction of future buildings, these samples are evaluated separately as a "hot spot." Analytical results for detected compounds are shown below and compared to USEPA Region 3 RBCs for long-term residential and industrial exposure (soil ingestion):

Analytical Results for Saturated Soil Samples and Comparison to RBCs
OHM Hillside Excavation (1) (mg/kg)

Sample ID	Trichloroethene	1,1,2-2-Tetrachloroethane
MS-10	<5	121
MS-11	134	2920
MS-12	7	32
Mean	48	**1024**
Res. RBC (c)	58	3.2
Res. RBC (n)	468	-
Ind. RBC (c)	520	29
Ind. RBC (n)	12000	-

(1) OHM 1995b.

RBC = Residential Risk-Based Concentration for soil (USEPA Region 3 1995).
Res. = Residential; Ind. = Industrial.
(c) = cancer effects; (n) = noncancer effects.

Only the mean concentration of 1,1,2,2-tetrachloroethane exceeded RBCs for cancer effects. Long-term exposure to the mean concentration of 1,1,2,2-tetrachloroethane in soil at this location could result in a cancer risk of 3E-04 (residential) or 4E-05 (industrial). The estimated residential cancer risk estimate somewhat exceeds EPA's target risk range of 1E-06 to 1E-04. However, direct exposure to saturated soil at this depth is unlikely.

5.4.3 Groundwater at PRDA

RME concentrations of numerous COCs in the shallow zone and deep aquifer exceeded RBCs for residential use of groundwater (see Appendix B). The cumulative noncarcinogenic hazard index exceeded 1 and the total lifetime excess cancer risk exceeded 1E-04 for domestic use of groundwater from the shallow zone or deep aquifer, indicating that COCs in groundwater at PRDA would pose an unacceptable risk to human health if groundwater at PRDA were used for domestic purposes. Groundwater at PRDA is not currently used and there are no residents or wells downgradient (north) of PRDA. The potential for residential or commercial development and groundwater use is remote.

Hazard/risk results for COCs in groundwater at PRDA are discussed in detail below and summarized in Table 5-9.

Cumulative Lifetime Excess Cancer Risk: Cumulative lifetime excess cancer risk from residential ingestion and inhalation exposure to compounds in groundwater was 3E-01 (3 in 10) in the shallow zone and 4E-02 (4 in 100) in the deep aquifer, indicating unacceptable cancer risk levels in this hypothetical scenario. 1,1,2,2-Tetrachloroethane and trichloroethene were the primary contributors to total lifetime excess cancer risk estimates in the shallow zone and deep aquifer. Numerous other COCs exceeded RBCs for residential use of groundwater (see tables in Appendix B). Other COCs with cancer risk levels equal to or above 1E-04 were carbon tetrachloride, chloroform, 1,1-dichloroethene, tetrachloroethene, and 1,1,2-trichloroethane in the shallow zone.

Cumulative Noncarcinogenic Hazard Index: The noncarcinogenic hazard index for residential use of groundwater was 25 in the deep aquifer and 200 in the shallow zone. Both of these hazard indexes exceed 1, the level of potential concern for noncarcinogenic effects. These results indicate that exposure to groundwater at PRDA may pose an unacceptable risk of noncarcinogenic health effects if groundwater at the PRDA were used for domestic purposes. Trichloroethene was the primary contributor to the hazard indexes in the shallow zone and deep aquifer (HQs of 170 and 20, respectively). Other solvents with hazard quotients above 1 were carbon tetrachloride, cis-1,2-dichloroethene, tetrachloroethene, and 1,1,2-trichloroethane in the shallow zone.

5.4.4 Wetland Surface Water and Sediment

COCs in wetland surface water were toluene, one explosive (1,3-dinitrobenzene), and copper, lead, and nickel.. All COCs may have noncancer effects; in addition, lead is classified by EPA as a probable carcinogen. Concentrations of COCs in wetland surface water did not exceed RBCs for drinking water and the cumulative hazard index (0.9) was less than 1, indicating that wetland surface water at the PRDA does not pose a threat to human health even assuming it were used as drinking water.

COCs in sediments consisted of low levels of three explosives. Risks/hazards were evaluated by comparing RME concentrations to RBCs for soil ingestion, although this highly conservative approach will overestimate risk under actual exposure conditions. Concentrations of COCs in sediments did not exceed RBCs for residential ingestion of soil. Cumulative lifetime excess cancer risk was negligible for residential (2E-08) and industrial (2E-09) soil ingestion, and the noncarcinogenic hazard index for residential (0.2) and industrial (0.008) soil ingestion were each well below EPA's level of potential concern of 1. Therefore, COCs in sediment at the wetland do not pose a threat to human health under conservative residential and industrial exposure scenarios.

5.4.5 Groundwater Offsite (at the Eagle River)

Groundwater transport modeling was used to estimate time of travel for the leading edge of the plume in the shallow zone and deep aquifer to reach the Eagle River, assuming no depletion or remediation of the contaminant source and no biodegradation over time. The leading edge was defined by 0.005 mg/L, the limit of the model's capability to estimate low concentrations given the uncertainties in the model. Higher concentrations of contaminants would be expected near the center of the plume, but these cannot be predicted with confidence because of the simplifying assumptions that had to be incorporated in the model. Estimated travel times for three contaminants were:

- Shallow zone - TCE (120 years); 1,1,2,2-tetrachloroethane (170 years); 1,1,2-trichloroethane (> 500 years).

- Deep aquifer - TCE (130 years); 1,1,2,2-tetrachloroethane (180 years); 1,1,2-trichloroethane (> 500 years).

Concentrations of 0.005 mg/L TCE, 1,1,2,2-tetrachloroethane, and 1,1,2-trichloroethane do not exceed levels of concern for domestic use of groundwater using conservative exposure assumptions nor do they exceed AWQC for ingestion of freshwater organisms (0.081, 0.011, and 0.042 mg/L, respectively). Therefore, concentrations in the leading edge of the plume, were it to reach the Eagle River, would not pose a threat to human health. These results indicate no imminent or near future threat to future offsite residents or to the Eagle River.

5.4.6 Vapor Intrusion Into a Building

Migration of vapors of two chief COCs (TCE and 1,1,2,2-tetrachloroethane) from soil (approximately 15 to 20 feet bgs) and from perched and shallow groundwater through a building foundation was modeled in order to evaluate whether this exposure route could potentially result in unacceptable exposure levels for future residential or commercial receptors exposed to indoor air at the PRDA. This pathway was evaluated separately from other exposure routes because it is not included in the RBCs and because it is conceivable that the only exposure to contaminants in soil and groundwater at this site would be through vapor intrusion into a future structure.

The vapor intrusion model used was developed by ASTM for application in Risk-Based Corrective Action (RBCA) (ASTM 1995; GSI 1995). Using site-specific estimates of parameters such as soil porosity and depth to contaminated layer, the model estimates site-specific target levels (SSTLs) for chemical concentrations in soil and groundwater that are protective of the indoor inhalation pathway. Potential hazards from this exposure route are evaluated by comparing representative site concentrations to the SSTLs.

The SSTLs are considered screening-level because only rough estimates of model input parameters were possible. ASTM cautions that, because of the conservative assumptions built into the vapor intrusion model, remediation decisions should not be based on screening-level model predictions. Instead, if site concentrations significantly exceed screening-level SSTLs, air or soil vapor measurements should be performed prior to making remedial decisions based on the indoor air pathway.

Additional detail on the modeling approach, calculation of representative site concentrations, input parameters, and results are presented in Appendix F. Representative site concentrations for contaminated soil and groundwater in and near Areas A-3 and A-4 are compared to the modeled SSTLs in Table 5-10. Site concentrations exceed the SSTLs in all cases evaluated, indicating that air or soil vapor measurements are warranted prior to making remedial decisions based on the indoor air pathway.

5.4.7 Summary of Risk Characterization Results

Cumulative lifetime excess cancer risk was less than 1E-04 and hazard indexes were less than 1 for residential exposure to unsaturated soil and wetland surface water and sediments at PRDA. These results indicate that COCs in soil 0 to 15 feet, wetland surface water, and wetland sediments at PRDA would not be expected to pose an unacceptable risk of cancer or noncancer health effects for hypothetical residents assumed to reside onsite at PRDA. It therefore follows that COCs in unsaturated soil and the wetland at PRDA would not pose an unacceptable risk to current authorized personnel and future receptors such as recreational users or commercial workers, who would be expected to receive much less exposure than that assumed for residents in this assessment.

The "hot spot" evaluation of saturated soil in the perched zone at 14 feet bgs in the hillside southwest of Area A-3 indicated a cancer risk of 3E-04 for residential exposure and 4E-05 for industrial exposure. The estimated cancer risk for residential exposure exceeds EPA's target range. However, exposure to deep soil in this location is unlikely.

For residential ingestion of groundwater onsite, cumulative lifetime excess cancer risk exceeded 1E-04 and hazard indexes exceeded 1 for both the shallow zone and deep aquifer, indicating that use of groundwater as a water supply would pose an unacceptable health threat. Currently, groundwater at PRDA is not used and there are no residents or wells downgradient (north) of PRDA.

Conservative (no source decay or biodegradation) transport modeling estimates that the groundwater contaminant plume from PRDA will not reach the Eagle River (defined by 0.005 mg/L, the limit of the model's capability to estimate low concentrations given the uncertainties in the model) for more than 100 years, indicating no imminent or near future threat to the Eagle River.

Vapor intrusion into a building was evaluated separately because it is conceivable that the only exposure to contaminants in soil and groundwater at the PRDA would be through vapor intrusion into a future structure. Representative site concentrations of selected solvents in soil and groundwater near Areas A-3 and A-4 exceeded conservative screening levels calculated using the ASTM model for soil vapor migration into a building (ASTM 1995). Therefore, air or soil vapor measurements would be warranted prior to making remedial decisions based on the vapor migration to indoor air pathway.

Hazard/risk results for onsite residential and industrial exposure to soil and groundwater at PRDA are summarized below and in Table 5-9.

SUMMARY OF RISK RESULTS
FOR DIRECT EXPOSURE TO SOIL AND GROUNDWATER

Receptor	Media	Total Lifetime Excess Cancer Risk	Noncarcinogenic Hazard Index
Resident	Soil 0 to 15 feet (A-3, A-4, T)		
	Ingestion	2E-06	7E-02
	Inhalation	1E-05	3E-02
	Total	1E-05	1E-01
	Soil 0 to 15 feet (A-1, A-2, O)		
	Ingestion	2E-08	6E-03
	Inhalation	2E-07	2E-02
	Total	2E-07	3E-02
	Hot Spot Soil, 14 feet (hillside)	3E-04	—
	Groundwater (Shallow Zone)	3E-01	2E+02
	Groundwater (Deep Aquifer)	4E-02	2.5E+01
	Surface Water (Wetland)	-	9E-01
	Ingestion of Sediment (Wetland)	2E-08	2E-01
Industrial Worker	Soil Ingestion (A-3, A-4, T)	2E-07	2E-03
	Soil Ingestion (A-1, A-2, O)	2E-09	2E-04
	Hot Spot Soil (hillside)	4E-05	—
	Ingestion of Sediments (Wetland)	2E-09	8E-03

5.5 UNCERTAINTIES IN THE RISK ASSESSMENT

To streamline the HHRA, conservative (health protective) exposure assumptions for long-term residential and industrial exposure, instead of site-specific assumptions, were used throughout the assessment. Risks calculated using site-specific exposure assumptions would be lower than those estimated by this approach.

5.5.1 Chemical Analytical Database for Risk Assessment

Uncertainties related to the chemical analytical database used in risk assessment are discussed below.

- Detection limits for the field screening analytical method for VOCs in soil (OHM 1994a, WC 1996) were higher than those for the laboratory analytical method (about 0.005 mg/kg) and were higher than many detected values from laboratory sampling results. When there were duplicate field screening and laboratory results, the maximum value was used; otherwise, field screening results were used as reported, including one-half the detection limit for results reported as non-detect. The higher detection limits in field screening samples adds uncertainty to the estimates of VOC exposure point concentrations (they may have been overestimated).

- All soil confirmation sampling results (OHM 1994a) were used to characterize exposure area A-3, A-4, T, even though the number of OHM samples far exceeded the number of samples collected for the RI (WC 1996). Therefore, estimates of the mean concentration (i.e., the 95% UCL of the mean) were heavily weighted towards the OHM 1994 sampling event, which had a large fraction of non-detects at detection limits of 5 mg/kg. However, the field screening sample results were judged to be useable in risk assessment because the detection limits for the chief COCs fell between the minimum and maximum detected values from all sampling events. Therefore, assuming the COCs are present in non-detect samples at one-half the detection limit is a conservative means of accounting for uncertainty regarding the actual concentration in soil at exposure area A-3, A-4, T.

These sources of uncertainty have a minimal impact on the results and conclusions of the risk assessment because, even if they resulted in an overestimate of exposure concentrations, risks from direct contact with unsaturated soil 0 to 15 feet bgs were below levels of concern.

5.5.2 Exposure Assessment

Conservative assumptions that result in overestimation of exposure (and therefore risk) are discussed below.

- Hazard/risk results were assessed based on onsite residential exposure scenarios that assumed an exposure frequency of 350 days/year; an exposure duration of 30 years; and daily intake rates for soil, air, and water based on an exposure time of 24 hours/day. The potential for future development of PRDA for residential use is remote. Exposure of current and possible future receptors at PRDA would be much less than that for the residential scenario (e.g., an open space recreational user might visit the site for a few hours per day only a few days per year). Therefore, hazard/risk results reported in the HHRA will overestimate risk to current and possible future receptors.

- For the purpose of evaluating risk from exposure to groundwater at PRDA, it was assumed that groundwater was used for household purposes including drinking water. However, the potential for residential or commercial development and groundwater use is remote. Therefore, the calculated risk levels do not represent actual risks under current or probable future exposure conditions. In addition, an alternate water supply (pipeline from Eklutna Lake) could meet future water demands near the site, if developed.

- As discussed in Section 5.3.3, risk from potential exposure to wetland surface water and sediments at PRDA was assessed by comparing wetland concentrations to residential tap water and soil ingestion RBCs, respectively. This conservative approach will significantly overestimate risk because incidental ingestion of surface water and sediment from intermittent contact at the wetland will be much less than residential ingestion of tap water (2 L/day) and soil (100 mg/day).

Assumptions in the assessment that could result in underestimation of exposure (and therefore risk) are discussed below.

- Some potentially complete exposure pathways were not evaluated in the assessment. Excluding exposure pathways from the HHRA may result in underestimation of total hazard/risk. In most cases, the elimination of these pathways from quantitative evaluation in the risk assessment did not affect the conclusions of the risk evaluation because (1) they are negligible pathways or (2) they are potentially significant pathways but quantification would not affect the conclusions of the risk assessment (Section 5.3.4).

- Hazard/risk from exposure to soil was evaluated using sample results from 0 to 15 feet. This was a conservative approach in general because subsurface soil had higher contaminant concentrations than found in the 0 to 3 foot soil interval. However, concentrations of chromium and nickel were identified as being higher than background for the 0 to 3 foot interval (which included results from a historic 0- to

9-foot composite sample), but not for the 0 to 15 foot interval (Section 4.4.3, Background Comparison). However, concentrations of chromium (50.1 mg/kg) and nickel (67 mg/kg) in the "0 to 3 foot" interval were well below residential soil ingestion RBCs (78,000 and 1600 mg/kg, respectively), indicating that these metals in shallow soil do not pose a threat to human health under conservative exposure assumptions. For risks drivers, subsurface soil had higher contaminant concentrations than found in the 0 to 3 foot soil interval.

5.5.3 Toxicity Assessment

Lead, a COC in soil and in wetland surface water was not evaluated quantitatively in this HHRA because there are no EPA-approved toxicity values for lead. The exposure point concentrations for lead in soil (8.9 mg/kg in exposure area A-1, A-2, O and 44.9 mg/kg in exposure area A-3, A-4, T) are well below EPA's residential screening level of 400 mg/kg (EPA 1994b). The concentration of lead in surface water in the wetland (0.0077 mg/L) did not exceed the federal standard for lead in drinking water (0.015 mg/L) (EPA 1995a). Therefore, lead in soil and surface water at PRDA does not pose an unacceptable risk to public health under conservative (residential) exposure assumptions..

A toxicity assessment evaluating the uncertainty associated with using Region 3 RBCs to evaluate health risk was performed for the COCs that contribute most to overall risk at the PRDA (see Appendix E). The key COCs were ten volatile organic compounds in groundwater. Three major sources of uncertainty in the toxicity assessment are (1) use of withdrawn cancer slope factors for TCE, (2) estimating cancer risk for class C carcinogens that may not be human carcinogens, and (3) using oral reference doses (RfDs) to estimate inhalation toxicity in the absence of inhalation RfDs. The impact of these uncertainties are summarized below.

The largest source of uncertainty in cancer risk estimates for exposure to groundwater is the assumption (inherent in the application of slope factors for cancer effects) that 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, tetrachloroethene, and TCE are each potent human carcinogens, when they may not be carcinogenic to humans at all. TCE is not classified as to carcinogenicity, and the slope factors for this compound were withdrawn by EPA in 1989; however, the withdrawn slope factors were used in calculating EPA Region 3 RBCs and in estimating risk at PRDA. The other compounds have an EPA cancer weight-of-evidence classification of C (possible human carcinogen based on limited data in animals and inadequate evidence in humans).

These compounds contributed 99.8 percent of the total cancer risk estimates in the shallow zone and deep aquifer (1,1,2,2-tetrachloroethane alone contributed greater than 98 % of total cancer risk). If these compounds are excluded from the cancer risk estimate, the total estimated cancer risk for residential use of shallow groundwater decreases from 3E-01 to 5E-04 and the cancer risk for use of deep groundwater decreases from 4E-02 to 1E-04. These values are at the upper limit or exceed EPA's target risk range of 1E-06 to 1E-04 for cancer effects. Therefore, the exclusion of class C carcinogens from risk calculations does not change the overall conclusions of the risk assessment that unacceptable cancer risk is predicted for residential use of groundwater at PRDA.

Total hazard index estimates for residential use of groundwater may also have been overestimated because, in the absence of inhalation toxicity values, oral RfDs were used to evaluate toxicity by both the oral and inhalation routes in calculating tap water RBCs for chloroform, 1,1-dichloroethene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, TCE, and 1,2-dichloroethene. However, total noncancer hazard indexes for residential exposure to groundwater still exceeded 1 when noncancer RBCs for these COCs were calculated using only the oral exposure route (calculations not shown).

Therefore, the overall conclusion of the risk assessment that residential use of groundwater at PRDA could pose an unacceptable health threat to humans is not affected by the uncertainties in the carcinogenicity assessments and use of oral RfDs for estimating toxicity by inhalation.

5.5.4 Risk Characterization

The conservative methodology employed throughout the HHRA (assumptions of long-term residential or industrial exposure, upper bound estimates of toxicity, conservative concentration terms) result in conservative estimates of risk that overestimate actual risk at the site. However, the results of the HHRA can support risk management decisions for the PRDA because (1) risks for exposure to unsaturated soil 0 to 15 feet are below levels of concern, (2) risks for hypothetical domestic use of groundwater onsite exceed acceptable levels, and (3) screening-level modeling of soil vapor migration indicated that air or soil vapor measurements should be considered prior to making remediation decisions based on the indoor air pathway. In addition, groundwater fate and transport modeling demonstrated that there is no imminent threat to the

Eagle River, and there are no domestic wells onsite or downgradient of the site, so there is no exposure to groundwater under current land use.

5.6 SUMMARY AND CONCLUSIONS

Contamination at PRDA consists of (1) relatively low levels of VOCs and metals in the vadose zone (soil at depths from 0-15 feet) and wetland surface water, (2) low levels of explosives in groundwater and wetland surface water and sediment, and (3) high levels of VOCs in soil at depths greater than 15 feet (near the water table) and in groundwater.

An HHRA was performed to determine whether existing levels of these contaminants in media at PRDA could pose a threat to human health under conservative (health-protective) exposure assumptions. The risk assessment is conservative because it is based on long-term residential or occupational exposures which are not likely at this site, thereby overestimating risk for site-specific exposure scenarios. Following is a summary of results and conclusions.

The relatively low levels of contaminants in soils and wetland surface water and sediments at PRDA do not pose an unacceptable risk to public health under conservative exposure assumptions of long-term residential or industrial use. It therefore follows that exposure to contaminants in soil and the wetland at PRDA would not pose an unacceptable risk to current authorized personnel and or other potential receptors such as recreational users or commercial workers, who would be expected to receive much less exposure than that assumed for residents in this assessment.

- No carcinogens were detected in surface water in the wetland. The low levels of VOCs, explosives, and metals in wetland surface water do not pose a threat of noncarcinogenic health effects. Low levels of explosives in sediments in the wetland do not pose unacceptable risk of cancer or noncancer health effects.

- In exposure area A-1, A-2, O, risk of cancer and noncancer health effects from exposure to low levels of VOCs and metals in soil at depths of 0-15 feet were negligible.

- Lifetime excess cancer risk was 1E-05 (1 in 100,000) and noncarcinogenic hazard index was less than 1 for residential exposure to soil in area A-3, A-4, T at depths of 0-15 feet. The primary contributors to cancer risk were 1,1,2,2-tetrachloroethane and TCE (exposure point concentrations of 4.6 and 4.1 mg/kg, respectively) via the soil ingestion and soil-to-air inhalation route of exposure. Generally, remediation is not warranted for protection of public health if total lifetime excess cancer risk does not exceed 1E-04 and if noncarcinogenic effects are not a concern (HI < 1) (EPA 1991c).

- The highest concentrations of VOCs in soil were detected in exposure area A-3, A-4, T at depths greater than 15 feet bgs, below the depth of potential direct human exposure (e.g., 2,030 mg/kg 1,1,2,2-tetrachloroethane and 0.384 mg/kg TCE were detected at MW-14 at a depth of 16-18 feet). Higher concentrations were also detected in soil in the perched zone at about 14 feet bgs in the hillside at the southwest edge of Area A-3. Contaminants at this depth could serve as a continuing contaminant source to groundwater or to vapor migration.

Use of groundwater from the shallow zone or deep aquifer at PRDA as a drinking water source would pose an unacceptable risk of cancer and noncancer health effects (i.e., estimated cancer risk exceeds 1E-04 and the HI for noncancer effects exceeds 1 (see Section 5.4.3). Groundwater at PRDA or downgradient from it is not currently used in any capacity nor is it expected to be used in the future. Groundwater fate and transport modeling indicates that contaminants in PRDA do not pose a threat to the Eagle River in the imminent or near future.

- Primary contributors to lifetime excess cancer risk in groundwater at PRDA were 1,1,2,2-tetrachloroethane and TCE (exposure point concentrations in the shallow zone of 16.9 and 6.3 mg/L, respectively). Concentrations of carbon tetrachloride, chloroform, cis-1,2-dichloroethene, 1,1-dichloroethene, tetrachloroethene, and 1,1,2-trichloroethane also exceeded levels of concern (HI > 1 or cancer risk > 1E-04) for residential exposure to groundwater.

- The highest concentrations of VOCs in groundwater at PRDA were detected in the perched zone (e.g., 1900 mg/L 1,1,2,2-tetrachloroethane and 220 mg/L TCE were detected in MW-14 at a depth of 22 feet in the perched water zone). Although these contaminants do not pose a threat to human health (the perched zone would not be used as a water supply), they could serve as a continuing contaminant source to the shallow zone and deep aquifer.

- Based on groundwater fate and transport modeling for the shallow zone and deep aquifer (assuming no source decay or biodegradation), it would take 120 to 130

> years for detectable concentrations (0.005 mg/L) of TCE to reach the Eagle River and 170 years for detectable concentrations (0.005 mg/L) of 1,1,2,2-tetrachlorethane to reach the Eagle River. These 0.005 mg/L concentrations of 1,1,2,2-tetrachloroethane and TCE do not exceed health-based levels of concern for residential drinking water and for ingestion of fish by humans (AWQC 0.011 mg/L for 1,1,2,2-tetrachloroethane and 0.081 mg/L for TCE). Therefore, contaminant concentrations in groundwater do not pose a threat to the Eagle River for over 100 years.

Screening-level modeling of vapor migration from soil and groundwater and vapor intrusion into a building indicated that contaminant concentrations in deep soil and groundwater could pose an indoor inhalation hazard. Air or soil vapor measurements are recommended, however, prior to making remedial decisions based on the indoor air exposure route.

In conclusion, contaminants in unsaturated soil (0 to 15 feet) and the wetlands at PRDA do not pose a threat to human health. Contaminants in deeper soil and in groundwater also do not pose a threat under current conditions. Contaminant migration in groundwater is not expected to reach the Eagle River (assuming no decay of source concentrations) for over 100 years. However, unacceptable risk would be associated with onsite residential use of the groundwater, and vapor migration from soil and groundwater could pose an indoor inhalation hazard, based on a screening level analysis.

TABLE 5-1
SUMMARY OF CHEMICALS OF CONCERN(1)
FORT RICHARDSON PRDA

Chemicals of Concern	Soil (Depth 0-15 feet)(2)		Groundwater(3)		Wetlands(4)	
	Area A, B, O	Area C, D, T	Shallow Zone	Deep Aquifer	Surface Water	Sediments
VOLATILE ORGANIC COMPOUNDS						
Acetone			X			
Benzene			X	X		
Carbon tetrachloride			X	X		
Chlorobenzene			X	X		
Chloroform	X	X	X	X		
1,4-Dichlorobenzene			X			
1,2-Dichloroethane			X	X		
1,1-Dichloroethene			X	X		
cis-1,2-Dichloroethene		X	X	X		
trans-1,2-Dichloroethene	X	X	X	X		
1,1,2,2-Tetrachloroethane	X	X	X	X		
Hexachloroethane			X			
Tetrachloroethene	X	X	X	X		
Toluene	X		X	X	X	
1,1,2-Trichloroethane		X	X	X		
Trichloroethene	X	X	X	X		
Vinyl chloride				X		
EXPLOSIVES						
1,3-Dinitrobenzene					X	
m-Nitrotoluene						X
1,3,5-Trinitrobenzene						X
2,4,6-Trinitrotoluene						X
RDX			X			
METALS						
Copper		X			X	
Lead	X	X			X	
Mercury	X	X				
Nickel					X	
Silver		X				
Zinc		X				

(1) Chemicals of concern (COCs) are site-related chemicals to be evaluated in the human health risk assessment.
(2) COCs in soil included organics detected at depths of 0-15 feet bgs, and metals whose site concentrations at depths of 0-15 feet bgs exceeded background concentrations.
(3) COCs in groundwater included detected organics, explosives, and metals whose maximum site concentrations exceeded Alaska MCLs. No metals exceeded MCLs.
(4) COCs in surface water and sediments included detected organics, explosives, and metals whose site concentrations exceeded background concentrations in surface water and sediments.

TABLE 5-2
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN SOIL (mg/kg) INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET) FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency (1)	Maximum Detected Concentration	95% UCL of the Mean (2)	Concentration Used in Risk Assessment (3)
Chloroform	1/176	0.0042	0.023	0.004
Lead	24/24	15	8.900	8.900
Mercury	18/24	0.21	0.130	0.130
trans-1,2-Dichloroethene	1/176	0.01	0.023	0.010
1,1,2,2-Tetrachloroethane	11/176	1.7	0.067	0.067
Tetrachloroethene	1/176	0.001	0.023	0.001
Toluene	3/24 (4)	0.0024	0.001	0.001
Trichloroethene	4/176	0.02	0.023	0.02

(1) No. detects/no. samples. 152 field screening samples and 17 laboratory samples were collected by WC 1996. Seven samples were collected by ESE 1991.

(2) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(3) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) is used to represent the upper bound soil concentration. (EPA 1989a)

(4) Toluene was analyzed for in 17 laboratory samples by WC 1996 and 7 samples by ESE 1991.

TABLE 5-3
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency (1)	Maximum Detected Concentration	95% UCL of the Mean (2)	Concentration Used in Risk Assessment (3)
Chloroform	6/139	0.16	1.89	0.16
cis-1,2-Dichloroethene	21/139	1.6	1.93	1.60
trans-1,2-Dichloroethene	24/139	1.16	1.93	1.16
1,1,2,2-Tetrachloroethane	54/170	65	4.64	4.64
Tetrachloroethene	21/170	8.5	2.10	2.10
1,1,2-Trichloroethane	1/139	0.0099	1.89	0.01
Trichloroethene	42/170	116	4.12	4.12
Copper	13/13 (4)	190	77.8	77.8
Lead	13/13	160	44.9	44.9
Mercury	2/13	0.58	0.18	0.18
Silver	6/13	1.9	0.79	0.79
Zinc	13/13	1000	369.5	369.5

(1) No. detects/no. samples. 11 field screening samples and 13 laboratory samples were collected by WC 1996. 146 samples were collected by OHM 1994a; 31 of the samples measured only 1,1,1,2-TCA, PCE, and TCE.

(2) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(3) The maximum detected concentration or the 95% UCL (whichever is smaller) is used to represent the upper bound soil concentration. (EPA 1989a)

(4) Inorganics were analyzed for in 13 laboratory samples collected by WC 1996.

TABLE 5-4
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency (1)	Maximum Detected Concentration	95% UCL of the Mean (2)	Concentration Used in Risk Assessment (3)
Acetone	1/16	8.4	1.53	1.53
Benzene	4/26	0.0116	0.0445	0.0116
Carbon tetrachloride	7/45	0.3	0.0437	0.0437
Chlorobenzene	1/26	0.0004	0.0440	0.0004
Chloroform	15/45	0.14	0.0326	0.0326
1,4-Dichlorobenzene	1/26	0.0005	0.0361	0.0005
1,2-Dichloroethane	1/45	0.0015	0.0261	0.0015
1,1-Dichloroethene	7/26	0.008	0.0428	0.008
cis-1,2-Dichloroethene	21/45	3.1	0.464	0.464
trans-1,2-Dichloroethene	13/37	1	0.144	0.144
Hexachloroethane	1/11	0.0093	0.00278	0.00278
1,1,2,2-Tetrachloroethane	25/45	93	16.9	16.9
Tetrachloroethene	10/45	0.9	0.111	0.111
Toluene	3/26	0.0004	0.044	0.0004
1,1,2-Trichloroethane	11/45	0.28	0.079	0.0791
Trichloroethene	24/45	46	6.35	6.35
RDX	1/26	0.00284	0.00077	0.00077

(1) No. detects/No. samples. 19 field screening and 10 laboratory samples were collected by WC 1996. 16 historical samples were available from ESE 1991, OHM 1993, and OHM 1994a. Number of samples for specific chemicals depends on analytical sampling programs (e.g., acetone was analyzed for in historical samples only; benzene was not analyzed for in 19 field screening samples by WC 1996).

(2) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(3) The maximum detected concentration or the 95% UCL (whichever is smaller) is used to represent the upper bound groundwater concentration. (EPA 1989a)

TABLE 5-5
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN GROUNDWATER (mg/L)
DEEP AQUIFER
FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency (1)	Maximum Detected Concentration	95% UCL of the Mean (2)	Concentration Used in Risk Assessment (3)
Benzene	2/10	0.00073	0.0034	0.00073
Carbon tetrachloride	2/10	0.0043	0.00392	0.00392
Chlorobenzene	1/10	0.00055	0.00337	0.00055
Chloroform	2/10	0.0032	0.00382	0.0032
1,2-Dichloroethane	1/10	0.0012	0.00362	0.0012
1,1-Dichloroethene	2/10	0.004	0.00382	0.00382
cis-1,2-Dichloroethene	6/8	0.3	0.169	0.169
trans-1,2-Dichloroethene	3/10	0.079	0.0318	0.0318
1,1,2,2-Tetrachloroethane	6/10	4.9	2.28	2.28
Tetrachloroethene	2/10	0.018	0.00831	0.00831
Toluene	2/10	0.0015	0.00369	0.0015
1,1,2-Trichloroethane	2/10	0.033	0.0173	0.0173
Trichloroethene	2/10	1.8	0.727	0.727
Vinyl chloride	1/10	0.0008	0.00355	0.0008

(1) No. detects/No. samples. 5 laboratory samples were collected by WC 1996, and 5 historical samples were available from ESE 1991 and OHM 1993. Sampling results for some chemicals were missing from historical data.

(2) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(3) The maximum detected concentration or the 95% UCL (whichever is smaller) is used to represent the upper bound groundwater concentration (EPA 1989a).

TABLE 5-6
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN SURFACE WATER
WETLANDS
FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency	Maximum Detected Concentration (mg/L)	95% UCL of the Mean (mg/L)	Concentration Used in Risk Assessment (mg/L)
1,3-Dinitrobenzene	2/4	0.0034	0.0029	0.0029
Toluene	1/4	0.0045	0.00428	0.00428
Copper	2/4	0.099	0.08	0.08
Lead	4/4	0.008	0.0077	0.0077
Nickel	2/4	0.019	0.0189	0.0189

(1) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(2) The maximum detected concentration or the 95% UCL (whichever is smaller) is used to represent the upper bound surface water concentration. (EPA 1989a)

TABLE 5-7
DETECTION FREQUENCY AND CONCENTRATION TERMS FOR CHEMICALS OF CONCERN IN SEDIMENT (mg/kg)
WETLANDS
FORT RICHARDSON PRDA

Chemical of Concern	Detection Frequency	Maximum Detected Concentration	95% UCL of the Mean (1)	Concentration Used in Risk Assessment (2)
1,3,5-Trinitrobenzene	4/4	0.78	0.81	0.78
2,4,6-Trinitrotoluene	1/4	0.48	0.42	0.42
m-Nitrotoluene	1/4	3	2.53	2.53

(1) The 95 percent upper confidence limit (95% UCL) of the mean. See Appendix A.

(2) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) is used to represent the upper bound sediment concentration. (EPA 1989a)

TABLE 5-8
RISK-BASED CONCENTRATIONS (RBCs) AND SOIL SCREENING LEVELS (SSLs) FOR CHEMICALS OF CONCERN (1)
FORT RICHARDSON PRDA

Chemical of Concern	RBC Tap Water (mg/L)	RBC Residential Soil (mg/kg)	RBC Industrial Soil (mg/kg)	SSL Transfer to Air (mg/kg)
Acetone	3.7 n	NA	NA	NA
Benzene (c)	0.00036 c	NA	NA	NA
Benzene (n)	0.0104 n (2)	NA	NA	NA
Carbon Tetrachloride (c)	0.00016 c	NA	NA	NA
Carbon Tetrachloride (n)	0.0036 n (2)	NA	NA	NA
Chlorobenzene	0.039 n	NA	NA	NA
Chloroform (c)	0.00015 c	100 c	940 c	0.2 c
Chloroform (n)	0.0608 n (2)	780 n (2)	20000 n (2)	-
1,4-Dichlorobenzene (c)	0.00044 c	NA	NA	NA
1,4-Dichlorobenzene (n)	1.393 n (2)	NA	NA	NA
1,2-Dichloroethane (c)	0.00012 c	NA	NA	NA
1,2-Dichloroethane (n)	0.0174 n (2)	NA	NA	NA
1,1-Dichloroethene (c)	0.000044 c	NA	NA	NA
1,1-Dichloroethene (n)	0.0548 n (2)	NA	NA	NA
cis-1,2-Dichloroethene	0.061n	780 n	20000 n	1500 n
trans-1,2-Dichloroethene	0.12 n	1600 n	41000 n	3600 n
1,3-Dinitrobenzene	0.0037 n	NA	NA	NA
Hexachloroethane (c)	0.00075 c	NA	NA	NA
Hexachloroethane (n)	0.0061 n (2)	NA	NA	NA
m-Nitrotoluene	0.061 n	780 n	20000 n	460 n
RDX (c)	0.0061 c	NA	NA	NA
RDX (n)	0.11 (2)	NA	NA	NA
1,1,2,2-Tetrachloroethane	0.00052 c	3.2 c	29 c	0.4 c
Tetrachloroethene (c)	0.0011 c	12 c	110 c	11 c
Tetrachloroethene (n)	0.0608 n (2)	780 n (2)	20000 n (2)	-
Toluene	0.75 n	16000 n	410000 n	520 n
1,1,2-Trichloroethane (c)	0.00019 c	11 c	100 c	0.8 c
1,1,2-Trichloroethane (n)	0.0243 n (2)	310 n (2)	8200 n (2)	-
Trichloroethene (c)	0.0016 c	58 c	520 c	3 c
Trichloroethene (n)	0.0365 n (2)	468 n (2)	12000 n (2)	-
1,3,5-Trinitrobenzene	NA	3.9 n	100 n	-
2,4,6-Trinitrotoluene (c)	NA	21 c	190 c	-
2,4,6-Trinitrotoluene (n)	NA	39 n	1000 n	-
Vinyl chloride	0.000019 c	NA	NA	NA
Copper	1.5 n	3100 n	82000 n	-
Lead	-	-	-	-
Mercury	0.011 n	23 n	610 n	7
Nickel	0.73 n	NA	NA	NA
Silver	0.18 n	390 n	10000 n	-
Zinc	11 n	23000 n	610000 n	-

(1) RBCs are based on ingestion of soil and ingestion and VOC inhalation from groundwater. SSLs are based on inhalation of contaminants from soil in air. Unless otherwise indicated, RBCs and SSLs were obtained from EPA 1995a.

(2) Noncancer RBC calculated using EPA Region 3 methodology; see Appendix E.

c - RBC or SSL based on cancer effects

n - RBC or SSL based on noncancer effects

NA - Not Applicable - chemical is not a contaminant in the medium.

- = Noncancer RBC or SSL was not available from EPA 1995a nor was it calculated.

TABLE 5-9
SUMMARY OF RME CANCER RISK AND NONCANCER HAZARD INDEX
HUMAN HEALTH RISK ASSESSMENT
FORT RICHARDSON PRDA

Receptor	Media		Total Excess Lifetime Cancer Risk	Noncarcinogenic Hazard Index
Resident	Soil 0 to 15 feet (A-3, A-4, T)			
	Ingestion		2E-06	7E-02
	Inhalation		1E-05	3E-02
		Total	1E-05	1E-01
	Soil 0 to 15 feet (at A-1, A-2, O)			
	Ingestion		2E-08	6E-03
	Inhalation		2E-07	2E-02
		Total	2E-07	3E-02
	Hot spot soil, 14 feet (hillside)		3E-04	--
	Groundwater (Shallow Zone)		3E-01	2E+02
	Groundwater (Deep Aquifer)		4E-02	2.5E+01
	Surface Water (Wetland)		-	9E-01
	Ingestion of Sediments (Wetland)		2E-08	2E-01
Industrial Worker	Soil Ingestion (A-3, A-4, T)		2E-07	2E-03
	Soil Ingestion (A-1, A-2, O)		2E-09	2E-04
	Hot spot soil (hillside)		4E-05	--
	Ingestion of Sediments (Wetland)		2E-09	8E-03

-- = Not evaluated.

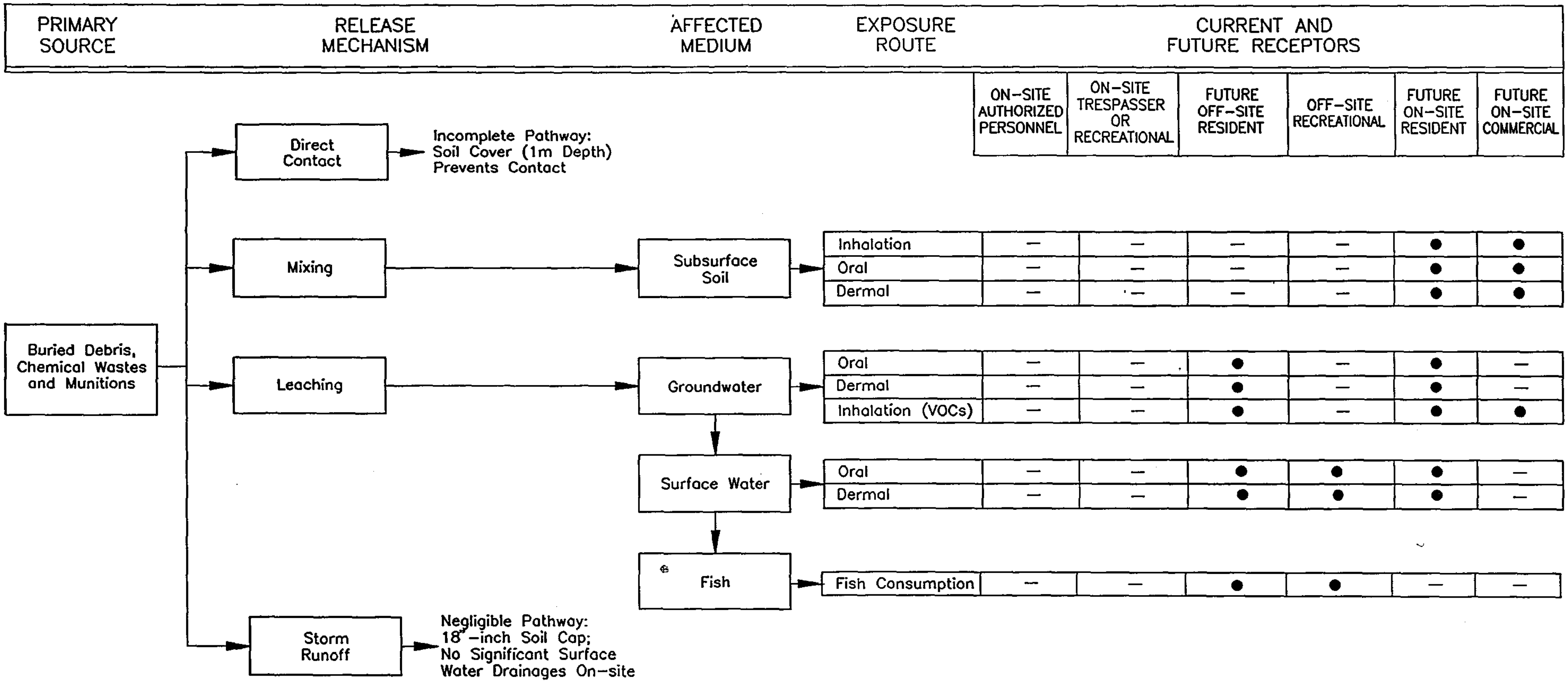
TABLE 5-10
COMPARISON OF SITE CONCENTRATIONS TO SCREENING-LEVEL SSTLs FOR VAPOR MIGRATION

Parameter	1122-Tetrachloroethane Conc. (mg/kg)	1122-Tetrachloroethane Site Conc. > SSTL?	Trichloroethylene Conc. (mg/kg)	Trichloroethylene Site Conc. > SSTL?
Soil (14-20 ft. bgs)				
Commercial SSTL (a)	4.1		2.7	
Residential SSTL (a)	1.3		0.87	
Mean Site Concentration (b)	579	Yes	62	Yes
95% UCL Site Concentration (b)	1260	Yes	141	Yes
Groundwater (perched and shallow)				
Commercial SSTL (a)	36		9.7	
Residential SSTL (a)	12		3.1	
Mean Site Concentration (b)	182	Yes	31	Yes
95% UCL Site Concentration (b)	438	Yes	60	Yes

SSTL = Site-specific target level
UCL = upper confidence limit on the mean

(a) See Appendix F. SSTLs are estimated target level concentrations in soil or groundwater protective of the vapor migration-indoor air exposure route. They are estimated using a model developed by ASTM (ASTM 1995; GSI 1995). SSTLs are screening-level because they are based on conservative exposure and fate and transport assumptions. They are calculated using a 1E-06 cancer risk level for class A and B carcinogens and a 1E-05 cancer risk level for class C carcinogens. 1122-Tetrachloroethane is a class C carcinogen; TCE is unclassified, and a 1E-06 cancer risk level was used. ASTM cautions that remediation decisions should not be based on comparing site concentrations to screening-level SSTLs for the vapor migration pathway; however, the SSTLs may be used to judge whether air or soil vapor measurements are warranted.

(b) Estimated from samples collected in and near Areas A-3 and A-4. See Tables F-1 and F-2.



Affected Medium	Exposure Route	ON-SITE AUTHORIZED PERSONNEL	ON-SITE TRESPASSER OR RECREATIONAL	FUTURE OFF-SITE RESIDENT	OFF-SITE RECREATIONAL	FUTURE ON-SITE RESIDENT	FUTURE ON-SITE COMMERCIAL
Subsurface Soil	Inhalation	—	—	—	—	●	●
	Oral	—	—	—	—	●	●
	Dermal	—	—	—	—	●	●
Groundwater	Oral	—	—	●	—	●	—
	Dermal	—	—	●	—	●	—
	Inhalation (VOCs)	—	—	●	—	●	●
Surface Water	Oral	—	—	●	●	●	—
	Dermal	—	—	●	●	●	—
Fish	Fish Consumption	—	—	●	●	—	—

Figure 5-1

LEGEND

● POTENTIALLY COMPLETE PATHWAY

— INCOMPLETE PATHWAY

Job No. : E9408L

Prepared by : P.A.W.

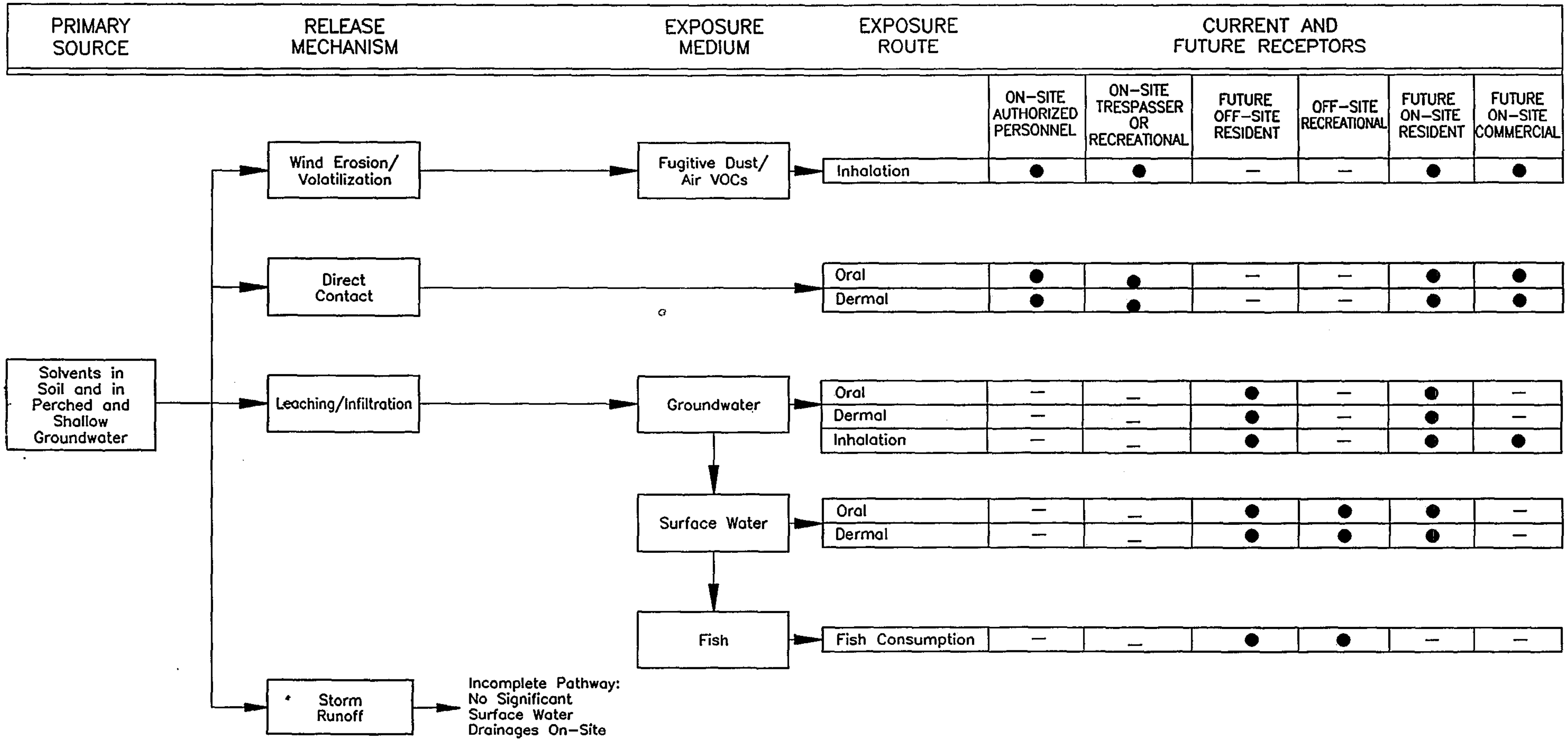
Date : 3/15/96

FORT RICHARDSON OUB
POLELINE ROAD DISPOSAL AREA

CONCEPTUAL SITE MODEL (HHRA)
EXPOSURE AREA A-1, A-2, 0

9408CSM1

Woodward-Clyde



Exposure Medium	Exposure Route	ON-SITE AUTHORIZED PERSONNEL	ON-SITE TRESPASSER OR RECREATIONAL	FUTURE OFF-SITE RESIDENT	OFF-SITE RECREATIONAL	FUTURE ON-SITE RESIDENT	FUTURE ON-SITE COMMERCIAL
Fugitive Dust/ Air VOCs	Inhalation	●	●	—	—	●	●
Direct Contact	Oral	●	●	—	—	●	●
	Dermal	●	●	—	—	●	●
Groundwater	Oral	—	—	●	—	●	—
	Dermal	—	—	●	—	●	—
	Inhalation	—	—	●	—	●	●
Surface Water	Oral	—	—	●	●	●	—
	Dermal	—	—	●	●	●	—
Fish	Fish Consumption	—	—	●	●	—	—

LEGEND

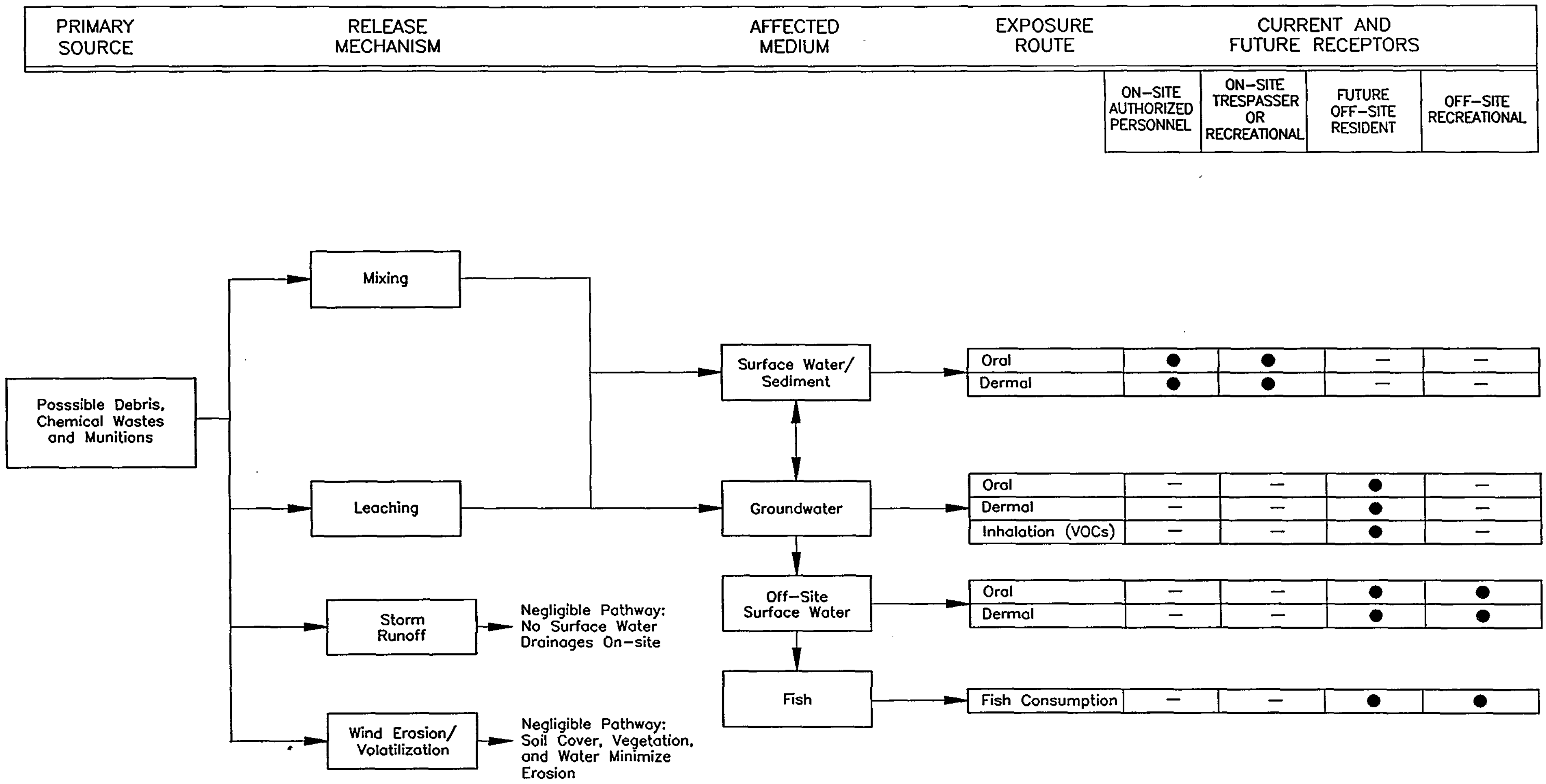
- ● POTENTIALLY COMPLETE PATHWAY
- — INCOMPLETE PATHWAY

Figure 5-2

Job No. : E9408L
Prepared by : P.A.W.
Date : 3/15/96

FORT RICHARDSON OUB
POLELINE ROAD DISPOSAL AREA
CONCEPTUAL SITE MODEL (HHRA)
EXPOSURE AREA A-3, A-4, T

9408CSM2



Negligible Pathway: No Surface Water Drainages On-site

Negligible Pathway: Soil Cover, Vegetation, and Water Minimize Erosion

Affected Medium	Exposure Route	ON-SITE AUTHORIZED PERSONNEL	ON-SITE TRESPASSER OR RECREATIONAL	FUTURE OFF-SITE RESIDENT	OFF-SITE RECREATIONAL
Surface Water/ Sediment	Oral	●	●	—	—
	Dermal	●	●	—	—
Groundwater	Oral	—	—	●	—
	Dermal	—	—	●	—
	Inhalation (VOCs)	—	—	●	—
Off-Site Surface Water	Oral	—	—	●	●
	Dermal	—	—	●	●
Fish	Fish Consumption	—	—	●	●

LEGEND

- ● POTENTIALLY COMPLETE PATHWAY
- — INCOMPLETE PATHWAY

Figure 5-3

Job No. : E9408L
Prepared by : P.A.W.
Date : 3/15/96

FORT RICHARDSON OUB
POLELINE ROAD DISPOSAL AREA

CONCEPTUAL SITE MODEL (HHRA) WETLAND AREA

9408CSM6

6.0
ECOLOGICAL RISK ASSESSMENT

6.1 INTRODUCTION

6.1.1 Purpose

The purpose of this Ecological Risk Assessment (ERA) was to evaluate the likelihood that ecological resources are or may be adversely affected as a result of exposure to chemicals identified in soils, sediments, and surface water at the Fort Richardson PRDA site. This information will be used to assist risk managers in making informed decisions about the current and future threats to the environment posed by potential hazardous substance release at this site. This ERA uses the validated database presented in the RI report (WC 1996), historic data from ESE's site investigation (ESE 1991) in 1990, and historic data from OHM's removal action in 1993 and 1994 (OHM 1995a,b), to address potential current and future risks associated with site-related chemicals.

The PRDA OUB site consists of three exposure areas (which were defined in Section 4.1):

1. Areas A-1, A-2, O;
2. Areas A-3, A-4, T;
3. Wetland Area.

6.1.2 Scope

This ERA is part of the RI of the PRDA. It was prepared within the guidelines set forth in documents issued by EPA and the Department of Defense (DOD):

- Framework for Ecological Risk Assessment ([Framework], USEPA 1992b);
- Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual ([*RAGS* II] USEPA 1989b);

- Ecological Assessment of Hazardous Waste Sites, A Field and Laboratory Manual (USEPA 1989c);
- Procedural Guidelines for Ecological Risk Assessments at U.S. Army Sites (Wentsel et al. 1994); and
- Wildlife Exposures Factors Handbook (USEPA 1993).

In addition to the basic guidance, supporting literature used to evaluate current and future risk are included in Section 8.0.

This ERA follows the process described in EPA's (1992b) Framework and is presented in the following format:

- Section 6.2 - Site Description
- Section 6.3 - Problem Formulation
  - Selection of chemicals of ecological concern (COECs)
  - Identification of complete exposure pathways
  - Selection of ecological endpoints and key ecological receptors
- Section 6.4 - Exposure and Ecological Effects Analysis
  - Exposure Assessment
  - Ecological Effects Assessment
- Section 6.5 - Ecological Risk Characterization and Summary
  - Risk Estimation
  - Uncertainty Analysis
  - Risk Description

The site description provides geological setting and soils geochemistry of the site. In addition, a detailed description of the site's ecological setting and ecological resources is provided as the basis for identifying key receptors and ecological endpoints during Problem Formulation.

The Problem Formulation phase identifies the COECs, potential ecological receptors and ecological endpoints. Site chemical concentrations are screened against a series of conservative criteria (e.g., background concentrations and state water quality criteria) in order to identify chemicals to be carried through the Analysis Phase. During this phase, a conceptual site model is developed to address likely contaminant migration routes and appropriate exposure pathways for ecological receptors at PRDA. A conservative approach is followed during the COEC screening effort, conceptual model development and exposure pathway evaluation to ensure that the specific constituents and exposure pathways that potentially contribute to risk are included, while at the same time removing from further consideration those factors which do not or only negligibly contribute to risk (e.g., incomplete exposure pathways, background levels; USEPA 1989a, 1992c).

The Analysis Phase incorporates the complete and potentially significant pathways and relationships identified in Problem Formulation that are to be pursued. The Analysis Phase consists of two interrelated efforts: the exposure and the ecological effects assessments (USEPA 1992b). In the exposure assessment, the magnitude and spatial and temporal distributions of exposure to COECs are identified and evaluated (USEPA 1992b). In the ecological effects assessment, information is assembled to identify and evaluate the potential adverse ecological effects elicited by the site COECs. The assessment of ecological effects for this ERA is based on toxicity information found in the literature.

The Risk Characterization phase integrates the information from the exposure and ecological effects assessments to evaluate the likelihood of adverse ecological effects. In this phase, calculations and data from the exposure and ecological affects assessments are related to the objective(s) of this ERA through the conceptual model and the assessment endpoints. The Risk Characterization phase of this ERA involves qualitative and quantitative comparisons of exposure estimates (exposure assessment) for the COECs and ecological receptors to threshold concentrations for adverse ecological effects. A qualitative uncertainty analysis is provided as part of the Risk Characterization. The uncertainty analysis provides an explanation of the values, calculations, and assumptions that may overestimate or underestimate the potential for risk in each of the three ERA phases. Factors that contribute to the uncertainty of a value, assumption, or decision are documented throughout this ERA at the point where the data are introduced and are also summarized in the uncertainty analysis section.

The process and methods used to evaluate the potential for ecological resources to be adversely affected are consistent with the EPA and DOD guidance documents listed above. EPA cautions that these documents are intended to provide guidance only and that considerable professional judgment must be exercised in applying the guidance to site-specific ERAs. Specific tasks requiring the use of professional judgment in this ERA include:

- Selection of environmental criteria for screening potential COECs;
- Selection of appropriate key receptors;
- Selection and application of an analysis approach and methodology for risk characterization; and
- Interpretation of results and uncertainties.

6.2 SITE DESCRIPTION

Descriptions of the PRDA location and existing physical conditions are provided in Section 2.0 of this report. The chemical results for this RI are given in Section 3.0. This site description provides additional details on the geochemistry and ecological setting of the PRDA area.

6.2.1 Geologic Setting and Soils Geochemistry

The following geology and soils geochemistry information provides additional background for evaluating naturally occurring metals concentrations in soil at PRDA. The geologic region around PRDA contains parts of two accreted lithotectonic terrains, the Peninsular and Chugach, which are generally separated by the Knik/Border Range Fault (Silberling and Jones, 1984). A lithotectonic terrain is a group of rocks which share similar origin, structure, and geologic history. To the north of the fault is the Peninsular Terrain, which contains Jurassic and Paleozoic age metamorphic rock, limestone, volcanic flows and volcaniclastic strata, fossiliferous marine shale, ultramafic rocks, Jurassic and Cretaceous-Tertiary age batholithic granitic rocks, and Tertiary age flows of andesite and olivine-basalt (Arbogast et al., 1987). To the south of the fault lies the Chugach Terrain, which consists primarily of weakly metamorphosed deposits of graywacke and slate of Upper Cretaceous age (Siberling and Jones 1984). The rocks of both terrains are cut by numerous igneous felsic dikes and stocks of Tertiary age.

Within the study area, the Peninsular Terrain is identified as consisting of intrusive and metamorphic rocks of Paleozoic and Jurassic age. The Chugach Terrain is composed of rocks from the Early Cretaceous McHugh Complex and the Valdez Group. The McHugh complex consists of mafic metavolcanic and metaclastic rocks, bedded chert, and minor lenses of limestone and metamorphosed volcanic ash. The Valdez Group consists of rhythmically interbedded graywacke, siltstone, and argillite and minor pebble conglomerates deposits. The Valdez Group also contains hemipelagic and pelagic sedimentary rocks, volcanic tuff, and pillow basalts (Winkler et al. 1984).

The Quaternary age glacial sediments which make up the soils at PRDA were derived from the bedrock of the Chugach Mountains. This bedrock consists predominately of magnesium and iron rich igneous and volcanic rocks. The natural abundance of elements iron, magnesium, manganese, copper, chromium, cobalt, vanadium, zinc and lead are generally high within these types of deposits. In addition, mineralization and ultramafic rocks have been documented within the immediate vicinity of Eagle River Flats and the PRDA (USATHAMA 1990). Given these circumstances it would not be unusual for metals to be enriched at PRDA in contrast to representative levels reported for the U.S. and Alaska.

6.2.2 Ecological Setting

This section describes the plants and animals that inhabit and surround the PRDA site. A list of the common and scientific names of the plants observed at the site and the animals that were observed or potentially use the site is provided in Table 6-1.

6.2.2.1 Plant Communities

The general vegetation type of the PRDA is interior spruce-hardwood forests and brush (Alaska Department of Fish and Game [ADFG] 1978), and a general vegetation map of the region characterizes it as lowland spruce-hardwood forest (State of Alaska 1974). Four major habitat types are present at and near the Poleline Road site: spruce-hardwood forest; wetland; herbaceous vegetation; and unvegetated areas (Figure 6-1). All of the vegetation appeared to be normal during a July 1995 site visit; no dead, dying, damaged, or dwarf vegetation was observed. However, most vegetation at the PRDA was removed in a 1994 removal action, and the PRDA was mostly unvegetated at the time of the site visit. Very small areas of herbaceous vegetation and shrubs were present on the east side of the clearing, apparently in areas not affected by the removal, and included fireweed, yarrow, alder, willows, and dandelion. The PRDA clearing covers about 3 acres. These areas are expected to readily revegetate with herbaceous and shrub cover becoming fairly well established within 5 years. The fairly quick re-establishment of herbaceous vegetation will minimize surface water runoff from the cleared areas. Vegetation was mapped from field observations and 1:1200 scale color aerial photography dated May 15, 1994 (Figures 6-1 and 6-2).

Spruce-hardwood forest is the predominant vegetation type in upland areas surrounding the PRDA clearing (Figure 6-2). Most of the forests surrounding the PRDA are dominated by paper birch and aspen, but white spruce is common. Forests mostly have a closed canopy, with a dense shrub and/or herb understory. Most trees are 6 to 8 inches in diameter, but a few 10 to 18 inch diameter birch and aspen trees were observed. Most trees are probably 40 to 50 years old and likely became established after fire or other disturbance. Successional processes will eventually lead to dominance by white spruce, unless additional disturbance restarts the process of succession. Common understory species observed include Sitka alder, Labrador-tea, Barclay willow, blueberry, highbush cranberry, prickly rose, buffaloberry, fireweed, and field horsetail.

Narrow transitional areas occur between the forest and some of the smaller wetlands, and are also present as narrow meadows within the forest. These areas are dominated by Beauvard spirea, polar grass, field horsetail, Labrador tea, resin birch, bunchberry, and yarrow, and were not wet at the time of the site visit.

The clearing along the powerline and road to the west of the PRDA is dominated by herbaceous and shrub vegetation including Sitka alder, various species of willows, fireweed, yarrow, dandelion, wild geranium, lupines, and others.

6.2.2.2 Mammals

Relatively little wildlife or its sign was observed during the July 1995 site visit, and assessment of species potentially present at the PRDA is based largely on habitat conditions and ecological literature. No dead or dying animals were observed during the field visit.

Several large game mammals are known or expected to be common in the PRDA vicinity. Moose sign was observed within the PRDA clearing. Moose have annual movements, and the PRDA vicinity is mapped as known calving, rutting and winter habitat (ADFG 1985a). The annual wintering moose population on Fort Richardson is estimated at 450 to 500 animals mainly east of cantonment area and around the Moose Run Golf Course (USACOE 1994b). Moderate populations of black bear occur in most lowland areas of Fort Richardson (USACOE 1994b). Grizzly bear are likely to occur occasionally.

Common furbearers in the vicinity of the PRDA include red fox, snowshoe hare, muskrat, mink, short-tailed weasel, least weasel, and wolverine. Other common mammals include red squirrel, red-backed vole, meadow vole, deer mouse, porcupine, and shrews. Wolf, lynx, marten and northern flying squirrel may also occur.

Primary consumers of plant foliage, stems, barks, buds, fruit, seeds and bark (herbivores) include snowshoe hare, northern red-backed vole, red squirrel, meadow vole, deer mouse, porcupine, and moose. Carnivores and omnivores include red fox, short-tailed weasel, least weasel, wolverine, lynx, and wolf.

6.2.2.3 Birds

Raptors likely to be present in the study area include sharp-shinned hawk, red-tailed hawk, American kestrel, great-horned owl, northern hawk owl, short-eared owl, and boreal owl. No raptor nests were observed at or near the PRDA.

Insect-eating birds likely to be common in the vicinity of the PRDA include northern flicker, grey jay, black-capped chickadee, boreal chickadee, gray cheeked thrush, Swainson's thrush, orange-crowned warbler, yellow warbler, yellow-rumped warbler, blackpoll warbler, Wilson's warbler, and common redpoll. Most feed among trees and shrubs, but flickers and thrushes are ground feeders.

Seed-eating and ground-feeding birds likely to be common in the area include fox sparrow, white-crowned sparrow, dark-eyed junco.

Spruce grouse, the only game bird likely to be present, feed mainly on the buds and needles of conifers in the winter.

6.2.2.4 Aquatic Habitats

The only aquatic habitats present in the vicinity of the PRDA are the 4- to 5-acre wetland immediately south of the PRDA clearing, and several smaller wetlands 1 acre or less in size. These wetlands are protected under Section 404 of the Clean Water Act. The wetlands occupy small basins in rolling to hummocky terrain. There are no rivers, streams or drainages in the vicinity of the PRDA. The Eagle River is located about 1 mile to the north and Fossil Creek about 1,500 feet to the southeast.

The large wetland immediately south of the PRDA clearing had water about 8 inches deep at the time of the field visit, over a peat substrate. Most of this wetland is dominated by russet sedge, with sparse shrub cover of resin birch, Alaska bog willow, and bog rosemary. About one-third of the wetland has shallower water and is dominated by intermediate sedge with moderate to high shrub cover, including crowberry, bog rosemary, resin birch, and some labrador tea. Marginal areas, especially near the PRDA, are dominated by polar grass and marsh five-finger. A few black spruce are present near the east edge. Sphagnum is abundant and sundew is common. The smaller wetlands are dominated by polar grass on the edges, and russet sedge and marsh five-finger.

The wetlands present in the PRDA vicinity are classified as palustrine, emergent - persistent and scrub-shrub - broad-leaved deciduous, according to the mapping conventions used in the National Wetlands Inventory. Most of the species observed were facultative wetland species, along with some obligate and some facultative species (Reed 1988). These areas are jurisdictional wetlands under the three-parameter approach of the U.S. Army Corps of Engineers. They exhibited a preponderance of hydrophytic vegetation and positive evidence of hydric soils and wetland hydrology, including inundation and saturation.

The wetlands are classified as non-forested bog or wet meadow, in the system used by the Municipality of Anchorage (Fugro Northwest, Inc. 1990). Wetlands in this class have low functional values for protected species or habitats, ecological uniqueness, mammals, birds, and fish and most other functions. They have moderate functional value for water purification and drinking water.

6.2.2.5 Aquatic Life

The primary aquatic life in the wetland adjacent to the PRDA site are invertebrates such as dragonflies, mayflies, midges (chironomids), and Ceratopogonidae larvae. Fish are not likely to be present because of the shallow water and the likelihood that it freezes to the bottom during winter. Wood frog are likely to be present but were not observed during the field survey.

Fish species in the Eagle River include rainbow trout, dolly varden, arctic char, chum salmon (spawning habitat), king salmon (spawning and rearing habitat), pink salmon (spawning habitat), and sockeye salmon (rearing habitat) (ADFG 1985b). The Eagle River is mapped as a sport fishing harvest area for rainbow trout and for dolly varden and arctic char.

6.2.2.6 Aquatic Feeding Mammals and Birds

Muskrat trails were observed in the wetland during the field survey, and moose are likely to feed in the wetland occasionally. Other mammals that may occur include mink, northern bog lemming, and meadow vole.

The wetlands provide potential habitat for a number of waterfowl and shorebird species, but do not appear to represent important habitat because of the shallow water and dense vegetation. No waterfowl or shorebirds were observed during the field visit, and the area is about 3 miles away from mapped general distribution of ducks and geese (ADFG 1985b). Species which may occur include green-winged teal, mallard, northern pintail, northern shoveler, American wigeon, common golden eye, Barrow's golden eye, bufflehead, lesser yellow-legs, and common snipe. Least sandpiper and pectoral sandpiper may occur during spring migration.

6.2.2.7 Critical Habitats and Protected Biota

According to USFWS, no federally listed threatened or endangered species are known or expected to use the PRDA area or vicinity (G. Moran, pers. comm.). A review of the 1995 USFWS database for threatened and endangered species in Alaska, showed no new listings of species that could potentially occur at PRDA. Peregrine falcon could occasionally fly over the area, but no key habitat features are present at or near the PRDA site (G. Moran, pers. Comm.). Falcons were taken off the endangered species list for Alaska in 1993.

Another raptor, the northern goshawk, is currently a category 2 candidate species for federal listing. Category 2 species are those for which listing as threatened or endangered may be appropriate, but for which further information on threats or rarity is needed to support listing. Northern goshawk inhabit a large part of Alaska, preferring dense forested areas, especially old growth. Suitable habitat was not observed near the PRDA and northern goshawk are not expected to occur except occasionally during migration.

The North American lynx is another category 2 candidate species that may pass through the area. Lynx inhabit much of Alaska's forested areas, and use a variety of habitats, including spruce and hardwood forests (ADFG 1989). The best habitat is where there is an abundance of early successional growth, which provides the best habitat for snowshoe hares and other small prey. Lynx are likely to be present in the forests surrounding the PRDA.

6.3 PROBLEM FORMULATION

The focus of the Problem Formulation phase in this ERA is on the identification of COECs and the identification of complete exposure pathways and possible ecological receptors of these COECs. A conservative approach was followed during the COEC and receptor screening efforts to ensure that the specific constituents and exposure pathways that potentially contribute to risk were included, and that potential ecological threats were not overlooked. Conservative criteria were used to screen site chemicals and to document and eliminate from further consideration those chemicals and exposure pathways that were determined to pose little or no risk of potential adverse ecological effects.

The screening of chemicals, receptors, and exposure pathways are interrelated, making this an iterative process. For example, results of the chemical screening help delineate potential exposure pathways, which in turn, affects the identification of potential receptors and ecological endpoints.

6.3.1 Criteria for Identifying Chemicals of Ecological Concern

COECs are chemicals that may be released from buried debris, wastes, and munitions at the PRDA that may pose a risk to ecological receptors if an exposure pathway is complete. The identification of COECs is based on an evaluation of analytical results from the RI and historical sampling results. As part of the process, the presence of chemicals at background or acceptable levels, as determined using established screening criteria, are distinguished from chemicals that are present at abnormally high concentrations, due to site-related waste release, and which may possibly pose an unacceptable risk.

This section describes the criteria used to identify COECs for use in evaluating ecological risk for each of the exposure areas at the PRDA. The COEC selection process involves comparing the concentration of each detected analyte from the RI and historic analytical results against available screening criteria appropriate for water, sediment and soil. This screening process distinguishes the presence of chemicals at background or "acceptable" levels from chemicals that are present at abnormally high concentrations due to site-related waste releases. The following five screening criteria were used to select potential COECs for each investigation area:

Criterion 1 - Detection in at least one sample
Criterion 2 - Frequency of detection screening
Criterion 3 - Site background comparison
Criterion 4 - Toxicity-based criteria screening
Criterion 5 - Literature-based background comparison

<u>Detection in at Least One Sample</u>: All analytes in surficial soils and sediments and surface water at the site from the RI and usable historic data (USACE 1991; OHM 1995a,b) were included in the screening process. Historic data not included were sample stations which were later excavated during a removal action at the PRDA site and samples from the resultant excavated soil piles. To be considered as a potential COEC for an investigative area, the chemical must have been found in at least one sample at the investigative area above the detection limit. Soil samples for the RI were composited from various intervals (e.g., 0 to 3 feet, 1 to 4 feet) up to a maximum depth of 15 feet. Based on site history, surficial soil contamination was not expected. Trench areas A-3 and A-4 were excavated and backfilled, for example, and Areas A-1 and A-2 were covered with approximately 3 feet of soil. Soil depths

representative of a burrowing animal's exposure were not specifically sampled, therefore, the selection of COECs in soils and sediments was restricted to samples that included depth intervals ≤3 feet (i.e., 0 to 3 ft and 3 to 6 ft). Maximum concentrations from either of these depth intervals were considered to represent maximum exposure potential for ecological receptors such as burrowing mammals and plants. Uncertainties regarding the estimation of exposure concentration for wildlife at PRDA are also discussed in the uncertainty section (6.5.5.1 and 6.5.5.3).

Frequency of Detection: Chemicals retained after applying the first criterion (detection in at least one sample) were next screened against frequency of detection, a step that screens out chemicals which are not likely to be significant risk drivers because of their low frequency and low exposure potential. Chemicals that occurred at a low frequency at the exposure units were considered for exclusion as potential COECs following USEPA guidance (EPA 1989a). A ≤5 percent frequency threshold, requiring a minimum of 20 samples for a given medium, was applied for this criterion.

Those chemicals that were identified as occurring in ≤5 percent of the samples were further screened based on the following two criteria (EPA 1989a) before exclusion as a potential COEC:

- Chemical is not detected (ND) in other media at the exposure unit (includes groundwater and subsurface soils)
- Chemical has low bioaccumulation potential (log $K_{ow} < 3.0$ or $K_{oc} < 500$).

If the chemical was detected in ≤5 percent of samples of an exposure medium and these two additional criteria were met, the chemical was excluded as a potential COEC. If any one of the criteria was not met, the chemical was retained for further screening.

Site Background Screening: Metals remaining after applying the second criterion (frequency of detection) were retained as potential COECs if site concentrations were higher than site background concentrations. Comparison of site metal concentrations with local background concentrations for soils, wetland sediment, and surface water (WC 1996) was done to distinguish site-related chemicals from naturally occurring or other non-site related chemicals.

Statistical tests can be used to objectively test if concentrations of analytes in site media are higher than those in background media and therefore may be site related.

Section 4.4 provides the comparison of the WC (1996) local background metals data to site data. Confidence limits around the site and background means, respectively, are compared for data that are normally or lognormally distributed. Concentration ranges are compared for metals with ≥50 percent of the data as not detected (ND) or for data not normally or lognormally distributed.

Toxicity-Based Criteria Screening: For analytes remaining after the third criterion (site background comparison), a preliminary toxicity-based criteria screening was performed for the wetlands surface water and sediment data to determine whether chemical concentrations exceed applicable regulatory standards. Concentrations in surface water were compared to State of Alaska freshwater criteria (18 AAC 70) and to water quality benchmarks (Talmage and Opresko 1995a,b; van der Schalie 1983; USEPA 1980a,b,c) if state criteria were not available. Concentrations in sediment were compared to sediment benchmark values derived using equilibrium partitioning (EqP) with State of Alaska freshwater criteria (18 AAC 70) or with water quality benchmarks (Talmage and Opresko 1995a,b; van der Schalie 1983) if state criteria were not available. Table 6-2 provides a list of the surface water and sediment toxicity-based screening values and benchmarks used in this ERA.

For non-ionic organic compounds, the relationship between sediment concentration of a chemical (on a dry weight basis) and the interstitial water concentration is defined by the equilibrium partition coefficient (K_{oc}). Setting the allowable interstitial water concentration to be equivalent to a water quality benchmark concentration and using the equilibrium partitioning between water and sediment provides an estimate of a sediment benchmark concentration.

The maximum concentrations found in the wetland surface water and sediment were used in the comparisons. Analytes with maximum concentrations below toxicity-based screening criteria or benchmarks were considered for exclusion as potential COECs.

Those chemicals that were identified as being below toxicity-based screening criteria and benchmarks were further screened against bioconcentration potential. Chemicals with the potential to bioconcentrate or bioaccumulate (log $K_{ow} > 3.0$ or $K_{oc} > 500$) were retained as

COECs regardless if concentrations were below toxicity-based screening criteria. Chemicals that were below the toxicity-based criteria and have a log $K_{ow} < 3.0$ or $K_{oc} < 500$ were not retained as potential COECs.

Literature-Based Background Screening: Metals remaining after the site background and toxicity-based screening were eliminated from further consideration if their mean values were within the range and generally consistent with naturally occurring metal levels for this region. Background values from the literature were used as weight-of-evidence to qualitatively judge whether metals levels detected onsite were sufficiently elevated and representative of anomalous conditions resulting from historical contamination. Literature background values for metals were obtained from the following five sources:

- USATHAMA. 1990. Eagle River Flats Expanded Site Investigation, Ft. Richardson, Alaska, Final Technical Report.
- USGS. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. Authors: Shacklette and Boerngen. USGS Professional Paper 1270.
- USGS. 1988a. Element Concentrations in Soils and Other Surficial Materials of Alaska. Authors: Gough, Severson, and Shacklette. USGS Professional Paper 1458.
- USGS. 1988b. Analytical Results, Statistical Results, and Sample-locality Maps of Rocks from the Anchorage Quadrangle, Southern Alaska. Authors: Madden et al. USGS Open File Report 88-240.
- Mueller, K. 1994. Water, Sediment, and Tissue Baseline Metal Data From Four National Wildlife Refuges in Alaska. U.S. Fish and Wildlife Service.

6.3.2 Nature and Extent of Contamination

Analytical result summary tables from the RI conducted in 1995 are provided in Section 4.0 of the RI Report and summarized in Section 3.0 of this Risk Assessment Report. In all, over 500 soil samples (including historic samples) and 4 sediment and 4 surface water samples were collected. In addition, several background samples were collected during the RI for analysis of metals (16 soil, 6 surface water, and 6 sediment). Chemical analyses of the RI samples included CWM and their breakdown products, explosives, VOCs, and metals. A discussion of the extent of contamination in exposure area A-1, A-2, O (soil 0 to 3 feet); in exposure area A-3, A-4, T (soil 0 to 3 feet); and in the wetland is provided below. Section 3.0 of this report provides an overall summary of the results of the RI.

6.3.2.1 Exposure Area A-1, A-2, O

This exposure area consists of disposal areas A-1 and A-2 and other (O) surrounding areas (Figure 3-1). During 1994, Areas A-1 and A-2 were covered with approximately 18 inches of soil, resulting in a soil cover of at least 36 inches (18-inch soil cover plus a minimum of about 18 inches of pre-existing soil depth over the apparent disposal horizon) (USACE 1994a).

Soil samples were collected from soil borings at A-1, A-2 and O in 1990 and 1995 (Figure 3-1). The 1990 samples were composites of soil from the entire length of the 8-foot soil boring column. The 1995 samples were collected continuously in 3-foot intervals.

Near-surface soils (0 to 3 feet) in areas A-2 and O had levels of 1,1,2,2-tetrachloroethane ranging from <0.050 to 0.47 mg/kg. This compound was not detected (<0.050 mg/kg) in near-surface soil samples at Area A-1. Four other VOCs (toluene, trans-1,2-dichloroethene, tetrachloroethene, and trichloroethene) were detected in near-surface soils. The metals antimony, arsenic, beryllium, chromium, copper, lead, mercury, nickel, silver, and zinc were also detected in near-surface soil samples.

6.3.2.2 Exposure Area A-3, A-4, T

This exposure area consists of two disposal areas (A-3 and A-4) and the toe of the hill (T) adjacent to the southwest corner of A-3, and the area south of A-3 to the north edge of the wetland (Figure 3-1). Soil was excavated from Areas A-3 and A-4 during a removal action in 1993/1994. Excavated soils that met removal action levels for TCE, tetrachloroethene, and 1,1,2,2- tetrachloroethane were mixed with borrow soil and returned to the excavations. Soils that exceeded the action levels were stockpiled.

Except on the south side of A-3, where depth of excavation was 1 to 4 feet, the depth of excavation in these areas was greater than 11 feet and sidewall samples were collected halfway up the excavated walls. Therefore, of samples collected during the removal action, only samples collected from the south side of Area A-3 were used to characterize contaminant concentrations in near-surface soils (0 to 3 feet). In the 1995 RI, 1,1,2,2-tetrachloroethane was detected in soil from 0 to 3 feet in concentrations ranging from 0.0018 to 8.1 mg/kg. In addition, low levels of six other VOCs were detected in near-surface soils in exposure area A-3, A-4, T. Detected concentrations of these six VOCs ranged from 0.0078 to 0.16 mg/kg for chloroform, 0.008 to 0.026 mg/kg for cis-1,2-dichloroethene, 0.0039 to 0.011 mg/kg for trans-1,2-dichloroethene, 0.011 to 0.056 mg/kg for tetrachloroethene, 0.0099 mg/kg for 1,1,2-trichloroethane, and 0.0014 to 0.73 mg/kg for TCE.

The metals antimony, arsenic, beryllium, chromium, copper, lead, mercury, nickel, silver, and zinc were detected throughout the soil column at exposure area A-3, A-4, T.

6.3.2.3 Wetland Area

This exposure area consists of the wetland area to the south of Area A-3 (Figure 3-1). The wetland area is bounded on two sides by hills, on one side by Poleline Road, and on the remaining side by Area A-3. The surface of the main disposal areas (A-1, A-2, A-3, A-4) is elevated above the level of the wetlands. During rainfall events and spring snowmelt, the wetlands probably act as a catch basin for surface water run-off from the site. Wastes in the main disposal area were buried approximately 5 feet below the surface, so surface water run-off is not expected to have carried chemicals to the wetland area. There is a potential for seasonal groundwater discharge from the main disposal area into the wetlands. A geophysical survey indicated the possible presence of small metallic objects in the wetland area.

Sediment samples and surface water were collected from four locations during the RI.

The explosive 2,4,6-trinitrotoluene was detected in one sediment sample (0.48 mg/kg). The TNT breakdown product 1,3,5-trinitrobenzene was detected in all four sediment samples (0.53 to 0.78 mg/kg). In addition, the explosive by-product m-nitrotoluene was detected in one sediment sample (3 mg/kg) and the by-product 1,3-dinitrobenzene was detected in two of the four surface water samples (0.00048 to 0.0034 mg/L). Toluene was detected in one surface water sample (0.0045mg/L).

Five metals (arsenic, chromium, copper, nickel, and lead) were detected at concentrations above detection limits in sediment. Four metals (copper, lead, nickel, and zinc) were detected at concentrations above detection limits in surface water.

6.3.3 COEC Selection

Soils at the PRDA represent a potential exposure medium for terrestrial biota. Sediments and surface water in the wetlands represent potential exposure media for aquatic biota present in the wetland and terrestrial biota that use the wetland. As discussed in Section 6.3.1, the following criteria were used for the selection of COECs in near-surface soil (to a depth of 3 feet), sediments, and surface water:

Criterion 1 - Detection in at least one sample
Criterion 2 - Frequency of detection screening
Criterion 3 - Background comparison
Criterion 4 - Toxicity-based criteria screening
Criterion 5 - Literature-based background evaluation

6.3.3.1 Exposure Area A-1, A-2, O

Table 6-3 lists the results of the COEC selection process for near-surface soils in exposure area A-1, A-2, O. In the first screening step, detection in at least one sample, there were 15 analytes (10 metals and 5 VOCs) detected in surficial soils (depth ≤3 feet). Three of the VOCs (trans-1,2-dichloroethene, tetrachloroethene, and trichloroethene) had a detection frequency in near-surface soil of less than 5 percent, but these compounds were also detected in subsurface soils and groundwater at the site. Therefore, the 5 VOCs and 10 metals were carried over into the third screening step, site background comparison. Near-surface soil concentrations of six metals (antimony, arsenic, beryllium, copper, mercury, and silver) were at or below WC (1996) background concentrations and were eliminated as site-related COECs. Because toxicity-based screening values are not available for soils, Criterion 4 (toxicity-based screening) was not used for soils. Therefore, the five VOCs and four metals were carried into the fifth step, literature-based background comparison.

Mean concentrations of the four remaining metals (chromium, lead, nickel, zinc) from the 0- to 3-foot samples were compared to local and regional literature-based background concentrations (Table 6-4). Mean values for chromium and lead are below mean values for Alaska soils (USGS 1988a), sediment control samples for Eagle River Flats (USATHAMA 1990), western U.S. soils (USGS 1984), and local Anchorage rock samples (USGS 1988b). Mean values for chromium and lead appear elevated relative to site background levels due to the higher concentrations found in the historic, deeper (0 to 7, 0 to 8, and 0 to 9 foot) composite samples that were included as 0 to 3 foot samples. Chromium levels in the 0 to 3 foot and 3 to 6 foot composite samples are lower (≤35 mg/kg) than levels found in the deeper composite samples (43 to 61 mg/kg) and the deepest composite samples (0 to 9 foot, 84.5 mg/kg). Lead levels in the 0 to 3 foot and 3 to 6 foot composite samples are lower (≤6.6 mg/kg) than levels found in the deeper composite samples (9 to 12 mg/kg) and the deepest composite samples (0 to 9 foot, 12.8 mg/kg). The lower values reported for chromium and lead in the near-surface soil samples are within the range of site background values (WC 1996).

Mean values for nickel and zinc also appear slightly elevated relative to site background values due to the higher concentrations found in the historic, deeper (0 to 7, 0 to 8, and 0 to 9 foot) composite samples. Lower values for nickel (<45 mg/kg) are found in the 0 to 3 foot and 3 to 6 foot composite samples. The same is true for zinc. Lower concentrations (≤67 mg/kg) are found in the shallower samples, higher values (>100 mg/kg) are found in the 0 to 7 foot and 0 to 8 foot composite samples, and the maximum concentration is found in the deepest (0 to 9 foot) composite sample. The lower values for nickel (<45 mg/kg) and zinc (≤67 mg/kg) in the shallower composite samples are within the range of site background values (WC 1996). These lower values are also consistent with mean values for Alaska soils (USGS 1988a), sediment control samples for Eagle River Flats (USATHAMA 1990), and local Anchorage rock samples (USGS 1988b).

Overall concentrations for chromium, lead, nickel, and zinc in 1995 near-surface soil samples appear consistent with local and regional metal concentrations and thus these metals were not retained as COECs. Chemicals retained as COECs for exposure area A-1, A-2, O are trans-1,2-dichloroethene, 1,1,2,2-tetrachloroethene, toluene, and TCE.

6.3.3.2 Exposure Area A-3, A4, T

Table 6-5 lists the results of the COEC selection process for near-surface soil in exposure area A-3, A-4, T. In the first screening step, detection in at least one sample, there are 17 analytes

(10 metals and 7 VOCs) detected in near-surface soil (depth ≤3 feet). Four of the VOCs (cis-1,2-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, and 1,1,2-trichloroethene) have a detection frequency in near-surface soils of less than 5 percent, but these compounds were also detected in subsurface soils and groundwater at the site. Therefore, the 10 metals and 7 VOCs are carried over into the third screening criterion, background comparison. Near-surface soil concentrations of eight metals (antimony, arsenic, beryllium, chromium, copper, nickel, silver and zinc) are at or below site background concentrations (WC 1996) and are eliminated as site-related COECs. Because toxicity-based screening values are not available for soils, criterion 4 (toxicity-based screening) was not used for soils. Therefore, two metals and seven VOCs were carried into the fifth step, literature-based background comparison.

The mean concentration for lead at this location is considered consistent with local and regional values as reported in the literature. Lead was detected within each of the six 0 to 2 foot composite samples. The mean value for lead (13 mg/kg) is below the mean value for lead in Alaska soil (USGS 1988a), below the mean sediment control values for Eagle River Flats (USATHAMA 1990), below the mean value for local Anchorage rock samples (USGS 1988b), below the mean value for western U.S. soil (USGS 1984), and within the mean range for sediment values from four Anchorage Alaska national wildlife refuges (Mueller 1994). Lead was not retained as a COEC based on this comparison with literature-based background values.

Mercury was detected in one surficial (0 to 2 foot) soil sample at a concentration of 0.58 mg/kg at this exposure area. The five other surficial soil samples reported non-detect values for mercury (detection limit = 0.055 mg/kg). Although the mean concentration of 0.143 mg/kg appears generally consistent with literature-based background values, the single detected (maximum) value appears to be an elevated anomalous value. The mean mercury concentration is within the range of the Eagle River Flats sediment controls (USATHAMA 1990) and the mean range of sediment values from four Alaska wildlife refuges (Mueller 1994). The single detected value, however, exceeds the maximum Eagle River Flats sediment control value (USATHAMA 1990), but is within the range of mean values reported for the four Alaska wildlife refuges (Mueller 1994) and western U.S. soil (USGS 1984). Mercury was not retained as a COEC based on comparison of the mean value with literature-based values. The single, detected value, however, is considered to represent an elevated anomalous sample result and is addressed further in the uncertainty analysis (see Section 6.5.5.2).

The COECs retained for exposure area A-3, A-4, T are: chloroform, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1,2,2-tetrachloroethane, tetrachloroethene, 1,1,2-trichloroethane, and TCE.

6.3.3.3 Wetland Area Sediment Screening

Table 6-6 lists the results of the COEC selection process for wetland sediments. In the first screening step, detection in at least one sample, there were eight analytes (five metals and three explosive residues) detected in wetland sediment. Because the sample size is less than 20 for sediments, all eight analytes were retained for the second screening step, detection frequency. Sediment concentrations of all five metals (arsenic, chromium, copper, nickel, and zinc) were found to be at or below site background concentrations and were eliminated as site-related COECs. The three explosive residues were retained for the fourth criterion, toxicity-based screening.

Sediment quality benchmarks, protective of chronic effects, for 1,3,5-trinitrobenzene (0.02 mg/kg normalized to 1 percent organic carbon) and 2,4,6-trinitrotoluene (0.52 mg/kg normalized to 1 percent organic carbon) were obtained from the ORNL draft ecological criteria documents (Talmage and Opresko 1995a,b). Because there are no data on the organic carbon content of the PRDA wetland sediment, an organic carbon content of 1 percent for sediment was used for calculating the toxicity-screening benchmark values. This provides a conservative toxicity-screening value because the type of wetland present (i.e., peat substrate, abundant vegetation) is likely to have sediment with a higher organic carbon content than 1 percent.

Sediment concentrations of 2,4,6-trinitrotoluene (maximum of 0.48 mg/kg) are below the sediment toxicity-based screening value (0.52 mg/kg). Based on a low log K_{ow} (1.60), this compound is unlikely to bioconcentrate in aquatic organisms. Because sediment concentrations do not exceed chronic levels and the log K_{ow} is <3.0, 2,4,6-trinitrotoluene was eliminated as a site COEC. Because the 1,3,5-trinitrobenzene maximum concentration of 0.76 mg/kg exceeds its toxicity-based screening value (0.02 mg/kg), it was retained as a COEC. No toxicity-based screening value was found for m-nitrotoluene, and therefore this analyte was also retained as a wetland sediment COEC. The final COECs for wetland sediment are 1,3,5-trinitrobenzene and m-nitrotoluene.

6.3.3.4 Wetland Area Surface Water Screening

The toxicity-based screening values used for surface water include State of Alaska water quality criteria (18 AAC 70, 1995), federal ambient water quality guidance values, and benchmark values derived from literature (see Table 6-2). There are no acute or chronic water quality criteria for toluene. Therefore, a guidance value, the lowest observed effect level (LOEL) for toluene (species mean LC_{50} of 17.5 mg/L for bluegills [USEPA 1980a]) was adjusted to a chronic benchmark value (0.175 mg/L) using a safety factor of 0.01. A surface water quality benchmark, protective of chronic effects, for 1,3-dinitrobenzene of 0.030 mg/L was obtained from the ORNL draft ecological criteria document (Talmage and Opresko 1995c). State of Alaska chronic freshwater quality criteria were used for screening copper, lead, and nickel. Copper, lead, and nickel chronic criteria values are dependent on water hardness (copper: $e^{[0.8545*\ln[\text{hardness}]-1.465]}$; lead: $e^{[1.273*\ln[\text{hardness}]-4.705]}$; and nickel $e^{[0.8460*\ln[\text{hardness}]+1.1645]}$). A water hardness of 100 mg/L as $CaCO_3$ was assumed in calculating the metals criteria because water hardness was not measured in the wetland surface water. The uncertainty of assuming 100 mg/L as the water hardness value is documented in the section on uncertainty (Section 6.5.5.2).

Table 6-7 lists the results of the initial COEC selection process for wetland surface water. In the first screening step, detection in at least one sample, there were six analytes (four metals and two VOCs) detected in surface waters. All six analytes were retained in the second screening step, detection frequency, because the sample size was less than 20. In the third screening step, site background comparison, surface water concentrations of zinc were at or below site background concentrations and zinc was therefore eliminated as a site-related COEC. Concentrations of the remaining three metals (copper, lead, nickel) appear higher than site background and are therefore retained for toxicity-based screening along with the two VOCs.

Surface water concentrations of toluene (maximum of 0.0045 mg/L), 1,3-dinitrobenzene (maximum of 0.0034 mg/L), and nickel (0.0019 mg/L) are below their respective toxicity-based screening values (0.175 mg/L toluene, 0.03 mg/L 1,3-dinitrobenzene, and 0.158 mg/L nickel). In addition, based on low log K_{ow}s, toluene (2.73) and 1,3-dinitrobenzene are unlikely to bioconcentrate in aquatic organisms. Therefore, toluene, 1,3-dinitrobenzene, and nickel were eliminated as COECs because surface water concentrations do not exceed chronic levels and bioaccumulation potential is low. Because the copper and lead maximum concentrations of 0.099 mg/L and 0.0081 mg/L, respectively, exceed toxicity-based screening values (0.0118 mg/L copper and 0.0032 mg/L lead), these two metals were retained for further screening against literature based background values.

Lead and copper concentrations in surface water were compared with control water samples reported in the Eagle River Flats study (USATHAMA 1990) and surface water concentrations reported for four national wildlife refuges in Alaska (Mueller 1994) (Table 6-8). Lead was detected in all four surface water wetland samples. The mean and range of the site lead concentrations are generally consistent with values reported in the two literature studies. The mean lead concentration of 0.0056 mg/L is below the mean value (0.0071 mg/L) reported for Eagle River control samples (USATHAMA 1990) and the mean value (0.027 mg/L) reported for surface water from four Alaska national wildlife refuges (Mueller 1994). Dry fallout and rainout of particulate lead, especially in areas with automobile traffic, is probably a factor in the circulation of lead (Hem 1989). An average of 0.034 mg/L was reported for 32 surface water sampling points in the U.S. during 6 months in 1966 and 1967, and concentrations above 0.01 mg/L were observed in a substantial number of U.S. locations in 1970 and 1971 (Hem 1989). Although the site lead concentration did exceed the toxicity-based screening value, it was not retained as a COEC based on the consistency of the site values with local and regional literature-based values. This decision is addressed further in the uncertainty analysis (Section 6.5.5.2).

Copper was detected in two of four surface water samples. The mean copper concentration (0.0305 mg/L) is below the mean surface water value for control samples in the Eagle River Flats study (USATHAMA 1990) and within the range of mean values reported for four national wildlife refuges in Alaska (Mueller 1994). The maximum copper concentration of 0.099 mg/L does appear anomalous as it exceeds the maximum control sample value (0.0355 mg/L) reported for Eagle River Flats, although it is within the range of values reported for the four Alaska wildlife refuges. Although this single surface water value appears elevated, it appears unrelated to sediment values as sediment copper values were all below background.

Copper concentrations in freshwater are generally expected to be below 0.010 mg/L (Forstner and Whittmann 1983). The concentration of copper in water, however, is governed by a number of factors such as the presence of complexing agents, alkalinity, pH, and the type of sediments. Copper concentrations are highly influenced by the presence of organic material (humus, peat) and the aerobic conditions. Any condition promoting a local increase in the rate of decomposition of normal rocks, however, can lead to the release of trace constituents in higher than normal amounts. Marmo (1953 in Rose et al. 1979) described well water with as much as 0.5 mg/L copper resulting from intense leaching by acid solution derived from the weathering of a pyritiferous but otherwise unmineralized granite. Chisholm (1950 in Rose et al. 1979), working in Ontario, also reported that the metal content of lake water could be correlated with mineralization in surrounding terrain. A systematic survey of lakes in northern Maine by Kleinkopf (1960 in Rose et al. 1979) showed that anomalous, high (>1000 ppm) copper concentrations of the lake waters correlated with known occurrence of copper sulfides. Due to likely presence of mineralized substrates in the vicinity of the PRDA (see Section 6.2.1), anomalous copper surface water concentrations are considered possible.

Copper concentrations are also quite variable depending on the aerobic condition of the water body. Copper concentrations were shown to increase from 0.15 to 0.85 mg/L and the pH drop from 6.5 to 4.0 in 28 days in water overlying lake sediments in "live" aerobic conditions, whereas little change took place under anaerobic conditions (Stokes and Szokalo 1977 in Demayo et al. 1982).

Elevated copper concentrations are of concern due to their high potential toxicity to aquatic organisms. Copper complexes, however, are generally of very low toxicity to aquatic organisms compared to the copper ion. The copper concentrations reported for the wetland are for total copper; thus the toxic potential of the surface water to aquatic organics cannot be truly evaluated. Due to the high organic component of the wetland, it is possible that most copper is bound in an organic complexed form.

Although the mean copper concentration exceeded toxicity-based screening criteria, copper was not retained as a COEC due to the consistency of the mean value with the two reported literature-based values and the knowledge that the sediment copper values were all low. Uncertainty in not retaining copper as a COEC largely rests on the unknown cause of the single anomalous value (0.099 mg/L). This decision is addressed further in the uncertainty analysis.

6.3.3.5 Eagle River

Groundwater, due to its depth at 15 feet or deeper, was not considered an important exposure medium for terrestrial ecological receptors at the PRDA. Exposure pathways for ecological receptors to groundwater at the site are for the most part incomplete. Groundwater migration to the Eagle River was modeled to evaluate a hypothetical surface water exposure scenario for ecological and human receptors (see Section 3 of this report and Appendix XIII of the RI Report). Because solvents were the primary site-related chemicals detected in groundwater, three solvents were selected to represent the potential for migration of VOCs from the site. 1,1,2,2-Tetrachloroethane and TCE were selected for the model because they had the highest concentrations of the VOCs (several orders of magnitude above the other VOCs) detected in both the shallow zone and deep aquifer and were the most toxic in regards to human risk. 1,1,2-Trichloroethane was also modeled because it is among the most mobile of the VOCs detected.

Based on the model and assuming a constant source at the site, it would take over 100 years for groundwater concentrations of 1,1,2,2-tetrachloroethane and TCE and over 500 years for groundwater concentrations of 1,1,2-trichloroethane to reach levels discernible by the model (0.005 mg/L at the hypothetical point of discharge to the Eagle River). A value of 0.005 mg/L at the leading edge of the plume for the three VOCs was used for the following toxicity-based screen. Higher concentrations of the VOCs would be expected near the center of the plume, but these cannot be predicted with confidence because of the simplifying assumptions that had to be incorporated into the model. The uncertainties in the risk assessment from assuming a constant source when in reality the source is limited and evaluating the concentration at the leading edge of the plume are discussed in the uncertainty section (Section 6.5.5.3).

Toxicity-based screening values for water are estimated chronic no-effect concentrations or levels (NOELs). Because there are no chronic fresh water quality criteria for 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and TCE available toxicity data had to be extrapolated to a chronic no-effect concentration. Adjustment factors are used to deal with extrapolating from a less than chronic exposure (e.g., acute) or no-effect endpoint data (e.g., lowest observed effect level [LOEL]) to a NOEL). EPA (1980a,b,c) does provide LOELs for 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and TCE. The LOELs for 1,1,2,2-tetrachloroethane (2.4 mg/L) and 1,1,2-trichloroethane (9.4 mg/L) are chronic threshold values from early life stage tests with fathead minnows (USEPA 1980a,b). Screening values of 0.24 mg/L and 0.94 mg/L are derived, respectively, by using an adjustment factor of 0.1 to convert the chronic threshold values of an early life stage test (LOELs) to chronic benchmark values (NOELs). For TCE, the LOEL (EC_{50} = 21.9 mg/L) is from an acute effects study on the loss of equilibrium in fathead minnows (USEPA 1980c). A screening value of 0.219 mg/L for trichlorethene was derived by using an adjustment factor of 0.01 to convert an EC_{50} to a NOEL.. Adjustment factors of 0.1 to convert a LOEL to the NOEL and 0.01 to convert a LC_{50} to a NOEL were recommended EPA values for screening (EPA 1994e).

The groundwater concentration of 0.005 mg/L at the hypothetical discharge point into the Eagle River is over 40 times lower than toxicity-based screening concentrations protective of chronic effects for 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and TCE (0.24, 0.94, and 0.219 mg/L, respectively) (Table 6-2). These three VOCs were therefore not retained as COECs in this ERA.

6.3.3.6 Summary of the Fort Richardson PRDA COECs

Based on the above discussion, the following COECs were retained for further consideration in this ERA.

- Chloroform - soils: A-3, A-4,T
- Cis-1,2-dichloroethene - soils: A-3, A-4,T
- Trans-1,2-dichloroethene - soils: A-1, A-2, O; A-3, A-4,T
- 1,1,2,2-Tetrachloroethane - soils: A-1, A-2, O; A-3, A-4,T
- Tetrachloroethene - soils: A-1, A-2, O; A-3, A-4,T
- 1,1,2-Trichloroethane - soils: A-3, A-4,T
- Toluene - soils: A-1, A-2, O
- Trichloroethene - soils: A-1, A-2, O; A-3, A-4,T
- 1,3,5-Trinitrobenzene - wetland sediment
- m-Nitrotoluene - wetland sediment

6.3.4 Conceptual Site Model and Selection of Key Receptors and Endpoints

Information concerning chemical sources, transport mechanisms, and the location of potential receptors is used to develop a conceptual understanding of the site in terms of potential ecological exposure pathways. An exposure pathway is the mechanism by which a receptor may come into contact with a chemical. As defined by Risk Assessment Guidance for Superfund (USEPA 1989a), there are five major elements which characterize a complete exposure pathway:

- A source of chemicals (e.g., soils)

- A mechanism of chemical release (e.g., contact, uptake)
- An environmental transport medium (e.g., surface water)
- An exposure point where receptors are present (e.g., feeding site)
- An intake route (e.g., ingestion, direct contact)

For an exposure pathway to be complete, all five elements must be present. The absence of any one of these elements results in an incomplete exposure pathway for which site-related ecological risks do not exist. Thus, the evaluation of potential exposure pathways is necessary to focus on only those pathways which are considered complete based on the data reviewed and the assumptions described below and in the exposure assessment.

Several aspects of the potential exposure pathways have already been discussed. The potential sources of chemical release were identified in Sections 6.3.2 (Nature and Extent of Contamination) and 6.3.3 (COEC Selection). The mechanism of release refers to the physicochemical properties of the chemicals that influence their mobility and potential contact with a receptor. The presence and identification of ecological receptors potentially using the site has been discussed in Section 6.2.2 (Ecological Setting).

Potential exposure pathways are depicted in an ecological conceptual site model (ECSM) in Figure 6-3. The terrestrial ECSM presented in Figure 6-3 shows the potential pathways for chemicals to move from soils to ecological receptors and is applicable to all of the PRDA. The model provides a schematic representation of exposure pathways from chemical sources to potential receptors within each exposure unit. An evaluation of potential exposure pathways (receptor populations, exposure points, and uptake routes) identified in this figure is presented in the following sections.

6.3.4.1 Potential Surface Soil Exposure Routes

Buried debris, chemical wastes, and munitions may either directly or indirectly affect site soils. Soils may be contaminated by products which were spilled directly onto the soil and then mixed with surrounding soils, by releases from the buried debris and waste to the surrounding soils, or soils downgradient of the contaminated area may become contaminated via transport with water percolating through soils. Soils are considered the primary affected source medium at the PRDA.

Dermal Contact: Dermal contact is not considered a significant pathway for the COECs at this site because of the volatile nature and relatively low COEC concentrations in near-surface soils and the fact that birds and mammals are protected by their fur and feathers. Ecotoxicological information for dermal exposure from VOCs is also relatively scant. One dermal effects (LD_{50}) soil level for toluene of 12,124 mg/kg is reported in the literature (Kappleman 1993 in Maughan 1993). Site VOC concentrations are well below this concentration.

Ingestion of Soil: Small herbivorous animals may directly ingest contaminated soils while feeding. Incidental ingestion may occur from soil adhered to the surface of food or from preening/cleaning activities. Indirect ingestion may occur if a receptor eats a food/prey item which has taken up a COEC into its tissues. In the ECSM, the exposure pathways shown include direct or incidental soil ingestion by primary consumers and indirect exposure to COECs through ingestion of primary producers (i.e., plants) that have taken up COECs from soil or sediment.

Uptake from Soil: Consideration of the potential toxicity of chemicals to plants is important because plants are the primary producers and foundation for higher trophic levels. Toxic effects to plants indirectly affect higher trophic levels through alteration of habitat quality. Chemical absorption by plants is affected by numerous factors controlled by: (1) concentration and speciation of the chemical in soil solution, (2) movement of the chemical from bulk soil to the root surface, (3) transport of the chemical from the root surface into the root, (4) translocation from the root to the short, and (5) chemical absorption through foliage (Alloway 1990).

Plant toxicity (phytotoxicity) as well as plant uptake is dependent on both the total quantity of the chemical in soil as well as the root mass present. Phytotoxicological and plant bioaccumulation information for VOCs and explosive-related chemicals in soil and sediment is relatively scant. Conservative assumptions were used for the evaluation of adverse effects in this pathway.

Ingestion of Food: Primary consumers may be exposed through direct ingestion of plants in which chemicals have accumulated. Plants can take up chemicals with low log K_{ow} values by way of their roots, but generally cannot transport significant amounts of compounds with high molecular weights and high log K_{ow} values in the same manner (EPA 1989b). Plants can also become contaminated from soil or water by sorption of volatilized chemicals on the leaves or by deposits of dust and vapors (EPA 1989b). Conservative assumptions were used in the evaluation of this pathway.

6.3.4.2 Potential Subsurface Soil Exposure Routes

Direct contact (dermal contact and ingestion) with subsurface soils (depth >3 feet) is considered an insignificant or incomplete pathway in this ERA because of the limited use of deeper soils at this site by local biota (see Section 6.2.2).

6.3.4.3 Potential Air Exposure Routes

Airborne chemicals can be derived from two possible sources:

- Direct volatilization of chemicals in soil and water, and
- Fugitive dust emissions from soil containing adsorbed chemicals.

During 1994, Areas A-1 and A-2 were covered with 18 inches of soil, resulting in a soil cover of at least 3 feet (18 inches soil cover plus a minimum of about 18 inches pre-existing soil depth over the apparent disposal horizon [USACE 1994a]). Fugitive dust release from buried wastes at this exposure location is unlikely.

Inhalation by volatilization and wind erosion are generally not considered a significant pathway to ecological receptors, except possibly in the case of burrowing animals. Several of the COECs are VOCs. The maximum site VOC concentration in soil depths where burrowing animals potentially occur (depth <3 feet) was 21 mg/kg (1,1,2,2-tetrachloroethane) in a historic sample from the ≥ 1 and ≤ 4 feet depth interval. The other VOCs had concentrations generally less than 1 mg/kg. VOC concentrations of 100 ppm or greater in air are generally needed to induce toxic responses in laboratory rats and mice from inhalation (NIOSH 1987 in Newell et. al 1987). Concentrations in soils would have to be several orders of magnitude greater than site concentrations to produce these toxic levels in air.

Recent models have been developed to evaluate inhalation exposure for burrowing mammals. Based on a site-specific model developed for a Vermont wetland soil, a soil toluene concentration of 1.9 mg/kg may be potentially toxic (reproductive effects) to burrowing muskrats and *Peromyscus* based on an inhalation pathway (Kappleman 1993 in Maughan

1993). Based on this single toxicity value, the inhalation pathway is generally not of concern given site VOC concentrations that were generally less than 1 mg/kg in soil, except for 1,1,2,2-tetrachloroethane. The air exposure and inhalation pathway are not evaluated further in this ERA. This decision is addressed further in the uncertainty analysis, and in particular, the uncertainty regarding the potential inhalation toxicity for 1,1,2,2-tetrachloroethane.

6.3.4.4 Potential Surface Water/Sediment Exposure Routes

Buried debris, chemical wastes and munitions may either directly or indirectly release chemicals to surface water and sediments. The sediments may be directly contaminated by buried wastes in the wetland or sediments may have become contaminated via transport with water percolating through soils from the main disposal areas which are at a higher elevation than the wetlands. The surface water may be contaminated from water percolating through soils from the main disposal area or from contaminated sediments. Chemical constituents measured in the wetland sediments and surface water are assumed to be representative of future conditions as well as current conditions.

Wetland plants may be exposed by:

- Direct uptake from sediment via roots (rooted macrophytes) or
- Direct uptake from surface water across cell membranes (phytoplankton, non-rooted macrophytes).

Aquatic organisms may intake waterborne chemicals by:

- Transdermal uptake across gills or through skin and
- Indirect ingestion via food.

Terrestrial animals may be exposed to sediment and surface water contamination by:

- Direct ingestion of water;
- Incidental ingestion of sediment while feeding on food/prey items;
- Indirect ingestion of food/prey items that have ingested contaminated sediment or bioaccumulated chemicals from surface water.

Some chemicals have the ability to produce adverse effects in organisms via the "food chain." That is, these chemicals have the potential to be absorbed and stored in tissues of plants or animals that are used as food sources.

6.3.4.5 Potential Groundwater Exposure Routes

Exposure to the groundwater is not considered a significant pathway due to the depth of the groundwater at 15 feet or deeper and because there are no surface water exposure points (i.e., seeps) that have been identified for ecological receptors. Contaminant migration in groundwater was modeled to the Eagle River. Modeled concentrations from a hypothetical groundwater discharge scenario are screened in Section 6.3.3.5, Eagle River. Because of the time of travel and toxic levels required to impact biota, the groundwater pathway is not considered a significant pathway for ecological receptors in the Eagle River.

6.3.5 Identification of Key Receptors

The selection of ecological resources of concern and key receptors for this ERA is based on several criteria, some of which are objective (e.g., listing as a species of special concern), and some that require professional judgment (identifying key components within a food web). Selection of key receptors to represent wildlife at the PRDA site includes consideration of the following criteria:

- Known or expected occurrence in the vicinity of the PRDA site;
- Potential exposure to site-related chemicals;
- Regulatory protection or status (wetlands, threatened or endangered species, candidates for listing);
- Game species or commercially important species;
- Key component of ecosystem structure and function (e.g., keystone species, major prey item);
- Habitat preferences;
- Size of home range; and

- Availability of toxicological information for the species or a suitable surrogate (e.g., vole as a surrogate for other small mammal species).

Based on the site characterization and the conceptual site model, two key receptor species were selected. Red-backed vole was selected for the upland areas (Sites A-1 to A-4), and muskrat was selected for the wetland. Both species are primary consumers, have relatively small home ranges, and serve as important prey for other animals. Northern red-backed voles are weak burrowers but may be exposed to site chemicals on the ground surface, from consuming plants growing on the site (after it revegetates), and potentially in burrows. No other rodents that are strong burrowers are present. Muskrats may be exposed to chemicals in the water and sediments of the wetland because of their aquatic lifestyle and feeding on wetlands plants. The wetlands themselves are also considered an environmental resource of concern and therefore a key receptor because of their protected status under the Clean Water Act.

<u>Northern Red-backed vole</u>: This species is likely to be the most abundant small mammal in the upland habitats around the PRDA site. It is a major prey species of furbearers, raptors, and other carnivorous animals including shrews, weasels, marten, mink, red fox, lynx (when snowshoe hare populations are low), bears, hawks, and owls. Red-backed voles weigh approximately 21.9 (17.8 to 29.6) grams, and feed mainly on leaves, buds, twigs, seeds, and fruit of a wide variety of shrubs and forbs (Banfield 1974). They also eat green grassy vegetation and mushrooms (Gromov and Polakov 1992). Animal food is consumed rarely and in small amounts (Gromov and Polakov 1992). Northern red-backed voles are active all winter and construct tunnels under the snow. They also utilize surface runways through vegetation during the summer. Nests are built in a short underground burrow, or under a protective object such as a rock or root, and winter nests are placed on the ground under the snow. In Eurasia, all nests of the northern red-backed vole are located under individual stones, between the stones and underground roots, and no underground burrows have been found (Gromov and Polakov 1992). Nests are made from dried plant materials, and summer nests from grass stems split lengthwise. They have a high reproductive potential, and only a small number of individuals live more than one year. Northern red-backed voles, like other vole species, exhibit wide fluctuations in population density based on food supply, weather, and other factors. Home range of a similar species, Gapper's red-backed vole, has been reported as about 1/4 acre, with population densities up to 10 per acre but normally less (Burt and Grossenheider 1976).

Muskrat: Muskrat are in the same family (Cricetidae) as northern red-backed voles, but are adapted to aquatic habitats and are much larger. They measure about 2 feet in total length and weigh about 3 pounds (Banfield 1974). They are one of the most important North American furbearers, and their trails were observed in the wetland south of the PRDA. They spend most of their time in the water, and are chiefly nocturnal or crepuscular. Muskrats live in family units, which occupy a house, several feeding platforms, and canals or tunnels. The diameter of their home range is about 67 yards, and territories are defended against neighbors. They usually feed close to their houses. Population densities may vary from 3 per acre in open ponds to as much as 23 to 26 per acre in cattail marsh, but populations show dramatic long-term fluctuations. Muskrat population densities at the wetland near the PRDA site appear to be relatively low. The summer food of muskrats consists primarily of roots and shoots of emergent vegetation, including marsh grasses and sedges, and winter food consists of submerged vegetation. Animal foods such as mussels are consumed in some areas. Mink is the most serious predator, but a number of other animals also feed on them including foxes, wolves, black bears, lynx, and larger raptors. The wetlands in the study area probably freeze to the bottom during the winter season and are probably abandoned by muskrats in the fall. Muskrats construct lodges of vegetation beginning in the fall, or preferentially use bank dens where available.

Wetlands. The wetlands adjacent to and near the PRDA site are protected under Section 404 of the Clean Water Act, and are therefore considered a key ecological receptor. The characteristics of the wetland have already been described (Section 6.2.2.4). Ecological risk to wetland community structure and function will be assessed by evaluating potential effects on emergent vegetation and invertebrates.

A number of other species that met one or more of the criteria listed above were considered for inclusion as key receptors, but were initially rejected for this ERA because their home range or feeding range is known to be far larger than the PRDA site. The PRDA site would represent a minor part of their overall range, their exposure frequency would likely be low, and rates of ingestion of chemicals either directly or indirectly would be minor or insignificant. Should the risk analysis show a high magnitude of potential risk to the small mammals, however, potential risk to the larger, more mobile receptors would require reevaluation. Species considered but not selected for this reason include:

- Game animals (moose and black bear)
- Raptors
- Lynx (Category 2 candidate species)
- Mink, red fox, and other furbearers

Snowshoe hare have relatively small home ranges, about 4 acres average in Canada (Banfield, 1974), and they are important prey animals. However, they do not burrow and they live above the snow in the winter, and are therefore less likely to be exposed to chemicals at the PRDA site than northern red-backed vole.

Several ground-feeding birds are likely to occur in the PRDA area, such as dark-eyed junco and sparrows, and they could be exposed to chemicals while foraging. They were not identified as key receptors for the uplands because they have larger home ranges than the red-backed vole, are migratory, are less important in the food chain, and are likely to be less exposed than surface-dwelling animals.

Some shorebirds and waterfowl may occasionally feed in the wetland and be exposed to chemicals in water, sediments, and food items. They were not identified as key receptors because the wetland is marginal habitat and not likely to be regularly used by them.

6.3.6 Ecological Endpoints

Ecological endpoints include assessment endpoints and measurement endpoints. Assessment endpoints are formal expressions of the environmental values (resources) to be protected and refer to characteristics of populations and ecosystems defined over a large scale or to individuals, in the case of endangered and threatened species. To operationally define an assessment endpoint, two elements are required. The first is the valued ecological entity. This can be a species, a functional group of species (e.g., small mammals), or a specific valued habitat (e.g., wetland). The second element is the characteristic about the entity of concern that is important to protect and potentially at risk (e.g., reproductive success of the species or functional group). Assessment endpoints are effective only when they are accessible to prediction and measurement. Measurement endpoints are measurable responses to a chemical that are related to the valued characteristics chosen to be evaluated in a risk assessment.

Ecological risk assessments are predominantly concerned with effects to the overall ecosystem of the site, such as population changes. The primary assessment endpoint for this ERA is potential serious adverse affects (e.g., reproductive impairment or acute lethality) to mammal populations in the wetland and upland sites from chronic or acute exposure to the chemicals at the Fort Richardson PRDA. The measurement endpoints for this assessment endpoint are lethal or toxic responses from chronic exposures for small mammal key receptors based on values reported in the literature. The potential for serious adverse effects (lethality) to the wetland and upland plant communities as a result of exposure to site-related chemicals is the second assessment endpoint. Serious adverse effects to the wetland invertebrate community is the third assessment endpoint for this site. The measurement endpoints for evaluating toxic responses in plant and invertebrate communities are based on threshold toxicity values reported in the literature.

6.4 EXPOSURE AND ECOLOGICAL EFFECTS ANALYSIS

The following sections present the risk analysis, which includes the ecological effects and exposure assessment, and the risk characterization.

6.4.1 Ecological Effects Assessment

In order to conduct the ecological effects assessment and screening risk calculations, the toxicological characteristics of the individual COECs and the link between COECs and key receptors must be taken into consideration. The ecological effects assessment for PRDA was based on the use of dose-response relationships using information found in the literature. Information regarding the toxicity of each COEC is presented as the basis for the discussion of ecological effects.

6.4.1.1 Toxicity Overview

The toxicity of a substance is usually determined in terrestrial systems by the lethal dose (in relation to body weight) for animals, and the lethal or chronic no-effect concentration for plants. For aquatic organisms, toxicity is determined by the lethal or chronic no-effect concentration. Lethal concentrations and doses are also usually expressed in terms of an exposure duration. Amounts of a chemical in relation to body weight (bw) are typically expressed as ingested amounts on a daily basis, i.e., mg/kg-bw/day. Dietary concentrations for terrestrial organisms are expressed as mg/kg, with duration usually expressed in terms of acute or chronic exposure. Dietary concentrations are reported on a wet weight basis in most toxicological studies. Comparison with dry weight dietary concentrations is generally ignored as the moisture content of laboratory diets is typically less than 10 percent (Beyer and Stafford 1993).

To be toxic, an element must be "available" to the receptors. In order for this to occur, the chemical must exist in a form that can enter tissues of the organisms either in solution (generally aqueous) or as a solid (food item). Total amounts of a chemical in the environment are not relevant to an adequate estimation of toxicity hazard that may be present unless it can be shown that the element exists in or is likely to assume an available form under the environmental conditions in which it occurs and that animals or plants are likely to contact this form either directly or indirectly.

Some of the terms that are used extensively in discussing the ecotoxicological effects are:

- LD_{50}: Median Lethal Dose - a calculated dose of a material that is expected to cause the death of 50% of an entire defined experimental animal population.

- LC_{50}: Median Lethal Concentration - a calculated concentration of a material that is expected to cause the death of 50% of an entire defined experimental plant or animal population.

- EC_{50}: Median Effect Concentration - a calculated concentration of a material that is expected to cause a designated effect (e.g., loss of equilibrium) in 50% of an entire defined experimental animal or plant population.

- LOAEL: lowest observed adverse effect level.

- NOAEL: no observed adverse effect level.

- Diet - COEC concentration in food, expressed as mg-COEC/kg-food.

- Dose - daily intake of the COEC per unit receptor body weight, expressed as mg-COEC/kg-bw/day; dose = chemical concentration in food (diet) x food intake per day/receptor body weight.

6.4.1.2 Explanation of Selected Benchmarks

Toxicity benchmark values were selected for small mammals, aquatic invertebrates, and plants based on the COECs found in upland soils and wetland sediments. The following two sections provide a general explanation of how the terrestrial and aquatic benchmark values were derived. Following this discussion is a more detailed description of how benchmarks were derived for each COEC.

Explanation of Small Mammal Benchmarks: Benchmark toxicity values for small mammals in upland and wetland habitat are based upon chronic (>364 days) or intermediate (15 to 364 days) values whenever possible. Benchmarks are based on the NOAEL (no observable adverse effects) or the lowest LOAEL (lowest observable adverse effects) times an adjustment factor to estimate the NOAEL. Only LOAELs that measure reproductive, developmental, or other effects likely to result in functional toxicity to a receptor population were used. Where NOAELs were unavailable, adjustment factors were used to convert LOAELs, or LD_{50} values if LOAELs were unavailable, to the chronic NOAEL benchmark values. An adjustment factor of 0.2 was used to convert the chronic LOAELs to NOAELs (Newell 1987) and an adjustment factor of 0.1 was used to convert acute LOAELs to NOAELs (Newell 1987). An adjustment factor of 0.01 was used to convert LD_{50} values to a chronic NOAEL. EPA has no clear guidance on the dividing line between subchronic exposure and chronic exposure (Opresko et al. 1994). Because lifespans of the small mammal receptor populations are generally short (<1 year, EPA 1993) and less than the approximate 2-year lifespan for laboratory rodents (Opresko et al. 1994) an adjustment factor of 0.2 rather than 0.1 (Opresko et al. 1994) was used to convert subchronic NOAELs to chronic NOAELs. Table 6-9 shows the benchmark toxicity values for small mammalian receptors selected for upland and wetland habitat at the PRDA.

Explanation of Upland Plant Benchmarks: The COECs in PRDA soils are all VOCs with maximum concentrations generally less than 1 mg/kg. The maximum concentration in surficial soils at the PRDA was 21 mg/kg (1,1,2,2-tetrachloroethane) in a historic sample from the ≥1 and ≤4 feet depth interval. Phytotoxic effects are not expected to occur at these VOC soil concentrations, because concentrations of >1000 mg/kg for toluene and chlorinated solvents (i.e., tetrachloroethene and trichloroethane) are required to observe phytotoxic effects (Hulzebos et al. 1993).

Explanation of Aquatic Organism Benchmarks. Toxicity-based benchmark values are estimated chronic no-effect concentrations or levels (NOELs). Chronic effects include effects on reproduction, growth, mortality, and behavioral modifications deemed critical for the population to function. Where toxicity data available for a chemical is of less than chronic duration (e.g., acute) or is less than a no-effect endpoint (e.g., LOEL), adjustment factors are used to extrapolate to a NOEL. If a chronic water quality criteria value was available, this was used as the pore water NOEL benchmark for aquatic invertebrate receptors exposed to sediment; no adjustment factor was applied. If a chronic threshold value (geometric mean of the no observed effect concentration [NOEC] and lowest observed effect concentration [LOEC]) was available this was used as the chronic benchmark value; no adjustment factor was applied. If only chronic LOECs were available, the lowest LOEC was multiplied by an adjustment factor of 0.1 to extrapolate to a NOEL. If only acute lethal concentrations (LC_{50}s) were available, the lowest LC_{50} was extrapolated to a NOEL using an adjustment factor of 0.01. Adjustment factors of 0.1 to convert a LOEL to a NOEL and 0.01 to convert a LC_{50} to a NOEL were EPA recommended values for screening (EPA 1994e).

For aquatic invertebrate receptors, sediment benchmarks for the nonpolar organic COECs were based on water quality benchmarks adjusted to sediment benchmarks using the equilibrium partitioning approach (EqP) (EPA 1989e):

$$SQC = WQC \times f_{oc} \times K_{oc}$$

where:

SQC = sediment quality criteria (mg/kg);
WQC = water quality criteria (mg/L);
f_{oc} = fraction of organic carbon content in sediment (unitless); and
K_{oc} = partition coefficient for particle organic carbon (pore water to sediment partition coefficient) (L/kg);

Because there are no data on the organic carbon content of the PRDA wetland sediment, an organic carbon content of 1 percent for sediment was used for calculating the toxicity-screening benchmark values. This provides a conservative toxicity-screening value because the type of wetland present (i.e., peat substrate, abundant vegetation) is likely to have sediment with a higher organic carbon content than 1 percent.

Toxicity values for emergent vegetation were not found for the wetland sediment COECs (1,3,5-trinitrotoluene and m-nitrotoluene). Therefore, toxicity data for terrestrial plant data was used for evaluating risk to the emergent vegetation. Table 6-9 lists the benchmark toxicity values selected for wetland habitat key receptors at the PRDA.

6.4.1.3 Toxicity Benchmarks for Soil COECs

Chloroform: The subchronic NOAEL benchmark value for chloroform of 150 mg/kg-bw/d is based on a oral incubation study with rats measuring liver, kidney, and gonadal condition (Palmer et al. 1979 in Opresko et al. 1994). The subchronic benchmark was converted to a chronic NOAEL benchmark of 30 mg/kg-bw/d using an adjustment factor of 0.2.

Based on the low values for K_{oc} (44 L/kg) and log K_{ow} (1.90 to 1.97) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains.

1,2-Dichloroethene: Both the trans- and cis- isomers were detected in near-surface site soils. The benchmark subchronic NOAEL value for 1,2-dichloroethene of 452 mg/kg-bw/d is based on a drinking water study conducted with mice (Palmer et al. 1979). Endpoints measured in the study were body and organ weights, blood chemistry, and hepatic function. An adjustment factor of 0.2 was used to convert this subchronic NOAEL to a chronic NOAEL of 90.4 mg/kg-bw/d.

Based on the low values for K_{oc} (59 L/kg) and log K_{ow} (2.09) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100%.

1,1,2,2-Tetrachloroethane: Most of the reported toxicity data for this chemical are for carcinogenic effects. Values reported by Lewis (1992) for non-carcinogenic effects include a non-lethal LOAEL of 30 mg/kg-bw/d for the hamster; an oral LD_{50} of 800 mg/kg-bw/d for the rat and an oral lethal LOAEL of 300 mg/k-bw/d for a dog. The lowest value of 30 mg/kg-bw/d was selected as the LOAEL benchmark. As it was unknown whether this was a chronic or subchronic value, an adjustment factor of 0.1 was used to derive the final benchmark NOAEL of 3 mg/kg-bw/d.

Based on the low values for K_{oc} (46-117 L/kg) and log K_{ow} (2.39-2.56) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100 percent.

Tetrachloroethene: The benchmark value for tetrachloroethene is based on chronic dietary NOAELs for small mammals. Tetrachloroethene is not highly toxic to experimental laboratory animals: chronic NOAELs for rats and mice range from 100-1000 mg/kg-bw/d (EPA 1994), while oral LD_{50}s are reported to be greater than 3000 mg/kg-bw/d. Based on this information, a conservative benchmark value of 100 mg/kg-bw/d was chosen based on chronic NOAELs of 100-1000 mg/kg-bw/day for rats and mice (USEPA 1994c).

According to ATSDR (1992), biomagnification of tetrachloroethene in terrestrial food chains is not expected to be important because the compound is metabolized in animals. Based on the low values for K_{oc} (360 L/kg) (Lyman et al. 1982) and log K_{ow} (2.1 to 2.9) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100 percent.

Toluene: A review of the toxicity literature for toluene showed that there is a wide range of effect levels for chronic dietary concentrations in the diets of small mammals. A chronic NOAEL (reproductive effects) of 2500 mg/kg-bw/day was shown for mice (NTP 1990 in USDHHS 1992). However, this NOAEL was compared with several LOAEL values in the published literature and it was found that adverse effects have been reported at dose levels as low as 3.0 mg/kg-bw/d to 2500 mg/kg-bw/d. Therefore, a conservative benchmark value of 0.6 mg/kg-bw/day was selected for small mammals. This value was obtained by selecting the lowest LOAEL reported in the literature, 3.0 mg/kg-bw/d (Kostas and Hotchin 1981 in USDHHS 1992) for mice, and applying an adjustment factor of 0.2 for converting a non-lethal LOAEL to a NOAEL.

Based on the low values for K_{oc} (114-115 L/kg) and log K_{ow} (2.1 to 2.8) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100 percent.

1,1,2-Trichloroethane: Toxicity data were found in the literature for trichloroethane effects on small mammals. The reported data include acute oral LD_{50}s and chronic LOAELs for reproductive and carcinogenic effects. The lowest LOAEL reported in the literature is for chronic ingestion of trichloroethane by mice (76 mg/kg-bw/day) (Lewis 1992). An adjustment factor of 0.2 was used to convert the chronic LOAEL to a chronic NOAEL benchmark value of 15.2 mg/kg-bw/day for the upland small mammal receptor.

Based on the low values for K_{oc} (56 L/kg) and log K_{ow} (2.8) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100 percent.

Trichloroethene: TCE is not highly toxic and does not bioaccumulate to any notable extent. Toxicity data for TCE are limited to small mammals. Trichloroethene has an oral LD_{50} of 2402 mg/kg-bw/d for mice and 7330 mg/kg-bw/d for rabbits (Lewis 1992). Opresko et al. (1994) report a subchronic LOAEL value of 100 mg/kg-bw/d based on hepatotoxicity. After applying an adjustment factor of 0.2, the benchmark value for TCE for a small mammal is 20 mg/kg-bw/d.

Based on the low values for K_{oc} (65-126 L/kg) and log K_{ow} (2.3 to 3.3) (Montgomery and Welkom 1990), bioaccumulation potential appears to be limited for terrestrial food chains. The ingestion bioavailability is conservatively assumed to be 100%.

6.4.1.4 Toxicity Benchmarks for Wetland Sediment COECs

1,3,5-Trinitrobenzene: The benchmark value for this COEC was based on a subchronic dietary study by Reddy et al. (1994) using Fischer 344 laboratory rats. A NOAEL of 4 mg/kg-bw/day for reproductive effects (degeneration of the seminiferous tubules of testes) for this study was reported by Talmage and Opresko (1995a). The benchmark value was derived using an adjustment factor of 0.2 to convert the non-lethal subchronic NOAEL to a chronic NOAEL (0.8 mg/kg-bw/day).

A benchmark value for aquatic benthic invertebrates was derived using a benchmark water quality value and the EqP approach. A chronic threshold value of 0.59 mg/L was reported for a chronic flow-through toxicity test with the invertebrate *Daphnia magna* (water flea) (van der Schalie 1983 in Talmage and Opresko 1995a). The benchmark value of 8.0 mg/kg for aquatic invertebrate receptors was derived using the EqP approach to convert the water quality benchmark to a sediment benchmark (0.59 mg/L x 0.1 x 136 L/kg).

No rooted macrophyte toxicity data were found for 1,3,5-trinitrobenzene. A NOEC value for 2,4,6-TNT based on cucumber and radish seedling survival and growth tests (Simini et al. 1995) was used as a surrogate phytotoxicity benchmark for 1,3,5-trinitrotoluene. Higher NOEC values of 10 mg/kg are reported using bean, wheat, and blando broom for 2,4,6-TNT (Cataldo et al. 1989). Because nitro substituted toluene and benzene have toxicities of the same magnitude for alga (Table 6-10), a similar phytotoxic relationship was assumed to exist for rooted, vascular plants. Based on this, a phytotoxic benchmark value of 7 mg/kg in soil was used for 1,3,5-trinitrotoluene.

Based on the low log K_{ow} values (1.18 and 1.36) (cited in Talmage and Opresko 1995a) bioaccumulation potential appears to be limited.

m-Nitrotoluene: Acute dietary LD_{50}s for four species (rat, mouse, rabbit, and guinea pig) range from 330 mg/kg-bw/day (mouse) to 3600 mg/kg-bw-day (guinea pig) (Lewis 1992). A benchmark value for small mammals was derived from the dietary mouse LD_{50} using an adjustment factor of 0.01 to convert to a NOAEL (3.3 mg/kg-bw-day). Based on the low log K_{ow} values (2.40 to 2.45) (Montgomery 1991) bioaccumulation potential appears to be limited for m-nitrotoluene.

No aquatic invertebrate sediment toxicity values for m-nitrotoluene or water quality toxicity values from which a sediment value could be derived using the EqP approach were found in the literature. A conservative benchmark value for m-nitrotoluene of 7.4 mg/kg was selected based on the following information. The lowest 96-hr LC_{50} value (3.1 mg/L) for an isomer of dinitrotoluene (DNT) was converted to a chronic water benchmark value (0.031 mg/L) by applying an adjustment factor of 0.01. The EqP method was used to calculate the concentration in sediment (7.4 mg/kg) that would result in a pore water concentration equivalent to the water benchmark value. Use of a DNT benchmark provides a conservative estimate of m-nitrotoluene toxicity because of the relationship between increasing nitro groups on toluene and toxicity. As the number of nitro-groups on toluene increases, there appears to be an increase in toxicity. The water flea species mean acute value for toluene is 137 mg/L (USEPA 1980a). Acute toxicity for toluene with two nitro groups range from 3.1 mg/L for 2,5-DNT to 47.5 mg/L for 2,4-DNT

(Burrows et al. 1989). Acute toxicity of trinitro substitutions for the water flea range from 0.8 to 11.7 mg/L (Burrows et al. 1989).

No rooted macrophyte toxicity data were found for m-nitrotoluene. The benchmark value of 7 mg/kg in soil for 1,3,5-trinitrotoluene was, therefore, used as a conservative phytotoxic benchmark for m-nitrotoluene. The toxicity of nitro-substituted toluene and benzene compounds are within similar magnitudes for aquatic plants and there appears to be a relationship between the number of nitro substitutions and toxicity. As the number of nitro substitutions increases, toxicity increases (Table 6-10). The uncertainty associated with this decision is documented in the Uncertainty Analysis (see Section 6.5.5.3).

6.4.2 Exposure Assessment

The exposure investigation and assessment is the step where the magnitude of a receptor's exposure to the COECs is generally identified. Exposure assessment includes identification of the source-receptor exposure pathways taking into account environmental fate and transport through both physical and biological means. Pathways are described in terms of the ecological COECs and media involved and the potential ecological receptors. The exposure assessment includes the following steps:

- Evaluation of the actual or potential source-receptor pathways for completeness and significance;
- Determination of exposure points and concentrations;
- Estimation of chemical intake by key receptors; and
- Estimation of exposure duration, frequency, and area use.

Exposure pathways have already been discussed in Section 6.3.4. COECs were selected in Section 6.3.3. The remainder of this section addresses the Quotient Method for quantifying exposure and the input values used.

6.4.2.1 Estimation of Exposure Concentrations

Exposure point concentrations are the chemical concentrations to which a receptor is exposed when contact is made with a specific environmental medium. Exposure point concentrations for ingestion of surficial soils for site COECs are provided in Tables 6-11 and 6-12. Exposure point concentrations for ingestion of sediment COECs by the muskrat and direct contact by aquatic biota are provided in Table 6-13.

6.4.2.2 Quotient Method

The Quotient Method as applied to environmental risk is similar to calculating a Hazard Index for human health assessments (see Risk Assessment Guidance for Superfund, Volume I, Human Health [USEPA 1989a]). Because the COECs for this ERA area are primarily VOCs which tend not to bioaccumulate, biomagnification of the chemicals through food/prey items to the uppermost trophic levels was not considered in this ERA. However, since plants can uptake chemicals with low log K_{ow} values, uptake via primary producers (vegetation) to the small mammal receptors was evaluated.

The risk approach used evaluates the exposure through direct ingestion of COECs in food and soil. The potential for emergent wetland vegetation and terrestrial vegetation to potentially uptake some fraction of COEC concentrations in sediment and soil was incorporated in the exposure quantification for small mammals. A bioaccumulation factor (BAF) (e.g., the ratio of the concentration of a chemical in vegetation to the concentration and/or sediment in soil) was applied to soil concentrations to estimate exposure from ingesting vegetation on site.

To calculate an Ecotoxicological Quotient (EQ), the exposure concentration (reasonable maximum exposure [RME] and/or maximum soil or sediment concentration) for each COEC is divided by a benchmark value for the given receptor developed from the published toxicological literature. To calculate the Ecotoxicological Index (EI), the EQs for direct ingest of soil and vegetation (vole) or sediment and vegetation (muskrat) are summed. The EIs are then summed to obtain an overall EI for the receptor.

Tables 6-14 through 6-17 show the EQ calculations for the red-backed vole at exposure areas A-1, A2, O and A-3, A-4, T. Tables 6-18 through 6-19 show the EQ calculations for the muskrat.

For aquatic biota and wetland emergent vegetation, the risk analysis approach assesses direct exposure to sediment and soil COECs. EQs for aquatic biota and wetland emergent vegetation are obtained by dividing the exposure concentration (RME and/or maximum concentration) by a benchmark value developed from the published literature. The EQs for each COEC are then summed to obtain an overall EI. Tables 6-20 and 6-21 provide the results of the risk calculations for emergent vegetation and aquatic invertebrates exposed to maximum sediment concentrations.

Quotient values (EQs or EIs) of one or less are commonly interpreted as indicating a "low likelihood" for adverse ecological effects. Quotient values from 1 to 10 indicate a "possibility" for adverse ecological effects to occur. While these are still relatively low values, they need to be interpreted in the light of receptor population exposure conditions and uncertainties in the risk analysis approach and methods (see section 6.6). Values greater than 10 are generally interpreted as indicating a high likelihood that adverse effects may occur due to the presence of chemicals in the environment (Watkin and Stelljes 1993). Values greater than 1 or 10 are cause for further detailed consideration of the uncertainties and limitations involved in the EQ calculation and the nature of the potential adverse effects on the valued ecological resources. Correct interpretation and usage of the Quotient Method is also highly dependent on professional judgment and an understanding of the assumptions and uncertainties involved in the calculations, particularly in instances where the EI approaches 1 (Watkin and Stelljes 1993; USEPA 1989a,b).

Generally, if multiple chemicals of ecological concern exist, it is only appropriate to sum the EQs for contaminants with the same ecological effect endpoint and/or the same mechanism of toxic effect. In applying the Quotient Method, at PRDA a conservative assumption was made that chemical effects are additive and could be summed to provide an EI. This may be overly conservative, as even similar classes of chemicals tend to affect organisms differently. The Quotient Method does not account for the various interactions that may take place in chemical mixtures within the soil column. Such interactions can either increase or reduce the overall risk. These interactions and their impact on overall risk are largely unknown and, given the current level of scientific understanding, the interactions cannot be evaluated. These and other uncertainties regarding the risk analysis method are documented further in the Uncertainty Analysis section.

6.4.2.3 Ecotox Index Calculations

The following discussion provides insight into how input values were selected, as well as the calculations that were used to develop the final EIs for the upland and wetland small mammal receptors (northern red-backed vole and muskrat). In order to obtain a final EI value for mammalian receptors, the exposure dose (amount of chemical taken in by a receptor [mg/kg-bw/day]) is compared to the benchmark value (mg/kg-bw/day). Exposure doses are calculated for individual chemicals and receptors, using the following equations:

Upland and Wetland, Small Mammal Receptors:

$$ED = \frac{\left(C_{(s)} \times SI\right)_{soil} + \left(C_{(s)} \times FI \times BAF\right)_{vegetation}}{BW}$$

where:

ED: Exposure dose (mg/kg-bw/d) for an individual chemical and receptor;
$C_{(s)}$: Concentration in the soil (mg/kg);
SI: Daily soil intake (kg/d);
BW: Body weight of the receptor (kg);
FI: Food intake (kg/d); and
BAF: Bioaccumulation factor (mg-COEC in food/mg-COEC in soil).

Aquatic Biota and Emergent Vegetation:

$$EC = C_{(s)}$$

where:

EC: Exposure concentration (mg/kg) for an individual chemical and receptor;
$C_{(s)}$: Concentration in the soil (mg/kg).

Values for these parameters were estimated using values presented in the literature and professional judgment to adapt them to the specific situation. For uncertainties inherent in this process, see Section 6.6.

Parameter Values

The body weight of 21.9 g used for the northern red-backed vole is the average value given in the literature (Banfield 1974) for adults. Daily food intake for the vole was estimated as 3.07 g/day (wet-weight basis), equivalent to 14.0 percent of its body size daily, based on the food ingestion rate provided by EPA (1993a) for the prairie vole. Diet was assumed to be composed entirely of vegetation for this ERA. The literature indicates that northern red-backed voles feed mainly on vegetation with animal food rarely consumed (Gromov and Polakov 1992). A soil ingestion rate of 5 percent was used to estimate exposure from incidental soil ingestion while burrowing or grooming, and from soil adhering to food items. This was a conservative estimate compared to the 2.4 soil in diet percentage (dry weight) listed by EPA (1993) for the meadow vole.

For the adult muskrat, an average body weight of 1500 g and a daily food ingestion rate equivalent to 30 percent of its body size (450 g/day) were used based on values provided in the Wildlife Exposure Factors Handbook (EPA 1993a). The diet for the muskrat was assumed to be composed entirely of vegetation for this ERA. A soil ingestion rate of 5 percent was used to estimate incidental soil ingestion for the muskrat. Uncertainty is high for this soil ingestion rate, as no data from the literature were available.

For the concentration of the COEC in the soil (or sediment), both the reasonable maximum exposure concentration (RME, the 95% upper confidence limit [UCL] of the mean site concentration) and the maximum concentration found on site were used in separate comparisons for the small mammal receptors. Use and derivation of the RME follow EPA guidance for calculating the exposure concentration term (EPA 1989a, 1992d). Where variability is high and the 95% UCL exceeds the maximum detected value, the maximum detected value is used as the RME. The concentration in vegetation is the RME (or maximum) concentration for the soil (or sediment) times the BAF appropriate for a particular COEC.

EIs were calculated for aquatic invertebrates by comparing exposure concentrations in sediment (mg/kg) to benchmark sediment (mg/kg) values.

6.5 RISK CHARACTERIZATION

Risk Characterization is the final phase in the ERA. The following Risk Characterization description consists of a summary of results of the risk estimation and uncertainty analysis and an assessment of confidence in the risk estimates. As described in Section 6.3.3 (COEC Selection) five VOCs were found to be surficial soil COECs for exposure unit A-1,A-2, O, seven VOCs were found to be surficial soil COECs for exposure unit A-3, A-4, T, and two explosive-related chemicals, m-nitrotoluene and 1,3,5-trinitrobenzene, were found to be sediment COECs for the wetland.

6.5.1 Ecotox Index for Northern Red-backed Vole

The primary exposure pathway evaluated for the northern red-backed vole was oral ingestion of soil and vegetation. The soil ingestion rate used for the vole (5 percent of food intake; see Section 6.4.2.3) includes both the direct ingestion of soil while feeding and incidental soil ingestion through grooming. Inhalation and dermal exposure pathways were considered potentially complete but negligible pathways because wastes are buried more than 2 feet below the surface. Little burrowing activity from voles or other small mammals was observed at the PRDA.

6.5.1.1 Exposure Area A-1, A-2, O

The EI for the vole at this exposure area is well below one (0.003) (Table 6-15). The EI based on maximum COEC concentrations is also well below one (0.02) (Table 6-14). Based on these results, the potential for adverse effects to small mammal populations at this exposure area appears negligible.

6.5.1.2 Exposure Area A-3, A-4, T

The EI based on RME COEC concentrations in surficial soil for this exposure area is 0.2 (Table 6-17). The EI based on maximum COEC concentrations in surficial soils is one (1.05) (Table 6-16). The EI of 1 is largely due to the one elevated maximum concentration of 1,1,2,2-tetrachloroethane at 21 mg/kg at the 1 to 4 ft depth interval. Exposure to concentrations this high are considered unlikely because 45 samples out of 46 taken in this exposure area had <8 mg/kg. The EI of 0.2 based on RME concentrations indicates the potential for adverse effects to small mammal populations at this exposure area are probably negligible.

6.5.2 Ecotox Index for Muskrat

The primary exposure pathway evaluated for the muskrat is oral ingestion of sediment and vegetation. The sediment ingestion rate for the muskrat (5 percent of food intake) includes both the direct ingestion of soil while feeding and incidental soil ingestion through grooming. Inhalation and dermal exposure pathways are considered potentially complete but negligible pathways. It was conservatively assumed that the muskrat lived and ate only in the wetland area.

Using RME concentrations, the EI for the muskrat is 0.5, indicating negligible potential for adverse effects to the muskrat from site COECs (Table 6-19). The EI based on maximum sediment concentrations is also less than one (0.96) (Table 6-18). Although close to one, these EIs are considered to be conservative estimates, largely due to the conservative assumption that the vegetation has a tissue concentration equivalent to the sediment concentration. There is little evidence in the literature to support the assumption that wetland vegetation might uptake these compounds or that the toxic effects from these compounds are additive.

6.5.3 Ecotox Index for Emergent Vegetation

The exposure route considered was direct contact of roots with sediment. The EI using maximum soil concentrations was less than one (0.16) (Table 6-20) indicating negligible potential for adverse effects to emergent vegetation in the wetland from site-related COECs.

6.5.4 Ecotox Index for Aquatic Invertebrates

The primary exposure route considered was direct contact with sediments. The EI for aquatic invertebrates using maximum concentrations was less than one (0.5) (Table 6-21). This EI result indicates negligible potential for adverse effects from site-related COECs to aquatic invertebrates in the wetland area.

6.5.5 Uncertainty Analysis

This section identifies and discusses the uncertainties and limitations involved in the risk assessment process that may influence the risk estimates and/or decisions based on these estimates. Uncertainties and limitations are inherent in each of the three ERA phases. These uncertainties can lead to an overestimation or underestimation of potential risk. The approach taken in this ERA, in the absence of certainty or data, was to make conservative assumptions and calculations to ensure that potential risk was not underestimated. When assumptions of a conservative nature are made in the development of the risk analysis, the final result may be overly conservative. The following discussion identifies the primary contributing factors to uncertainty in each phase of the risk assessment process. Table 6-21 presents a summary of these factors, as well as the magnitude and direction of each uncertainty on the risk estimate.

6.5.5.1 Data Assumptions

Detection Limits: The VOC results from the 1995 screening samples were included in the estimation of exposure point concentrations for soils. The detection limits (DLs) for the screening level of effort were higher than the laboratory effort. For example, the trichloroethene screening DL was 0.05 mg/kg, whereas the laboratory had DLs of 0.0011 mg/kg. In addition, historic laboratory data had DLs much higher than either the 1995 screening or laboratory analyses. For example, the DL for trichloroethene for the historic data is 5.0 mg/kg. Inclusion of these high detection limits in calculation of the exposure concentrations in soils may overestimate the exposure concentration and therefore risk.

Composite Soil Samples: Composite soil samples that included both the surficial (≤3 feet) and subsurface (>3 feet) stratum (e.g., 0 to 7 feet, 3 to 6 feet) were included in the calculation of surficial soil exposure concentrations. Because VOC concentrations increased with soil depth, inclusion of composite samples with soil from the subsurface stratum may result in an overestimate of the surficial soil exposure concentration and therefore the risk estimate.

6.5.5.2 Problem Formulation

Literature Background Comparison: Site metal concentrations in soil (e.g., mercury and lead) and water (e.g., lead) that were higher than sampled site background locations were considered to be potentially site-related. These statistically high metal concentrations were also compared to literature-based background concentrations. Metal levels that were within the literature-based background concentration range were further eliminated from the risk analysis. While statistics provide an objective comparison of the data, choice of background location, biases in analytical results from different laboratories, data variability, number of samples, and inclusion of composited samples from various depths, can influence whether a difference is declared statistically significant. EPA's Region 10 Supplemental Guidance for Ecological Risk Assessment (USEPA 1994d) suggests that "for smaller sample sizes, an arbitrary factor, such as 2x or 5x be applied for comparison of background, sample means and maximum concentrations." A qualitative comparison of on-site metals concentrations with literature-based background was performed to ensure that small differences in local metal concentrations that may or may not be attributed to site activities and are judged to pose little concern from an ecological perspective, were not included. The uncertainty of this qualitative screen against literature background values could result in the underestimation of the number of COECs and exposure concentrations and the resultant risk estimate. The estimated magnitude of the effect on the risk estimate of making potentially incorrect judgments and eliminating COECs based on the literature background comparison is low.

Single, elevated, anomalous results for metals such as mercury at the A-3, A-4, T exposure area or copper in wetland surface water may be source related, but such metals pose little concern from an ecological population perspective because of their limited occurrence. Use of site background data without consideration of regional or literature background information and the many variables that influence metals concentrations can result in the unnecessary inclusion of normally-occurring metals levels in the risk analysis and the subsequent overestimation of risk. The uncertainty of not retaining metals such as mercury and copper as COECs due to their single, elevated, anomalous occurrence could result in the underestimation of risk. The estimated magnitude of this uncertainty on the resultant risk estimate is considered low.

Water Hardness: In the water quality criteria calculations for metals, water hardness was assumed to be 100 mg/L $CaCO_3$ because of a lack of data. Surface water pH, specific conductivity, and the type of plants observed (i.e., peat and sundews) indicate that a low hardness, acidic system may be present. The use of a water hardness of 100 mg/L $CaCO_3$ in criteria calculations may underestimate risk (i.e., as hardness increases the criteria allows higher total metal concentrations). Given the indications that this may be an acidic system, the magnitude of the effect on risk may be moderate. However, see the discussion on applicability of these criteria to the wetland surface waters in the paragraph below.

Toxicity Screening Values: The water quality criteria used were for Class C freshwaters in Alaska and are applicable to waterbodies like creeks, tributaries, and lakes. These criteria were developed from toxicity studies using species that are typical of waters of the U.S. Most state and federal criteria are derived in a manner such that the values will be protective of typical bodies of water (Stephen et al. 1985). Criteria derived using species not typically present in naturally acidic, softwater, wetland systems like that present on PRDA, may overestimate risk, especially for chemicals like metals which generally become more soluble as pH decreases. For example, water hardness and pH are known to affect the presence or absence of several different aquatic biota including mussels, snails, insects and fish (Hart and Fuller 1974).

Key Receptor Selection: It is possible that the wildlife selected as key receptors in this ERA are not those receptors that have the greatest likelihood of being at risk or are sensitive to the selected COECs. Amphibians are not addressed in most ERAs nor this ERA, as ecological exposure and toxicity information on which to base an assessment are generally lacking. Potential risks to birds and ducks were also not assessed given the marginal nature of the wetland habitat. Ecosystem and community level assessment endpoints such as adverse impacts to nutrient cycling, predator-prey relationships, community metabolism, and structure shifts were not addressed, although based on the risk analysis results and small size of this site, such effects are considered to be negligible. The ECSM is the product of the problem formulation phase, which in turn, provides the foundation for the effects characterization and risk estimation. If incorrect assumptions are made during development of the ECSM regarding the potential toxic effects or the ecosystems and receptors potentially impacted, then the final risk characterization may result in an underestimation of risk. The estimated magnitude of potentially incorrect assumptions on the risk characterization at this site is considered low.

6.5.5.3 Exposure Assessment

Soil Exposure: Soil sampling intervals were selected in the RI based on contamination history for the site; i.e., waste was buried in trenches that were excavated and backfilled or the area was capped with 3 feet of soil. Contamination in surficial soil depths up to 2 feet where burrowing animals would be exposed, was not expected. A reasonable worst case assumption was therefore made that chemicals detected in soil intervals ≤3 feet would represent surficial exposure concentrations for burrowing animals or animals ingesting surficial soil. Inclusion of the deeper soil intervals likely results in an overestimation of the number of COECs and the concentrations to which wildlife receptors might be exposed.

Groundwater Exposure: Groundwater at the site is contaminated with VOCs. However, there are no known on-site or off-site seeps by which wildlife can be exposed. It was assumed that groundwater at the site and the contaminants within the groundwater could eventually reach the Eagle River. There is a lack of information regarding migration of the groundwater beneath the site. However, an evaluation of the modeled groundwater data indicates that because of time of travel and concentrations required for toxic effects, the additional risk estimate is negligible.

A further hypothetical exposure scenario was evaluated, wherein it was assumed that site groundwater would migrate to the Eagle River. It was assumed that modeled concentrations of three VOCs would represent the risk from all VOCs detected in the shallow zone and deep aquifer. The identification of these three VOCs as the only groundwater COECs in the model is not accurate. Other chemicals were measured in groundwater and would likely migrate jointly with the other three VOCs. Exclusion of these contaminants from the risk assessment could potentially result in an underestimation of risk. However, given the difference in magnitude between concentrations of the modeled VOCs (total > 100 mg/L) with a risk estimate of <0.05 and the magnitude of the other VOCs in groundwater (total > 10 mg/L), inclusion of the other VOCs would contribute negligible additional risk.

Results of the groundwater model assumptions (e.g., constant source, lack of information on load) provide conservative estimates of time to travel and magnitude of the VOCs. The assumption of a constant source is a conservative, worst-case scenario where ultimately, the model will predict concentrations at the Eagle River discharge point which are equivalent to current site concentrations. This is not realistic because sources of VOCs have been reduced or eliminated and will become depleted over time. For example, chlorinated solvents are no longer used or disposed of at PRDA. In addition, an attempt was made to remove solid waste and soils in Areas A-3 and A-4 with chlorinated solvent concentrations above health-risk based removal action levels approved by ADEC. Areas A-3 and A-4 appear to have been the source of soil and groundwater contamination at the site.

Evaluation of site concentrations at the groundwater discharge point is inappropriate and would introduce a high degree of uncertainty to risk interpretation and to remediation decision-making. The leading edge of the modeled plume was used to evaluate imminent or near future threat to the Eagle River biota. Higher concentrations of contaminants would be expected near the center of the plume, but these cannot be predicted with confidence because of simplifying assumptions that had to be incorporated in the model. The potential magnitude of underestimating imminent or near future risk to Eagle River due to the use of the concentrations in the leading edge of the plume is considered negligible.

The groundwater exposure pathway for ecological receptors is assumed to be incomplete or negligible. The rooting depth for most plants in the area is assumed to be less than 15 feet. Trees may have rooting depths greater than 15 feet. The assumption that the exposure pathway for plants is negligible may result in an underestimation of risk. The estimated magnitude of the effect on risk is considered low.

Sediment Ingestion: A sediment ingestion rate of 5 percent was assumed for the muskrat. Few data are available on soil ingestion rates for wildlife. EPA (1993) has published values for the meadow vole (2.4 percent), white-footed mouse (< 2 percent), and raccoon (9.4 percent). The actual sediment ingestion rate for the raccoon could be higher or lower than 5 percent, resulting in the underestimation or overestimation of risk. The potential magnitude of this effect on the risk estimate is considered low.

Bioaccumulation of VOCs: Little to no data are available to support the assumptions that VOCs and the explosives residues, m-nitrotoluene and 1,3,5-trinitrobenzene, can be taken up by plants. Available studies do show that metabolite residues derived from VOC or explosive compounds can accumulate in plants to a small degree. Such metabolites are not assumed in this ERA to have similar toxicity values to the parent compound. Investigations at Aberdeen Proving Ground have shown that the explosive compounds trinitrotoluene and 1,3,5-trinitrobenzene do not bioaccumulate in top predators in the aquatic ecosystem (e.g., snapping turtles) (DOA/USACE 1996). The low concentrations of VOCs and explosive compounds found at the PRDA wetland were thus assumed to pose little concern to primary consumers even if they did bioaccumulate in plants.

Using a BAF of 1 for VOCs and explosive residues in plants is considered likely to result in an overestimation of risk. The potential magnitude of the effect on risk is considered low.

Exposure Duration and Area Usage: Exposure duration and area use by potential receptors as presented in this ERA assumed a worst-case scenario. Area usage by receptors was conservatively assumed to be 100 percent. That is to say that the receptors spend 100 percent of their time on site. It is also assumed that exposure to contaminated soils and vegetation is continuous. Because mobile receptors are likely to feed or visit several locations, or avoid VOC contaminated areas, their daily dose, if averaged over time, could be less than that used in this ERA for evaluating risk. Adverse effects in small localized areas on a few small mammal individuals are negligible considerations in terms of risk to the biological population. These assumptions may result in an overestimation of risk.

Dermal/Inhalation Pathways: The dermal and inhalation pathways for small mammals were considered negligible in this ERA. Little to no data are available to confirm or refute this assumption. Small burrowing mammals may or may not avoid VOC contaminated areas. Exclusion of these pathways may result in an underestimation of risk. The potential magnitude on the risk analysis from the exclusion of these two pathways is considered low, given the overall low VOC COEC site concentrations.

The threshold effects soil concentration of 1.9 mg/kg based on the inhalation pathway for a muskrat (Kappleman 1993 in Maughan 1993) is uncertain (see Section 6.3.4.3). Inhalation effects levels reported in the literature are generally several hundred ppm. For example, Lewis (1992) reports a toxic concentration low (TCLo) for toluene inhalation by a mouse at 400 ppm. The TCLo for 1,1,2,2-tetrachloroethane inhalation by a hamster is 1,000 mg/m^3 (= 142 ppm) (Lewis 1992). Soil concentrations would likely have to be substantially higher than levels reported at PRDA in order to produce these air concentrations at the surface or in shallow burrows. The potential magnitude on the risk analysis from not performing a quantitative analysis on the inhalation pathway for burrowing mammals or visiting wildlife receptors is considered low.

6.5.5.4 Ecological Effects Assessment

Toxicity Values/Benchmark Values: No standardized system is available for identifying toxicity-based "safe" benchmark values for terrestrial wildlife. The potential exists for wildlife species to be more or less sensitive than test species (some biota adapt) and the toxicological benchmarks used. Toxic dose values for laboratory organisms may also be substantially lower than those for wildlife due to the sensitive strain of laboratory animals used and the direct means by which they are dosed. LD_{50} studies are usually designed to promote maximum exposure (absorption) and lessen any chemical complexing with dietary material. The LD_{50} dietary studies probably give a better indication of the toxicity of the chemical tested, while NOAELs from longer studies are the best (however, still imperfect) laboratory studies to use as predictors of field effects.

EPA (1986) guidance for pesticides recommends adjustment or safety factors of 0.2 the LD_{50} value for non-endangered terrestrial species and 0.1 the LD_{50} or 0.1 the LD_{10} for endangered terrestrial species. For this ERA, benchmarks were selected from laboratory tests measuring the LOAEL or NOAEL for reproductive or developmental effects from chronic or intermediate exposure (>2 weeks). If no-effects levels were unavailable, an adjustment factor of 0.2 or 0.1 was applied to the LOAEL, depending on whether the LOAEL was a chronic or acute effects level, respectively. When LOAELs and NOAELs were unavailable, the lowest available LD_{50} or LD_{10} values were used times a protection factor of 0.01 to arrive at a "safe" benchmark value. When a range of toxicity values was available for a receptor species or its surrogate, the most conservative value (for a serious effect) was used as the benchmark value. Chronic benchmark values were used, although the lifespan of small mammals such as the vole or muskrat may be expected to be much shorter than that of laboratory test animals. The conservative selection and derivation of benchmark values in this ERA was considered likely to result in an overestimation of risk. The estimated magnitude of this effect on risk is considered moderate.

No rooted macrophyte toxicity data were found for m-nitrotoluene. The toxicity benchmark for 1,3,5-trinitrotoluene was therefore substituted. The toxicity of nitro-substituted toluene compounds are within similar magnitudes for aquatic plants. The magnitude of the effect on the risk estimation from substituting this benchmark is considered low.

6.5.5.5 Risk Characterization

The Quotient Method: The quotient method of risk estimation assumes all effects of specific COECs are additive and that the standardized algorithms to calculate chemical intakes and associated risks are applicable to wildlife receptors. Use of the quotient method precludes the potential for multiplicative or synergistic effects possible among COECs for any given receptor. Additionally, the quotient method precludes the possibility that certain combinations of chemicals may buffer a system against the toxic effects of another chemical, resulting in an antagonistic effect. Generally, if multiple chemicals of concern exist, it is only appropriate to sum the hazard quotients (i.e., calculate a hazard index) for chemicals with the same ecological effect endpoint and/or the same mechanism of toxic effect. In the conservative screening approach applied in this ERA, the risk effect was presumed to be additive within the similar class of COECs (i.e., all VOCs), which could result in an overestimation of risk. In light of the lack of literature on the potential for diminutive toxic effects of COEC combinations, the resultant hazard index could also provide an underestimation of risk. The potential magnitude of the effect on risk is considered low to moderate.

6.5.6 Risk Characterization Summary

In the ERA of the PRDA site, 15 chemicals were detected at exposure area A-1, A-2, O; 17 chemicals were detected at exposure area A-3, A-4, T; 8 chemicals were detected in wetland sediment; and 6 chemicals were detected in wetland surface water. Chemical concentrations in each of these media were screened against five criteria: detection in at least one sample; frequency of detection; WC (1996) background data; toxicity-based values; and literature-based background data. A screen was done to assess which of the detected chemicals required further evaluation to assess potential risk to ecological receptors. The results of the screening process indicated that five VOC COECs at upland exposure area A-1, A-2, O; seven VOC COECs at upland exposure area A-3, A-4, T; and two explosive-related COECs in the wetland sediment required further evaluation.

The northern red-backed vole and muskrat were selected as representative key receptors for the upland and wetland habitats, respectively based on site-specific exposure pathway and ecological considerations. The potential for adverse effects from COECs on upland and wetland plant communities and aquatic invertebrates was also evaluated. Benchmark toxicity values for COECs for each receptor were determined. The Quotient Method was used to quantitatively evaluate potential risk to the principal key receptors from exposure to COECs in soil and sediment. The Quotient Method is based on the comparison of estimated maximum and RME exposure concentrations for on-site receptors with protective benchmark values derived from the toxicological literature.

Based on the risk analysis, COEC concentrations at the PRDA result in negligible risk to small mammal populations, aquatic invertebrates, emergent wetland vegetation, and upland plant vegetation. The overall potential for valued environmental resources at this site to be adversely affected is considered negligible. The uncertainties and limitations associated with the assumptions used in the Risk Characterization phases of this ERA are provided.

TABLE 6-1
SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN TEXT

PLANTS

Alaska bog willow	*Salix fuscescens*
Alder	*Alnus* sp.
Barclay willow	*Salix barclayi*
Beauverd spirea	*Spirea beauverdiana*
Black spruce	*Picea mariana*
Blueberry	*Vaccinium* sp.
Bog rosemary	*Andromeda polifolia*
Buffaloberry	*Shepherdia canadensis*
Bunchberry	*Cornus stolonifera*
Crowberry	*Empetrum nigrum*
Dandelion	*Taraxaum officianale*
Field horsetail	*Equisetum arvense*
Fireweed	*Epilobium angustifolium*
Highbush cranberry	*Viburnum edule*
Intermediate sedge	*Carex media*
Labrador tea	*Ledum groenlandicum*
Lupine	*Lupinus* sp.
Marsh five-finger	*Potentilla palustris*
Paper birch	*Betula papyrifera*
Polar grass	*Arctagrostis latifolia*
Prickly rose	*Rosa acicularis*
Quaking aspen	*Populus tremuloides*
Resin birch	*Betula glandulosa*
Russet sedge (FACW) (common)	*Carex saxitilis*
Sitka alder	*Alnus sinuata*
Sphagnum	*sphagnum* sp.
Sundew	*Drosera anglica*
White spruce	*Picea glauca*
Wild geranium	*Geranium erianthum*
Willow	*Salix* sp.
Yarrow	*Achillea millefolium*

TABLE 6-1
SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN TEXT

BIRDS

American kestrel	*Falco sparverius*
American wigeon	*Anas americana*
Barrow's golden eye	*Bucephala islandica*
Black-capped chickadee	*Parus atricapillus*
Blackpoll warbler	*Dendroica striata*
Boreal chickadee	*Parus hudsonicus*
Boreal owl	*Aegolius funereus*
Bufflehead	*Bucephala albeola*
Common golden eye	*Bucephala clangula*
Common redpoll	*Carduelis flammea*
Common snipe	*Gallinago gallinago*
Dark-eyed junco	*Junco hyemalis*
Fox sparrow	*Passerella iliaca*
Gray jay	*Perisoreus canadensis*
Gray-cheeked thrush	*Catharus minimus*
Great-horned owl	*Bubo virginianus*
Green-winged teal	*Anas crecca*
Least sandpiper	*Calidris minutilla*
Lesser yellow-legs	*Tringa flavipes*
Mallard	*Anas platyrhynchos*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern hawk owl	*Surnia ulula*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Orange-crowned warbler	*Vermivora celata*
Pectoral sandpiper	*Calidris melanotos*
Red-tailed hawk	*Buteo jamaicensis*
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Spruce grouse	*Dendragapus canadensis*
Swainson's thrush	*Catharus ustulatus*
White-crowned sparrow	*Zonotrichia leucophrys*

TABLE 6-1
SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN TEXT

Wilson's warbler	*Wilsonia pusilla*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
MAMMALS	
Black bear	*Ursus americanus*
Deer mouse	*Peromyscus maniculatus*
Grizzly bear	*Ursus horribilis*
Least weasel	*Mustela rixosa*
Marten	*Martes americana*
Meadow vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Moose	*Alces alces*
Muskrat	*Ondotra zibethica*
North American lynx	*Lynx canadensis*
Northern bog lemming	*Synaptomys borealis*
Northern flying squirrel	*Glaucomys sabrinus*
Northern red-back vole	*Clethrionomys rutilus*
Porcupine	*Erethizon dorsatum*
Red fox	*Vulpes vulpes*
Red squirrel	*Tamiasciurus hudsonicus*
Short-tailed weasel (ermine)	*Mustela erminea*
Shrew	*Sorex* sp.
Snowshoe (varying) hare	*Lepus americanus*
Wolf	*Canis lupus*
Wolverine	*Gulo gulo*
AMPHIBIANS	
Wood frog	*Rana sylvatica*

TABLE 6-1
SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN TEXT

FISH (Eagle River)	
Arctic char	*Salvelinus alpinus*
Chum salmon	*Oncorhynchus keta*
Dolly varden	*Salvelinus malma*
Chinook (king) salmon	*Oncorhynchus tshawytscha*
Pink salmon	*Oncorhynchus gorbuscha*
Rainbow trout	*Salmo gairdneri*
Sockeye salmon	*Oncorhynchus nerka*
INVERTEBRATES	
Biting midge larvae	Family Ceratopogonidae
Dragonflies	Order Odonata
Mayflies	Order Ephemeroptera
Non-biting midges	Family Chironomidae
Mosquitos	

TABLE 6-2
SURFACE WATER AND SEDIMENT TOXICITY-BASED SCREENING VALUES AND BENCHMARKS

	Surface Water			Sediment	
Chemical	Acute mg/L	Chronic mg/L	Reference	Chronic mg/kg	Reference
Copper	17.7[a]	11.8[a]	18 AAC 70	----- N/A -----	
1,3-Dinitrobenzene	110	30	Talmage and Opresko 1995c	----- N/A -----	
Lead	81.6[a]	3.2[a]	18 AAC 70	----- N/A -----	
Nickel	1418[a]	158[a]	18 AAC 70	----- N/A -----	
m-Nitrotoluene	----- N/A ----			No value found.	
1,1,2,2-Tetrachloroethane		240[b]	U.S. EPA 1980b	----- N/A -----	
Toluene	1750[c]	175[d]	U.S. EPA 1980a	----- N/A -----	
1,1,2-Trichloroethane		940[e]	U.S. EPA 1980b	----- N/A -----	
Trichloroethene	10900[f]	219[g]	U.S. EPA 1980c	----- N/A -----	
1,3,5-Trinitrobenzene	----- N/A -----			0.02	Talmage and Opresko 1995b
2,4,6-Trinitrotoluene	----- N/A -----			0.52	Talmage and Opresko 1995b

N/A - Not applicable because compound was not detected in specified media.

[a] Hardness was assumed to be 100 mg/L as $CaCO_3$

Copper:

Criterion Maximum Concentration (CMC): $e^{(0.9422 \times \ln[\text{hardness}] - 1.464)}$

Criterion Continuous Concentration (CCC) : $e^{(0.8545 \times \ln[\text{hardness}] - 1.465)}$

Lead:

Criterion Maximum Concentration (CMC): $e^{(1.273 \times \ln[\text{hardness}] - 1.460)}$

Criterion Continuous Concentration (CCC) : $e^{(1.273 \times \ln[\text{hardness}] - 4.705)}$

Nickel:

Criterion Maximum Concentration (CMC): $e^{(0.846 \times \ln[\text{hardness}] + 3.3612)}$

Criterion Continuous Concentration (CCC) : $e^{(0.8460 \times \ln[\text{hardness}] + 1.1645)}$

[b] Chronic threshold value of 2.4 mg/L for an early life stage test with fathead minnows converted to a chronic benchmark value using a safety factor of 0.1.

[c] LC_{50} value of 17.5 mg/L converted to an acute benchmark value using a safety factor of 0.1.

[d] LC_{50} value of 17.5 mg/L converted to a chronic benchmark value using a safety factor of 0.01.

[e] Chronic threshold value of 9.4 mg/L for an early life stage test with fathead minnows converted to a chronic benchmark value using a safety factor of 0.1.

[f] EC_{50} value of 21.9 mg/L for loss of equilibrium in fathead minnows converted to an acute benchmark value using a safety factor of 0.5.

[g] EC_{50} value of 21.9 mg/L for loss of equilibrium in fathead minnows converted to a chronic benchmark value using a safety factor of 0.01.

TABLE 6-3
COEC SELECTION FOR SURFICIAL SOILS FROM INVESTIGATIVE UNIT A-1, A-2, AND O FORT RICHARDSON PRDA

Criteria 1	Criteria 2[a]				Criteria 3[b]		Criteria 5[c]		
Chemicals Detected In At Least One Sample	Number of Samples	Frequency of Detects (%)	Detected In Other Media?	Retained	Site Exceeds Background Concentration? (WC 1995)	Retained	Site Exceeds Literature Background Concentration?[d]	Retained	Retained as COEC
trans-1,2-Dichloroethen	71	1.4	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
1,1,2,2-Tetrachloroetha	71	9.9	--	Yes	--	Yes	--	Yes	Yes
Tetrachloroethene	71	1.4	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
Toluene	10	20	--	Yes	--	Yes	--	Yes	Yes
Trichloroethene	71	1.4	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
Antimony	10	30	--	Yes	No	No	--	No	No
Arsenic	10	100	--	Yes	No	No	--	No	No
Beryllium	10	30	--	Yes	No	No	--	No	No
Chromium	10	100	--	Yes	Yes	Yes	No	No	No
Copper	10	30	--	Yes	No	No	--	No	No
Lead	10	100	--	Yes	Yes	Yes	No	No	No
Mercury	10	80	--	Yes	No	No	--	No	No
Nickel	10	100	--	Yes	Yes	Yes	No	No	No
Silver	10	20	--	Yes	No	No	--	No	No
Zinc	10	100	--	Yes	Yes	Yes	No	No	No

Sf: surficial soil (depth ≤3 feet)
Sb: subsurface soil (depth >3feet)
GW: groundwater
--: Not screened because the chemical was not retained in a previous step or the criteria is not applicable for the chemical.

[a] Bioaccumulation potential was not assessed because all analytes either had a detection frequency >5 percent or were detected in more than one media at the site.

[b] See Section 4.3 for comparison of site concentrations with local background concentrations.

[c] Criteria 4, toxicity-based screening, is not part of the COC selection process for site soils.

[d] See Table 6-4 for comparison of site concentrations with literature-based concentrations.

TABLE 6-4
COEC SELECTION FOR METALS (mg/kg) IN SURFICIAL SOILS
COMPARISON WITH LITERATURE VALUES

			Literature Background Values							
								USATHAMA (1990)[4]		
	Site Values (from Tables 6.1 & 6.2)		USGS (1984)[a] Western U.S. Soil		USGS (1988a)[b] Alaska Soil		ANWR (Mueller 1994)[c]	Eagle River Flats[d] (sediment control locations)		USGS (1988b)[e] S. Alaska Rocks
	Mean	Max	Mean	Max	Mean	Max	Range of Sediment Means	Mean	Max	Mean
A-1, A-2, O										
Chromium	50.34	84.5	56	2000	64	390	2.0-34.8	56.8	61.6	230.6
Lead	9.2	10.9	20	700	14	310	1.7-81.4	15.5	21.8	22.9
Nickel	62.32	79.3	19	700	33	320	7.9-41.6	56.8	63.8	85.6
Zinc	114.3	190	65	2500	79	2700	19-120	133	139	64.3
A-3, A-4, T										
Lead	13	25	19	700	14	310	1.7-81.4	15.5	21.8	22.9
Mercury	0.143	0.58	0	4.6	NR	NR	<0.1-1.74	0.093	0.286	NR

[a] USGS. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. Authors: Shacklette, H. and J. Boerngen. USGS Professional Paper 1270.

[b] USGS. 1988a. Element Concentrations in Soils and Other Surficial Materials of Alaska. Authors: Gough, L., R. Severson, and H. Shacklett USGS Professional Paper 1458.

[c] Mueller, K. 1994. Water, sediment, and tissue baseline metal data from four National Wildlife Refuges in Alaska, Presentation at Society of Environmental Toxicology & Chemistry, Denver, CO.

[d] USATHAMA. 1990. Eagle River Flats Expanded Site Investigation, Fort Richardson, Alaska, Final Technical Report, Data Item A011; Sediment Values from Control Locations.

[e] USGS. 1988b. Analytical Results, Statistical Results, and Sample-locality Maps of Rocks from the Anchorage Quadrangle, Southern Alask Authors: Madden, D., B. Arbogast, R. O'Leary, G. Van Trump and M. Silberman. USGS Open-File Report 88-240.

TABLE 6-5
COEC SELECTION FOR SOILS FROM INVESTIGATIVE UNIT A-3, A-4, AND T FORT RICHARDSON PRDA

Criteria 1	Criteria 2[a]				Criteria 3[b]		Criteria 5[c]		
Chemicals Detected In At Least One Sample	Number of Samples	Frequency of Detects (%)	Detected In Other Media?	Retained	Site Exceeds Background Concentration?	Retained	Site Exceeds Literature Background Concentrations [d]	Retained	Retained as COEC
Chloroform	46	6.5	--	Yes	--	Yes	--	Yes	Yes
cis-1,2-Dichloroethene	46	4.3	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
trans-1,2-Dichloroethene	46	4.3	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
1,1,2,2-Tetrachloroethane	46	17.4	--	Yes	--	Yes	--	Yes	Yes
Tetrachloroethene	46	2.2	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
1,1,2-Trichloroethane	46	4.3	Sf, Sb, GW	Yes	--	Yes	--	Yes	Yes
Trichloroethene	46	10.9	--	Yes	--	Yes	--	Yes	Yes
Antimony	6	100	--	Yes	No	No	--	No	No
Arsenic	6	100	--	Yes	No	No	--	No	No
Beryllium	6	33.3	--	Yes	No	No	--	No	No
Chromium	6	100	--	Yes	No	No	--	No	No
Copper	6	100	--	Yes	No	No	--	No	No
Lead	6	100	--	Yes	Yes	Yes	No	No	No
Mercury	6	16.7	--	Yes	Yes	Yes	No	No	No
Nickel	6	100	--	Yes	No	No	--	No	No
Silver	6	50	--	Yes	No	No	--	No	No
Zinc	6	100	--	Yes	No	No	--	No	No

Sf: surficial soil (depth ≤3 feet)
Sb: subsurface soil (depth >3feet)
GW: groundwater
--: Not screened because the chemical was not retained in a previous step or the criteria is not applicable for the chemical.

[a] Criteria 2, Bioaccumulation potential was not assessed because all analytes failed the first frequency of detection or number of media detected in exceeded one.

[a] See Section 4.3 for comparison of site concentrations with local background concentrations.

[c] Criteria 4, toxicity-based screening, is not part of the COC selection process for site soils

[d] See Table 6-4 for comparison of site concentrations with literature-based concentrations.

TABLE 6-6
COEC SELECTION FOR WETLAND SEDIMENTS
FORT RICHARDSON PRDA

Criteria 1	Criteria 2[a]			Criteria 3		Criteria 4				
Chemicals Detected In At Least One Sample	**Number of Samples**	**Frequency of Detects (%)**	**Retained**	**Site Exceeds Background?**	**Retained**	**Maximum Site Concentration (mg/kg)**	**Toxicity-based Screening Value (mg/kg)**	**Log Kow**	**Retained**	**Retained as COEC[d]**
1,3,5-Trinitrobenzene	4	100	Yes	--	Yes	0.76	0.02[b]	2.13[b]	Yes	Yes
2,4,6-Trinitrotoluene	4	25	Yes	--	Yes	0.48	0.52[c]	1.6	No	No
m-Nitrotoluene	4	25	Yes	--	Yes	3	NA	2.42	Yes	Yes
Arsenic	4	75	Yes	No	No	--	--	--	No	No
Chromium	4	100	Yes	No	No	--	--	--	No	No
Copper	4	100	Yes	No	No	--	--	--	No	No
Nickel	4	100	Yes	No	No	--	--	--	No	No
Zinc	4	100	Yes	No	No	--	--	--	No	No

NA: Not available

--: Not screened because the chemical was not retained in a previous step or the criteria is not applicable for the chemical.

[a] Criteria 2, Number of media detected in and bioaccumulation potential were not assessed because all analytes were detected in more than 5 percent of the samples.

[b] Talmage and Opresko 1995a

[c] Talmage and Opresko 1995b

[c] Criteria 5, Literature-based background comparisons were not made because metal concentrations in sediment were not retained in the local background screening step.

TABLE 6-7
COEC SELECTION FOR WETLAND SURFACE WATER
FORT RICHARDSON PRDA

Criteria 1	Criteria 2[a]			Criteria 3		Criteria 4			Criteria 5	
Chemicals Detected In At Least One Sample	Number of Samples	Frequency of Detects (%)	Retained	Site Exceeds Background Concentration ?	Retained	Maximum Site Concentration (mg/L)	Toxicity-based Screening Value (mg/L)	Retained	Site Exceeds Literature Background Concentration?[b]	Retained as COEC
Toluene	4	25	Yes	--	Yes	0.0045	0.175	No	--	No
1,3-Dinitrobenzene	4	50	Yes	--	Yes	0.0034	0.030	No	--	No
Copper	4	50	Yes	Yes	Yes	0.099	0.0118	Yes	No	No
Lead	4	100	Yes	Yes	Yes	0.0081	0.0032	Yes	No	No
Nickel	4	50	Yes	Yes	Yes	0.0019	0.158	Yes	No	No
Zinc	4	75	Yes	No	No	--	--	No	--	No

--: Not screened because the chemical was not retained in a previous step or the criteria is not applicable for the chemical.

[a] Criteria 2, Number of media detected in and bioaccumulation potential were not assessed because all analytes were detected in more than 5 percent of the samples.

[a] See Table 6-8 for comparison of site concentrations with literature-based Alaska soil background concentrations.

[c] U.S. EPA (1980a). LOEL LC_{50} (0.175 mg/L) adjusted using a safety factor of 0.01 to estimate a chonic toxicity screening value.

[d] Talmage and Opresko 1995c

[e] US EPA Ambient water quality criteria (see Table 6-2).

TABLE 6-8
COEC SELECTION FOR METALS IN SURFACE WATER (mg/L) COMPARISON WITH LITERATURE VALUES

			Literature Background			
			USATHAMA[a]			
	Surface Water Site Values		Eagle River Flats (surface water control locations)		USFWS (Mueller 1994)[b]	
	Mean	Range	Mean	Max	Mean Range	Range
Copper	0.0305	0.013-0.099	0.0331	0.0355	0.009 - 0.036	<0.001 - 0.8
Lead	0.0056	0.004-0.0081	0.0071	0.0076	0.027	<0.002 - 0.82

[a] USATHAMA. 1990. Eagle River Flats Expanded Site Investigation, Fort Richardson, Alaska, Final Technical Report, Data Item A011.

[b] Mueller. 1994. Water, sediment and tissue baseline data from four National Wildlife Refuges in Alaska. Presentation at SETAC, 1994, Denver, CO. U.S. Fish and Wildlife Service (USFWS).

TABLE 6-9
BENCHMARK TOXICITY VALUES FOR RECEPTORS
FORT RICHARDSON PRDA

Chemical	Effects Level (mg/kg-bw/d)	Endpoint	Adjustment Factor	Benchmark Dose (mg/kg-bw/day)	Test Organism	Reference
Small Mammals						
Chloroform	150	subchronic NOAEL	0.2	30[a]	Rats	Palmer et al. 1979
Dichloroethenes	452	subchronic NOAEL	0.2	90.4[a]	Mouse	Palmer et al. 1979
m-Nitrotoluene	330	LD50	0.01	3.3[a]	Mouse	Lewis 1992
1,1,2,2-Tetrachloroethane	30	LOAEL	0.1	3	Mouse	Lewis 1992
Tetrachloroethene	100	chronic NOAEL	1	100	Mouse	EPA 1994
Toluene	3	chronic LOAEL	0.2	0.6[a]	Rat	Kostas & Hotchin 1981
1,1,2-Trichloroethane	76	chronic LOAEL	0.2	15.2[a]	Mouse	Lewis 1992
Trichloroethene	100	subchronic LOAEL	0.2	20	Mouse	Opresko et al. 1994
1,3,5-Trinitrobenzene	0.2	subchronic NOAEL	0.2	0.8[a]	Rat	Reddy et al. 1994 in Talmage and Opresko 1995a

Chemical	Concentration (mg/kg)	Test Organism	Reference
Plants			
m-Nitrotoluene	7	Cucumbers and radish seedlings	Simini et al. 1995 in Talmage and Opresko 1995a
1,3,5-Trinitrobenzene	7	Cucumbers and radish seedlings	Simini et al. 1995 in Talmage and Opresko 1995a
Aquatic Invertebrates - Sediments			
m-Nitrotoluene	7.4[b]	Water flea	Burrows et al. 1989
1,3,5-Trinitrobenzene	8[c]	Water flea	van der Schalie 1983 cited in Talmage and Opresko 1995a

---

[a] A safety factor of 0.2 was applied to chronic LOAELs (Newell et al. 1987) to NOAELs (Newell et al. 1987); an adjustment factor of 0.1 was used to convert acute LOAELs to NOAELs (Newell et al. 1987); an adjustment factor of 0.01 was used to convert LD50 values to NOAELs. An adjustment factor of 0.2 was used to convert subchronic NOAELS to chronic NOAELs (Opresko et al. 1994).

[b] Lowest 96-hr LC$_{50}$ value for the an isomer of dinitrotoluene for the water flea converted to a sediment benchmark using the EqP method.

[c] A chronic threshold water benchmark for the invertebrate, *Daphnia magna* (water flea), converted to a sediment benchmark using the EqP method.

TABLE 6-10
COMPARISON OF PHYTOTOXICITY VALUES FOR NITRO SUBSTITUTED BENZENES AND TOLUENES

Chemical	Duration/Effect	Alga Species	Water Concentration mg/L	References
Benzene	48-hr LC_{50}	*Chlorella vulgaris* (alga)	525	Kauss and Hutchinson 1975 in USEPA 1980d
Toluene	24-hr EC_{50}	*Chlorella vulgaris* (alga)	245	Kauss and Hutchinson 1975 in USEPA 1980
Toluene	96-hr EC_{50}	*Selenastrum capricornutum* (alga)	>433	USEPA 1978 in USEPA 1980a
1,3-DNB	5-day NOEC	*Selenastrum capricornutum* (alga)	0.26	Van der Schalie 1983 in Talmage and Opresko 1995c
2,4,6-TNT	7-day NOEC	*Selenastrum capricornutum* (alga)	<1	Won et al. 1976 cited in Talmage and Opresko 1995b
1,3,5-TNB	5-day NOEC	*Selenastrum capricornutum* (alga)	<0.1	Bailey 1982 cited in Talmage and Opresko 1995a

TABLE 6-11
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene		1,1,2,2-tetrachloroethane		tetrachloroethene		toluene		trichloroethene	
95PRDA-O-261SL	MW-12	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-263SL	MW-13	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-063SL	SB-A2	0	2	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-110SL	SB-O1	0	2	Soil	Screen	WC 1995	ND	0.025		0.07	ND	0.025			ND	0.025
95PRDA-O-258SL	SB-O20	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-060SL	SB-A1	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-066SL	SB-A3	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-073SL	SB-A4	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-089SL	SB-A6	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-033SL	SB-B1	0	3	Soil	Screen	WC 1995	ND	0.025		0.47	ND	0.025			ND	0.025
95PRDA-B-036SL	SB-B2	0	3	Soil	Screen	WC 1995	ND	0.025		0.15	ND	0.025			ND	0.025
95PRDA-B-043SL	SB-B3	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-047SL	SB-B4	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-052SL	SB-B5	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-097SL	SB-B6	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-177SL	SB-O10	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-180SL	SB-O11	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-189SL	SB-O12	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-195SL	SB-O13	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-205SL	SB-O14	0	3	Soil	Screen	WC 1995	ND, J	0.025	J	0.179	ND, J	0.025			ND, J	0.025
95PRDA-O-226SL	SB-O16	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-234SL	SB-O17	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-248SL	SB-O19	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-116SL	SB-O2	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-122SL	SB-O3	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-132SL	SB-O4	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-147SL	SB-O6	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, R	0.025
95PRDA-O-155SL	SB-O7	0	3	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0024	ND	0.00055
95PRDA-O-233SL	SB-O8[a]	0	3	Soil	Screen	WC 1995	ND, R	0.025	J	0.07	ND, R	0.025			ND,R	0.025
95PRDA-O-171SL	SB-O9	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
90PRDA6	SB-6	0	7	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA7	SB-7	0	7	Soil	Lab	ESE 1991	ND	0.0015		0.02	ND	0.0004	ND	0.0004	ND	0.0015

TABLE 6-11
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene		1,1,2,2-tetrachloroethane		tetrachloroethene		toluene		trichloroethene	
90PRDA5	SB-5	0	7.5	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA10	SB-10	0	8	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA9	SB-9	0	8	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA4	SB-4	0	8.5	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA11	SB-11[a]	0	9	Soil	Lab	ESE 1991		0.01		0.2		0.001	ND	0.0004		0.02
95PRDA-B-104SL	SB-B7	1	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-141SL	SB-O5	1	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-262SL	MW-12	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-111SL	SB-O1	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-259SL	SB-O20	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-164SL	SB-O8	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-061SL	SB-A1	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-067SL	SB-A3	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-074SL	SB-A4	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-090SL	SB-A6	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-037SL	SB-B2	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-048SL	SB-B4	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-053SL	SB-B5[a]	3	6	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055
95PRDA-B-098SL	SB-B6	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-105SL	SB-B7	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-178SL	SB-O10	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-181SL	SB-O11	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-190SL	SB-O12	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-196SL	SB-O13	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-206SL	SB-O14	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-242SL	SB-O18	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-117SL	SB-O2	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-123SL	SB-O3	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-133SL	SB-O4[a]	3	6	Soil	Lab	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055
95PRDA-O-142SL	SB-O5	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-156SL	SB-O7	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-172SL	SB-O9	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025

TABLE 6-11
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene	1,1,2,2-tetrachloroethane	tetrachloroethene	toluene	trichloroethene
N[b]							63	64	63	10	63
Mean[b]							0.021	0.037	0.021	0.00063	0.022
Stdev[b]							0.0085	0.0651	0.0090	0.00063	0.0084
$t_{(1-a,n-1)}$							1.670	1.670	1.670	1.833	1.670
Maximum Detected Value							0.01	0.47	0.001	0.0024	0.020
95% UCL[b]							0.023	0.051	0.023	0.00099	0.023
RME[b]							0.01	0.051	0.001	0.00099	0.02
Basis							Max	UCL	Max	UCL	Max

Samples not included because results were all nondetect with an R (rejected data) qualifier: 95PRDA-0-214SL (SB-015, 0-3 feet), 0-241SL (SB-018, 0-3 feet), 0-264SL (MW-13, 3-5 feet), 0-214SL (SB-015, 3-6 feet), 0-227SL (SB-016, 3-6 feet), 0-235SL (SB-017, 3-6 feet) and 0-249SL (SB-019, 3-6 feet).

[a] Highest detected value or lowest detection limit, as appropriate, of triplicate sample results.

[b] R (rejected) qualified data are not included in calculations.

ND - Not detected. The value given is one-half the detection limit.

☐ Detected result.

TABLE 6-12
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T
FORT RICHARDSON PRDA

Sample	Sample	Depth	Depth		Sample	Sample	Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		1,1,2-Trichloroethane		Trichloroethene	
95PRDA-O-265SL	MW-14	0	2	Soil	Screen	WC 1995	ND, J	0.00055	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-C-009SL	SB-C1[a]	0	2	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0018	ND	0.00055	ND	0.00055		0.0014
95PRDA-C-013SL	SB-C2[a]	0	2	Soil	Lab	WC 1995	J	0.16	J	0.008	J	0.0039		1.49	J	0.011	ND,J	0.00055	J	0.15
95PRDA-C-017SL	SB-C3[a]	0	2	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0045	ND	0.00055	ND	0.00055		0.0082
95PRDA-D-001SL	SB-D1[a]	0	2	Soil	Lab	WC 1995	ND	0.00275		0.026		0.011	D4	8.1		0.056		0.0099		0.73
95PRDA-D-005SL	SB-D2[a]	0	2	Soil	Lab	WC 1995		0.0078	ND	0.00205	ND	0.00205		1.58	ND	0.00205	ND	0.00205		0.16
95PRDA-T-021SL	SB-T1[a]	0	2	Soil	Lab	WC 1995		0.013	ND	0.0007	ND	0.0007	ND	0.0007	ND	0.0007	ND	0.0007	ND	0.0007
95PRDA-T-029SL	SB-T2	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-T-031SL	SB-T3	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
South of A-3	SC-137	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-139	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-141	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-143	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-145	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-205	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-207	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-209	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-211	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5		21	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-213	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5		6	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-273	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-275	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-277	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-279	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-281	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-341	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-343	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-409	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-411	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-413	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-415	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-417	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5

TABLE 6-12
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T
FORT RICHARDSON PRDA

Sample	Sample	Depth	Depth		Sample	Sample	Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		1,1,2-Trichloroethane		Trichloroethene	
South of A-3	SC-477	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-479	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-481	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-483	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-485	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5		6	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-552	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-553	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-554	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-555	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-557	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-558	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-559	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-71	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-73	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
95PRDA-T-024SL	SB-T1	2	4	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
N								46		46		46		46		46		46		46
Mean								1.96		1.96		1.96		2.76		1.96		1.96		1.98
Stdev								1.03		1.04		1.04		3.13		1.04		1.04		1.00
Variance																				
$t_{(1-a,n-1)}$								1.680		1.680		1.680		1.680		1.680		1.680		1.680
Maximum Detected Value								0.16		0.026		0.011		21		0.056		0.0099		0.73
95% UCL								2.22		2.22		2.22		3.53		2.22		2.22		2.23
RME								0.16		0.026		0.011		3.53		0.056		0.01		0.73
Basis								Max		Max		Max		UCL		Max		Max		Max

☐ Detected result.

TABLE 6-13
SUMMARY OF SEDIMENT ANALYTICAL RESULTS (mg/kg)
WETLAND AREA
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	1,3,5-trinitrobenzene	m-nitrotoluene	
95PRDA-W-331SD[(a)]	SED-1	1995	0.760	ND	0.125
95PRDA-W-337SD	SED-2	1995	0.740		3.0
95PRDA-W-339SD	SED-3	1995	0.530	ND	0.125
95PRDA-W-341SD	SED-4	1995	0.650	ND	0.125

	1,3,5-trinitrobenzene	m-nitrotoluene
N	4	4
Mean	0.670	0.844
Stdev	0.105	1.438
$t_{(1\text{-}a,n\text{-}1)}$	2.353	2.353
Maximum Detected Value (mg/kg)	0.760	3.0
95% UCL (mg/kg)	0.793	2.535
RME (mg/kg)	0.760	2.535
Basis	Max	UCL

(a) Value shown is the highest detected value or the lowest detection limit of the sample and its field duplicate.

ND - Not detected. Values shown are half the detection limit.

TABLE 6-14
ECOTOX INDEX CALCULATION FOR THE RED-BACKED VOLE IN FOOD (VEGETATION) AND SOILS (A-1, A-2, O)
FORT RICHARDSON PRDA
(Based on Maximum Soil Concentrations)

References	Food	trans-1,2-DCE	1,1,2,2-TCA	Tetrachloro ethene	Toluene	Trichloro ethene
Banfield 1974	Body Weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	% Vegetation in diet	100	100	100	100	100
	Vegetation intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	BAF (soil to vegetation)	1	1	1	1	1
	Concentration in vegetation (mg/kg)	0.01	0.47	0.001	0.0024	0.02
	Dose (mg/kg-bw/d)	1.40E-03	6.59E-02	1.40E-04	3.36E-04	2.80E-03
	Benchmark Value (mg/kg-bw/d)	90.4	3	100	0.6	20
	Ecotox Quotient	1.55E-05	2.20E-02	1.40E-06	5.61E-04	1.40E-04
	Soil					
Banfield 1974	Body weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/day)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	Soil in Diet (% of Food Intake)	5	5	5	5	5
	Soil Intake (kg/day)	0.0002	0.0002	0.0002	0.0002	0.0002
	Concentration in Soil (mg/kg)	0.01	0.47	0.001	0.0024	0.02
	Dose (mg/kg-bw/d)	9.13242E-05	4.29E-03	9.132E-06	2.1918E-05	1.83E-04
	Benchmark Value (mg/kg-bw/d)	90.4	3	100	0.6	20
	Ecotox Quotient	1.01E-06	1.43E-03	9.13E-08	3.65E-05	9.13E-06
	Ecotox Index	1.65E-05	2.34E-02	1.49E-06	5.97E-04	1.49E-04
	Total Ecotox Index					0.02

TABLE 6-15
ECOTOX INDEX CALCULATION FOR THE RED-BACKED VOLE IN FOOD (VEGETATION) AND SOILS (A-1, A-2, O)
FORT RICHARDSON PRDA
(Based on RME Soil Concentrations)

References	**Food**	trans-1,2-dichloro-ethene	1,1,2,2-Trichloro-ethane	Tetrachloro ethene	Toluene	Trichloro ethene
Banfield 1974	Body Weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	% Vegetation in diet	100	100	100	100	100
	Vegetation intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	BAF (soil to vegetation)	1	1	1	1	1
	Concentration in vegetation (mg/kg)	0.01	0.051	0.001	0.00099	0.02
	Dose (mg/kg-bw/d)	1.40E-03	7.15E-03	1.40E-04	1.39E-04	2.80E-03
	Benchmark Value (mg/kg-bw/d)	90.4	3	100	0.6	20
	Ecotox Quotient	1.55E-05	2.38E-03	1.40E-06	2.31E-04	1.40E-04
	Soil					
Banfield 1974	Body weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/day)	0.00307	0.00307	0.00307	0.00307	0.00307
see text	Soil in Diet (% of Food Intake)	5	5	5	5	5
	Soil Intake (kg/day)	0.0002	0.0002	0.0002	0.0002	0.0002
	Concentration in Soil (mg/kg)	0.01	0.051	0.001	0.00099	0.02
	Dose (mg/kg-bw/d)	9.13E-05	4.66E-04	9.13E-06	9.04E-06	1.83E-04
	Benchmark Value (mg/kg-bw/d)	90.4	3	100	0.6	20
	Ecotox Quotient	1.01E-06	1.55E-04	9.13E-08	1.51E-05	9.13E-06
	Ecotox Index	1.65E-05	2.54E-03	1.49E-06	2.46E-04	1.49E-04
	Total Ecotox Index					0.003

TABLE 6-16
ECOTOX INDEX CALCULATION FOR THE RED-BACKED VOLE IN FOOD (VEGETATION) AND SOILS (A-3, A-4, T)
FORT RICHARDSON PRDA
(Based on Maximum Soil Concentrations)

References	Food	Chloroform	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,1,2,2-Tetrachloro ethane	Tetrachloro ethene	1,1,2-Trichlor ethane	Trichloro ethene
Banfield 1974	Body Weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	% Vegetation in diet	100	100	100	100	100	100	100
	Vegetation intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	BAF (soil to vegetation)	1	1	1	1	1	1	1
	Concentration in vegetation (mg/kg)	0.16	0.026	0.011	21	0.056	0.0099	0.73
	Dose (mg/kg-bw/d)	2.24E-02	3.64E-03	1.54E-03	2.94E+00	7.85E-03	1.39E-03	1.02E-01
	Benchmark Value (mg/kg-bw/d)	30	90.4	90.4	3	100	15.2	20
	Ecotox Quotient	7.48E-04	4.03E-05	1.71E-05	9.81E-01	7.85E-05	9.13E-05	5.12E-03
	Soil							
Banfield 1974	Body weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/day)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	Soil in Diet (% of Food Intake)	5	5	5	5	5	5	5
	Soil Intake (kg/day)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	Concentration in Soil (mg/kg)	0.16	0.026	0.011	21	0.056	0.0099	0.73
	Dose (mg/kg-bw/d)	1.46E-03	2.37E-04	1.00E-04	1.92E-01	5.11E-04	9.04E-05	6.67E-03
	Benchmark Value (mg/kg-bw/d)	30	90.4	90.4	3	100	15.2	20
	Ecotox Quotient	4.87E-05	2.63E-06	1.11E-06	6.39E-02	5.11E-06	5.95E-06	3.33E-04
	Ecotox Index	7.96E-04	4.29E-05	1.82E-05	1.05E+00	8.36E-05	9.73E-05	5.45E-03
	Total Ecotox Index							1.05

TABLE 6-17
ECOTOX INDEX CALCULATION FOR THE RED-BACKED VOLE IN FOOD (VEGETATION) AND SOILS (A-3, A-4, T)
FORT RICHARDSON PRDA
(Based on RME Soil Concentrations)

References	Food	Chloroform	cis-1,2-Dichloro ethene	trans-1,2-Dichloro ethene	1,1,2,2-Tetrachloro ethane	Tetrachloro ethene	1,1,2-Trichloro ethane	Trichloro ethene
Banfield 1974	Body Weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	% Vegetation in diet	100	100	100	100	100	100	100
	Vegetation intake (kg/d)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	BAF (soil to vegetation)	1	1	1	1	1	1	1
	Concentration in vegetation (mg/kg)	0.16	0.026	0.011	3.531	0.056	0.0099	0.73
	Dose (mg/kg-bw/d)	2.24E-02	3.64E-03	1.54E-03	4.95E-01	7.85E-03	1.39E-03	1.02E-01
	Benchmark Value (mg/kg-bw/d)	30	90.4	90.4	3	100	15.2	20
	Ecotox Quotient	7.48E-04	4.03E-05	1.71E-05	1.65E-01	7.85E-05	9.13E-05	5.12E-03
	Soil							
Banfield 1974	Body weight (kg)	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219
	Food Intake (kg/day)	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307	0.00307
see text	Soil in Diet (% of Food Intake)	5	5	5	5	5	5	5
	Soil Intake (kg/day)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	Concentration in Soil (mg/kg)	0.16	0.026	0.011	3.531	0.056	0.0099	0.73
	Dose (mg/kg-bw/d)	1.46E-03	2.37E-04	1.00E-04	3.22E-02	5.11E-04	9.04E-05	6.67E-03
	Benchmark Value (mg/kg-bw/d)	30	90.4	90.4	3	100	15.2	20
	Ecotox Quotient	4.87E-05	2.63E-06	1.11E-06	1.07E-02	5.11E-06	5.95E-06	3.33E-04
	Ecotox Index	7.96E-04	4.29E-05	1.82E-05	1.76E-01	8.36E-05	9.73E-05	5.45E-03
	Total Ecotox Index							0.18

TABLE 6-18
ECOTOX INDEX CALCULATION FOR THE MUSKRAT IN FOOD (VEGETATION) AND SEDIMENT (WETLAND AREA)
FORT RICHARDSON PRDA
(Based on Maximum Soil Concentrations)

References	Food	1,3,5-Trinitrobenzene	m-Nitrotoluene
EPA 1993	Body Weight (kg)	1.5	1.5
	Food Intake (kg/d)	0.45	0.45
see text	% Vegetation in diet	100	100
	Vegetation Intake (kg/d)	0.45	0.45
see text	BAF (soil to vegetation)	1	1
	Concentration in vegetation (mg/kg)	0.76	3
	Dose (mg/kg-bw/d)	2.28E-01	9.00E-01
	Benchmark Value (mg/kg-bw/d)	0.8	3.3
	Ecotox Quotient	2.85E-01	2.73E-01
	Soil		
EPA 1993	Body weight (kg)	1.5	1.5
	Food Intake (kg/day)	0.45	0.45
see text	Soil in Diet (% of Food Intake)	5	5
	Soil Intake (kg/day)	0.0225	0.0225
	Concentration in sediment (mg/kg)	0.76	3
	Dose (mg/kg-bw/d)	1.14E-02	4.50E-02
	Benchmark Value (mg/kg-bw/d)	0.8	3.3
	Ecotox Quotient	1.43E-02	1.36E-02
	Ecotox Index	2.99E-01	2.86E-01
	Total Ecotox Index		0.59

TABLE 6-19
ECOTOX INDEX CALCULATION FOR THE MUSKRAT IN FOOD (VEGETATION) AND SEDIMENT (WETLAND AREA)
FORT RICHARDSON PRDA
(Based on RME Soil Concentrations)

References	Food	1,3,5-Trinitrobenzene	m-Nitrotoluene
EPA 1993	Body Weight (kg)	1.5	1.5
	Food Intake (kg/d)	0.45	0.45
see text	% Vegetation in diet	100	100
	Vegetation Intake (kg/d)	0.45	0.45
see text	BAF (soil to vegetation)	1	1
	Concentration in vegetation (mg/kg)	0.76	2.535
	Dose (mg/kg-bw/d)	2.28E-01	7.61E-01
	Benchmark Value (mg/kg-bw/d)	0.8	3.3
	Ecotox Quotient	2.85E-01	2.30E-01
	Soil		
EPA 1993	Body weight (kg)	1.5	1.5
EPA 1993	Food Intake (% of Body Weight)	30	30
	Food Intake (kg/day)	0.45	0.45
see text	Soil in Diet (% of Food Intake)	5	5
	Soil Intake (kg/day)	0.0225	0.0225
	Concentration in sediment (mg/kg)	0.76	2.535
	Dose (mg/kg-bw/d)	1.14E-02	3.80E-02
	Benchmark Value (mg/kg-bw/d)	0.8	3.3
	Ecotox Quotient	1.43E-02	1.15E-02
	Ecotox Index	2.99E-01	2.42E-01
	Total Ecotox Index		0.54

TABLE 6-20
ECOTOX INDEX CALCULATION FOR EMERGENT VEGETATION
FORT RICHARDSON PRDA
(Based on Maximum Sediment Concentrations)

References **Sediment**	1,3,5-Trinitrobenzene	m-Nitrotoluene
Concentration (mg/kg)	0.76	3
Benchmark Value (mg/kg-bw/d)	7	7
Ecotox Quotient	1.09E-01	4.29E-01
Ecotox Index		0.5

TABLE 6-21
ECOTOX INDEX CALCULATION FOR AQUATIC INVERTEBRATES IN SEDIMENT
Fort Richardson PRDA
(Based on Maximum Sediment Concentration)

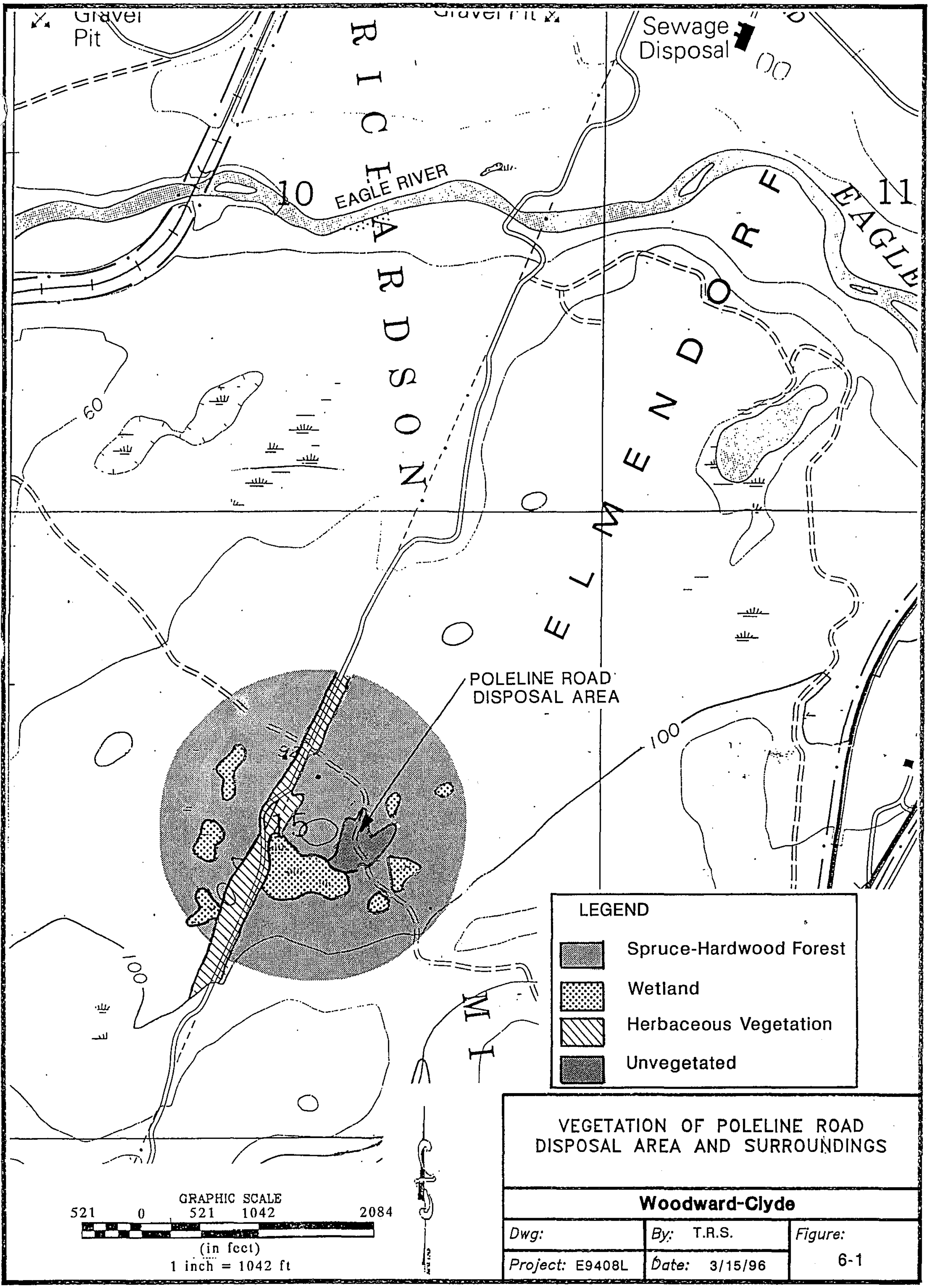
References **Sediment**	1,3,5-Trinitrobenzene	m-Nitrotoluene
Concentration (mg/kg)	0.76	3
Benchmark Value (mg/kg-bw/d)	8	7.4
Ecotox Quotient	9.50E-02	4.05E-01
Ecotox Index		0.5

TABLE 6-22
SUMMARY OF UNCERTAINTIES ASSOCIATED WITH THE ECOLOGICAL RISK ASSESSMENT FOR THE PRDA OUB SITE

Assumption	Estimated Magnitude of Effect on Risk	Direction of Effect on Risk Estimate
Data		
Inclusion of high detection limits for the organics from the historic and screening level samples provides an estimate of the exposure concentration for soil.	Low-Moderate	May overestimate risk
Inclusion of soil composite samples which include both surficial and subsurface stratum, provides an estimate of the exposure concentration for surficial soils.	Moderate-High	May overestimate risk
Problem Formulation		
Assumed a water hardness of 100 mg/L $CaCo_3$ for the water quality criteria for metals.	Low-high	May over or underestimate risk
Appropriate wildlife receptors were selected.	Low	May underestimate risk
Toxicity-based screening criteria are protective of a broad spectrum of receptors.	Moderate-High	May overestimate risk
Background data screening process is representative of background for the site.	Low-High	May overestimate risk
Literature background screening values are representative of regional background.	Low	May underestimate risk
Single, elevated anomalous values for mercury (A-3, A-4, T) and copper (wetland surface water are not included in the risk analysis).	Low	May underestimate risk
Exposure Assessment		
Assumed that groundwater migrates to the Eagle River.	Low	May overestimate risk
Soil samples which include soil from subsurface depths are representative of surface soils.	Moderate-High	May overestimate risk

TABLE 6-22
SUMMARY OF UNCERTAINTIES ASSOCIATED WITH THE ECOLOGICAL RISK ASSESSMENT FOR THE PRDA OUB SITE

Assumption	Estimated Magnitude of Effect on Risk	Direction of Effect on Risk Estimate
The VOCs 1,1,2,2-trichloroethane, trichloroethene, and 1,1,2-trichloroethane are the only groundwater COECs, if groundwater from the site migrates to the Eagle River.	Low	May underestimate risk
Groundwater model assumes a constant source supply from the site.	Moderate-High	May overestimate risk
Groundwater exposure pathway for ecological receptors is incomplete or negligible.	Low	May underestimate risk
Sediment ingestion rate for muskrat.	Low-Moderate	May over or underestimate risk
Assumed VOCs and explosive residues can bioaccumulate (BAF = 1) in plants.	Low-Moderate	May under or overestimate risk
Assumed 100 percent exposure duration and area usage.	Low-Moderate	May overestimate risk
Dermal and inhalation routes considered negligible relative to direct ingestion of soil and indirect ingestion from vegetation.	Low	May underestimate risk
Ecological Effects Assessment		
Selected benchmark values are protective against adverse effects to key receptor populations.	Moderate-High	May overestimate risk
Toxicity benchmark for 1,3,5-nitrotoluene may be substituted for m-nitrotoluene	Low	May under or overestimate risk
Risk Characterization		
Quotient Method assumes effects are additive.	Low to Moderate	May under or overestimate risk

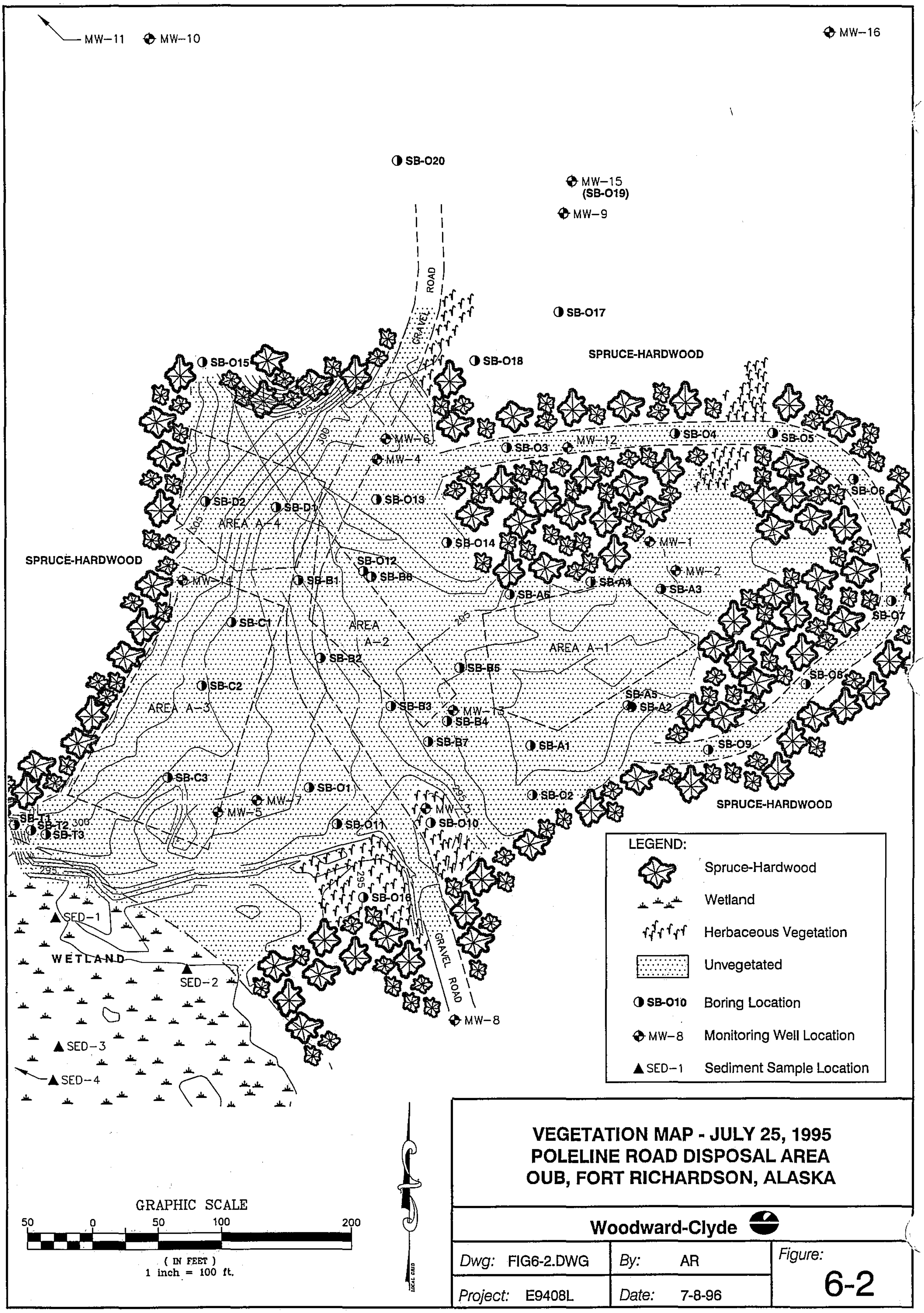


VEGETATION OF POLELINE ROAD DISPOSAL AREA AND SURROUNDINGS

Woodward-Clyde

Dwg:	By: T.R.S.	Figure:
Project: E9408L	Date: 3/15/96	6-1

E9408LTB

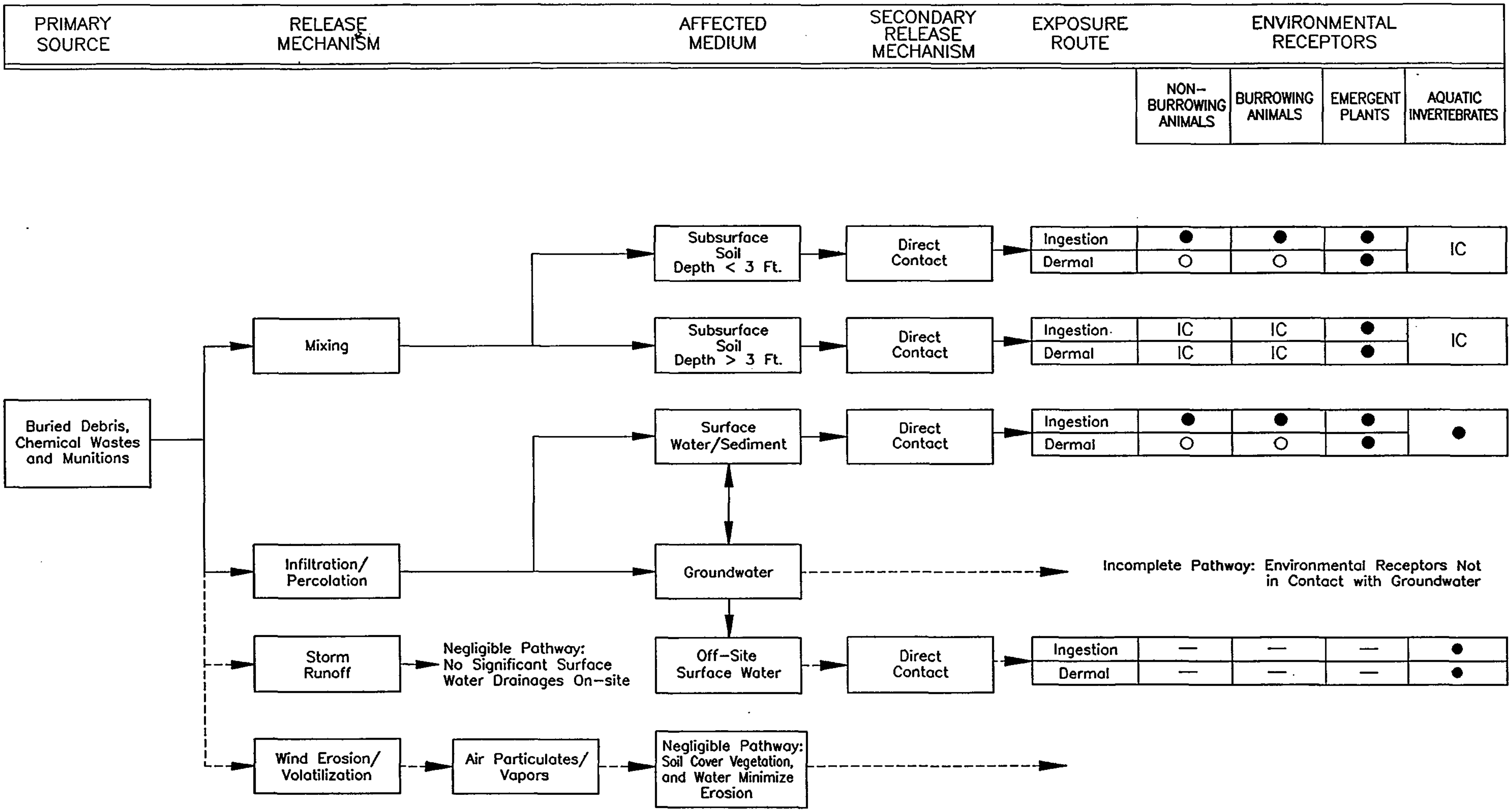


VEGETATION MAP - JULY 25, 1995
POLELINE ROAD DISPOSAL AREA
OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIG6-2.DWG	*By:* AR	*Figure:* 6-2
Project: E9408L	*Date:* 7-8-96	

Woodward-Clyde



Affected Medium	Exposure Route	NON-BURROWING ANIMALS	BURROWING ANIMALS	EMERGENT PLANTS	AQUATIC INVERTEBRATES
Subsurface Soil Depth < 3 Ft.	Ingestion	●	●	●	IC
	Dermal	○	○	●	
Subsurface Soil Depth > 3 Ft.	Ingestion	IC	IC	●	IC
	Dermal	IC	IC	●	
Surface Water/Sediment	Ingestion	●	●	●	●
	Dermal	○	○	●	
Off-Site Surface Water	Ingestion	—	—	—	●
	Dermal	—	—	—	●

LEGEND

- ● POTENTIALLY COMPLETE EXPOSURE ROUTE
- ○ MINOR EXPOSURE ROUTE
- IC INCOMPLETE PATHWAY
- ---- INCOMPLETE PATHWAY OR MINOR PATHWAY
- —— COMPLETE PATHWAY

Figure 6-3

Job No. : E9408L	FORT RICHARDSON OUB POLELINE ROAD DISPOSAL AREA CONCEPTUAL SITE MODEL ENVIRONMENTAL EXPOSURE PATHWAYS
Prepared by : P.A.W.	
Date : 3/15/96	

9408CSM5

7.0
CONCLUSIONS FOR THE HHRA AND ERA

A baseline human health risk assessment (HHRA) and an ecological risk assessment (ERA) were performed to evaluate potential adverse effects to human health and the environment associated with exposure to contaminants in soil, groundwater, and wetland surface water and sediments at PRDA, and in groundwater at the Eagle River.

Contamination at PRDA consists of (1) relatively low levels of VOCs in soil (at depths less than 15 feet) and wetland surface water, (2) low levels of explosives in groundwater and wetland surface water and sediment, and (3) high levels of VOCs in soil at depths > 15 feet (perched water table) and in groundwater. CWM was not detected in any sampled medium.

Metals at PRDA were either not identified as chemicals of concern based on background comparisons or did not pose a risk to human or ecological receptors.

7.1 HUMAN HEALTH RISK ASSESSMENT

A HHRA was performed to determine whether existing levels of contaminants in media at PRDA could pose a threat to human health under conservative (health-protective) exposure assumptions. The risk assessment is conservative because it is based on long-term residential or occupational exposures which are not likely at this site, thereby overestimating risk for site-specific exposure scenarios.

The relatively low levels of contaminants in soils from 0 to 15 feet bgs (the depth of potential direct human exposure) and wetland surface water and sediments at PRDA do not pose an unacceptable risk to public health under conservative exposure assumptions of long-term residential or industrial use. It therefore follows that exposure to contaminants in soil and the wetland at PRDA would not pose an unacceptable risk to current authorized personnel and/or other potential receptors such as recreational users or commercial workers, who would be expected to receive much less exposure than that assumed for residents in this assessment.

- No carcinogens were detected in surface water in the wetland. The low levels of VOCs, explosives, and metals in wetland surface water do not pose a threat of noncarcinogenic health effects. Trace levels of explosives in sediments in the wetland do not pose unacceptable risk of cancer or noncancer health effects.

- In exposure area A-1, A-2, O, risk of cancer and noncancer health effects from exposure to low levels of VOCs and metals in soil at depths of 0-15 feet were negligible.

- Lifetime excess cancer risk was 1E-05 (1 in 100,000) and noncarcinogenic hazard index was less than 1 for residential exposure to soil in area A-3, A-4, T at depths of 0-15 feet. The primary contributors to cancer risk were 1,1,2,2-tetrachloroethane and TCE (exposure point concentrations of 4.6 and 4.1 mg/kg, respectively) via the soil ingestion and soil-to-air inhalation route of exposure. Generally, remediation is not warranted for protection of public health if total lifetime excess cancer risk does not exceed 1E-04 and if noncarcinogenic effects are not a concern (HI < 1) (EPA 1991b).

- The highest concentrations of VOCs in soil were detected in exposure area A-3, A-4, T at depths greater than 15 feet bgs, below the depth of potential direct human exposure (e.g., 2,030 mg/kg 1,1,2,2-tetrachloroethane and 0.384 mg/kg TCE were detected at MW-14 at a depth of 16-18 feet). Higher concentrations were also detected in soil in the perched zone at about 14 feet bgs in the hillside at the southwest edge of Area A-3. Contaminants at this depth could serve as a continuing contaminant source to groundwater or to vapor migration.

Use of groundwater from the shallow zone or deep aquifer at PRDA as a drinking water source would pose an unacceptable risk of cancer and noncancer health effects. Groundwater at PRDA or downgradient from it is not currently used in any capacity nor is it expected to be used in the future. Groundwater fate and transport modeling indicates that contaminants in PRDA do not pose a threat to the Eagle River in the imminent or near future.

- Primary contributors to lifetime excess cancer risk in groundwater at PRDA were 1,1,2,2-tetrachloroethane and TCE (exposure point concentrations in the shallow zone of 16.9 and 6.3 mg/L, respectively). Concentrations of carbon tetrachloride, chloroform, cis-1,2-dichloroethene, 1,1-dichloroethene, tetrachloroethene, 1,1,2-trichloroethane also exceeded levels of concern (HI > 1 or cancer risks > 1E-04) for residential exposure to groundwater.

- The highest concentrations of VOCs in groundwater at PRDA were detected in the shallow, perched zone (e.g., 1900 mg/L 1,1,2,2-tetrachloroethane and 220 mg/L TCE were detected in MW-14 at a depth of 22 feet in the perched water zone). Although these contaminants do not pose a threat to human health (the perched zone would not be used as a water supply), they could serve as a continuing contaminant source to the shallow zone and deep aquifer.

Based on groundwater fate and transport modeling, it would take 120 years for detectable concentrations (0.005 mg/L) of TCE to reach the Eagle River and 170 years for detectable concentrations (0.005 mg/L) of 1,1,2,2-tetrachloroethane to reach the Eagle River. These 0.005 mg/L concentrations of 1,1,2,2-tetrachloroethane and TCE do not exceed health-based levels of concern for residential drinking water and for ingestion of fish by humans (0.011 mg/L for 1,1,2,2-tetrachloroethane and 0.081 mg/L for TCE).

Screening-level modeling of vapor migration from soil and groundwater and vapor intrusion into a building indicated that contaminant concentrations in deep soil and groundwater could pose an indoor inhalation hazard. Air or soil vapor measurements are recommended, however, prior to making remedial decisions based on the indoor air exposure route because of the highly conservative nature of the model.

In conclusion, contaminants in unsaturated soil (0 to 15 feet) and the wetlands at PRDA do not pose a threat to human health. Contaminants in deeper soil and in groundwater also do not pose a threat under current conditions. Contaminants in groundwater are not expected to reach the Eagle River (assuming no decay of source concentrations) for over 100 years. However, unacceptable risk would be associated with onsite residential use of the groundwater, and vapor migration from soil and groundwater could pose an indoor inhalation hazard, based on a screening level analysis.

7.2 ECOLOGICAL RISK ASSESSMENT

In the ERA, detected organic chemicals, explosives, and metals were screened against five criteria: frequency of detection; WC (1996) background data; toxicity based screening; and literature-based background values. The screen was done to assess which of the detected chemicals required further evaluation to assess potential risk to ecological receptors. The results of the screening process indicated that 7 VOCs in soil from 0 to 3 feet (the depth of potential direct exposure for ecological receptors) and 2 explosives in wetland sediment were COECs that required further evaluation of risk to ecological receptors (see Tables 6-3, 6-5, 6-6, and 6-7).

The northern red-backed vole and muskrat were selected as representative terrestrial site receptors for the upland and wetland habitats, respectively, based on site-specific exposure pathways and ecological considerations. The potential for adverse effects from COECs on upland and wetland plant communities and aquatic invertebrates were also evaluated. Benchmark toxicity values for the COECs were determined for each receptor. The Quotient Method (QM) was used to quantitatively evaluate potential risk from exposure to COECs in soil and sediment. The QM is based on the comparison of estimated maximum and RME dose concentrations for onsite receptors with protective benchmark toxicity values derived from the toxicological literature.

Based on the risk analysis, COEC concentrations at the PRDA result in negligible risk to small mammal populations, aquatic invertebrates, emergent wetland vegetation, and upland plant vegetation. The overall potential for valued environmental resources at this site to be adversely affected is considered negligible.

Based on groundwater fate and transport modeling, detectable concentrations (0.005 mg/L) of TCE and 1,1,2,2-tetrachloroethane would be estimated to reach the Eagle River in 120 and 170 years, respectively. These 0.005 mg/L concentrations of 1,1,2,2-tetrachloroethane and TCE are well below levels of concern for protection of aquatic organisms. These results indicate no imminent or near future threat to the Eagle River.

8.0
REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1992. Toxicological Profile for Tetrachloroethylene. U.S. Public Health Service. Atlanta, Georgia.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. Toxicological Profile for 1,1,2,2-Tetrachloroethane. U.S. Public Health Service. Atlanta, Georgia.

Alaska Department of Fish and Game (ADFG). 1978. Alaska's Wildlife and Habitat.

Alaska Department of Fish and Game (ADFG). 1989. Wildlife Notebook Series.

Alaska Department of Fish and Game (ADFG). 1985a. Alaska Habitat Management Guide Reference Maps. South-central Region. Vol. I. Distribution and Human Use of Mammals. State of Alaska, Department of Fish and Game, Division of Habitat. Juneau.

Alaska Department of Fish and Game (ADFG). 1985b. Alaska Habitat Management Guide Reference Maps. South-central Region. Vol. II. Distribution and Human Use of Birds and Fish. State of Alaska, Department of Fish and Game, Division of Habitat. Juneau.

Alaska Department of Environmental Conservation (ADEC). 1990. Interim Guidance for Surface and Groundwater Cleanup Levels. September 26.

Alaska Department of Environmental Conservation (ADEC). 1995. Water Quality Standards. 18AAC70. As amended through January 4, 1995.

Alaska Department of Natural Resources (ADNR). 1992. Water Supply Aquifers at Eagle River, Alaska. Professional Report 108. Division of Geological and Geophysical Surveys. Winter.

Alloway, B. 1990. Heavy Metals in Soils. John Wiley & Sons. New York, NY. 339 p.

American Conference of Government Industrial Hygienists (ACGIH). 1995. 1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. ACGIH. Cincinnati, OH.

American Society for Testing and Materials (ASTM). 1995. Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. ES 38-94.

Arbogast, B. D. Madden, J.D. Hoffman, and R.M. O'Leary. 1987. Analytical Results and Sample Locality Map of Stream-Sediment, Moraine-Sediment, and Heavy-Mineral-Concentrate Samples from the Anchorage Quadrangle, South-Central Alaska: USGS Open File Report 87-151.

Aughey, E. Grant, L., Furman, G.L. and Dryden, W.F. 1977. The effects of oral zinc supplementation in the mouse. J. Comp. Pathol. 87-1-14. *Cited In:* U.S. EPA 1995d.

Bailey, H.C. 1982. *Toxicity of TNT Wastewater to Aquatic Organisms.* Monthly Progress Report No. 80. SRI International, Menlo Park, CA. (Cited in van der Schalie, 1983).

Banfield, A. W. F. 1974. The Mammals of Canada. University of Toronto Press, Toronto.

Barnthouse, L.W. and G.W. Suter (eds.). 1986. User's Manual for Ecological Risk Assessment. Environmental Sciences Division, Public No. 2679. Prepared for Office of Research and Development. *Cited in:* U.S. EPA 1988.

Beyer, W.N. and C. Stafford. 1993. Survey and Evaluation of Contaminants in Earthworms and in Soils Derived from Dredged Material at Confined Disposal Facilities in the Great Lakes Region. Environmental Monitoring and Assessment 24: 151-165.

Burrows, E.P., D.H. Rosenblatt, W.R. Mitchell, and D.L. Palmer. 1989. Organic explosives and related compounds: Environmental and health considerations. U.S. Army Medical Bioengineering. Research and Development Laboratory, Ft. Detrick, Frederick, MD. Technical Report 8901 (draft).

Burt, W. H. and R. P. Grossenheider. 1976. A Field Guide to the Mammals. Third Edition. Houghton Mifflin Company, Boston.

Cataldo, D.A., S.D. Harvey, R.J. Fellows, R.M. Bean, and B.D. McVeety. 1989. An Evaluation of the Environmental Fate and Behavior of Munitions Material (TNT, RDX) in Soil and Plant Systems. Environmental Fate and Behavior of TNT. Final Report. U.S. Army Medical Research and Development Command Fort Detrick, Frederick, MD. Project Order No. 8853.

Demayo, Adrian, Margaret Taylor, and Kenneth Taylor. 1982. Effects of Copper on Humans, Laboratory and Farm Animals, Terrestrial Plants, and Aquatic Life. In: Critical Reviews in Environmental Control. Vol. 12, Issue 3. pp. 183-253.

Environmental Science & Engineering, Inc. (ESE). 1990. Surface Geophysical Investigation. U.S. Army Ft. Richardson Facility, Anchorage, Alaska. August 24.

Environmental Science & Engineering, Inc. (ESE). 1991. Expanded Site Investigation Report, Poleline Road Disposal Area. Final. Fort Richardson, Alaska. February.

Environmental Science & Engineering, Inc. (ESE). 1992. Soil Gas Results and Total Volatile Organic Compound Concentration Contours. Poleline Road Disposal Area, Fort Richardson, Alaska.

Environmental Science & Engineering, Inc. (ESE). 1993. PRDA Water Level Study. U.S. Army Ft. Richardson Facility, Anchorage, Alaska. April.

Forstner, U. and G.T. Whittman. 1983. Metal Pollution in the Aquatic Environment. Springer-Verlag, New York. 486 pp.

Furgo Northwest Inc. 1990.

Gardner, Major Kevin, personal communication. 1994. Fort Richardson Division of Public Works.

Gilbert, Richard O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. New York, NY.

Groundwater Services, Inc. (GSI). 1995. Guidance Manual for Risk-Based Corrective Action.

Hart, C.W. and S.L.H. Fuller (eds.). 1974. Pollution Ecology of Freshwater Invertebrates. Academic Press, New York, New York, 389 pp.

Hem, John D. 1989. Study and Interpretation of the Chemical Characteristics of Natural Water. USGS Water-Supply Paper 2254, 263 p.

Hulzebos, E.M., D.M. Adima, et al. 1993. Phytotoxicity Studies with Lactuca Sativa in Soil and Nutrient Solution. Environmental Toxicology and Chemistry. Vol. 12, pp. 1079-1091.

Kappleman, W.B. 1993. Pine Street Canal Ecological Assessment: A Case Study. In: Maughn, J.T., Ecological Assessment of Hazardous Waste Sites. Van Nostrand Reinhold, New York.

Kauss, P.B. and T.C. Hutchinson. 1975. The Effectives of Water-soluble Petroleum Components on the Growth of *Chlorella vulgaris* Beijerinck. Environ. Pollut. 9:157.

Kostas, J. and J. Hotchin. 1981. Behavioral Effects of Low-level Perinatal Exposure to Toluene in Mice. Neurobehav. Toxicol. Teratol. 3:467-469 in USDHHS 1992.

Lewis, R.J., Sr. 1992. Sax's Dangerous properties of Industrial Materials., Eighth Edition. von Nostrand Reinhold, New York.

Lyman, W.J. et al. 1982. handbook of Chemical Property Estimation Methods. McGraw-Hill. New York.

Maughan, J.T. 1993. Ecological Assessment of Hazardous Waste Sites. Van Nostrand Reinhold, New York. 352 p.

Montgomery, J.H. 1991. Groundwater Chemicals Desk Reference. Volume 11. Lewis Publishers, Inc., Chelsea, Michigan.

Montgomery, J.H. and L.M. Welkom. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers.

Moran, Ginny, personal communication, U.S. Fish and Wildlife Service. 1994. In: Woodward-Clyde (WC), 1995a, Remedial Investigation Management Plan, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska. Prepared for U.S. Army Corps of Engineers. Alaska District. July.

Mueller, K. 1994. *Water, Sediment, and Tissue Baseline Metal Data From Four National Wildlife Refuges in Alaska.* U.S. Fish and Wildlife Service. Presentation at Society of Environmental Toxicology and Chemistry, Denver, CO.

National Toxicology Program (NTP). 1990. National Toxicology Program technical report on the toxicology and carcinogenesis studies of toluene (CAS No. 108-88-3) in F344/N rats and 86C3F mice (inhalation studies). Research Triangle Par, NC: U.S. Environmental Protection Agency, Department of Health and Human Services. No. 371. PB90-256371 in USDHHS 1992.

Newell, A.J., D.W. Johnson, and L.K. Allen. 1987. Niagara River biota contamination project: fish flesh criteria for piscivorous wildlife. New York State Department of Environmental Conservation, Division of Fish and Wildlife, Bureau of Environmental Protection. Technical Report 87-3.

OHM Remediation Services (OHM). 1993. Sampling and Analysis Summary, Rapid Response Removal Action, Poleline Road Disposal Area, Fort Richardson, Alaska. December.

OHM Remediation Services (OHM). 1994a. Draft Final Report, Phase I & II, Poleline Road Disposal Area Project, Fort Richardson, Alaska. December.

OHM Remediation Services (OHM). 1994b. Well logs and chemical analytical results from groundwater sampling. July.

OHM Remediation Services (OHM). 1995a. Phase I, Sampling and Analysis Summary. Excavation of the Poleline Road Disposal Area Fort Richardson Army Installation, Anchorage, Alaska. USACE Contract No. DACW 45-89-D-0516.

OHM Remediation Services Corp. (OHM). 1995b. Phase II, Sampling and Analysis Report. Excavation of the Poleline Road Disposal Area Fort Richardson Army Installation, Anchorage, Alaska. USACE Contract No. DACW 645-94-D-0005.

Opresko, D.M., B.E. Sample, and G.W, Suter. 1994. Toxicological Benchmarks for Wildlife: Revision of 1991 edition. Oak Ridge National Laboratory, Oak Ridge Tennessee. ES/ER/TM-86/Rl.

Palmer, A.K., A.E. Street, F.J.C. Roe, A.N. Worden, and N.J. Van Abbe. 1979. Safety Evaluation of Toothpaste Containing Chloroform, U. Long Term Studies in Rats. J. Environ. Pathol. Toxicol. 2:821-833.

Reddy, T.V., F.B. Daniel, M. Robinson, et al. 1994. Subchronic Toxicity Studies on 1,3,5-Tritrobenzene, 1,3-Dinitrobenzene, and Tetryl in Rats: Subchronic Toxicity Evaluation of 1,3,5-Trinitrobenzene in Fischer 344 Rats. Prepared by Environmental Monitoring Systems Laboratory, U.S. EPA, for U.S. Army Medial Research, Development, Acquisition and Logistics Command (Provisional), Fort Detrick, MD.

Reed, Porter B., Jr. 1988. National List of Plant Species that Occur in Wetlands: National Summary. U.S. Fish and Wildlife Service, U.S. Department of the Interior. Biological Report 88(24).

Rose, A.W., H. Hawkes, and J.S. Webb. 1979. Geochemistry in Mineral Exploration. Academic Press, New York. 657 pp.

Silberling, N.J. and D. L. Jones. 1984. Lithotectonic Terrane Maps of the North American Cordillera: USGS Open File Report 84-523.

Simini, M., R.S. Wentsel, R.T. Checkai, et al. 1995. Evaluation of Soil Toxicity at Joliet Army Ammunition Plant. Environ. Toxicol. Chem. 14:623-630. *Cited In*: Talmage and Opresko 1995a.

State of Alaska, Department of Environmental Conservation. 1995. 18 AAC 70, Water Quality Standards. 18AAC 70.020(b) Toxic and Other Deleterious Organic and Inorganic Substances. Register 133, April 1995.

State of Alaska, Office of the Governor. 1974. Alaska Regional Profiles. Southcentral Region.

Stephen, C.E., D.I. Mount, D.J. Hansen, J.H. Gentile, G.A. Chapman, and W.A. Brungs. 1985. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. U.S. Environmental Protection Agency, Office of Research and Development. NTIS Report No. PB85-227049.

Talmage, S.S., and D.M. Opresko. 1995a. Ecological Criteria Document For 1,3,5-Trinitrobenzene (Cas No. 99-35-4). DRAFT. Chemical Hazard Evaluation Group, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Talmage, S.S., and D.M. Opresko. 1995b. Ecological Criteria Document For 2,4,6-Trinitrotoluene (Cas No. 118-96-7). DRAFT. Chemical Hazard Evaluation Group, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Talmage, S.S., and D.M. Opresko. 1995c. Ecological Criteria Document For 1,3-Dinitrobenzene (Cas No. 99-65-0). DRAFT. Chemical Hazard Evaluation Group, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U.S. Army Corps of Engineers (USACE). 1994a. Reconnaissance Ground-Penetrating Radar and Electromagnetic Induction Surveys of the Poleline Road Site. Draft Final. USACE Alaska District CRREL. Prepared by Daniel E. Lawson et al. May.

U.S. Army Corps of Engineers. 1994b. Finding of No Significant Impact and Environmental Assessment: Poleline Road Removal Action. Fort Richardson, Alaska. Alaska District, U.S. Army Corps of Engineers, June.

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1990. Eagle River Flats, Expanded Site Investigation. Ft. Richardson, Alaska, Final Technical Report, Data Item A011. Aberdeen Proving Ground, MD.

U.S. Department Health and Human Services (USDHH). 1992. Public Health Service, Agency for Toxic Substances and Disease Registry. Draft Toxicological Profile for Toluene.

U.S. Department of the Army (DOA)/U.S. Army Corps of Engineers (USACE). 1996. Aberdeen Proving Ground Snapping Turtle Contamination Survey Workplan and Aberdeen Proving Ground Snapping Turtle Contamination Survey. Appendix G in Risk Assessment Handbook: Volume II - Environmental Evaluation. Final. USACE Missouri River Division, H TRW CX, Omaha, Nebraska. EM-200-1-6.

U.S. Environmental Protection Agency (USEPA). 1978. In-depth Studies on Health and Environmental Impacts of Selected Water Pollutants. U.S. Environ. Prot. Agency, Contract No. 68-01-4646.

U.S. Environmental Protection Agency (USEPA). 1980a. Ambient Water Quality Criteria for Toluene. Office of Water Regulations and Standards, Washington, D.C. EPA 440/5-80-075.

U.S. Environmental Protection Agency (USEPA). 1980b. Ambient Water Quality Criteria for Chlorinated Ethanes. Office of Water Regulations and Standards, Washington, D.C. EPA-440/5/5-80-029.

U.S. Environmental Protection Agency (USEPA). 1980c. Ambient Water Quality Criteria for Trichloroethylene. Office of Water Regulations and Standards, Washington, D.C. PB81-117871.

U.S. Environmental Protection Agency (USEPA). 1980d. Ambient Water Quality Criteria for Benzene. Office of Water Regulations and Standards, Washington, D.C. EPA 440/5-80-018.

U.S. Environmental Protection Agency (USEPA). 1986. Hazard Evaluation Division, Standard Evaluation Procedure, Ecological Risk Assessment. Office of Pesticide Programs, Washington, DC. June. EPA-540/9-85-001.

U.S. Environmental Protection Agency (USEPA). 1989a. Risk Assessment Guidance for Superfund. Volume I - Human Health Evaluation Manual. Interim Final. OSWER 9285.7-01a.

U.S. Environmental Protection Agency (USEPA). 1989b. Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final. EPA/540/1-89-001.

U.S. Environmental Protection Agency (USEPA). 1989c. Ecological Assessment of Hazardous Waste Sites, A Field and Laboratory Manual. Office of Research and Development. EPA/600/3-89/013. March.

U.S. Environmental Protection Agency (USEPA). 1989d. Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document. Office of Research and Development. EPA/600/3-89/013. March.

U.S. Environmental Protection Agency (USEPA). 1989e. Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria. Office of Water, Office of Regulations and Standards, Washington, D.C.

U.S. Environmental Protection Agency (USEPA). 1991a. Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors." OSWER 9285.6-03. March.

U.S. Environmental Protection Agency (USEPA). 1991b. Water Quality Criteria Summary. Office of Science and Technology. U.S. EPA. Washington, D.C. May.

U.S. Environmental Protection Agency (USEPA). 1991c. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER 9355.0-30. April.

U.S. Environmental Protection Agency (USEPA). 1992a. Guidelines for Exposure Assessment. Office of Health and Environmental Assessment. Federal Register. Vol. 57, No. 104: 22888-22938.

U.S. Environmental Protection Agency (USEPA). 1992b. Framework for Ecological Risk Assessment. EPA/630/R-92/001.

U.S. Environmental Protection Agency (USEPA). 1992c. Guidance for Data Useability in Risk Assessment (Part A). Final. PB92-963356.

U.S. Environmental Protection Agency (USEPA). 1992d. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response. Publication 9285.7-081.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, Washington, D.C., 2 Volumes. EPA/600/R-93/187a. December.

U.S. Environmental Protection Agency (USEPA). 1994a. Soil Screening Guidance. Review Draft. OSWER 9355.4-14FS. December.

U.S. Environmental Protection Agency (USEPA). 1994b. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER Directive 9355.4-12. Office of Solid Waste and Emergency Response. U.S. EPA, Washington, D.C. July.

U.S. Environmental Protection Agency (USEPA). 1994c. Integrated Risk Information System (IRIS). On-line database. Tetrachloroethene.

U.S. Environmental Protection Agency (USEPA). 1994d. Region 10. Supplemental Guidance for Ecological Risk Assessments. Draft. September.

U.S. Environmental Protection Agency (USEPA). 1994e. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments; Review Draft. September.

U.S. Environmental Protection Agency (USEPA). 1995a. Drinking Water Regulations and Health Advisories. Office of Water. U.S. EPA, Washington, D.C. May.

U.S. Environmental Protection Agency (USEPA). 1995b. Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors. EPA-820-B-95-005. Office of Water, Washington, D.C.

U.S. Environmental Protection Agency Region 3 (USEPA Region 3). 1995. Risk-based Concentration Table, July - December 1995. Technical & Program Support Branch. Philadelphia, PA. October.

U.S. Environmental Protection Agency (USEPA). 1996. Integrated Risk Information System (IRIS). On-line database.

U.S. Environmental Protection Agency (USEPA). Undated. Carcinogenicity Characterization of Perchloroethylene (PERC) and Trichloroethylene (TCE) (Luke Air Force Base, Arizona). Memorandum from Joan Dollarhide, Superfund Health Risk Technical Support Center. Environmental Criteria and Assessment Office (ECAO). U.S. EPA. Cincinnati, OH.

U.S. Environmental Protection Agency Region 10 (EPA Region 10). 1991. Supplemental Risk Assessment Guidance for Superfund. August.

U.S. Geological Survey (USGS). 1964. Geology and Groundwater Resources of the Anchorage Area, Alaska. Geological Survey Water Supply Paper 1773.

U.S. Geological Survey (USGS). 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. Authors: H. Shacklette and J. Boerngen. USGS Professional Paper 1270.

U.S. Geological Survey (USGS). 1988a. Element Concentrations in Soils and Other Surficial Materials of Alaska. Authors: L. Gough, R. Severson, and H. Shacklette. USGS Professional Paper 1458.

U.S. Geological Survey (USGS). 1988b. Analytical Results, Statistical Results, and Sample-locality Maps of Rocks from the Anchorage Quadrangle, Southern Alaska. Authors: D. Madden, B. Arbogast, R. O'Leary, G. Van Trump, and M. Silberman. USGS Open File Report 88-240.

U.S. Geological Survey (USGS). 1991. Water Resources Data. Alaska. Water Year 1990. Water-Data Report AK-90-1.

van der Schalie. 1983. The Acute and Chronic Toxicity of 3,5-Dinitroaniline, 1,3-Dinitrobenzene, and 1,3,5-Trinitrobenzene to Freshwater Aquatic Organisms. AD A138408, U.S. Army Medical Bioengineering Research and Development Laboratory, Fort Detrick, Frederick, *MD. Cited in:* Talmage and Opresko 1995a.

Watkin, E.G. and M.E. Stelljes. 1993. A Proposed Approach to Quantitatively Assess Potential Ecological Impacts to Terrestrial Receptors from Chemical Exposure. In: Environmental Toxicology and Risk Assessment: 2nd volume, ASTM STP 1173, J.W. Gorsuch, F. Dwyer, C.G. Ingersoll, and T.W. Lapoint, Eds., American Society for Testing and Materials, Philadelphia, PA.

Wentsel, R., T. LaPoint, M. Simini, et al. 1994. Procedural Guidelines for Ecological Risk Assessments at U.S. Army Sites. Performed by U.S. Army Edgewood Research, Development Engineering Center (USA-ERDEC). Sponsored by U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground MD.

Winkler, G.R., M.L. Miller,. R.B. Hoekzena, and J.A. Dumoulin. 1984. Guide to the Bedrock Geology of a Transverse of the Chugach Mountains from Anchorage to Cape Resurrection. Geol. Soc. of Am. and Alaska Geol. Survey. Anchorage AK, 10p.

Won, W.D., L.H. DiSalvo, and J. Ng. 1976. Toxicity and Mutagenicity of 2,4,6-Trinitrotoluene and Its Microbial Metabolites. App. Environ. Microbiol. 31:576-580.

Woodward-Clyde (WC). 1995a. Remedial Investigation Management Plan, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska. Prepared for U.S. Army Corps of Engineers, Alaska District. July

Woodward-Clyde (WC). 1995b. Human Health Risk Assessment Approach Document, Operable Unit B, Fort Richardson, Alaska. December.

Woodward-Clyde (WC). 1995c. Screening-Level Baseline Ecological Risk Assessment Approach Document, Operable Unit B, Fort Richardson, Alaska. July.

Woodward-Clyde (WC). 1996. Remedial Investigation Report, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska. Prepared for U.S. Army Corps of Engineers. September.

APPENDIX A

CALCULATION OF CONCENTRATION TERMS FOR HUMAN HEALTH RISK ASSESSMENT

TABLE A-1
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		Toluene		Trichloroethene		Lead		Mercury	
90PRDA4	SB-4 (0-8.5')	ESE 1991	ND	0.00045	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015		12.3		0.074
90PRDA5	SB-5(0-7.5')	ESE 1991	ND	0.00045	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015		8.92		0.064
90PRDA6	SB-6(0-7')	ESE 1991	ND	0.00045	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015		9.02		0.083
90PRDA7	SB-7(0-7')	ESE 1991	ND	0.00045	ND	0.0015		0.02	ND	0.0004	ND	0.0004	ND	0.0015		9.52		0.065
90PRDA9	SB-9(0-8')	ESE 1991	ND	0.00045	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015		11.6		0.134
90PRDA10	SB-10(0-8')	ESE 1991	ND	0.00045	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015		8.87	ND	0.025
90PRDA11	SB-5(0-9')**	ESE 1991	ND	0.00045		0.01		0.2		0.001	ND	0.0004		0.02		12.8		0.065
95PRDA-B-045SL	SB-B3 (7-10')**	WC 1995	ND	0.0006	ND	0.0006	ND	0.0006	ND	0.0006	ND	0.0006	ND	0.0006		15		0.15
95PRDA-B-053SL	SB-B5 (3-6')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		6.5		0.2
95PRDA-A-064SL	SB-A2 (3.5-7')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		6.5		0.19
95PRDA-B-106SL	SB-B7 (6-9')**	WC 1995		0.0042	ND	0.0006	ND	0.0006	ND	0.0006	ND	0.0006	ND	0.0006	D1	9.3	ND	0.06
95PRDA-O-112SL	SB-O1 (6-8')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055		4.5		0.16
95PRDA-O-133SL	SB-O4 (3-6')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055		6.1	ND	0.055
95PRDA-O-155SL	SB-O7 (0-3')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		0.0024	ND	0.00055		6.6		0.17
95PRDA-O-165SL	SB-O8 (5-8')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	J	0.0014	ND,J	0.00055		8.5	ND	0.055
95PRDA-O-174SL	SB-O9 (9-12')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	J	0.0018	ND,J	0.00055		4.4		0.13
95PRDA-O-179SL	SB-O10 (6-9')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055		7.1		0.18
95PRDA-O-182SL	SB-O11 (6-9')**	WC 1995	ND,J	0.00055	ND,J	0.00055	J	0.11	ND,J	0.00055	ND,J	0.00055	J	0.0083		8.2		0.16
95PRDA-O-194SL	SB-O12 (15-18')**	WC 1995	ND,J	0.0005	ND,J	0.0005	ND,J	0.0005	ND,J	0.0005	ND,J	0.0005	J	0.0012		7.3		0.12
95PRDA-O-204SL	SB-O13 (12-15')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		8.6		0.21
95PRDA-O-218SL	SB-O15 (12-15')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		6.4		0.11
95PRDA-O-231SL	SB-O16 (15-18')**	WC 1995	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055	ND,J	0.00055		2.3	ND	0.055
95PRDA-O-267SL	SB-O20 (12-22.5')	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		4.4		0.13
95PRDA-O-301SL	MW-13 (10-12')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055		0.0036		2.9	ND	0.055
Field Screening Samples (WC 1995)																		
95PRDA-B-033SL	SB-B1 (0-3')	WC 1995	ND	0.025	ND	0.025		0.47	ND	0.025	-		ND	0.025		-		-
95PRDA-B-034SL	SB-B1 (4-6')	WC 1995	ND	0.025	ND	0.025		1.7	ND	0.025	-		ND	0.025		-		-
95PRDA-B-036SL	SB-B2 (0-3')	WC 1995	ND	0.025	ND	0.025		0.15	ND	0.025	-		ND	0.025		-		-
95PRDA-B-037SL	SB-B2 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-038SL	SB-B2 (7-10')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-039SL	SB-B2 (10-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-040SL	SB-B2 (14-17')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-043SL	SB-B3 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-044SL	SB-B3 (4-7')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-047SL	SB-B4 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-048SL	SB-B4 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-
95PRDA-B-049SL	SB-B4 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-		ND	0.025		-		-

TABLE A-1
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		Toluene	Trichloroethene		Lead	Mercury
95PRDA-B-052SL	SB-B5 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-056SL	SB-B5 (14-14.5')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-058SL	SB-B5 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-059SL	SB-B5 (9-10.5')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-A-060SL	SB-A1 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-061SL	SB-A1 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-063SL	SB-A2 (0-2')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-066SL	SB-A3 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-067SL	SB-A3 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-068SL	SB-A3 (8-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-069SL	SB-A3 (12-15')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-073SL	SB-A4 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-A-074SL	SB-A4 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-A-076SL	SB-A4 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-077SL	SB-A4 (9-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-078SL	SB-A4 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-A-079SL	SB-A4 (15-17')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-A-081SL	SB-A5(8-10')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-082SL	SB-A5 (12.5-13.5')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-083SL	SB-A5 (14-17')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-089SL	SB-A6 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-090SL	SB-A6 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-091SL	SB-A6 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-092SL	SB-A6 (9-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-093SL	SB-A6 (12-15')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-A-094SL	SB-A6 (15-18')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-097SL	SB-B6 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-098SL	SB-B6 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-099SL	SB-B6 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-100SL	SB-B6 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-B-101SL	SB-B6 (12-14')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-104SL	SB-B7 (1-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-B-105SL	SB-B7 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-B-107SL	SB-B7 (13-15')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-B-108SL	SB-B7 (15-17')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-110SL	SB-O1 (0-2')	WC 1995	ND	0.025	ND	0.025		0.07	ND	0.025	-	ND	0.025	-	-
95PRDA-O-111SL	SB-O1 (3-5')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-116SL	SB-O2 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-117SL	SB-O2 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-118SL	SB-O2 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-

TABLE A-1
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		Toluene	Trichloroethene		Lead	Mercury
95PRDA-O-119SL	SB-O2 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-120SL	SB-O2 (15-25')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-122SL	SB-O3 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-123SL	SB-O3 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-124SL	SB-O3 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-125SL	SB-O3 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-126SL	SB-O3 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-127SL	SB-O3 (15-18')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-132SL	SB-O4 (0-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-134SL	SB-O4 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-135SL	SB-O4 (9-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-136SL	SB-O4 (12-14.5')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-137SL	SB-O4 (15-18')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-141SL	SB-O5 (1-3')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-142SL	SB-O5 (3-6')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-143SL	SB-O5 (6-9')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-144SL	SB-O5 (10-13')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-145SL	SB-O5 (13-16')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-147SL	SB-O6 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-148SL	SB-O6 (4-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-149SL	SB-O6 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-150SL	SB-O6 (12-16')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-156SL	SB-O7 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-158SL	SB-O7 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-159SL	SB-O7 (12-14')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-164SL	SB-O8 (3-5')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-166SL	SB-O8 (8-11')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-167SL	SB-O8 (11-14')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-168SL	SB-O8 (14-17')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-171SL	SB-O9 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-172SL	SB-O9 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-173SL	SB-O9 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-177SL	SB-O10 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-178SL	SB-O10 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-180SL	SB-O11 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-181SL	SB-O11 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-183SL	SB-O11 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-184SL	SB-O11 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-185SL	SB-O11 (15-18')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-

TABLE A-1
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		Toluene	Trichloroethene		Lead	Mercury
95PRDA-O-189SL	SB-O12 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-190SL	SB-O12 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-191SL	SB-O12 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	J	0.72	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-192SL	SB-O12 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-193SL	SB-O12 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-195SL	SB-O13 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-196SL	SB-O13 (9-12')**	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-197SL	SB-O13 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-198SL	SB-O13 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-200SL	SB-O13 (15-18')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-205SL	SB-O14 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	J	0.179	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-206SL	SB-O14 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-207SL	SB-O14 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-208SL	SB-O14 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-209SL	SB-O14 (13.5-14.5)	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-216SL	SB-O15 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-219SL	SB-O15 (15-18')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-226SL	SB-O16 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-228SL	SB-O16 (6-9')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-233SL	SB-O8 (0-3')	WC 1995	D, R	0.025	ND, R	0.025	J	0.07	ND,R	0.025	-	ND, R	0.025	-	-
95PRDA-O-234SL	SB-O17 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-237SL	SB-O17 (9-11')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-242SL	SB-O18 (3-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-244SL	SB-O18 (9-12')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-245SL	SB-O18 (12-14')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-248SL	SB-O19 (0-3')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-251SL	SB-O19 (9-11')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-252SL	SB-O19 (12-15')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-254SL	SB-O19 (15-18')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-258SL	SB-O20 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-259SL	SB-O20 (3-5')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-261SL	MW-12 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-262SL	MW-12 (3-5')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-263SL	MW-13 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	-	ND, J	0.025	-	-
95PRDA-O-289SL	MW-12 (7-7.5')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-
95PRDA-O-290SL	MW-12 (11-13')	WC 1995	ND	0.025	ND	0.025	ND	0.025	ND	0.025	-	ND	0.025	-	-

TABLE A-1
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform	trans 1,2-Dichloroethene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	Toluene	Trichloroethene	Lead	Mercury
95PRDA-O-291SL	MW-12 (14-14.5')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-299SL	MW-13 (6-8')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-300SL	MW-13 (8-10')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-302SL	MW-13 (12-14')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-303SL	MW-13 (14-16')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-318SL	MW-16 (4-6')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	-
95PRDA-O-319SL	MW-16 (9-11')	WC 1995	ND 0.025	ND 0.025	0.56	ND 0.025	-	ND 0.025	-	-
95PRDA-O-320SL	MW-16 (14-16')	WC 1995	ND 0.025	ND 0.025	ND 0.025	ND 0.025	-	ND 0.025	-	
Number of Samples			158	158	159	158	24	158	24	24
Number of Detects			1	1	11	1	3	4	24	18
Maximum Detected Value			0.0042	0.01	1.7	0.001	0.0024	0.02	15	0.21
Average			0.021	0.021	0.047	0.021	0.00067	0.022	7.82	0.11
STDEV			0.0088	0.0086	0.15	0.0088	0.00049	0.0084	3.10	0.06
t			1.645	1.645	1.645	1.645	1.714	1.645	1.714	1.714
95%UCL			0.022	0.023	0.067	0.022	0.00084	0.023	8.9	0.13
Exposure Point Concentration For Risk Assessment			0.0042	0.01	0.067	0.001	0.00084	0.020	8.9	0.13
Basis			UCL	UCL	UCL	UCL	95%UCL	UCL	95%UCL	95%UCL

Samples not included because results were all non-detect with an R qualifier: 95PRDA-O-157SL (SB-O7, 6-9 feet), O-214SL (SB-O15, 0-3 feet), O-215SL (SB-O15, 3-6 feet), O-217SL(SB-O15, 9-12 feet), O-227SL (SB-O16, 3-6 feet), O-229SL (SB-O16, 9-12 feet), O-230SL (SB-O16, 12-15 feet), O-235SL (SB-O17, 3-6 feet), O-236SL (SB-O17, 6-9 feet), O-238SL (SB-O17, 14-15 feet), O-241SL (SB-O18, 0-3 feet), O-243SL (SB-O18, 6-6.5 feet), O-246SL (SB-O18, 15-18 feet), O-249SL (SB-O19, 3-6 feet), O-250SL (SB-O19, 6-9 feet), O-260SL (SB-O20SL, 6-8 feet), and O-264SL (MW-13, 3-5 feet).

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected Result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

D1 = Value from two fold diluted analysis

TABL
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date		Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloro-ethene		1,1,2-Trichloroethane
95PRDA-T-021SL	SB-T1 (0-2')**	WC 1995		0.013	ND	0.0007	ND	0.0007	ND	0.0007	ND	0.0007	ND	0.0007
95PRDA-D-001SL	SB-D1 (0-2')**	WC 1995	ND	0.00275		0.026		0.011	D4	8.1		0.056		0.0099
95PRDA-D-002SL	SB-D1 (5-7')**	WC 1995		0.07		0.14		0.088		1.95		0.039	ND	0.0028
95PRDA-D-003SL	SB-D1 (10-12')	WC 1995	ND	0.00055		0.004		0.0025		0.41		0.0024	ND	0.00055
95PRDA-D-005SL	SB-D2 (0-2')	WC 1995		0.0078	ND	0.00205	ND	0.00205		1.58	ND	0.00205	ND	0.00205
95PRDA-D-007SL	SB-D2 (10-13')**	WC 1995	ND	0.0026		0.012		0.0076		0.16		0.01	ND	0.0026
95PRDA-C-009SL	SB-C1 (0-2')	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0018	ND	0.00055	ND	0.00055
95PRDA-C-010SL	SB-C1 (9-11')	WC 1995	ND	0.025	ND	0.025	ND	0.025		4.4	ND	0.025	ND	0.025
95PRDA-C-011SL	SB-C1 (13-15')	WC 1995		0.0073		0.042		0.015		3.3		0.071	ND	0.00285
95PRDA-C-013SL	SB-C2 (0-2')**	WC 1995	J	0.16	J	0.008	J	0.0039		1.49	J	0.011	ND,J	0.00055
95PRDA-C-014SL	SB-C2 (9-12')	WC 1995	J	0.017	J	0.017	J	0.0063		0.51	J	0.0092	ND,J	0.00225
95PRDA-C-017SL	SB-C3 (0-2')**	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0045	ND	0.00055	ND	0.00055
95PRDA-C-019SL	SB-C3 (8-10')**	WC 1995	ND	0.0006		0.006		0.0039		0.2	ND	0.0006	ND	0.0006
95PRDA-T-024SL	SB-T1 (2-4')	WC 1995	ND, J	0.025	ND, J	0.025	ND,	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-T-029SL	SB-T2 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND,	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-T-031SL	SB-T3 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND,	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-D-006SL	SB-D2 (5-7')	WC 1995	ND	0.025	ND	0.025	ND	0.025		0.41	ND	0.025	ND	0.025
95PRDA-O-265SL	MW-14 (0-2')	WC 1995	ND, J	0.025	ND, J	0.025	ND,	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
95PRDA-O-266SL	MW-14 (4-6')	WC 1995	ND, J	0.025	ND, J	0.025	ND,	0.025	J	1.37	ND, J	0.025	ND, J	0.025
95PRDA-O-310SL	MW-14 (6-8')	WC 1995	ND	0.025	ND	0.025	ND	0.025		1.45	ND	0.025	ND	0.025
95PRDA-O-311SL	MW-14 (8-10')	WC 1995	ND	0.025	ND	0.025	ND	0.025		0.48	ND	0.025	ND	0.025
95PRDA-O-312SL	MW-14 (10-12')	WC 1995	ND	0.025	ND	0.025	ND	0.025		0.123	ND	0.025	ND	0.025
95PRDA-O-313SL	MW-14 (12-14')	WC 1995	ND	0.025	ND	0.025	ND	0.025		0.98	ND	0.025	ND	0.025
95PRDA-O-314SL	MW-14 (14-15')	WC 1995	ND	0.025	ND	0.025	ND	0.025		1.63	ND	0.025	ND	0.025
	SW-28	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-29	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-30	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-31	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-32	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-33	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-34	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-35	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-36	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-37	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-38	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-39	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-40	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-41	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-42	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-444	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-446	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-448	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-376	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5

TABLE A-2
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date		Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloro-ethene		1,1,2-Trichloroethane
	SC-378	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-380	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-367	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-308	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-310	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-312	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-299	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-242	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-244	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-231	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-444A	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-446A	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-01	OHM 1994	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025
	SW-02	OHM 1994	ND	0.025	ND	0.025		0.08		0.13	ND	0.025	ND	0.025
	SW-03	OHM 1994	ND	0.025		0.13		0.3		0.19		0.09	ND	0.025
	SW-07	OHM 1994	ND	0.025		0.09		0.15		0.17	ND	0.025	ND	0.025
	SW-11	OHM 1994	ND	0.025		0.22		0.4		0.61		0.07	ND	0.025
	SW-12	OHM 1994	ND	0.025		1.06		1.16		0.31		0.16	ND	0.025
	SW-14	OHM 1994	ND	0.025	ND	0.025		0.07	a	3.1		0.16	ND	0.025
	SW-15	OHM 1994	ND	0.025	ND	0.025		0.09		0.12	ND	0.025	ND	0.025
	SW-16	OHM 1994	ND	0.025		0.22		0.42		0.27		0.07	ND	0.025
	SW-17	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-18	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-19	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-20	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5		8.5	ND	2.5
	SW-21	OHM 1994	ND	2.5	ND	2.5	ND	2.5		5.6	ND	2.5	ND	2.5
	SW-22	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-23	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-24	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-25A	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-26	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-27	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-43	OHM 1994	*		*		*			7	ND	2.5	*	
	SW-44	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SW-45	OHM 1994	*		*		*		ND	2.5		7	*	
	SW-46	OHM 1994	ND	2.5	ND	2.5	ND	2.5		13	ND	2.5	ND	2.5
	SW-47	OHM 1994	ND	2.5	ND	2.5	ND	2.5		12	ND	2.5	ND	2.5
	SW-49	OHM 1994	ND	2.5	ND	2.5	ND	2.5	a	27	ND	2.5	ND	2.5
	SC-157	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-217	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-219	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-221	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-223	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5

TABL
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date		Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloro-ethene		1,1,2-Trichloroethane
	SC-225	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-283	OHM 1994	ND	0.025	a	1.6		1.15		0.49		0.13	ND	0.025
	SC-285	OHM 1994	ND,a	0.025	a	0.8	a	0.9	b	28	ND,a	0.025	ND,a	0.025
	SC-287A	OHM 1994	ND	2.5	ND	2.5	ND	2.5		18	ND	2.5	ND	2.5
	SC-291	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-293	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-318	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-349	OHM 1994	ND	0.025		0.24		0.33		0.29		0.09	ND	0.025
	SC-351	OHM 1994	ND	0.025		0.12		0.14		65		0.13	ND	0.025
	SC-353A	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SC-355	OHM 1994	ND	0.025		1.08		0.82	a	8.3		0.35	ND	0.025
	SC-357A	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-359	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-361	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-389A	OHM 1994	*		*		*			15	ND	2.5	*	
	SC-419	OHM 1994	ND	0.025		0.4		0.37		0.28		0.19	ND	0.025
	SC-421A	OHM 1994	ND	2.5	ND	2.5	ND	2.5		13	ND	2.5	ND	2.5
	SC-425	OHM 1994	ND	2.5	ND	2.5	ND	2.5		13	ND	2.5	ND	2.5
	SC-487	OHM 1994	ND	0.025		0.14		0.28		0.23		0.16	ND	0.025
	SC-515	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	SS-489	OHM 1994	ND	0.025		0.06		0.08	c	1.9		0.1	ND	0.025
	SS-513	OHM 1994	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025
	SS-517	OHM 1994	ND	0.025	ND	0.025	ND	0.025		0.12	ND	0.25	ND	0.25
	D-SW-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-SW-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-SW-03	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-SW-04	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	C-SW-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	C-SW-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5		12	ND	2.5	ND	2.5
	C-SW-03	OHM 1994	ND	2.5	ND	2.5	ND	2.5		5	ND	2.5	ND	2.5
	C-SW-04	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	B-SW-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5		23	ND	2.5	ND	2.5
	B-SW-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	B-SW-04A	OHM 1994	*		*		*		ND	2.5	ND	2.5	*	
	D-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-03	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	D-04	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	C-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	C-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5		5	ND	2.5	ND	2.5
	C-03	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	B-01	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	B-02	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5

TABLE A-2
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloro-ethene		1,1,2-Trichloroethane	
	B-03	OHM 1994	ND	2.5	ND	2.5	ND	2.5		19	ND	2.5	ND	2.5
	SW-50	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-54	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SW-55	OHM 1994	ND	2.5	ND	2.5	ND	2.5		16	ND	2.5	ND	2.5
	SW-56	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-71	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-73	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-137	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-139	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-141	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-143	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-145	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-205	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-207	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-209	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-211	OHM 1994	ND	2.5	ND	2.5	ND	2.5		21	ND	2.5	ND	2.5
	SC-213	OHM 1994	ND	2.5	ND	2.5	ND	2.5		6	ND	2.5	ND	2.5
	SC-273	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-275	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-277	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-279	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-281	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-341	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-343	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-409	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-411	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-413	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-415	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-417	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-477	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-479	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-481	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-483	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-485	OHM 1994	ND	2.5	ND	2.5	ND	2.5		6	ND	2.5	ND	2.5
	SC-552	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-553	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-554	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5

TABLE
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloro-ethene		1,1,2-Trichloroethane	
	SC-555	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-557	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-558	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
	SC-559	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
Number of samples				139		139		139		170		170		139
Number of Detects				6		21		24		54		21		1
Maximum Detected Concentration				0.16		1.60		1.16		65		8.50		0.0099
Average				1.73		1.78		1.78		3.81		1.94		1.73
STDEV				1.15		1.10		1.09		6.57		1.24		1.15
t				1.645		1.645		1.645		1.645		1.645		1.645
95%UCL				1.89		1.93		1.93		4.64		2.10		1.89
Exposure Point Concentration For Risk Assessment				0.16		1.60		1.16		4.64		2.10		0.0099
Basis				Max		Max		Max		95%UCL		95%UCL		Max

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

D4 = Value from ten fold diluted analysis (WC 1996)

a = Value from ten-fold diluted analysis (OHM 1994a)

b = Value from 100-fold diluted analysis (OHM 1994a)

c = Value from 2-fold diluted analysis (OHM 1994a)

TABLE A-2
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date		Trichloroethene	Copper		Lead		Mercury		Silver	Zinc
95PRDA-T-021SL	SB-T1 (0-2')**	WC 1995	ND	0.0007	25		7.9	ND	0.065	ND	0.175	58
95PRDA-D-001SL	SB-D1 (0-2')**	WC 1995		0.73	48		17	ND	0.05		0.33	260
95PRDA-D-002SL	SB-D1 (5-7')**	WC 1995		1.8	190		160	ND	0.055		1.9	1000
95PRDA-D-003SL	SB-D1 (10-12')	WC 1995		0.19	130		39	ND	0.055		1.7	650
95PRDA-D-005SL	SB-D2 (0-2')	WC 1995		0.16	57		25		0.58		0.49	390
95PRDA-D-007SL	SB-D2 (10-13')**	WC 1995		0.22	37		11		0.17		0.51	110
95PRDA-C-009SL	SB-C1 (0-2')	WC 1995		0.0014	31		8.7	ND	0.055		0.38	59
95PRDA-C-010SL	SB-C1 (9-11')	WC 1995		1.1	22		5.4	ND	0.05	ND	0.145	48
95PRDA-C-011SL	SB-C1 (13-15')	WC 1995		0.55	22		5.3	ND	0.055	ND	0.15	45
95PRDA-C-013SL	SB-C2 (0-2')**	WC 1995	J	0.15	33		12	ND	0.055	ND	0.15	100
95PRDA-C-014SL	SB-C2 (9-12')	WC 1995	J	0.14	35		13	ND	0.055	ND	0.16	82
95PRDA-C-017SL	SB-C3 (0-2')**	WC 1995		0.0082	28		5.9	ND	0.055	ND	0.14	51
95PRDA-C-019SL	SB-C3 (8-10')**	WC 1995		0.02	32		4.6	ND	0.055	ND	0.16	65
95PRDA-T-024SL	SB-T1 (2-4')	WC 1995	ND, J	0.025	-		-		-		-	-
95PRDA-T-029SL	SB-T2 (0-2')	WC 1995	ND, J	0.025	-		-		-		-	-
95PRDA-T-031SL	SB-T3 (0-2')	WC 1995	ND, J	0.025	-		-		-		-	-
95PRDA-D-006SL	SB-D2 (5-7')	WC 1995		0.0002	-		-		-		-	-
95PRDA-O-265SL	MW-14 (0-2')	WC 1995	ND, J	0.025	-		-		-		-	-
95PRDA-O-266SL	MW-14 (4-6')	WC 1995	ND, J	0.025	-		-		-		-	-
95PRDA-O-310SL	MW-14 (6-8')	WC 1995		0.94	-		-		-		-	-
95PRDA-O-311SL	MW-14 (8-10')	WC 1995		0.16	-		-		-		-	-
95PRDA-O-312SL	MW-14 (10-12')	WC 1995		0.15	-		-		-		-	-
95PRDA-O-313SL	MW-14 (12-14')	WC 1995		0.11	-		-		-		-	-
95PRDA-O-314SL	MW-14 (14-15')	WC 1995		0.82	-		-		-		-	-
	SW-28	OHM 1994	ND	2.5	-		-		-		-	-
	SW-29	OHM 1994	ND	2.5	-		-		-		-	-
	SW-30	OHM 1994	ND	2.5	-		-		-		-	-
	SW-31	OHM 1994	ND	2.5	-		-		-		-	-
	SW-32	OHM 1994	ND	2.5	-		-		-		-	-
	SW-33	OHM 1994	ND	2.5	-		-		-		-	-
	SW-34	OHM 1994	ND	2.5	-		-		-		-	-
	SW-35	OHM 1994	ND	2.5	-		-		-		-	-
	SW-36	OHM 1994	ND	2.5	-		-		-		-	-
	SW-37	OHM 1994	ND	2.5	-		-		-		-	-
	SW-38	OHM 1994		6	-		-		-		-	-
	SW-39	OHM 1994	ND	2.5	-		-		-		-	-
	SW-40	OHM 1994	ND	2.5	-		-		-		-	-
	SW-41	OHM 1994	ND	2.5	-		-		-		-	-
	SW-42	OHM 1994	ND	2.5	-		-		-		-	-
	SC-444	OHM 1994	ND	2.5	-		-		-		-	-
	SC-446	OHM 1994	ND	2.5	-		-		-		-	-
	SC-448	OHM 1994	ND	2.5	-		-		-		-	-
	SC-376	OHM 1994	ND	2.5	-		-		-		-	-

TABL
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Trichloroethene		Copper	Lead	Mercury	Silver	Zinc
	SC-378	OHM 1994	ND	2.5	-	-	-	-	-
	SC-380	OHM 1994	ND	2.5	-	-	-	-	-
	SC-367	OHM 1994	ND	2.5	-	-	-	-	-
	SC-308	OHM 1994	ND	2.5	-	-	-	-	-
	SC-310	OHM 1994	ND	2.5	-	-	-	-	-
	SC-312	OHM 1994	ND	2.5	-	-	-	-	-
	SC-299	OHM 1994	ND	2.5	-	-	-	-	-
	SC-242	OHM 1994	ND	2.5	-	-	-	-	-
	SC-244	OHM 1994	ND	2.5	-	-	-	-	-
	SC-231	OHM 1994		8	-	-	-	-	-
	SC-444A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-446A	OHM 1994	ND	2.5	-	-	-	-	-
	SW-01	OHM 1994		0.1	-	-	-	-	-
	SW-02	OHM 1994		0.21	-	-	-	-	-
	SW-03	OHM 1994	c	3	-	-	-	-	-
	SW-07	OHM 1994		0.36	-	-	-	-	-
	SW-11	OHM 1994		0.82	-	-	-	-	-
	SW-12	OHM 1994	a	3.8	-	-	-	-	-
	SW-14	OHM 1994		1	-	-	-	-	-
	SW-15	OHM 1994		0.14	-	-	-	-	-
	SW-16	OHM 1994		0.68	-	-	-	-	-
	SW-17	OHM 1994	ND	2.5	-	-	-	-	-
	SW-18	OHM 1994	ND	2.5	-	-	-	-	-
	SW-19	OHM 1994	ND	2.5	-	-	-	-	-
	SW-20	OHM 1994	ND	2.5	-	-	-	-	-
	SW-21	OHM 1994	ND	2.5	-	-	-	-	-
	SW-22	OHM 1994	ND	2.5	-	-	-	-	-
	SW-23	OHM 1994	ND	2.5	-	-	-	-	-
	SW-24	OHM 1994		29	-	-	-	-	-
	SW-25A	OHM 1994	ND	2.5	-	-	-	-	-
	SW-26	OHM 1994	ND	2.5	-	-	-	-	-
	SW-27	OHM 1994	ND	2.5	-	-	-	-	-
	SW-43	OHM 1994	ND	2.5	-	-	-	-	-
	SW-44	OHM 1994	ND	2.5	-	-	-	-	-
	SW-45	OHM 1994		116	-	-	-	-	-
	SW-46	OHM 1994	ND	2.5	-	-	-	-	-
	SW-47	OHM 1994	ND	2.5	-	-	-	-	-
	SW-49	OHM 1994	ND	2.5	-	-	-	-	-
	SC-157	OHM 1994	ND	2.5	-	-	-	-	-
	SC-217	OHM 1994	ND	2.5	-	-	-	-	-
	SC-219	OHM 1994	ND	2.5	-	-	-	-	-
	SC-221	OHM 1994	ND	2.5	-	-	-	-	-
	SC-223	OHM 1994	ND	2.5	-	-	-	-	-

TABLE A-2
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Trichloroethene		Copper	Lead	Mercury	Silver	Zinc
	SC-225	OHM 1994	ND	2.5	-	-	-	-	-
	SC-283	OHM 1994	a	3.6	-	-	-	-	-
	SC-285	OHM 1994	a	4.3	-	-	-	-	-
	SC-287A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-291	OHM 1994		7.1	-	-	-	-	-
	SC-293	OHM 1994	ND	2.5	-	-	-	-	-
	SC-318	OHM 1994	ND	2.5	-	-	-	-	-
	SC-349	OHM 1994		0.86	-	-	-	-	-
	SC-351	OHM 1994		0.67	-	-	-	-	-
	SC-353A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-355	OHM 1994	a	6.2	-	-	-	-	-
	SC-357A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-359	OHM 1994	ND	2.5	-	-	-	-	-
	SC-361	OHM 1994	ND	2.5	-	-	-	-	-
	SC-389A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-419	OHM 1994		2.8	-	-	-	-	-
	SC-421A	OHM 1994	ND	2.5	-	-	-	-	-
	SC-425	OHM 1994	ND	2.5	-	-	-	-	-
	SC-487	OHM 1994		0.9	-	-	-	-	-
	SC-515	OHM 1994		0.17	-	-	-	-	-
	SS-489	OHM 1994		0.88	-	-	-	-	-
	SS-513	OHM 1994	ND	0.025	-	-	-	-	-
	SS-517	OHM 1994		0.24	-	-	-	-	-
	D-SW-01	OHM 1994	ND	2.5	-	-	-	-	-
	D-SW-02	OHM 1994	ND	2.5	-	-	-	-	-
	D-SW-03	OHM 1994	ND	2.5	-	-	-	-	-
	D-SW-04	OHM 1994	ND	2.5	-	-	-	-	-
	C-SW-01	OHM 1994	ND	2.5	-	-	-	-	-
	C-SW-02	OHM 1994	ND	2.5	-	-	-	-	-
	C-SW-03	OHM 1994	ND	2.5	-	-	-	-	-
	C-SW-04	OHM 1994	ND	2.5	-	-	-	-	-
	B-SW-01	OHM 1994	ND	2.5	-	-	-	-	-
	B-SW-02	OHM 1994	ND	2.5	-	-	-	-	-
	B-SW-04A	OHM 1994	ND	2.5	-	-	-	-	-
	D-01	OHM 1994	ND	2.5	-	-	-	-	-
	D-02	OHM 1994	ND	2.5	-	-	-	-	-
	D-03	OHM 1994	ND	2.5	-	-	-	-	-
	D-04	OHM 1994	ND	2.5	-	-	-	-	-
	C-01	OHM 1994	ND	2.5	-	-	-	-	-
	C-02	OHM 1994	ND	2.5	-	-	-	-	-
	C-03	OHM 1994	ND	2.5	-	-	-	-	-
	B-01	OHM 1994	ND	2.5	-	-	-	-	-
	B-02	OHM 1994	ND	2.5	-	-	-	-	-

TABLE
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Trichloroethene		Copper	Lead	Mercury	Silver	Zinc
	B-03	OHM 1994	ND	2.5	-	-	-	-	-
	SW-50	OHM 1994	ND	2.5	-	-	-	-	-
	SW-54	OHM 1994	ND	2.5	-	-	-	-	-
	SW-55	OHM 1994	ND	2.5	-	-	-	-	-
	SW-56	OHM 1994	ND	2.5	-	-	-	-	-
	SC-71	OHM 1994	ND	2.5	-	-	-	-	-
	SC-73	OHM 1994	ND	2.5	-	-	-	-	-
	SC-137	OHM 1994	ND	2.5	-	-	-	-	-
	SC-139	OHM 1994	ND	2.5	-	-	-	-	-
	SC-141	OHM 1994	ND	2.5	-	-	-	-	-
	SC-143	OHM 1994	ND	2.5	-	-	-	-	-
	SC-145	OHM 1994	ND	2.5	-	-	-	-	-
	SC-205	OHM 1994	ND	2.5	-	-	-	-	-
	SC-207	OHM 1994	ND	2.5	-	-	-	-	-
	SC-209	OHM 1994	ND	2.5	-	-	-	-	-
	SC-211	OHM 1994	ND	2.5	-	-	-	-	-
	SC-213	OHM 1994	ND	2.5	-	-	-	-	-
	SC-273	OHM 1994	ND	2.5	-	-	-	-	-
	SC-275	OHM 1994	ND	2.5	-	-	-	-	-
	SC-277	OHM 1994	ND	2.5	-	-	-	-	-
	SC-279	OHM 1994	ND	2.5	-	-	-	-	-
	SC-281	OHM 1994	ND	2.5	-	-	-	-	-
	SC-341	OHM 1994	ND	2.5	-	-	-	-	-
	SC-343	OHM 1994	ND	2.5	-	-	-	-	-
	SC-409	OHM 1994	ND	2.5	-	-	-	-	-
	SC-411	OHM 1994	ND	2.5	-	-	-	-	-
	SC-413	OHM 1994	ND	2.5	-	-	-	-	-
	SC-415	OHM 1994	ND	2.5	-	-	-	-	-
	SC-417	OHM 1994	ND	2.5	-	-	-	-	-
	SC-477	OHM 1994	ND	2.5	-	-	-	-	-
	SC-479	OHM 1994	ND	2.5	-	-	-	-	-
	SC-481	OHM 1994	ND	2.5	-	-	-	-	-
	SC-483	OHM 1994	ND	2.5	-	-	-	-	-
	SC-485	OHM 1994	ND	2.5	-	-	-	-	-
	SC-552	OHM 1994	ND	2.5	-	-	-	-	-
	SC-553	OHM 1994	ND	2.5	-	-	-	-	-
	SC-554	OHM 1994	ND	2.5	-	-	-	-	-

TABLE A-2
CALCULATION OF CONCENTRATION TERMS FOR SOIL (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T (DEPTH 0-15) FEET
FORT RICHARDSON PRDA

Sample Number	Location	Sample Date	Trichloroethene	Copper	Lead	Mercury	Silver	Zinc
	SC-555	OHM 1994	ND 2.5	-	-	-	-	-
	SC-557	OHM 1994	ND 2.5	-	-	-	-	-
	SC-558	OHM 1994	ND 2.5	-	-	-	-	-
	SC-559	OHM 1994	ND 2.5	-	-	-	-	-
Number of samples			170	13	13	13	13	13
Number of Detects			42	13	13	2	6	13
Maximum Detected Concentration			**116**	**190**	**160**	**0.58**	**1.9**	**1000**
Average			2.98	53.1	24.2	0.1	0.5	224.5
STDEV			9.04	50.0	41.9	0.1	0.6	293.5
t			1.645	1.782	1.782	1.782	1.782	1.782
95%UCL			**4.12**	**77.8**	**44.9**	**0.18**	**0.79**	**369.5**
Exposure Point Concentration For Risk Assessment			**4.12**	**77.8**	**44.9**	**0.18**	**0.79**	**370**
Basis			95%UCL	95%UCL	95%UCL	95%UCL	95%UCL	95%UCL

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

D4 = Value from ten fold diluted analysis (WC 1996)

a = Value from ten-fold diluted analysis (OHM 1994a)

b = Value from 100-fold diluted analysis (OHM 1994a)

c = Value from 2-fold diluted analysis (OHM 1994a)

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	Acetone	Benzene		Carbon Tetrachloride		Chlorobenzene		Chloroform	
95PRDA-A-085GW	SB-A5**	WC 1995	-	ND	0.0001	ND	0.0001	ND	0.0001		0.00046
95PRDA-O-199GW	SB-O13**	WC 1995	-	ND, J	0.25	ND	0.025	D, J	0.25	ND	0.025
95PRDA-O-387GW	MW-15**	WC 1995	-	ND	0.0001		0.0017	ND	0.0001		0.002
95PRDA-O-393GW	MW-12**	WC 1995	-	ND	0.0001		0.0022	ND	0.0001		0.0011
95PRDA-O-397GW	MW-2	WC 1995	-	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001
95PRDA-O-398GW	MW-13	WC 1995	-		0.00034		0.00038		0.00038	ND	0.0001
95PRDA-O-399GW	MW-8	WC 1995	-	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001
95PRDA-O-400GW	MW-3	WC 1995	-	ND	0.0001	ND	0.0001	ND	0.0001		0.00053
95PRDA-O-403GW	MW-5	WC 1995	-	ND, J	0.1	ND, J	0.1	ND, J	0.1	ND, J	0.1
95PRDA-O-405GW	MW-4	WC 1995	-	ND	0.1	ND	0.1	ND	0.1	ND	0.1
Screening Samples											
95PRDA-B-042GW	SB-B2	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-B-057GW	SB-B5	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-A-071GW	SB-A3	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-A-080GW	SB-A4	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-A-096GW	SB-A6	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-B-109GW	SB-B7	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-115GW	SB-O1	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-121GW	SB-O2	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-131GW	SB-O3	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-139GW	SB-O4	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-154GW	SB-O6	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-162GW	SB-O7	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-187GW	SB-O11	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-213GW	SB-O14	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-232GW	SB-O16	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-240GW	SB-O17	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-O-253GW	SB-O20	WC 1995	-	-		ND	0.025	-		ND	0.025
95PRDA-D-004GW	SB-D1	WC 1995	-	-			0.3	-			0.14
95PRDA-D-008GW	SB-D2	WC 1995	-	-			0.146	-			0.087

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date		Acetone		Benzene		Carbon Tetrachloride		Chlorobenzene		Chloroform
Historical Samples												
	MW-2	OHM 1994	ND	0.0025	ND	0.001	ND	0.001	ND	0.001	ND	0.001
	MW-3	OHM 1994	ND	0.0025	ND	0.001	ND	0.001	ND	0.001	ND	0.001
	MW-5	OHM 1994	ND	0.0025		0.004	ND	0.001	ND	0.001		0.009
	MW-8	OHM 1994	ND	0.0025	ND	0.001	ND	0.001	ND	0.001	ND	0.001
	MW-12	OHM 1994	ND	0.0025		0.003	ND	0.001	ND	0.001		0.009
	MW-2	OHM 1993	ND	0.001	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025
	MW-3**	OHM 1993	ND	0.001	ND	0.00025	ND	0.00025	ND	0.00025		0.0015
	MW-8	OHM 1993	ND	0.001	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025
	MW2	ESE Sept. 1990	ND	0.0065	ND	0.00025	ND	0.00029	ND	0.00025	ND	0.00025
	MW3	ESE Sept. 1990	ND	0.0065	ND	0.00025	ND	0.00029	ND	0.00025	ND	0.00025
	MW4**	ESE Sept. 1990	ND	0.0325		0.0116		0.053	ND	0.00125		0.028
	MW5	ESE Sept. 1990	ND	0.0325	ND	0.00125	ND	0.00145	ND	0.00125	ND	0.00125
	MW2	ESE Oct 1990	ND	0.0065	ND	0.00025	ND	0.00029	ND	0.00025	ND	0.00025
	MW3	ESE Oct 1990	ND	0.0065	ND	0.00025	ND	0.00029	ND	0.00025	ND	0.00025
	MW4**	ESE Oct 1990		8.4	ND	0.125	ND	0.145	ND	0.125	ND	0.125
	MW5	ESE Oct 1990	ND	1.3	ND	0.05		0.049	ND	0.05		0.028
Number of samples				16		26		45		26		45
Number of Detects				1		4		7		1		15
Maximum Detected Concentration				**8.4**		**0.012**		**0.3**		**0.0004**		**0.14**
Average				0.61		0.025		0.030		0.024		0.024
STDEV				2.10		0.058		0.054		0.058		0.034
t				1.753		1.708		1.684		1.706		1.684
95%UCL				**1.53**		**0.044**		**0.044**		**0.044**		**0.033**
Exposure Point Conc. For Risk Assessment				1.53		0.012		0.044		0.0004		0.033
Basis				95%UCL		Max		95%UCL		Max		95%UCL

Notes:
- Analyte not measured
* Sampling result not available
** Maximum of duplicate samples.
☐ Detected result. All other values are 1/2 detection limit.
ND = Non Detect
J = Estimated Value
D0 = Value from a 25 fold diluted analysis.

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	1,2-Dichloroethane		1,4-Dichlorobenzene		1,1-Dichloroethene		cis-1,2-Dichloroethene		trans-1,2-Dichloroethene	
95PRDA-A-085GW	SB-A5**	WC 1995	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001
95PRDA-O-199GW	SB-O13**	WC 1995	ND	0.0001	ND	0.25	ND, J	0.25		3.1	J	1
95PRDA-O-387GW	MW-15**	WC 1995	ND	0.0001	ND	0.0001		0.00086		0.019		0.0052
95PRDA-O-393GW	MW-12**	WC 1995	ND	0.0001	ND	0.0001	J	0.00014		0.0099		0.001
95PRDA-O-397GW	MW-2	WC 1995	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001
95PRDA-O-398GW	MW-13	WC 1995	ND	0.0001	ND	0.0001		0.00026	ND	0.0001	ND	0.0001
95PRDA-O-399GW	MW-8	WC 1995	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001	ND	0.0001
95PRDA-O-400GW	MW-3	WC 1995	ND	0.0001	ND	0.0001	ND	0.000095		0.028		0.0038
95PRDA-O-403GW	MW-5	WC 1995	ND	0.1	ND	0.1	ND, J	0.1	ND, J	0.1	ND, J	0.1
95PRDA-O-405GW	MW-4	WC 1995	ND	0.1	ND	0.1	ND	0.1		1.6		0.41
Screening Samples												
95PRDA-B-042GW	SB-B2	WC 1995	ND	0.025	-		-			0.779		0.198
95PRDA-B-057GW	SB-B5	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-A-071GW	SB-A3	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-A-080GW	SB-A4	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-A-096GW	SB-A6	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-B-109GW	SB-B7	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-115GW	SB-O1	WC 1995	ND	0.025	-		-			0.472		0.086
95PRDA-O-121GW	SB-O2	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-131GW	SB-O3	WC 1995	ND	0.025	-		-			0.062	ND	0.025
95PRDA-O-139GW	SB-O4	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-154GW	SB-O6	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-162GW	SB-O7	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-187GW	SB-O11	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-213GW	SB-O14	WC 1995	ND	0.025	-		-			0.11	ND	0.025
95PRDA-O-232GW	SB-O16	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-O-240GW	SB-O17	WC 1995	ND	0.025	-		-			0.073	ND	0.025
95PRDA-O-253GW	SB-O20	WC 1995	ND	0.025	-		-		ND	0.025	ND	0.025
95PRDA-D-004GW	SB-D1	WC 1995	ND	0.025	-		-			1.72		0.55
95PRDA-D-008GW	SB-D2	WC 1995	ND	0.025	-		-			0.947		0.315

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	1,2-Dichloroethane		1,4-Dichlorobenzene		1,1-Dichloroethene		cis-1,2-Dichloroethene		trans-1,2-Dichloroethene	
Historical Samples												
	MW-2	OHM 1994	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
	MW-3	OHM 1994	ND	0.001	ND	0.001	ND	0.001		0.013		0.002
	MW-5	OHM 1994	ND	0.001	ND	0.001		0.008		0.34		0.11
	MW-8	OHM 1994	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
	MW-12	OHM 1994	ND	0.001	ND	0.001		0.007		0.33		0.12
	MW-2	OHM 1993	ND	0.00025		0.0005	ND	0.00025	ND	0.00025	ND	0.00025
	MW-3**	OHM 1993		0.0015	ND	0.00025	ND	0.00025		0.033		0.023
	MW-8	OHM 1993	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025
	MW2	ESE Sept. 1990	ND	0.00025	ND	0.00085	ND	0.00025	ND	0.00025	*	
	MW3	ESE Sept. 1990	ND	0.00025	ND	0.00085	ND	0.00025		0.0061	*	
	MW4**	ESE Sept. 1990	ND	0.00125	ND	0.00085		0.00502		1.6	*	
	MW5	ESE Sept. 1990	ND	0.00125	ND	0.00085	ND	0.00125		0.19	*	
	MW2	ESE Oct 1990	ND	0.00025	ND	0.00085	ND	0.00025	ND	0.00025	*	
	MW3	ESE Oct 1990	ND	0.00025	ND	0.00085	ND	0.00025	ND	0.00025	*	
	MW4**	ESE Oct 1990	ND	0.125	ND	0.00085	ND	0.125		0.19	*	
	MW5	ESE Oct 1990	ND	0.05	ND	0.00085		0.00502		1.6	*	
Number of samples				45		26		26		45		37
Number of Detects				1		1		7		21		13
Maximum Detected Concentration				**0.0015**		**0.0005**		**0.008**		**3.1**		**1.0**
Average				0.019		0.018		0.023		0.303		0.089
STDEV				0.028		0.054		0.058		0.643		0.195
t				1.684		1.708		1.708		1.684		1.697
95%UCL				**0.026**		**0.036**		**0.043**		**0.464**		**0.144**
Exposure Point Conc. For Risk Assessment				0.0015		0.0005		0.008		0.464		0.144
Basis				Max		Max		Max		95%UCL		95%UCL

Notes:
- Analyte not measured
* Sampling result not available
** Maximum of duplicate samples.
☐ Detected result. All other values are 1/2 detection limit.
ND = Non Detect
J = Estimated Value
D0 = Value from a 25 fold diluted analysis.

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	Hexachloro-ethane		1,1,2,2-Tetrachloro-ethane		Tetrachloro-ethene		Toluene		1,1,2-Trichloro-ethane		Trichloro-ethene		RDX
95PRDA-A-085GW	SB-A5**	WC 1995	-	ND	0.00025	ND	0.0001		0.00043	ND	0.00025	ND	0.0001	ND	0.00042
95PRDA-O-199GW	SB-O13**	WC 1995	-	J	34		0.147	D, J	0.25	D, J	0.25		12	ND	0.00042
95PRDA-O-387GW	MW-15**	WC 1995	-		0.0074		0.0025	J	0.00018		0.0016	J	0.27	ND	0.00042
95PRDA-O-393GW	MW-12**	WC 1995	-	D0, J	0.49		0.00035	ND	0.0001		0.00094	D0, J	0.16	ND	0.00042
95PRDA-O-397GW	MW-2	WC 1995	-	ND	0.00025	ND	0.0001	ND	0.0001	ND	0.00025	ND	0.0001	ND	0.00042
95PRDA-O-398GW	MW-13	WC 1995	-		0.0011	ND	0.0001		0.00032	ND	0.00025		0.0067	ND	0.00042
95PRDA-O-399GW	MW-8	WC 1995	-	ND	0.00025	ND	0.0001	ND	0.0001	ND	0.00025	ND	0.0001	ND	0.00042
95PRDA-O-400GW	MW-3	WC 1995	-	D0	0.54		0.00062	ND	0.0001		0.0023	D0	0.26	ND	0.00042
95PRDA-O-403GW	MW-5	WC 1995	-	J	21	ND, J	0.1	ND	0.1	ND	0.25		4.8	ND	0.00042
95PRDA-O-405GW	MW-4	WC 1995	-		71		0.31	ND	0.1	ND	0.25		14	ND	0.00042
Screening Samples															
95PRDA-B-042GW	SB-B2	WC 1995	-		29	ND	0.025	-			0.115		7.7	-	
95PRDA-B-057GW	SB-B5	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025		0.057	-	
95PRDA-A-071GW	SB-A3	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-A-080GW	SB-A4	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-A-096GW	SB-A6	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-B-109GW	SB-B7	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-115GW	SB-O1	WC 1995	-		6.1	ND	0.025	-		ND	0.025		4.5	-	
95PRDA-O-121GW	SB-O2	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-131GW	SB-O3	WC 1995	-		2.69	ND	0.025	-		ND	0.025		1.14	-	
95PRDA-O-139GW	SB-O4	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-154GW	SB-O6	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-162GW	SB-O7	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-187GW	SB-O11	WC 1995	-		0.115	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-213GW	SB-O14	WC 1995	-		1.64	ND	0.025	-		ND	0.025		0.662	-	
95PRDA-O-232GW	SB-O16	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-O-240GW	SB-O17	WC 1995	-		0.175	ND	0.025	-		ND	0.025		0.998	-	
95PRDA-O-253GW	SB-O20	WC 1995	-	ND	0.025	ND	0.025	-		ND	0.025	ND	0.025	-	
95PRDA-D-004GW	SB-D1	WC 1995	-	J	89		0.9	-			0.28		43	-	
95PRDA-D-008GW	SB-D2	WC 1995	-		93		0.483	-			0.129		46	-	

TABLE A-3
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
SHALLOW ZONE
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date		Hexachloro-ethane		1,1,2,2-Tetrachloro-ethane		Tetrachloro-ethene		Toluene		1,1,2-Trichloro-ethane		Trichloro-ethene		RDX
Historical Samples																
	MW-2	OHM 1994	-		ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.00005
	MW-3	OHM 1994	-			0.18	ND	0.001	ND	0.001	ND	0.001		0.085	ND	0.00005
	MW-5	OHM 1994	-			17		0.11	ND	0.001		0.094		4.2	ND	0.00005
	MW-8	OHM 1994	-		ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.00005
	MW-12	OHM 1994	-			15		0.11	ND	0.001		0.089		6.4	ND	0.00005
	MW-2	OHM 1993	ND	0.000005	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00004
	MW-3**	OHM 1993	ND	0.000005		0.5		0.0059	ND	0.00025		0.022		0.29	ND	0.00004
	MW-8	OHM 1993	ND	0.000005	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00025	ND	0.00004
	MW2	ESE Sept. 1990	ND	0.00075	ND	0.000255	ND	0.0008	ND	0.00025	ND	0.0006	ND	0.00025	ND	0.001055
	MW3	ESE Sept. 1990	ND	0.00075		0.048	ND	0.0008	ND	0.00025	ND	0.0006		0.0281	ND	0.001055
	MW4**	ESE Sept. 1990	ND	0.00075		47	ND	0.004	ND	0.00125		0.23		9.99	ND	0.001055
	MW5	ESE Sept. 1990	ND	0.00075		7.5	ND	0.004	ND	0.00125		0.035		3.39		0.00284
	MW2	ESE Oct 1990	ND	0.00075	ND	0.000255	ND	0.0008	ND	0.00025	ND	0.0006	ND	0.00025	ND	0.001055
	MW3	ESE Oct 1990	ND	0.00075		0.049	ND	0.0008	ND	0.00025	ND	0.0006		0.0369	ND	0.001055
	MW4**	ESE Oct 1990		0.0093		44	ND	0.4	ND	0.125	ND	0.3		11.2	ND	0.001055
	MW5	ESE Oct 1990	ND	0.00075		17	ND	0.16	ND	0.05	ND	0.12		5.87	ND	0.001055
Number of samples				11		45		45		26		45		45		26
Number of Detects				1		25		10		3		11		24		1
Maximum Detected Concentration				**0.0093**		**93.0**		**0.90**		**0.0004**		**0.28**		**46.0**		**0.0028**
Average				0.0013		11.1		0.070		0.024		0.057		3.94		0.00057
STDEV				0.0027		23.2		0.163		0.058		0.087		9.58		0.00061
t				1.812		1.684		1.684		1.708		1.684		1.684		1.708
95%UCL				**0.0028**		**16.9**		**0.111**		**0.044**		**0.079**		**6.35**		**0.00077**
Exposure Point Conc. For Risk Assessment				0.0028		16.9		0.111		0.0004		0.079		6.35		0.00077
Basis				95%UCL		95%UCL		95%UCL		Max		95%UCL		95%UCL		95%UCL

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

D0 = Value from a 25 fold diluted analysis.

TABLE A-4
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
DEEP AQUIFER
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	Benzene	Carbon Tetrachloride	Chloro-benzene	Chloroform	1,2-Dichloro-ethane	1,1-Dichloro-ethene	cis-1,2-Dichloro-ethene
95PRDA-O-390GW	MW-9**	WC 1995	0.00073	ND 0.0001	0.00055	ND 0.0001	ND 0.0001	0.0012	ND 0.0001
95PRDA-O-402GW	MW-7	WC 1995	ND, J 0.01	ND 0.01	ND, J 0.01	ND 0.01	ND 0.01	ND, J 0.01	J 0.28
95PRDA-O-404GW	MW-6	WC 1995	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	0.0035
95PRDA-O-406GW	MW-1	WC 1995	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	0.0053
95PRDA-O-407GW	MW-16	WC 1995	ND 0.0001	ND 0.0001	ND 0.0001	ND 0.0001	ND 0.0001	ND 0.0001	ND 0.0001
Historical samples									
	MW-1	OHM 1993	ND 0.0025	ND 0.0025	ND 0.0025	ND 0.0025	ND 0.0025	ND 0.0025	0.006
	MW-6	OHM 1993	ND 0.00025	ND 0.00025	ND 0.00025	0.0032	0.0012	ND 0.00025	0.082
	MW-7	OHM 1993	0.0005	ND 0.00025	ND 0.00025	0.0024	ND 0.0025	0.004	0.3
	MW-1	ESE Sept. 1990	ND 0.00025	0.0043	ND 0.00025	ND 0.00025	ND 0.00025	ND 0.00025	*
	MW-1	ESE Oct. 1990	ND 0.00025	0.0019	ND 0.00025	ND 0.00025	ND 0.00025	ND 0.00025	*
Number of samples			10	10	10	10	10	10	8
Number of Detects			2	2	1	2	1	2	6
Maximum Detected Concentration			**0.00073**	**0.0043**	**0.00055**	**0.0032**	**0.0012**	**0.004**	**0.3**
Average			0.0017	0.0021	0.0016	0.0021	0.0019	0.0021	0.0846
STDEV			0.0030	0.0031	0.0030	0.0030	0.0030	0.0030	0.1298
t			1.833	1.833	1.8330	1.8330	1.8330	1.8330	1.8330
95%UCL			**0.0034**	**0.0039**	**0.0034**	**0.0038**	**0.0036**	**0.0038**	**0.1687**
Exposure Point Conc. For Risk Assessment			**0.00073**	**0.00392**	**0.00055**	**0.0032**	**0.0012**	**0.0038**	**0.1687**
Basis			Max	95%UCL	Max	Max	Max	95%UCL	95%UCL

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

TABLE A-4
CALCULATION OF CONCENTRATION TERMS FOR GROUNDWATER (mg/L)
DEEP AQUIFER
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date		trans-1,2-Dichloro-ethene		1,1,2,2-Tetrachloro-ethane		Tetrachloro-ethene		Toluene		1,1,2-Trichloro ethane		Trichloro-ethene		Vinyl chloride
95PRDA-O-390GW	MW-9**	WC 1995	ND	0.0001	ND	0.00025	ND	0.0001		0.00073	ND	0.00025		0.00091	ND	0.0001
95PRDA-O-402GW	MW-7	WC 1995	J	0.058	J	3.1	ND	0.01	ND, J	0.01	ND	0.025	J	1	ND	0.01
95PRDA-O-404GW	MW-6	WC 1995	ND	0.001		0.52	ND	0.001	ND	0.001	ND	0.0025		0.13	ND	0.001
95PRDA-O-406GW	MW-1	WC 1995	ND	0.001		0.082	ND	0.001	ND	0.001	ND	0.0025		0.043	ND	0.001
95PRDA-O-407GW	MW-16	WC 1995	ND	0.0001	ND	0.001	ND	0.0001	ND	0.0001	ND	0.00025		0.00031	ND	0.0001
Historical samples																
	MW-1	OHM 1993	ND	0.0025	ND	0.0025	ND	0.0025	ND	0.0025	ND	0.0025		0.047	ND	0.0025
	MW-6	OHM 1993		0.0097		4.9		0.018		0.0015		0.028		0.7	ND	0.00025
	MW-7	OHM 1993		0.079		3.4		0.012	ND	0.0025		0.033		1.8		0.0008
	MW-1	ESE Sept. 1990	ND	0.00025	ND	0.000255	ND	0.0008	ND	0.00025	ND	0.0006	ND	0.00025	ND	0.0013
	MW-1	ESE Oct. 1990	ND	0.00025		0.0056	ND	0.0008	ND	0.00025	ND	0.0006	ND	0.00025	ND	0.0013
Number of samples				10		0.01		0.01		10		10		10		10
Number of Detects				3		0.006		0.002		2		2		2		1
Maximum Detected Concentration				**0.079**		**4.9**		**0.018**		**0.0015**		**0.033**		**1.8**		**0.0008**
Average				0.0152		1.2012		0.0046		0.0020		0.0095		0.3722		0.0018
STDEV				0.0287		1.8568		0.0064		0.0029		0.0134		0.6115		0.0030
t				1.8330		1.8330		1.8330		1.8330		1.8330		1.8330		1.8330
95%UCL				**0.0318**		**2.2774**		**0.0083**		**0.0037**		**0.0173**		**0.7266**		**0.0035**
Exposure Point Conc. For Risk Assessment				**0.0318**		**2.2775**		**0.0083**		**0.0015**		**0.0173**		**0.7267**		0.0008
Basis				95%UCL		95%UCL		95%UCL		Max		95%UCL		95%UCL		Max

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of duplicate samples.

☐ Detected result. All other values are 1/2 detection limit.

ND = Non Detect

J = Estimated Value

TABLE A-5
CALCULATION OF CONCENTRATION TERMS FOR SEDIMENTS (mg/kg)
WETLAND AREA
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	1,3,5-Trinitrobenzene		2,4,6-Trinitrotoluene		m-Nitrotoluene
95PRDA-W-331SD	SED-1**	WC 1995	0.78	ND	0.125	ND	0.125
95PRDA-W-337SD	SED-2	WC 1995	0.74		0.48		3
95PRDA-W-339SD	SED-3	WC 1995	0.53	ND	0.125	ND	0.125
95PRDA-W-341SD	SED-4	WC 1995	0.65	ND	0.125	ND	0.125
Number of samples			4		4		4
Number of Detects			4		1		1
Maximum Detected Concentration			0.78		0.48		3
Average			0.675		0.214		0.844
STDEV			0.11		0.178		1.44
t			2.353		2.353		2.353
95%UCL			**0.805**		**0.423**		**2.53**
Exposure Point Concentration For Risk Assessment			**0.78**		**0.423**		**2.53**
Basis			Max		95%UCL		95%UCL

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of triplicate samples.

☐ Detected Result. All other values are 1/2 detection limit.

ND = Non Detect

TABLE A-6
CALCULATION OF CONCENTRATION TERMS FOR SURFACE WATER (mg/L)
WETLAND AREA
FORT RICHARDSON PRDA

Sample Number	Sample Location	Sample Date	Toluene	1,3-Dinitrobenzene	Copper	Lead	Nickel	Zinc
95PRDA-W-332SW	SED-1**	WC 1995	ND 0.0005	0.0034	0.013	0.0057	0.019	0.064
95PRDA-W-338SW	SED-2	WC 1995	0.0045	0.00048	0.099	0.0081	0.014	0.17
95PRDA-W-340SW	SED-3	WC 1995	ND 0.0025	ND 0.000125	ND 0.005	0.004	ND 0.005	0.042
95PRDA-W-342SW	SED-4	WC 1995	ND 0.0001	ND 0.000125	ND 0.005	0.0045	ND 0.005	0.053
Number of Samples			4	4	4	4	4	4
Number of Detects			1	2	2	4	2	4
Maximum Detected Concentration			**0.0045**	**0.0034**	**0.099**	**0.0081**	**0.0190**	**0.17**
Average			0.0019	0.0010	0.03	0.01	0.01	0.08
STDEV			0.0020	0.0016	0.05	0.00	0.01	0.06
t			2.353	2.353	2.353	2.353	2.353	2.353
95%UCL			**0.0043**	**0.0029**	**0.08**	**0.0077**	**0.0189**	**0.15**
Exposure Point Conc. For Risk Assessment			**0.0043**	**0.0029**	**0.08**	**0.0077**	**0.0189**	**0.15**
Basis			95%UCL	95%UCL	95%UCL	95%UCL	95%UCL	95%UCL

Notes:

- Analyte not measured

* Sampling result not available

** Maximum of triplicate samples.

☐ Detected Result. All other values are 1/2 detection limit.

ND = Non Detect

APPENDIX B
HEALTH RISK CALCULATIONS

TABLE B-1
ESTIMATED RME CANCER RISK
SOIL INGESTION
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential RBC (mg/kg)(2)	Ratio of Soil Concentration to RBC	Estimated Residential Cancer Risk(3)	Industrial RBC (mg/kg)(4)	Ratio of Soil Concentration to RBC	Estimated Industrial Cancer Risk(3)
Chloroform	0.004	100	4.2E-05	4.2E-11	940	4.5E-06	4.5E-12
1,1,2,2-Tetrachloroethane	0.067	3.2	2.1E-02	2.1E-08	29	2.3E-03	2.3E-09
Tetrachloroethene	0.001	12	8.3E-05	8.3E-11	110	9.1E-06	9.1E-12
Trichloroethene	0.023	58	4.0E-04	4.0E-10	520	4.4E-05	4.4E-11
Cumulative Cancer Risk				2.1E-08			2E-09

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk = Ratio of soil concentration/RBC*1E-06

(4) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on 1E-06 cancer risk level (U.S. EPA 1995).

TABLE B-2
ESTIMATED RME CANCER RISK
INHALATION
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential SSL for Transfer to Air (mg/kg)(2)	Ratio of Soil Concentration to SSL	Estimated Inhalation Cancer Risk(3)
Chloroform	0.004	0.2	2.1E-02	2.1E-08
1,1,2,2-Tetrachloroethane	0.067	0.4	1.7E-01	1.7E-07
Tetrachloroethene	0.001	11	9.1E-05	9.1E-11
Trichloroethene	0.023	3	7.6E-03	7.6E-09
Cumulative Cancer Risk				2.0E-07

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 soil screening level (SSL) for inhalation of constituents from soil by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk = Ratio of soil concentration/SSL*1E-06

TABLE B-3
ESTIMATED RME NONCANCER HAZARD INDEX
SOIL INGESTION
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential RBC (mg/kg)(2)	Ratio of Soil Concentration to RBC (Hazard Quotient)	Industr RBC (mg/kg)(3)	Ratio of Soil Concentration to RBC (Hazard Quotient)
Chloroform	0.004	780	5.4E-06	20000	2.1E-07
Lead	8.900	-	-	-	-
Mercury	0.130	23	5.7E-03	610	2.1E-04
trans-1,2-Dichloroethene	0.010	1600	6.3E-06	41000	2.4E-07
Tetrachloroethene	0.001	780	1.3E-06	20000	5.0E-08
Toluene	0.001	16000	5.3E-08	410000	2.0E-09
Trichloroethene	0.023	468	4.9E-05	12000	1.9E-06
Hazard Index			6E-03		2E-04

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

(3) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-4
ESTIMATED RME NONCANCER HAZARD INDEX
INHALATION
INVESTIGATIVE AREA A-1, A-2, AND O (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Resident SSL for Transfer to Air (mg/kg)(2)	Ratio of Soil Concentration to SSL (Hazard Quotient)
Mercury	0.130	7	1.9E-02
trans-1,2-Dichloroethene	0.010	3600	2.8E-06
Toluene	0.001	520	1.5E-06
Hazard Index			2E-02

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a).
See Appendix A.

(2) Region 3 soil screening level (SSL) for inhalation of constituents from soil by residents, based on a hazard
quotient of 1 (U.S. EPA 1995).

TABLE B-5
ESTIMATED RME CANCER RISK
SOIL INGESTION
INVESTIGATIVE AREA A-3, A-4, AND T (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential RBC (mg/kg)(2)	Ratio of Soil Concentration to RBC	Estimated Residential Cancer Risk(3)	Industrial RBC (mg/kg)(4)	Ratio of Soil Concentration to RBC	Estimated Industrial Cancer Risk(3)
Chloroform	0.160	100	1.6E-03	1.6E-09	940	1.7E-04	1.7E-10
1,1,2,2-Tetrachloroethane	4.634	3.2	1.4E+00	1.4E-06	29	1.6E-01	1.6E-07
Tetrachloroethene	2.101	12	1.8E-01	1.8E-07	110	1.9E-02	1.9E-08
1,1,2-Trichloroethane	0.010	11	9.0E-04	9.0E-10	100	9.9E-05	9.9E-11
Trichloroethene	4.119	58	7.1E-02	7.1E-08	520	7.9E-03	7.9E-09
Cumulative Cancer Risk				2E-06			2E-07

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk =Ratio of soil concentration/RBC*1E-06

(4) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on 1E-06 cancer risk level (U.S. EPA 1995).

TABLE B-6
ESTIMATED RME CANCER RISK
INHALATION
INVESTIGATIVE AREA A-3, A-4, AND T (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	**RME Soil Concentration (mg/kg)(1)**	**Residential SSL for Transfer to Air (mg/kg)(2)**	**Ratio of Soil Concentration to SSL**	**Estimated Inhalation Cancer Risk(3)**
Chloroform	0.160	0.2	8.0E-01	8.0E-07
1,1,2,2-Tetrachloroethane	4.636	0.4	1.2E+01	1.2E-05
Tetrachloroethene	2.101	11	1.9E-01	1.9E-07
1,1,2-Trichloroethane	0.010	0.8	1.2E-02	1.2E-08
Trichloroethene	4.119	3	1.4E+00	1.4E-06
Cumulative Cancer Risk				1E-05

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 soil screening level (SSL) for inhalation of constituents from soil by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk = Ratio of soil concentration/SSL*1E-06

TABLE B-7
ESTIMATED RME NONCANCER HAZARD INDEX
SOIL INGESTION
INVESTIGATIVE AREA A-3, A-4, AND T (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential RBC (mg/kg)(2)	Ratio of Soil Concentration to RBC (Hazard Quotient)	Industrial RBC (mg/kg)(3)	Ratio of Soil Concentration to RBC (Hazard Quotient)
Chloroform	0.160	780	2.1E-04	20000	8.0E-06
cis-1,2-Dichloroethene	1.600	780	2.1E-03	20000	8.0E-05
trans-1,2-Dichloroethene	1.160	1600	7.3E-04	41000	2.8E-05
Tetrachloroethene	2.101	780	2.7E-03	20000	1.1E-04
1,1,2-Trichloroethane	0.010	310	3.2E-05	8200	1.2E-06
Trichloroethene	4.100	468	8.8E-03	12000	3.4E-04
Copper	77.800	3100	2.5E-02	82000	9.5E-04
Lead	44.900	-	-	-	-
Mercury	0.180	23	7.8E-03	610	3.0E-04
Silver	0.790	390	2.0E-03	10000	7.9E-05
Zinc	369.500	23000	1.6E-02	610000	6.1E-04
Hazard Index			7E-02		2E-03

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

(3) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-8
ESTIMATED RME NONCANCER HAZARD INDEX
INHALATION
INVESTIGATIVE AREA A-3, A-4, AND T (0-15 FEET)
FORT RICHARDSON PRDA

Chemical of Concern	RME Soil Concentration (mg/kg)(1)	Residential SSL for Transfer to Air (mg/kg)(2)	Ratio of Soil Concentration to SSL (Hazard Quotient)
cis-1,2-Dichloroethene	1.600	1500	1E-03
trans-1,2-Dichloroethene	1.160	3600	3E-04
Mercury	0.180	7	3E-02
Hazard Index			3E-02

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 soil screening level (SSL) for inhalation of constituents from soil by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-9
ESTIMATED RME CANCER RISK
RESIDENTIAL INGESTION OF GROUNDWATER
SHALLOW ZONE
FORT RICHARDSON PRDA

Chemical of Concern	RME Groundwater Concentration (mg/L)(1)	Residential RBC (mg/L)(2)	Ratio of Groundwater Concentration to RBC	Estimated Cancer Risk(3)
Benzene	0.0116	0.00036	3.2E+01	3.2E-05(3)
Carbon Tetrachloride	0.0437	0.00016	2.7E+02	2.7E-04(3)
Chloroform	0.0326	0.00015	2.2E+02	2.2E-04(3)
1,4-Dichlorobenzene	0.0005	0.00044	1.1E+00	1.1E-06(3)
1,2-Dichloroethane	0.0015	0.00012	1.3E+01	1.3E-05(3)
1,1-Dichloroethene	0.008	0.000044	1.8E+02	1.8E-04(3)
Hexachlorethane	0.00278	0.00075	3.7E+00	3.7E-06(3)
1,1,2,2-Tetrachloroethane	16.866	0.000052	3.2E+05	2.8E-01(4)
Tetrachloroethene	0.111	0.0011	1.0E+02	1.0E-04(3)
1,1,2-Trichloroethane	0.0791	0.00019	4.2E+02	4.2E-04(3)
Trichloroethene	6.346	0.0016	4.0E+03	4.0E-03(3)
RDX	0.00077	0.00061	1.3E+00	1.3E-06(3)
Cumulative Cancer Risk				3E-01

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for groundwater ingestion by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk = Ratio of groundwater concentration/RBC*(1E-06); for risk estimates less than 1E-02 (EPA 1989a)

(4) Cancer risk = 1-exp$^{(\text{-groundwater concentration/RBC*1E-06})}$; for risk estimates that exceed 1E-02 (EPA 1989a)

TABLE B-10
ESTIMATED RME NONCANCER HAZARD INDEX
RESIDENTIAL INGESTION OF GROUNDWATER
SHALLOW ZONE
FORT RICHARDSON PRDA

Chemical of Concern	RME Groundwater Concentration (mg/L)(1)	Residential RBC (mg/L)(2)	Ratio of Groundwater Concentration to RBC (Hazard Quotient)
Acetone	1.534	3.7	4.1E-01
Benzene	0.0116	0.0104	1.1E+00
Carbon Tetrachloride	0.0437	0.0036	1.2E+01
Chlorobenzene	0.00038	0.039	9.7E-03
Chloroform	0.0326	0.0608	5.4E-01
1,4-Dichlorobenzene	0.0005	1.393	3.6E-04
1,2-Dichloroethane	0.0015	0.0174	8.6E-02
1,1-Dichloroethene	0.008	0.0548	1.5E-01
cis-1,2-Dichloroethene	0.464	0.061	7.6E+00
trans-1,2-Dichloroethene	0.144	0.12	1.2E+00
Hexachlorethane	0.00278	0.0061	4.6E-01
RDX	0.00077	0.11	7.0E-03
Tetrachloroethene	0.111	0.0608	1.8E+00
Toluene	0.00043	0.75	5.7E-04
1,1,2-Trichloroethane	0.0791	0.0243	3.3E+00
Trichloroethene	6.3464	0.0365	1.7E+02
Hazard Index			2.0E+02

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for groundwater ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-11
ESTIMATED RME CANCER RISK
RESIDENTIAL INGESTION OF GROUNDWATER
DEEP AQUIFER
FORT RICHARDSON PRDA

Chemical of Concern	RME Groundwater Concentration (mg/L)(1)	Residential RBC (mg/L)(2)	Ratio of Groundwater Concentration to RBC	Estimated Cancer Risk(3)
Benzene	0.00073	0.00036	2.0E+00	2.0E-06(3)
Carbon Tetrachloride	0.00392	0.00016	2.5E+01	2.5E-05(3)
Chloroform	0.0032	0.00015	2.1E+01	2.1E-05(3)
1,2-Dichloroethane	0.0012	0.00012	1.0E+01	1.0E-05(3)
1,1-Dichloroethene	0.00382	0.000044	8.7E+01	8.7E-05(3)
1,1,2,2-Tetrachloroethane	2.277	0.000052	4.4E+04	4.3E-02(4)
Tetrachloroethane	0.00831	0.0011	7.6E+00	7.6E-06(3)
1,1,2-Trichloroethane	0.01728	0.00019	9.1E+01	9.1E-05(3)
Trichloroethene	0.727	0.0016	4.5E+02	4.5E-04(3)
Vinyl Chloride	0.0008	0.000019	4.2E+01	4.2E-05(3)
Cumulative Cancer Risk				4E-02

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for groundwater ingestion by residents, based on 1E-06 cancer risk level (U.S. EPA 1995).

(3) Cancer risk = Ratio of groundwater concentration/RBC*(1E-06); for risk estimates less than 1E-02 (EPA 1989a)

(4) Cancer risk = 1-exp$^{(\text{-groundwater concentration/RBC* 1E-06})}$; for risk estimates that exceed 1E-02 (EPA 1989a)

TABLE B-12
ESTIMATED RME NONCANCER HAZARD INDEX
RESIDENTIAL INGESTION OF GROUNDWATER
DEEP AQUIFER
FORT RICHARDSON PRDA

Chemical of Concern	RME Groundwater Concentration (mg/L)(1)	Residential RBC (mg/L) (2)	Ratio of Groundwater Concentration to RBC (Hazard Quotient)
Benzene	0.00073	0.0104	7.0E-02
Carbon Tetrachloride	0.00392	0.0036	1.1E+00
Chlorobenzene	0.00055	0.03900	1.4E-02
Chloroform	0.0032	0.0608	5.3E-02
1,2-Dichloroethane	0.0012	0.0174	6.9E-02
1,1-Dichloroethene	0.00382	0.0548	7.0E-02
cis-1,2-Dichloroethene	0.169	0.061	2.8E+00
trans-1,2-Dichloroethene	0.032	0.120	2.7E-01
Tetrachloroethane	0.00831	0.0608	1.4E-01
Toluene	0.0015	0.7500	2.0E-03
1,1,2-Trichloroethane	0.01728	0.0243	7.1E-01
Trichloroethene	0.727	0.0365	2.0E+01
Hazard Index			2.5E+01

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for groundwater ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-13
ESTIMATED RME NONCANCER HAZARD INDEX
SURFACE WATER INGESTION BY RESIDENTS
WETLANDS
FORT RICHARDSON PRDA

Chemical of Concern	**RME Surface Water Concentration (mg/kg) (1)**	**Residential RBC for Groundwater (mg/kg) (2)**	**Ratio of Surface Water to RBC (Hazard Quotient)**
Copper	80.000	1500	5.3E-02
1,3-Dinitrobenzene	2.900	3.7	7.8E-01
Nickel	18.900	730	2.6E-02
Toluene	4.280	750	5.7E-03
Hazard Index			9E-01

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for groundwater ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

TABLE B-14
ESTIMATED RME CANCER RISK
SEDIMENT INGESTION
WETLANDS
FORT RICHARDSON PRDA

Chemical of Concern	RME Sediment Concentration (mg/kg)(1)	Residential RBC for Soil Ingestion (mg/kg)(2)	Ratio of Sediment Concentration to RBC	Estimated Residential Cancer Risk(3)	Industrial RBC for Soil Ingestion (mg/kg)(4)	Ratio of Sediment Concentration to RBC	Estimated Industrial Cancer Risk(3)
2,4,6-Trinitrotoluene	0.420	21	2E-02	2E-08	190	2E-03	2E-09
Cumulative Cancer Risk				2E-08			2E-09

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on 1E-06 cancer risk level (U.S. EPA 1995)

(3) Cancer risk = Ratio of sediment concentration/RBC*1E-06

(4) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on 1E-06 cancer risk level (U.S. EPA 1995).

TABLE B-15
ESTIMATED RME NONCANCER HAZARD INDEX
SEDIMENT INGESTION
WETLANDS
FORT RICHARDSON PRDA

Chemical of Concern	RME Sediment Concentration (mg/kg) (1)	Residential RBC for Soil Ingestion (mg/kg) (2)	Ratio of Sediment Concentration to RBC (Hazard Quotient)	Industrial RBC for Soil Ingestion (mg/kg)(3)	Ratio of Sediment Concentration to RBC (Hazard Quotient)
1,3,5-Trinitrobenzene	0.780	3.9	2E-01	100	8E-03
m-Nitrotoluene	2.530	780	3E-03	20000	1E-04
2,4,6-Trinitrotoluene	0.420	39	1E-02	1000	4E-04
Hazard Index			2E-01		8E-03

RME = Reasonable Maximum Exposure

(1) The maximum detected concentration or the 95% UCL of the mean (whichever is smaller) (EPA 1989a). See Appendix A.

(2) Region 3 risk-based concentration (RBC) for soil ingestion by residents, based on a hazard quotient of 1 (U.S. EPA 1995).

(3) Region 3 risk-based concentration (RBC) for soil ingestion by adult industrial workers, based on a hazard quotient of 1 (U.S. EPA 1995).

APPENDIX C

CALCULATION OF CONCENTRATION TERMS FOR ECOLOGICAL RISK ASSESSMENT

TABLE C-1
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene		1,1,2,2-tetrachloroethane		tetrachloroethene		toluene		trichloroethene	
95PRDA-O-261SL	MW-12	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-263SL	MW-13	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-063SL	SB-A2	0	2	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-110SL	SB-O1	0	2	Soil	Screen	WC 1995	ND	0.025		0.07	ND	0.025			ND	0.025
95PRDA-O-258SL	SB-O20	0	2	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-060SL	SB-A1	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-066SL	SB-A3	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-073SL	SB-A4	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-089SL	SB-A6	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-033SL	SB-B1	0	3	Soil	Screen	WC 1995	ND	0.025		0.47	ND	0.025			ND	0.025
95PRDA-B-036SL	SB-B2	0	3	Soil	Screen	WC 1995	ND	0.025		0.15	ND	0.025			ND	0.025
95PRDA-B-043SL	SB-B3	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-047SL	SB-B4	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-052SL	SB-B5	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-097SL	SB-B6	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-177SL	SB-O10	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-180SL	SB-O11	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-189SL	SB-O12	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-195SL	SB-O13	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-205SL	SB-O14	0	3	Soil	Screen	WC 1995	ND, J	0.025	J	0.179	ND, J	0.025			ND, J	0.025
95PRDA-O-214SL	SB-O15	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-226SL	SB-O16	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-234SL	SB-O17	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-241SL	SB-O18	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-248SL	SB-O19	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-116SL	SB-O2	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-122SL	SB-O3	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-132SL	SB-O4	0	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-147SL	SB-O6	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-155SL	SB-O7	0	3	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055		0.0024	ND	0.00055

TABLE C-1
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene		1,1,2,2-tetrachloroethane		tetrachloroethene		toluene		trichloroethene	
95PRDA-O-233SL	SB-O8[a]	0	3	Soil	Screen	WC 1995	ND, J	0.025	J	0.07	ND, J	0.025			ND, J	0.025
95PRDA-O-171SL	SB-O9	0	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
90PRDA6	SB-6	0	7	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA7	SB-7	0	7	Soil	Lab	ESE 1991	ND	0.0015		0.02	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA5	SB-5	0	7.5	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA10	SB-10	0	8	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA9	SB-9	0	8	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA4	SB-4	0	8.5	Soil	Lab	ESE 1991	ND	0.0015	ND	0.001	ND	0.0004	ND	0.0004	ND	0.0015
90PRDA11	SB-11[a]	0	9	Soil	Lab	ESE 1991		0.01		0.2		0.001	ND	0.0004		0.02
95PRDA-B-104SL	SB-B7	1	3	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-141SL	SB-O5	1	3	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-O-262SL	MW-12	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-264SL	MW-13	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-111SL	SB-O1	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-259SL	SB-O20	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-164SL	SB-O8	3	5	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-061SL	SB-A1	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-067SL	SB-A3	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-A-074SL	SB-A4	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-A-090SL	SB-A6	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-037SL	SB-B2	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-048SL	SB-B4	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-053SL	SB-B5[a]	3	6	Soil	Lab	WC 1995	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055	ND	0.00055
95PRDA-B-098SL	SB-B6	3	6	Soil	Screen	WC 1995	ND	0.025	ND	0.025	ND	0.025			ND	0.025
95PRDA-B-105SL	SB-B7	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-178SL	SB-O10	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-181SL	SB-O11	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-190SL	SB-O12	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-196SL	SB-O13	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025
95PRDA-O-206SL	SB-O14	3	6	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025			ND, J	0.025

TABLE C-1
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-1, A-2, AND O
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From Feet	Depth To Feet	Matrix	Sample Type	Sample Date	trans 1,2-dichloroethene	1,1,2,2-tetrachloroethane	tetrachloroethene	toluene	trichloroethene
95PRDA-O-214SL	SB-O15[a]	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-227SL	SB-O16	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-235SL	SB-O17	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-242SL	SB-O18	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-249SL	SB-O19	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-117SL	SB-O2	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-123SL	SB-O3	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-133SL	SB-O4[a]	3	6	Soil	Lab	WC 1995	ND,J 0.00055	ND,J 0.00055	ND,J 0.00055	ND,J 0.00055	ND,J 0.00055
95PRDA-O-142SL	SB-O5	3	6	Soil	Screen	WC 1995	ND 0.025	ND 0.025	ND 0.025		ND 0.025
95PRDA-O-156SL	SB-O7	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
95PRDA-O-172SL	SB-O9	3	6	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025		ND, J 0.025
N							71	71	71	10	71
Mean							0.022	0.036	0.022	0.001	0.022
Stdev							0.0081	0.062	0.0086	0.00063	0.008
Variance											
$t_{(1-a,n-1)}$							1.667	1.667	1.667	1.812	1.667
Maximum Detected Value							0.01	0.47	0.001	0.0024	0.02
95% UCL							0.023	0.048	0.023	0.001	0.023
RME							0.01	0.048	0.001	0.001	0.02
Basis							Max	UCL	Max	UCL	Max

ND - Not detected. The value given is half the detection limit.

TABLE C-2
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From	Depth To	Matrix	Sample Type	Sample Date	Chloroform	cis-1,2-Dichlorothene	trans 1,2-Dichloroethene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	1,1,2-Trichloroethane	Trichloroethene
95PRDA-O-265SL	MW-14	0	2	Soil	Screen	WC 1995	ND, J 0.00055	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025
95PRDA-C-009SL	SB-C1^a	0	2	Soil	Lab	WC 1995	ND 0.00055	ND 0.00055	ND 0.00055	0.0018	ND 0.00055	ND 0.00055	0.0014
95PRDA-C-013SL	SB-C2^a	0	2	Soil	Lab	WC 1995	J 0.16	J 0.008	J 0.0039	1.49	J 0.011	ND,J 0.00055	J 0.15
95PRDA-C-017SL	SB-C3^a	0	2	Soil	Lab	WC 1995	ND 0.00055	ND 0.00055	ND 0.00055	0.0045	ND 0.00055	ND 0.00055	0.0082
95PRDA-D-001SL	SB-D1^a	0	2	Soil	Lab	WC 1995	ND 0.00275	0.026	0.011	D4 8.1	0.056	0.0099	0.73
95PRDA-D-005SL	SB-D2^a	0	2	Soil	Lab	WC 1995	0.0078	ND 0.00205	ND 0.00205	1.58	ND 0.00205	ND 0.00205	0.16
95PRDA-T-021SL	SB-T1^a	0	2	Soil	Lab	WC 1995	0.013	ND 0.0007	ND 0.0007	ND 0.0007	ND 0.0007	ND 0.0007	ND 0.0007
95PRDA-T-029SL	SB-T2	0	2	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025
95PRDA-T-031SL	SB-T3	0	2	Soil	Screen	WC 1995	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025	ND, J 0.025
South of A-3	SC-137	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-139	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-141	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-143	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-145	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-205	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-207	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-209	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-211	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	21	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-213	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	6	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-273	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-275	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-277	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-279	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-281	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-341	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-343	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-409	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-411	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-413	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5
South of A-3	SC-415	≥1	≤4	Soil	Lab	OHM 1994	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5	ND 2.5

TABLE C-2
SUMMARY OF 0-3 FEET SOIL ANALYTICAL RESULTS (mg/kg)
INVESTIGATIVE AREA A-3, A-4, AND T
FORT RICHARDSON PRDA

Sample Number	Sample Location	Depth From	Depth To	Matrix	Sample Type	Sample Date	Chloroform		cis-1,2-Dichlorothene		trans 1,2-Dichloroethene		1,1,2,2-Tetrachloroethane		Tetrachloroethene		1,1,2-Trichloroethane		Trichloroethene	
South of A-3	SC-417	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-477	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-479	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-481	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-483	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-485	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5		6.0	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-552	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-553	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-554	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-555	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-557	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-558	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-559	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-71	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
South of A-3	SC-73	≥1	≤4	Soil	Lab	OHM 1994	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5
95PRDA-T-024SL	SB-T1	2	4	Soil	Screen	WC 1995	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025	ND, J	0.025
N								46		46		46		46		46		46		46
Mean								2.0		2.0		2.0		2.8		2.0		2.0		2.0
Stdev								1.0		1.0		1.0		3.1		1.0		1.0		1.0
Variance																				
$t_{(1-a,n-1)}$								1.680		1.680		1.680		1.680		1.680		1.680		1.680
Maximum Detected Value								0.16		0.026		0.011		21		0.056		0.0099		0.73
95% UCL								2.2		2.2		2.2		3.5		2.2		2.2		2.2
RME								0.16		0.026		0.011		3.53		0.056		0.01		0.73
Basis								Max		Max		Max		UCL		Max		Max		Max

APPENDIX D
ANALYTICAL RESULTS FOR METALS

TABLE D-1
METALS ANALYSIS - BACKGROUND SOIL (mg/kg)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Antimony EPA 6010	Arsenic EPA 7060	Beryllium EPA 6010	Cadmium EPA 6010	Chromium EPA 6010	Copper EPA 6010	Lead EPA 6020
95PRDA-U-273SL	SB-U1 (0-3')	11	5.4	0.34	ND (1.4)	32	28	5.4
95PRDA-U-274SL	SB-U1 (3-5')	11	7.0	0.36	ND (1.4)	34	27	5.5
95PRDA-U-275SL	SB-U1 (6-8')	11	7.2	0.29	ND (2.8)	30	31	5.0
95PRDA-U-276SL	SB-U1 (9-9.5')	7.6	12	0.35	ND (1.4)	40	31	6.0
95PRDA-U-277SL	SB-U1 (13-16')	7.6	9.8	0.29	ND (1.3)	33	26	5.2
95PRDA-U-278SL	SB-U2 (0-3')	8.2	10	0.34	ND (1.5)	33	23	5.8
95PRDA-U-279SL	SB-U2 (3-6')	7.6	39	0.39	ND (1.4)	33	31	9.0
95PRDA-U-280SL	SB-U2 (6-10')	9.2	14	0.34	ND (1.5)	39	33	6.8
95PRDA-U-281SL	SB-U2 (17-18.5')	7.7	7.2	ND (0.30)	ND (1.5)	30	26	3.7
95PRDA-U-282SL	Duplicate of 281	5.9	8.5	ND (0.28)	ND (1.4)	32	27	3.4
95PRDA-U-283SL	Triplicate of 281	NR	NR	NR	NR	NR	NR	NR
95PRDA-U-284SL	SB-U2 (19-19.5')	6.0	7.5	ND (0.30)	ND (1.5)	33	28	3.5
95PRDA-U-322SL	MW-17 (0-3')	9.6	8.9	0.32	ND (1.5)	29	23	6.2
95PRDA-U-323SL	MW-17 (3-6')	11	7.5	0.36	ND (2.6)	32	29	7.3
95PRDA-U-324SL	MW-17 (6-9')	9.9	8.1	0.39	ND (2.7)	34	30	7.2
95PRDA-U-325SL	MW-17 (10-13.5')	12	9.2	0.35	ND (1.5)	38	38	6.4
95PRDA-U-327SL	MW-17 (16-20')	6.1	3.9	ND (0.28)	ND (1.4)	24	22	3.0
95PRDA-U-330SL	MW-17 (23-25')	7.1	6.8	ND (0.30)	ND (1.5)	25	23	3.6
Average* Background Concentration		8.7	10.1	0.29	ND (1.7)	32.4	28.0	5.5
Risk Based Concentration		31 (N)	0.43 (C), 23 (N)	0.15 (C)	39 (N)	390 (N)**	3100 (N)	-

Notes:
ND = Non Detect
( ) = Detection Limit
NR = Not yet received
C = as a carcinogen
N = non-carcinogenic effects
*Averages include NDs at half the detection limit.
**RBC for chromium VI = 390 mg/kg, and chromium III = 78000 mg/kg

TABLE D-1
METALS ANALYSIS - BACKGROUND SOIL (mg/kg)
FORT RICHARDSON PRDA

Sample Number	Sample Location	**Mercury EPA 7471**	**Nickel EPA 6010**	**Selenium EPA 7740**	**Silver EPA 6010**	**Thallium EPA 7841**	**Zinc EPA 6010**
95PRDA-U-273SL	SB-U1 (0-3')	ND (0.11)	46	ND (0.30)	0.65	ND (0.30)	51
95PRDA-U-274SL	SB-U1 (3-5')	ND (0.11)	45	ND (0.27)	0.67	ND (0.27)	50
95PRDA-U-275SL	SB-U1 (6-8')	0.11	43	ND (0.28)	0.65	ND (0.28)	59
95PRDA-U-276SL	SB-U1 (9-9.5')	ND (0.11)	44	ND (0.29)	0.63	ND (0.29)	57
95PRDA-U-277SL	SB-U1 (13-16')	ND (0.10)	29	ND (0.27)	0.71	ND (0.27)	55
95PRDA-U-278SL	SB-U2 (0-3')	ND (0.11)	42	ND (0.29)	0.55	ND (0.29)	45
95PRDA-U-279SL	SB-U2 (3-6')	ND (0.11)	41	ND (0.28)	0.81	ND (0.28)	70
95PRDA-U-280SL	SB-U2 (6-10')	ND (0.11)	38	ND (0.30)	0.75	ND (0.30)	59
95PRDA-U-281SL	SB-U2 (17-18.5')	ND (0.11)	50	ND (0.30)	0.45	ND (0.30)	43
95PRDA-U-282SL	Duplicate of 281	ND (0.11)	52	ND (0.28)	0.44	ND (0.28)	45
95PRDA-U-283SL	Triplicate of 281	NR	NR	NR	NR	NR	NR
95PRDA-U-284SL	SB-U2 (19-19.5')	ND (0.11)	52	ND (0.27)	0.65	ND (0.27)	42
95PRDA-U-322SL	MW-17 (0-3')	ND (0.10)	36	ND (0.30)	0.65	ND (0.30)	85
95PRDA-U-323SL	MW-17 (3-6')	0.12	40	ND (0.27)	0.68	ND (0.27)	71
95PRDA-U-324SL	MW-17 (6-9')	ND (0.11)	39	ND (0.27)	0.73	ND (0.27)	87
95PRDA-U-325SL	MW-17 (10-13.5')	ND (0.12)	49	ND (0.29)	0.76	ND (0.29)	65
95PRDA-U-327SL	MW-17 (16-20')	ND (0.099)	29	ND (0.28)	0.49	ND (0.28)	38
95PRDA-U-330SL	MW-17 (23-25')	ND (0.11)	30	ND (0.29)	0.53	ND (0.29)	47
Average* Background Concentration		0.06	41	ND (0.28)	0.64	ND (0.28)	58
Risk Based Concentration		23 (N)	1600 (N)	390 (N)	390 (N)	-	23000 (N)

Notes:
ND = Non Detect
( ) = Detection Limit
NR = Not yet received
C = as a carcinogen
N = non-carcinogenic effects
*Averages include NDs at half the detection limit.
**RBC for chromium VI = 390 mg/kg, and chromium III = 78000 mg/kg

TABLE D-2
METALS ANALYSIS - SOILS (mg/kg)
AREAS A-1, A-2 AND OTHER AREAS
FORT RICHARDSON PRDA

Sample Number	Sample Location	Antimony EPA 6010	Arsenic EPA 7060	Beryllium EPA 6010	Cadmium EPA 6010	Chromium EPA 6010	Copper EPA 6010	Lead EPA 6020
Area A-1								
95PRDA-A-064SL	SB-A2 (3.5-7')	11	8.3	0.37	ND (1.5)	34	39	6.5
95PRDA-A-084SL	SB-A5 (20.5-22.5')	9.1	9.0	ND (0.32)	ND (3.2)	33	27	4.8
Area A-2								
95PRDA-B-045SL	SB-B3 (7-10')	9.9	12	0.45	ND (3.0)	36	42	15
95PRDA-B-053SL	SB-B5 (3-6')	7.4	8.1	0.32	ND (3.1)	30	34	6.5
95PRDA-B-054SL	Duplicate of 053	7.5	11	0.37	ND (2.8)	34	38	6.5
95PRDA-B-055SL	Triplicate of 053	NR	NR	NR	NR	NR	NR	NR
95PRDA-B-106SL	SB-B7 (6-9')	8.7	8.1	0.37	ND (3.2)	33	36	9.3
95PRDA-O-194SL	SB-O12 (15-18')	6.6	14	0.34	ND (1.4)	34	33	7.3
95PRDA-O-301SL	MW-13 (10-12')	10	7.0	ND (0.30)	ND (1.5)	27	26	2.9
Toe of Hill								
95PRDA-T-021SL	SB-T1 (0-2')	6.3	6.0	ND (0.40)	ND (2.0)	30	24	7.0
95PRDA-T-022SL	Duplicate of 021	5.2	5.6	ND (0.35)	ND (1.7)	23	25	7.9
95PRDA-T-023SL	Triplicate of 021	NR	NR	NR	NR	NR	NR	NR
South of Disposal Area								
95PRDA-O-112SL	SB-O1 (6-8')	6.8	6.1	ND (0.26)	ND (2.6)	27	28	4.5
95PRDA-O-165SL	SB-O8 (5-8')	9.4	9.8	0.39	ND (1.4)	41	38	8.5
95PRDA-O-174SL	SB-O9 (9-12')	5.8	12	ND (0.30)	ND (0.60)	28	24	4.4
95PRDA-O-179SL	SB-O10 (6-9')	8.9	10	0.30	ND (1.5)	28	35	7.1
95PRDA-O-182SL	SB-O11 (6-9')	9.5	15	0.37	ND (1.5)	30	42	8.2
95PRDA-O-231SL	SB-O16 (15-18')	7.7	7.2	ND (0.28)	ND (1.4)	26	23	2.3
North of Disposal Area								
95PRDA-O-133SL	SB-O4 (3-6')	12	9.0	0.34	ND (3.0)	35	26	6.1
95PRDA-O-155SL	SB-O7 (0-3')	10	7.0	0.45	ND (2.8)	33	37	6.6
95PRDA-O-204SL	SB-O13 (12-15')	9.2	13	0.40	ND (1.5)	37	40	8.6
95PRDA-O-218SL	SB-O15 (12-15')	9.1	15	0.30	ND (1.5)	28	32	6.4
95PRDA-O-247SL	SB-O18 (18-20')	5.8	4.1	ND (0.27)	ND (0.54)	23	21	2.2
95PRDA-O-267SL	SB-O20 (12-22.5')	6.6	6.1	0.28	ND (1.4)	27	25	4.4
95PRDA-O-268SL	Duplicate of 267	7.4	7.4	ND (0.28)	ND (1.4)	24	23	3.8
95PRDA-O-269SL	Triplicate of 269	NR	NR	NR	NR	NR	NR	NR
95PRDA-O-270SL	SB-O20 (24-26')	7.3	6.9	ND (0.26)	ND (1.3)	23	28	5.3
95PRDA-O-295SL	MW-12 (22-24')	7.0	5.9	ND (0.29)	ND (1.4)	21	27	3.5
95PRDA-O-381SL	MW-16 (120.4-122)	11.0	4.6	ND (0.28)	ND (2.8)	18	20	3.7
95PRDA-O-385SL	MW-16 (156.4-163')	8.6	4.6	ND (0.27)	ND (2.7)	19	18	3.3
Average A-1, A-2 and Other Areas Concentration		8.3	8.6	0.26	1.0	29	30	6.0
Average Background Concentration		8.7	10.1	0.29	ND (1.7)	32.7	28.0	5.5

ND = Non Detect
( ) = Detection Limit

NR = Not yet received
* = Detection limit elevated due to matrix interference.

TABLE D-2
METALS ANALYSIS - SOILS (mg/kg)
AREAS A-1, A-2 AND OTHER AREAS
FORT RICHARDSON PRDA

Sample Number	Sample Location	Mercury EPA 7471	Nickel EPA 6010	Selenium EPA 7740	Silver EPA 6010	Thallium EPA 7841	Zinc EPA 6010
Area A-1							
95PRDA-A-064SL	SB-A2 (3.5-7')	0.19	36	ND (0.30)	ND (0.29)	ND (0.30)	70
95PRDA-A-084SL	SB-A5 (20.5-22.5')	ND (0.12)	41	ND (0.30)	ND (0.32)	ND (0.30)	49
Area A-2							
95PRDA-B-045SL	SB-B3 (7-10')	0.15	43	ND (0.32)	ND (0.30)	ND (0.32)	83
95PRDA-B-053SL	SB-B5 (3-6')	0.20	39	ND (0.29)	ND (0.31)	ND (0.29)	55
95PRDA-B-054SL	Duplicate of 053	0.14	43	ND (0.30)	ND (0.28)	ND (0.30)	65
95PRDA-B-055SL	Triplicate of 053	NR	NR	NR	NR	NR	NR
95PRDA-B-106SL	SB-B7 (6-9')	ND (0.12)	42	ND (0.31)	ND (0.32)	ND (0.32)	66
95PRDA-O-194SL	SB-O12 (15-18')	0.12	40	ND (0.27)	0.63	ND (0.27)	65
95PRDA-O-301SL	MW-13 (10-12')	ND (0.11)	43	ND (0.28)	0.58	ND (0.28)	45
Toe of Hill							
95PRDA-T-021SL	SB-T1 (0-2')	ND (0.16)	37	ND (0.41)	ND (0.40)	ND (0.41)	57
95PRDA-T-022SL	Duplicate of 021	ND (0.13)	30	ND (0.35)	ND (0.35)	ND (0.35)	58
95PRDA-T-023SL	Triplicate of 021	NR	NR	NR	NR	NR	NR
South of Disposal Area							
95PRDA-O-112SL	SB-O1 (6-8')	0.16	44	ND (0.27)	0.41	ND (0.27)	49
95PRDA-O-165SL	SB-O8 (5-8')	ND (0.11)	47	ND (0.31)	0.99	ND (0.31)	70
95PRDA-O-174SL	SB-O9 (9-12')	0.13	35	ND (0.28)	0.40	ND (0.28)	44
95PRDA-O-179SL	SB-O10 (6-9')	0.18	36	ND (0.30)	0.75	ND (0.30)	62
95PRDA-O-182SL	SB-O11 (6-9')	0.16	39	ND (0.29)	0.69	ND (0.29)	79
95PRDA-O-231SL	SB-O16 (15-18')	ND (0.11)	43	ND (0.30)	0.60	ND (0.30)	37
North of Disposal Area							
95PRDA-O-133SL	SB-O4 (3-6')	ND (0.11)	35	ND (0.31)	0.68	ND (0.31)	58
95PRDA-O-155SL	SB-O7 (0-3')	0.17	40	ND (0.28)	0.46	ND (0.28)	67
95PRDA-O-204SL	SB-O13 (12-15')	0.21	43	ND (0.28)	0.86	ND (0.28)	74
95PRDA-O-218SL	SB-O15 (12-15')	0.11	43	ND (0.30)	0.75	ND (0.30)	60
95PRDA-O-247SL	SB-O18 (18-20')	ND (0.10)	27	ND (0.27)	ND (0.27)	ND (0.27)	38
95PRDA-O-267SL	SB-O20 (12-22.5')	ND (0.10)	28	ND (0.26)	ND (0.28)	ND (0.28)	52
95PRDA-O-268SL	Duplicate of 267	0.13	26	ND (0.28)	0.34	ND (2.8) *	45
95PRDA-O-269SL	Triplicate of 269	NR	NR	NR	NR	NR	NR
95PRDA-O-270SL	SB-O20 (24-26')	0.11	22	ND (0.27)	0.54	ND (0.27)	53
95PRDA-O-295SL	MW-12 (22-24')	ND (0.11)	32	0.27	0.50	ND (0.27)	39
95PRDA-O-381SL	MW-16 (120.4-122)	ND (0.091)	16	ND (0.27)	ND (0.28)	ND (0.27)	45
95PRDA-O-385SL	MW-16 (156.4-163')	ND (0.092)	14	ND (0.29)	ND (0.27)	ND (0.29)	39
Average A-1, A-2 and Other Areas Concentration		0.11	36	0.15	0.41	0.15	56
Average Background Concentration		0.06	41	ND (0.28)	0.64	ND (0.28)	58

ND = Non Detect
NR = Not yet received
( ) = Detection Limit
* = Detection limit elevated due to matrix interference.

TABLE D-3
METALS ANALYSIS - SOILS (mg/kg)
AREAS A-3 AND A-4
FORT RICHARDSON PRDA

Sample Number	Sample Location	Antimony EPA 6010	Arsenic EPA 7060	Beryllium EPA 6010	Cadmium EPA 6010	Chromium EPA 6010	Copper EPA 6010	Lead EPA 6020
Area A-3								
95PRDA-C-009SL	SB-C1 (0-2')	7.7	6.0	ND (0.28)	ND (0.55)	29	31	8.7
95PRDA-C-010SL	SB-C1 (9-11')	6.2	5.8	ND (0.29)	ND (0.29)	27	22	5.4
95PRDA-C-011SL	SB-C1 (13-15')	7.2	4.0	ND (0.30)	ND (0.61)	23	22	5.3
95PRDA-C-013SL	SB-C2 (0-2')	7.4	8.3	ND (0.30)	ND (3.0)	25	33	12
95PRDA-C-014SL	SB-C2 (9-12')	9.8	7.9	0.32	ND (3.2)	32	35	13
95PRDA-C-015SL	SB-C2 (17-18')	6.8	5.9	ND (0.31)	ND (3.1)	29	27	5.6
95PRDA-C-017SL	SB-C3 (0-2')	8.1	6.8	ND (0.28)	ND (2.8)	31	28	5.9
95PRDA-C-019SL	SB-C3 (8-10')	8.2	7.1	ND (0.32)	ND (3.2)	33	32	4.6
95PRDA-O-316SL	MW-14 (18-20')	12	10	0.35	ND (2.8)	31	30	4.9
Area A-4								
95PRDA-D-001SL	SB-D1 (0-2')	10	9.2	0.39	ND (1.5)	39	48	17
95PRDA-D-002SL	SB-D1 (5-7')	13	11	0.38	ND (1.4)	51	190	160
95PRDA-D-003SL	SB-D1 (10-12')	12	9.6	0.37	ND (1.5)	49	130	39
95PRDA-D-005SL	SB-D2 (0-2')	9.3	9.0	0.30	ND (0.28)	30	57	25
95PRDA-D-007SL	SB-D2 (10-13')	8.0	8.9	ND (0.29)	ND (0.59)	29	37	11
Average A-3 and A-4 Concentration		9.0	7.8	0.24	0.9	33	52	22.7
Average Background Concentration		8.7	10.1	0.29	ND (1.7)	32.4	28	5.5

ND = Non Detect
( ) = Detection Limit

TABLE D-3
METALS ANALYSIS - SOILS (mg/kg)
AREAS A-3 AND A-4
FORT RICHARDSON PRDA

Sample Number	Sample Location	Mercury EPA 7471	Nickel EPA 6010	Selenium EPA 7740	Silver EPA 6010	Thallium EPA 7841	Zinc EPA 6010
Area A-3							
95PRDA-C-009SL	SB-C1 (0-2')	ND (0.11)	40	ND (0.29)	0.38	ND (0.29)	59
95PRDA-C-010SL	SB-C1 (9-11')	ND (0.10)	37	ND (0.30)	ND (0.29)	ND (0.30)	48
95PRDA-C-011SL	SB-C1 (13-15')	ND (0.11)	29	ND (0.29)	ND (0.30)	ND (0.29)	45
95PRDA-C-013SL	SB-C2 (0-2')	ND (0.11)	32	ND (0.29)	ND (0.30)	ND (0.29)	100
95PRDA-C-014SL	SB-C2 (9-12')	ND (0.11)	44	ND (0.29)	ND (0.32)	ND (0.29)	82
95PRDA-C-015SL	SB-C2 (17-18')	ND (0.11)	38	ND (0.30)	ND (0.31)	ND (0.30)	97
95PRDA-C-017SL	SB-C3 (0-2')	ND (0.11)	39	ND (0.28)	ND (0.28)	ND (0.28)	51
95PRDA-C-019SL	SB-C3 (8-10')	ND (0.11)	47	ND (0.29)	ND (0.32)	ND (0.29)	65
95PRDA-O-316SL	MW-14 (18-20')	ND (0.11)	46	ND (0.29)	0.97	ND (0.29)	100
Area A-4							
95PRDA-D-001SL	SB-D1 (0-2')	ND (0.10)	49	ND (0.28)	0.33	ND (1.4)	260
95PRDA-D-002SL	SB-D1 (5-7')	ND (0.11)	44	ND (0.30)	1.9	ND (3.0)	1000
95PRDA-D-003SL	SB-D1 (10-12')	ND (0.11)	44	ND (0.29)	1.7	ND (2.9)	650
95PRDA-D-005SL	SB-D2 (0-2')	0.58	36	ND (0.31)	0.49	ND (0.31)	390
95PRDA-D-007SL	SB-D2 (10-13')	0.17	34	ND (0.29)	0.51	ND (0.29)	110
Average A-3 and A-4 Concentration		0.10	39.9	0.15	0.35	0.34	218.4
Average Background Concentration		0.06	41	ND (0.28)	0.64	ND (0.28)	58

ND = Non Detect
( ) = Detection Limit

TABLE D-4
TOTAL METALS - GROUNDWATER FROM WELL POINTS (mg/L)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Antimony EPA 6010	Arsenic EPA 7060	Beryllium EPA 6010	Cadmium EPA 6010	Chromium EPA 6010	Copper EPA 6010	Lead EPA 7421
95PRDA-T-026GW	SB-T1	ND (0.1)	0.073	ND (0.01)	ND (0.025)	0.66	0.55	0.11
95PRDA-T-027GW	Duplicate of 026	ND (0.1)	0.038	ND (0.005)	ND (0.01)	0.28	0.26	0.054
95PRDA-T-028GW	Triplicate of 026	RI	RI	RI	RI	RI	RI	RI
95PRDA-B-051GW	SB-B4	0.095	0.066	0.0051	ND (0.025)	0.38	0.62	0.094
95PRDA-A-085GW	SB-A5	1.5	ND (0.05)*	0.093	ND (0.25)*	6.4	13	0.79
95PRDA-O-199GW	SB-O13	2.5	0.15	0.057	ND (0.5)*	7.5	12	0.89

Sample Number	Sample Location	Mercury EPA 7470	Nickel EPA 6010	Selenium EPA 7740	Silver EPA 6010	Thallium EPA 7841	Zinc EPA 6010
95PRDA-T-026GW	SB-T1	0.001	1	ND (0.01)*	ND (0.01)	ND (0.005)	1.4
95PRDA-T-027GW	Duplicate of 026	0.00064	0.42	ND (0.005)	ND (0.005)	ND (0.005)	0.57
95PRDA-T-028GW	Triplicate of 026	RI	RI	RI	RI	RI	RI
95PRDA-B-051GW	SB-B4	0.0019	0.66	ND (0.005)	ND (0.005)	ND (0.005)	0.93
95PRDA-A-085GW	SB-A5	0.072 J	19	ND (0.05)*	0.16	ND (0.005)	17
95PRDA-O-199GW	SB-O13	0.016	14	ND (0.05)*	0.25	ND (0.005)	13

Notes:
RI = Reported in RI report: not used in risk assessment
( ) = Reporting Limit
NR = Not yet received
* Detection limit elevated due to matrix interference.

TABLE D-5
TOTAL METALS - GROUNDWATER FROM MONITORING WELLS (mg/L)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Zone	Arsenic EPA 7060	Chromium EPA 6010	Copper EPA 6010	Lead EPA 7421	Nickel EPA 6010	Zinc EPA 6010
95PRDA-O-406GW	MW-1	D	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-397GW	MW-2	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-400GW	MW-3	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-405GW	MW-4	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	0.024
95PRDA-O-403GW	MW-5	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	0.02	ND (0.01)
95PRDA-O-404GW	MW-6	D	ND (0.005)	0.062	0.058	0.012	0.046	0.095
95PRDA-O-402GW	MW-7	D	0.012	0.086	0.024	0.0031	0.057	0.038
95PRDA-O-399GW	MW-8	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-390GW	MW-9	D	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	0.015
95PRDA-O-391GW	Duplicate of 390		ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-392GW	Triplicate of 390		RI	RI	RI	RI	RI	RI
95PRDA-O-393GW	MW-12	S	ND (0.005)	0.017	ND (0.01)	ND (0.003)	0.021	ND (0.01)
95PRDA-O-398GW	MW-13	S	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-401GW	MW-14	P	ND (0.005)	0.02	0.015	ND (0.003)	0.028	0.016
95PRDA-O-387GW	MW-15	S	ND (0.005)	0.018	ND (0.01)	ND (0.003)	0.012	ND (0.01)
95PRDA-O-388GW	Duplicate of 387		ND (0.005)	0.013	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-389GW	Triplicate of 387		RI	RI	RI	RI	RI	RI
95PRDA-O-407GW	MW-16	D	ND (0.005)	ND (0.01)	ND (0.01)	ND (0.003)	ND (0.01)	ND (0.01)
95PRDA-O-396GW	MW-17*	S	ND (0.005)	0.036	0.02	0.0037	0.037	0.027
Alaska MCL			0.05	0.1	1	0.05	0.1	5

D = deep aquifer
S = shallow aquifer
P = perched zone
ND = Non Detect
( ) = Reporting Limit
RI = Reported in RI report: not used in risk assessment
MCL = Maximum contaminant level for drinking water
* MW-17 is the background well.

TABLE D-6
DISSOLVED METALS - GROUNDWATER FROM MONITORING WELLS (mg/L)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Arsenic EPA 7060	Nickel EPA 6010	Zinc EPA 6010
95PRDA-O-406GW	MW-1	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-397GW	MW-2	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-400GW	MW-3	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-405GW	MW-4	ND (0.005)	ND (0.01)	0.023
95PRDA-O-403GW	MW-5	ND (0.005)	0.018	ND (0.01)
95PRDA-O-404GW	MW-6	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-402GW	MW-7	0.0071	ND (0.01)	ND (0.01)
95PRDA-O-399GW	MW-8	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-390GW	MW-9	ND (0.005)	ND (0.01)	0.068
95PRDA-O-391GW	Duplicate of 390	ND (0.005)	ND (0.01)	0.018
95PRDA-O-392GW	Triplicate of 390	RI	RI	RI
95PRDA-O-393GW	MW-12	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-398GW	MW-13	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-401GW	MW-14	ND (0.005)	0.015	ND (0.01)
95PRDA-O-387GW	MW-15	ND (0.005)	ND (0.01)	0.16
95PRDA-O-388GW	Duplicate of 387	ND (0.005)	ND (0.01)	0.091
95PRDA-O-389GW	Triplicate of 387	RI	RI	RI
95PRDA-O-407GW	MW-16	ND (0.005)	ND (0.01)	ND (0.01)
95PRDA-O-396GW	MW-17*	ND (0.005)	ND (0.01)	ND (0.01)
Alaska MCL		0.05	0.1	5

ND = Non Detect

RI = Reported in RI report: not used in risk assessment

( ) = Reporting Limit

* MW-17 is the background well.

TABLE D-7
METALS ANALYSIS - WETLAND SURFACE WATER (mg/L)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Copper EPA 6010	Lead EPA 7421	Nickel EPA 6010	Zinc EPA 6010
Wetlands					
95PRDA-W-332SW	SED-1	0.013	0.0057	0.014	0.064
95PRDA-W-334SW	Duplicate of 332	0.013	0.0041	0.019	0.055
95PRDA-W-336SW	Triplicate of 332	NR	NR	NR	NR
95PRDA-W-338SW	SED-2	0.099	0.0081	0.014	0.17
95PRDA-W-340SW	SED-3	ND (0.010)	0.0040	ND (0.010)	0.042
95PRDA-W-342SW	SED-4	ND (0.010)	0.0045	ND (0.010)	0.053
Background Wetlands					
95PRDA-U-348SW	SEDB-1	ND (0.010)	ND (0.0030)	ND (0.010)	0.047
95PRDA-U-350SW	Duplicate of 348	ND (0.010)	ND (0.0030)	ND (0.010)	0.027
95PRDA-U-352SW	Triplicate of 348	NR	NR	NR	NR
95PRDA-U-354SW	SEDB-2	ND (0.010)	ND (0.0030)	ND (0.010)	0.16
95PRDA-U-356SW	SEDB-3	ND (0.010)	ND (0.0030)	ND (0.010)	0.22
95PRDA-U-358SW	SEDB-4	ND (0.010)	ND (0.0030)	ND (0.010)	0.26
95PRDA-U-360SW	SEDB-5	ND (0.010)	ND (0.0030)	ND (0.010)	0.078
95PRDA-U-362SW	SEDB-6	ND (0.010)	ND (0.0030)	ND (0.010)	0.026
	Average Background	ND (0.010)	ND (0.0030)	ND (0.010)	0.117

Notes:
ND = Non Detect
( ) = Detection Limit
NR = Not yet received
No other metals analyzed for were detected above detection limits (antimony, arsenic, beryllium, cadmium, chromium, mercury, selenium, silver, and thallium)

TABLE D-8
METALS ANALYSIS - WETLANDS SEDIMENT (mg/kg)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Antimony EPA 6010	Arsenic EPA 7060	Beryllium EPA 6010	Cadmium EPA 6010	Chromium EPA 6010	Copper EPA 6010	Lead EPA 6020
Wetlands								
95PRDA-W-331SD	SED-1	ND (16)	ND (1.5)	ND (1.6)	ND (1.6)	6.0	17	ND (9.5)
95PRDA-W-333SD	Duplicate of 332	ND (16)	1.7	ND (1.6)	ND (1.6)	6.8	18	ND (9.3)
95PRDA-W-335SD	Triplicate of 332	NR	NR	NR	NR	NR	NR	NR
95PRDA-W-337SD	SED-2	ND (2.7)	1.4	ND (0.27)	ND (0.27)	1.2	4.5	ND (1.6)
95PRDA-W-339SD	SED-3	ND (15)	2.6	ND (1.5)	ND (1.5)	5.7	19	ND (9.1)
95PRDA-W-341SD	SED-4	ND (15)	3.5	ND (1.5)	ND (1.5)	6.4	12	ND (8.9)
Background Wetlands								
95RDA-U-347SD	SEDB-1	ND (12)	1.6	ND (1.2)	ND (1.2)	8.2	25	ND (7.3)
95RDA-U-349SD	Duplicate of 347	ND (11)	21	ND (1.1)	ND (1.1)	8.2	21	ND (6.5)
95RDA-U-351SD	Triplicate of 348	NR	NR	NR	NR	NR	NR	NR
95RDA-U-353SD	SEDB-2	ND (9.2)	1.5	ND (0.92)	ND (0.92)	5.4	18	ND (5.5)
95RDA-U-355SD	SEDB-3	ND (10)	3.7	ND (1.0)	ND (1.0)	21	17	ND (6.1)
95RDA-U-357SD	SEDB-4	7.1	5.5	ND (0.65)	ND (1.3)	34	28	6.2
95RDA-U-359SD	SEDB-5	8.7	5.5	ND (0.34)	ND (3.4)	25	13	7.1
95RDA-U-361SD	SEDB-6	ND (7.7)	1.7	ND (0.77)	ND (0.77)	4.7	11	4.8
Average Background Concentration		5.8	5.8	ND (0.85)	ND (1.4)	15.2	19.0	3.1

ND = Non Detect
( ) = Detection Limit
NR = Not yet received
Averages include NDs at half of the detection limit.

TABLE D-9
METALS ANALYSIS - WETLANDS SEDIMENT (mg/kg)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Mercury EPA 7471	Nickel EPA 6010	Selenium EPA 7740	Silver EPA 6010	Thallium EPA 7841	Zinc EPA 6010
Wetlands							
95PRDA-W-331SD	SED-1	ND (0.58)	3.8	ND (1.5)	ND (1.6)	ND (1.5)	14
95PRDA-W-333SD	Duplicate of 332	ND (0.53)	4.4	ND (1.5)	ND (1.6)	ND (1.5)	16
95PRDA-W-335SD	Triplicate of 332	NR	NR	NR	NR	NR	NR
95PRDA-W-337SD	SED-2	ND (0.49)	1.5	ND (1.3)	ND (0.54)	ND (1.3)	3.7
95PRDA-W-339SD	SED-3	ND (0.56)	5.8	ND (1.5)	ND (1.5)	ND (1.5)	20
95PRDA-W-341SD	SED-4	ND (0.54)	5.4	ND (1.5)	ND (1.5)	ND (1.5)	23
Background Wetlands							
95RDA-U-347SD	SEDB-1	ND (0.43)	4.9	ND (1.1)	ND (1.2)	ND (1.1)	27
95RDA-U-349SD	Duplicate of 347	ND (0.40)	5.6	ND (1.1)	ND (1.1)	ND (1.1)	29
95RDA-U-351SD	Triplicate of 348	NR	NR	NR	NR	NR	NR
95RDA-U-353SD	SEDB-2	ND (0.36)	3.4	ND (0.90)	ND (0.92)	ND (1.1)	11
95RDA-U-355SD	SEDB-3	ND (0.41)	9.6	1.3	ND (1.0)	ND (0.63)	26
95RDA-U-357SD	SEDB-4	ND (0.22)	16	ND (0.62)	ND (0.65)	ND (0.33)	79
95RDA-U-359SD	SEDB-5	ND (0.12)	18	ND (0.33)	0.39	ND (0.77)	37
95RDA-U-361SD	SEDB-6	ND (0.29)	3.5	ND (0.77)	ND (0.77)	ND (0.25)	9.5
Average Background Concentration		ND (0.32)	8.7	0.5	0.5	ND (0.75)	31.2

ND = Non Detect
( ) = Detection Limit
NR = Not yet received
Averages include NDs at half of the detection limit.

TABLE D-10
METALS ANALYSIS - WETLAND SURFACE WATER (mg/L)
FORT RICHARDSON PRDA

Sample Number	Sample Location	Copper EPA 6010	Lead EPA 7421	Nickel EPA 6010	Zinc EPA 6010
Wetlands					
95PRDA-W-332SW	SED-1	0.013	0.0057	0.014	0.064
95PRDA-W-334SW	Duplicate of 332	0.013	0.0041	0.019	0.055
95PRDA-W-336SW	Triplicate of 332	NR	NR	NR	NR
95PRDA-W-338SW	SED-2	0.099	0.0081	0.014	0.17
95PRDA-W-340SW	SED-3	ND (0.010)	0.0040	ND (0.010)	0.042
95PRDA-W-342SW	SED-4	ND (0.010)	0.0045	ND (0.010)	0.053
Background Wetlands					
95PRDA-U-348SW	SEDB-1	ND (0.010)	ND (0.0030)	ND (0.010)	0.047
95PRDA-U-350SW	Duplicate of 348	ND (0.010)	ND (0.0030)	ND (0.010)	0.027
95PRDA-U-352SW	Triplicate of 348	NR	NR	NR	NR
95PRDA-U-354SW	SEDB-2	ND (0.010)	ND (0.0030)	ND (0.010)	0.16
95PRDA-U-356SW	SEDB-3	ND (0.010)	ND (0.0030)	ND (0.010)	0.22
95PRDA-U-358SW	SEDB-4	ND (0.010)	ND (0.0030)	ND (0.010)	0.26
95PRDA-U-360SW	SEDB-5	ND (0.010)	ND (0.0030)	ND (0.010)	0.078
95PRDA-U-362SW	SEDB-6	ND (0.010)	ND (0.0030)	ND (0.010)	0.026
	Average Background	ND (0.010)	ND (0.0030)	ND (0.010)	0.117

Notes:
ND = Non Detect
( ) = Detection Limit
NR = Not yet received
No other metals analyzed for were detected above detection limits (antimony, arsenic, beryllium, cadmium, chromium, mercury, selenium, silver, and thallium)

APPENDIX E
TOXICITY ASSESSMENT AND EPA REGION 3 RBC TABLES

APPENDIX E
TOXICITY ASSESSMENT AND EPA REGION 3 RBC TABLES

This Appendix contains:

1. A discussion of sources of toxicity values used in risk assessment and the uncertainties associated with the toxicity values used by EPA Region 3 in calculating risk-based concentrations (RBCs) for ten key chemicals of concern (COCs) in groundwater (each of which are hazard/risk drivers likely to affect remediation decisions at the Poleline Road Disposal Area [PRDA]).
2. Tables containing RBC calculations for noncancer effects of carcinogens in groundwater and soil.
3. A copy of EPA Region 3 RBC tables (USEPA 1995a).

E1 SOURCES OF TOXICITY VALUES USED IN CALCULATING EPA REGION III RBCs

EPA guidance for risk assessment (USEPA 1989) recommends that the following hierarchy of sources be used to select appropriate toxicity values for risk assessment:

1. Integrated Risk Information System (IRIS) online database (USEPA 1996a)
2. Health Effects Assessment Summary Tables (HEAST) (USEPA 1995b)
3. National Center for Environmental Assessment (NCEA) provisional values

If no toxicity values are available from these three sources, the chemical is generally not evaluated quantitatively in risk assessment (although uncertainties associated with not evaluating the chemical may be assessed qualitatively).

EPA Region 3 uses the same hierarchy to select toxicity values for calculating RBCs, except that toxicity values from additional sources may be used when no toxicity values are available from IRIS, HEAST, or NCEA (USEPA 1995a). As a result of using additional sources for toxicity values not available from EPA-approved sources, more chemicals and routes of exposure are evaluated in the EPA Region 3 RBCs, although greater uncertainty is associated with RBCs based on non-standard sources of toxicity values.

For key COCs at the PRDA, the following additional sources of toxicity values were used in the calculation of EPA Region 3 RBCs:

- Values withdrawn from IRIS or HEAST
- Adoption of the oral reference dose (RfDo) for the inhalation exposure route (or vice versa)

The basis and reliability of toxicity values from these sources is discussed below.

E1.1 IRIS

IRIS is "the Agency's official repository of Agency-wide consensus chronic human health risk information" (USEPA 1995b). Toxicity evaluations reported in IRIS are conducted by EPA's Work Group Review process, i.e., they have been examined by either the Reference Dose/Reference Concentration (RfD/RfC) Work Group or the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group. Verification of a toxicity value for inclusion on IRIS indicates that available information has been examined by an EPA Work Group, the toxicity value has been calculated using current Work Group methodology, and a unanimous consensus has been reached on the value by the Work Group (USEPA 1995b). Toxicity values from IRIS are designated with an "i" in EPA Region 3 RBC tables.

E1.2 HEAST

Toxicity values in HEAST are considered to be provisional, but they are the most up-to-date values available from EPA. Each value in HEAST has undergone review and has the concurrence of individual EPA Program Offices, and each value is supported by an EPA reference. The risk assessment information has not, however, had enough review to be recognized as high quality, EPA-wide consensus information (USEPA 1995b). Therefore, provisional risk assessment information on HEAST is subject to possible review and revision by EPA Work Groups. Toxicity values from HEAST are designated with an "h" in EPA Region 3 RBC tables.

E1.3 HEAST Alternate Methods

These toxicity values on HEAST are also considered to be provisional and were calculated by alternative methods that are not currently practiced by EPA Work Groups. These values are considered to be adequate provisional values for risk assessment purposes, but are subject to review and revision by the Work Group to reflect current Work Group practices (USEPA 1995b). Toxicity values from HEAST alternate methods are designated with an “a” in EPA Region 3 RBC tables.

E1.4 NCEA Derived

EPA-NCEA’s Superfund Health Risk Technical Support Center derives interim toxicity values in response to site-specific requests from EPA Regional risk assessors and then distributes the values on an as-needed basis. EPA Region 3 includes NCEA-derived toxicity values in their RBC tables, but states: “There may be more interim values of which we are unaware. Also, we don’t receive automatic updates when NCEA revisits a contaminant, so it’s likely that some interim values in the RBC table are obsolete” (USEPA 1995a). Toxicity values NCEA are designated with an “e” in EPA Region 3 RBC tables.

E1.5 Values Withdrawn from IRIS or HEAST

Withdrawn toxicity values that were once present on either IRIS or HEAST but were removed are used in calculating some EPA Region 3 RBCs. Such withdrawal usually indicates that consensus on the toxicity value no longer exists among EPA scientists, but not that EPA believes the contaminant to be unimportant. Withdrawn toxicity values are indicated by “w” in EPA Region 3 RBC tables. EPA Region 3 states: “We take the position that for the purpose of screening an obsolete RBC is better than none at all. The ‘W’ code should serve as a clear warning that before making any serious decision involving the contaminant you will need to develop an interim value based on current scientific understanding” (USEPA 1995a). The oral cancer slope factor (SFo) used to calculated the tap water RBC for trichloroethylene (TCE) and its cancer classification were withdrawn from IRIS in 1989.

E1.6 Toxicity Values Adopted from a Different Exposure Route

In EPA Region 3 RBC tables, both oral and inhalation toxicity values were used in calculating tap water RBCs for volatile organic compounds. When only one (either oral or inhalation) toxicity value was available, then that value was used to represent both oral and inhalation toxicity in the RBC equation (USEPA 1995a). The use of oral toxicity values for the inhalation route (or vice versa) is <u>not</u> indicated on the EPA's Region 3 RBC tables.

SFo and SFi values were available for all ten key COCs, but nine of ten key COCs had only an RfDo or an RfDi. Adopting one noncancer toxicity value for another exposure route assumes that the oral dose in mg/kg-day that is safe (i.e., an RfDo) is approximately equal to the inhalation dose in mg/kg-day that is safe (i.e., the RfDi). There are many physiological reasons that this assumption may not be true, including:

- potential for different portal of entry effects based on route of exposure (ingested substances may directly affect the gastrointestinal tract and inhaled substances may directly affect the respiratory tract);
- different absorption rates (most substances are absorbed to a greater extent from the lungs than from the gastrointestinal tract); and,
- differences in metabolism (ingested substances are metabolized by the liver before reaching the bloodstream and target organs while inhaled substances pass directly into the bloodstream and to target organs).

Therefore, large uncertainty is associated with this approach and confidence in RBCs calculated using toxicity values for an exposure route other than that for which they were developed is low.

E2 UNCERTAINTY ASSOCIATED WITH TOXICITY VALUES USED IN DERIVATION OF RBCs

This section discusses the uncertainty associated with using EPA Region 3 RBCs to evaluate risk from exposure to key COCs (hazard/risk drivers) at PRDA. Key COCs consisted of ten VOCs in groundwater, selected because they had either hazard quotients of 1 or greater or chemical-specific cancer risks exceeding 1E-04:

- benzene
- carbon tetrachloride
- chloroform
- 1,1-dichloroethene (1,1-DCE)
- 1,1,2,2-tetrachloroethane
- 1,1,2-trichloroethane (1,1,2-TCA)
- tetrachloroethylene (PCE)
- trichloroethene (TCE)
- cis-1,2-dichloroethene (cis-1,2-DCE)
- trans-1,2-dichloroethene (trans-1,2-DCE)

Other COCs in groundwater had hazard quotients less than 1 and cancer risk of 4E-05 (4 in 100,000) or less. COCs in soil, sediments, or surface water at PRDA had hazard quotients less than 1 and cancer risk less of 1E-05 (1 in 100,000) or less. These COCs were not evaluated for uncertainty in this Appendix because, based on hazard/risk estimates, they are unlikely to drive remediation decisions at PRDA.

The basis for the derivation of cancer and noncancer tap water RBCs for the ten key COCs and the uncertainty associated with using the RBCs to evaluate hazard/risk are discussed below.

E2.1 RBCs for Cancer Effects

The following paragraphs discuss sources and uncertainties in SFs and cancer classification for the key COCs. The uncertainties could result in a significant overestimate of cancer risk for groundwater at this site. The impact of uncertainty on total risk estimates for groundwater is discussed in Section E2.1.4

E2.1.1 Benzene, Carbon Tetrachloride, and Chloroform

Tap water RBCs for carcinogenic effects of these compounds are based on verified SFo and SFi values from IRIS. The EPA cancer classification for benzene is A (human carcinogen) and for carbon tetrachloride and chloroform is B2 (probable human carcinogen) (USEPA 1996a).

E2.1.2 1,1-DCE, 1,1,2,2-Tetrachloroethane, and 1,1,2-TCA

Tap water RBCs for carcinogenic effects of these compounds are based on verified SFo and SFi values from IRIS. However, the EPA cancer classification for 1,1-DCE, 1,1,2,2-tetrachloroethane, and 1,1,2-TCA is C, possible human carcinogen, based on limited cancer data in animals (data for human carcinogenicity is inadequate or does not exist) (USEPA 1996a). The International Agency for Research on Cancer (IARC) classifies 1,1-DCE, 1,1,2,2-tetrachloroethane, and 1,1,2-TCA as Group 3, "not classifiable as to carcinogenicity in humans" (ATSDR 1995a,b). Therefore, cancer risk associated with these compounds may be overestimated because they may not be human carcinogens.

E2.1.2 PCE

The tap water RBC for carcinogenic effects of PCE is based on provisional SFo and SFi values derived by NCEA (USEPA 1996b). Therefore, these SFs are not supported by EPA-wide consensus and are subject to review and revision by EPA Work Groups. No cancer classification for PCE is available from IRIS (USEPA 1996a). EPA's Science Advisory Board (SAB) has suggested that the weight-of-evidence cancer classification for PCE is on the C-B2 continuum based on carcinogenicity in animals and that PCE should be considered a possible human carcinogen, pending final Work Group evaluation (USEPA 1996b). IARC classifies PCE as 2B, possibly carcinogenic (ATSDR 1995c). Woodward-Clyde (1995) examined the possible mechanisms of tumor formation observed in animals exposed to PCE and reported that the tumors observed may have little relevance for humans. Therefore, cancer risk associated with PCE may be overestimated because it may not be a human carcinogen.

E2.1.3 TCE

The tap water RBC for carcinogenic effects of TCE is based on a SFo withdrawn from IRIS and a provisional SFi value derived by NCEA (EPA 1995c). Therefore, these toxicity values are subject to review and possible revision by EPA Work Groups. In 1989, EPA removed the carcinogenicity rating of TCE from IRIS pending further review. IARC classified PCE as Group 3, "not classifiable as to carcinogenicity in humans," and ATSDR (1995d) concluded that weight of evidence suggests that TCE, though a carcinogen in rodents, may not be carcinogenic in humans. The American Conference of Governmental Industrial Hygienists (ACGIH) has placed TCE in Category A5 (Not Suspected as a Human Carcinogen) (ACGIH 1995). Therefore, there is large uncertainty in cancer risk estimates for TCE because it may not be a human carcinogen.

E2.1.4 Magnitude of Uncertainty in Cancer Risk Estimates for Key COCs

The largest source of uncertainty in cancer risk estimates for exposure to key COCs in groundwater is the assumption that 1,1-DCE, 1,1,2,2-tetrachloroethane, 1,1,2-TCA, PCE, and TCE are each potent human carcinogens, when they may not be carcinogenic to humans at all. These compounds contributed 99.8 percent of total cancer risk estimates in the shallow and deep aquifers (1,1,2,2-tetrachloroethane alone contributed greater than 98% of total cancer risk in groundwater). Total cancer risk estimates for residential use of shallow groundwater decreased from 3E-01 to 5E-04 and for use of deep groundwater decreased from 4E-02 to 1E-04 when only probable and known human carcinogens are evaluated in the assessment (calculations not shown). Therefore, the exclusion of class C carcinogens from risk calculations does not change the overall conclusions of the risk assessment that unacceptable cancer risk is predicted from residential exposure to groundwater at PRDA.

E2.2 RBCs for Noncancer Effects

The following paragraphs discuss sources and uncertainties in RfDs for the key COCs. The uncertainties could result in an overestimate of noncancer hazard index for groundwater at this site. The impact of uncertainty on noncancer hazard index for groundwater is discussed in Section E2.2.4.

E2.2.1 Benzene

No RfDo value was available for benzene and the RfDi value was used to evaluate toxicity by both oral and inhalation routes in calculating the tap water RBC. Some uncertainty is associated with this approach because it predicts a hazard for an exposure route (oral) for which there is no EPA toxicity value. However, the magnitude of uncertainty is difficult to assess.

E2.2.2 Carbon Tetrachloride

The tap water RBC for noncarcinogenic effects of carbon tetrachloride was based on a verified RfDo from IRIS and a provisional RfDi (derived by NCEA); therefore, the RfDi value is subject to review and possible revision by EPA Work Groups.

E2.2.3 Chloroform, 1,1-DCE, PCE, 1,1,2-TCA, TCE, cis-1,2-DCE, and trans-1,2-DCE

No RfDi values are available for these compounds and the RfDo values were used to evaluate toxicity by both oral and inhalation routes in calculating tap water RBCs. Large uncertainty is associated with this approach because it predicts a hazard for an exposure route (inhalation) for which there are no EPA toxicity values; therefore, confidence in these RBCs is low. Tap water RBCs for these COCs calculated using RfDo values for only the oral route of exposure are about six-fold larger (and estimated hazard quotients using these RBCs are about six-fold smaller) than for tap water RBCs calculated using RfDo values for the oral and inhalation routes (calculations not shown). Therefore, use of Region 3 RBCs in this risk assessment may have overestimated potential noncancer hazard to human health from exposure to these COCs in groundwater at PRDA, but the magnitude of uncertainty is difficult to judge in the absence of inhalation toxicity information.

For the following chemicals, the noncancer tap water RBCs were calculated based on RfDo values that are subject to future revision by EPA Work Groups:

- TCE (interim value derived by NCEA)
- cis-1,2-DCE (provisional value from HEAST)
- 1,1-DCE (verified RfDo is currently under review, USEPA 1996a)

E2.2.4 Magnitude of Uncertainty in Noncancer Hazard Estimates for Key COCs

The largest source of uncertainty in the noncancer hazard index estimates derives from using the RfDo value to evaluate toxicity by both oral and inhalation routes in calculating tap water RBCs for chloroform, 1,1-DCE, PCE, 1,1,2-TCA, TCE, cis-1,2-DCE, and trans-1,2-DCE. These compounds contribute approximately 95% of total hazard index estimates in the shallow and deep aquifers. The total hazard index decreases from 200 to 30 for the shallow zone and from 25 to 4 for the deep aquifer when RBCs for these COCs were calculated for only the oral route of exposure (calculations not shown). Even the lower values exceed the level of potential concern (HI>1). Therefore, the uncertainties regarding inhalation toxicity for these compounds does not change the overall conclusion of the risk assessment that residential use of groundwater at PRDA could pose an unacceptable noncancer threat to human health.

E3 EFFECT OF UNCERTAINTY ON RISK ASSESSMENT

A toxicity assessment evaluating the uncertainty associated with using Region 3 RBCs to evaluate hazard/risk in this risk assessment was performed for the COCs that contribute most to overall risk at the PRDA (ten VOCs in groundwater). COCs in soil, sediments, or surface water were not evaluated for uncertainty in this Appendix because hazard/risk estimates were low (they did not exceed unacceptable levels) and they are not likely to affect remediation decisions.

Total cancer risk estimates for residential use of groundwater onsite were 3E-01 (shallow zone) and 4E-02 (deep aquifer). These values may overestimate actual risk because the following key COCs in groundwater (contributing to 99.8% of total cancer risk estimates) are class C carcinogens and may not be carcinogenic in humans:

- 1,1-DCE
- 1,1,2,2-tetrachloroethane
- 1,1,2-TCA
- PCE
- TCE

However, cancer risk estimates for residential exposure to groundwater still exceeded 1E-04 when only probable human carcinogens were evaluated in the assessment (i.e., carbon tetrachloride, chloroform, 1,2 dichloroethene) and known (benzene, vinyl chloride). Chemical-specific cancer risks are shown in Appendix B. Therefore, the conclusion of the risk assessment (that unacceptable cancer risk is predicted from residential use of groundwater at PRDA) is the same whether class C carcinogens are included or excluded from the assessment.

Total hazard index estimates for residential use of groundwater may have been overestimated because the RfDo value was used to evaluate toxicity by both oral and inhalation routes in calculating tap water RBCs for the following key COCs:

- chloroform
- 1,1-DCE
- 1,1,2,2-tetrachloroethane
- 1,1,2-TCA
- TCE
- cis-1,2-DCE
- trans-1,2-DCE

However, total noncancer hazard index for residential exposure groundwater still exceeded 1 when tap water RBCs for these COCs were calculated for only the oral route of exposure (calculations not shown). Therefore, the overall conclusion of the risk assessment that residential use of groundwater at PRDA could pose an unacceptable noncancer threat to human health is not affected by the uncertainty in the assessment of inhalation toxicity for these compounds.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1995a. Toxicological Profile for 1,1-Dichloroethene. Update (Draft). Division of Toxicology, ATSDR. Atlanta, GA. August.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995b. Toxicological Profile for 1,1,2,2-Tetrachloroethane. Update (Draft). Division of Toxicology, ATSDR. Atlanta, GA. August.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995c. Toxicological Profile for Tetrachloroethene. Update (Draft). Division of Toxicology, ATSDR. Atlanta, GA. August.

Agency for Toxic Substances and Disease Registry (ATSDR). 1995d. Toxicological Profile for Trichloroethylene. Update (Draft). Division of Toxicology, ATSDR. Atlanta, GA. August.

American Conference of Governmental Industrial Hygienists (ACGIH). 1995. 1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual. EPA 54011-891002.

U.S. Environmental Protection Agency (USEPA). 1993. Risk Assessment Issue Paper for: Carcinogenicity Information for Trichloroethylene (TCE) (CASRN 79-01-6). Environmental Criteria and Assessment Office (ECAO). Cincinnati, OH.

U.S. Environmental Protection Agency (USEPA). 1995a. Risk-Based Concentration Table, (July to December 1995). Technical Support Section, U.S. EPA Region 3. Philadelphia, PA. October.

U.S. Environmental Protection Agency (USEPA). 1995b. Health Effects Assessment Summary Table (HEAST) - Annual Plus Supplements 1 and 2. Environmental Criteria and Assessment Office, Office of Research and Development. Cincinnati, OH.

U.S. Environmental Protection Agency (USEPA). 1996a. Integrated Risk Information Systems (IRIS). On-line database.

U. S. Environmental Protection Agency (USEPA). 1996b. Risk Assessment Issue Paper For: Carcinogenicity Information for Tetracholoroethylene (perchloroethylene, PERC) (CASRN 127-18-4). National Center for Environmental Assessment (NCEA), Cincinnati, OH. June.

Woodward-Clyde. 1995. Draft Toxicity Profile for Perchloroethylene (Tetrachloroethylene) Genotoxicity. AGS Woodward-Clyde Pty Limited. St. Leonards, New South Wales. July.

TABLE E-1
CALCULATION OF RBCs FOR NONCANCER EFFECTS OF CARCINOGENS IN SOIL

Chemical of Concern	RfDo	Residential RBC	Industrial RBC
Chloroform	1.00E-02	7.8E+02	2.0E+04
Tetrachloroethene	1.00E-02	7.8E+02	2.0E+04
1,1,2-Trichloroethane	4.00E-03	3.1E+02	8.2E+03
Trichloroethene	6.00E-03	4.7E+02	1.2E+04
2,4,6-Trinitrotoluene	5.00E-04	3.9E+01	1.0E+03

Residential RBC: RBC = (THQ * RfDo * BWc * ATn)/(EFr * EDc * IRSc/CF)
Industrial RBC: RBC = (THQ * RfDo * BWa * ATn)/(EFo * EDo * FC * IRSa/CF)
where:

Risk-Based Concentration	RBC	=	chemical specific	mg/kg
Target Hazard Quotient	THQ	=	1	unitless
Body weight, Adult	BWa	=	70	kg
Body weight, Children	BWc	=	15	kg
Averaging Time, Occupational	ATn	=	9125	days
Averaging Time, Residential	ATn	=	2190	days
Exposure Frequency, Occupational	EFo	=	250	days/year
Exposure Frequency, Residential	EFr	=	350	days/year
Exposure Duration, Child	EDc	=	6	years
Exposure Duration, Occupational	EDo	=	25	years
Reference Dose, Oral	RfDo	=	chemical specific	mg/kg-day
Soil Ingestion, age 1-6	IRSc	=	200	mg/day
Soil ingestion, adult	IRSa	=	100	mg/day
Fraction Contaminated	FC	=	0.5	unitless
Conversion factor	CF	=	1.00E+06	mg/kg

TABLE E-2
CALCULATION OF RBCs FOR NONCANCER EFFECTS OF CARCINOGENS IN GROUNDWATER

1	2	3	4	5	6	7	8	9	10
Chemical of Concern	**Volatile?**	**RfDo**	**RfDi**	**THQ*BWa *ATn**	**EF * ED**	**K*IRa/RfDi**	**IRw/RfDo**	**Col 7 + Col 8**	**RBC=Col5/ (Col6*Col9)**
Benzene	Yes	(1)	1.71E-03	7.67E+05	1.05E+04	5.85E+03	1.17E+03	7.02E+03	1.04E-02
Carbon Tetrachloride	Yes	7.00E-04	5.71E-04	7.67E+05	1.05E+04	1.75E+04	2.86E+03	2.04E+04	3.58E-03
Chloroform	Yes	1.00E-02	(2)	7.67E+05	1.05E+04	1.00E+03	2.00E+02	1.20E+03	6.08E-02
1,4-Dichlorobenzene	Yes	(1)	2.29E-01	7.67E+05	1.05E+04	4.37E+01	8.73E+00	5.24E+01	1.393E+00
1,2-Dichloroethane	Yes	(1)	2.86E-03	7.67E+05	1.05E+04	3.50E+03	6.99E+02	4.20E+03	1.74E-02
1,1-Dichloroethene	Yes	9.00E-03	(2)	7.67E+05	1.05E+04	1.11E+03	2.22E+02	1.33E+03	5.48E-02
Hexachloroethane	Yes	1.00E-03	(2)	7.67E+05	1.05E+04	1.00E+04	2.00E+03	1.20E+04	6.08E-03
RDX	No	3.00E-03	NA	7.67E+05	1.05E+04	NA	6.67E+02	NA	1.095E-01
Tetrachloroethene	Yes	1.00E-02	(2)	7.67E+05	1.05E+04	1.00E+03	2.00E+02	1.20E+03	6.083E-02
1,1,2-Trichloroethane	Yes	4.00E-03	(2)	7.67E+05	1.05E+04	2.50E+03	5.00E+02	3.00E+03	2.433E-02
Trichloroethene	Yes	6.00E-03	(2)	7.67E+05	1.05E+04	1.67E+03	3.33E+02	2.00E+03	3.650E-02

(1) An RfDo was not available; therefore the RFDo value was assumed to equal the RfDi.
(2) An RfDi was not available; therefore the RfDi value was assumed to equal the RfDo.
NA - Not applicable because equation for calculation of RBCs for nonvolatiles does not include RfDi

Equation for nonvolatiles: RBC = (THQ * BWa* ATn)/((EFr * EDtot) * (IRWa/RfDo))
Equation for volatiles: RBC = (THQ * BWa* ATn)/((EFr * EDtot) * ((K * IRAa/RfDi) + (IRWa/RfDo)))
where:

Risk-Based Concentration	RBC	=	chemical specific	mg/L
Target Hazard Quotient	THQ	=	1	unitless
Body weight, Adult	BWa	=	70	kg
Averaging Time, Noncarcinogen	ATn	=	10950	days
Exposure Frequency, Residential	EFr	=	350	days
Exposure Duration, Residential	EDtot	=	30	years
Volatilization Factor	K	=	0.5	L/m3
Inhalation, Adult	IRAa	=	20	m3/day
Reference Dose, Inhalation	RfDi	=	chemical specific	mg/kg-day
Tap Water Ingestion, Adult	IRWa	=	2	L/day
Reference Dose, Oral	RfDo	=	chemical specific	mg/kg-day

ATTACHMENT E1
EPA REGION 3 RBC TABLES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region III
841 Chestnut Street
Philadelphia, Pennsylvania 19107

October 20, 1995

SUBJECT: Risk-Based Concentration Table, July - December 1995

FROM: Roy L. Smith, Ph.D.
Office of RCRA
Technical & Program Support Branch (3HW70)

TO: RBC Table mailing list

Attached is the EPA Region III risk-based concentration (RBC) table, which we distribute semi-annually to all interested parties.

IMPORTANT MESSAGE

EPA Region III has established a homepage on the World Wide Web which you can find at http://earth1.epa.gov:80/ or http://www.epa.gov/. Our homepage will soon include the RBC table in downloadable form. We strongly encourage all RBC table users having Internet access to obtain the table electronically rather than on paper. In this way, users can obtain the most current issue immediately in a form that can be used directly as input for risk assessment calculations. This distribution method will also save large amounts of paper and cost substantially less.

For those lacking Internet access, it's once again time to re-register to receive a paper copy of the RBC table. We need to hear from you periodically to ensure that you still have an interest and that we have your correct address. Please fax your registration request to Vanessa Sizer at 215-597-9890, including your name, address, and phone number. Please don't phone to re-register; we need hard copy to document your continued interest. If we don't hear from you by March 30, 1996, we'll assume you no longer need a paper copy. Thanks for your cooperation.

CONTENTS, USES, AND LIMITATIONS OF THE RBC TABLE

The table contains reference doses and carcinogenic potency slopes (obtained from IRIS through September 1, 1995, HEAST through May 1995, the EPA-NCEA Superfund Health Risk Technical Support Center, and other EPA sources) for nearly 600 chemicals. These toxicity constants have been combined with "standard" exposure scenarios to calculate RBCs--chemical concentrations corresponding to fixed levels of risk (*i.e.*, a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration) in water, air, fish tissue, and soil.

The RBC table also includes soil screening levels (SSLs) for protection of groundwater and air. Most SSLs were obtained directly from EPA/OSWER's proposed SSL guidance document, to which we have added some additional SSLs based on the same methodology. Sources of SSLs are noted in the table. SSLs incorporate the same exposure assumptions as RBCs, plus additional assumptions needed for inter-media extrapolation. SSLs are therefore distinct from RBCs, and should be used only in the framework proposed in the OSWER document (available from NTIS as document numbers 9355.4-1, PB95-965530, or EPA540/R-94/105).

The Region III toxicologists use RBCs to screen sites not yet on the NPL, respond rapidly to citizen inquiries, and spot-check formal baseline risk assessments. The background materials provide the complete basis for all the calculations, with the intent of showing users exactly how the RBCs were developed. Simply put, RBCs are risk assessments run in reverse. For a single contaminant in a single medium, under standard default exposure assumptions, the RBC corresponds to the target risk or hazard quotient.

RBCs also have several important limitations. Specifically excluded from consideration are (1) transfers from soil to air and groundwater, and (2) cumulative risk from multiple contaminants or media. Also, the toxicity information in the table has been assembled by hand, and (despite extensive checking and years of use) may contain errors. It's advisable to cross-check before relying on any RfDs or CPSs in the table. If you find any errors, please send me a note.

Many users want to know if the risk-based concentrations can be used as valid no-action levels or cleanup levels, especially for soils. The answer is a bit complex. First, it is important to realize that the RBC table does not constitute regulation or guidance, and should not be viewed as a substitute for a site-specific risk assessment. For sites where:

1. A single medium is contaminated;
2. A single contaminant contributes nearly all of the health risk;
3. Volatilization or leaching of that contaminant from soil is expected not to be significant;
4. The exposure scenarios used in the RBC table are appropriate for the site;
5. The fixed risk levels used in the RBC table are appropriate for the site; and
6. Risk to ecological receptors is expected not to be significant;

the risk-based concentrations would probably be protective as no-action levels or cleanup goals. However, to the extent that a site deviates from this description, as most do, the RBCs would not necessarily be appropriate.

To summarize, the table should generally not be used to (1) set cleanup or no-action levels at CERCLA sites or RCRA Corrective Action sites, (2) substitute for EPA guidance for preparing baseline risk assessments, or (3) determine if a waste is hazardous under RCRA.

ANSWERS TO FREQUENTLY ASKED QUESTIONS

To help you better understand the RBC table, here are answers to our most often-asked questions:

1. How can the age-adjusted inhalation factor (11.66) be less than either the inhalation rate for a child (12) or for an adult (20)?

Age-adjusted factors are not intake rates, but rather partial calculations which have different units than intake rates do. The fact that these partial calculations have values similar to intake rates is really coincidental, an artifact of the similar magnitude of years of exposure and time-averaged body weight.

2. Why does arsenic appear in the RBC table separately as a carcinogen and a non-carcinogen, while other contaminants do not?

Arsenic is double-entered to ensure that the risk assessor realizes that non-carcinogenic concerns are significant for arsenic. Otherwise, one might be tempted to accept a 1e-4 risk (37 ppm in residential soil), when the oral reference dose would be exceeded at 23 ppm.

Also, EPA has a little-known risk management policy for arsenic (dating from 1988) that suggests that arsenic-related cancer risks of up to 1e-3 can be accepted because the cancers are squamous cell carcinomas with a low mortality rate. Thus, noncarcinogenic RBCs represent an important limitation on acceptable arsenic concentrations.

3. Many contaminants have no inhaled reference dose or carcinogenic potency slope in IRIS, yet these numbers appear in the RBC table with IRIS given as the source. Where did the numbers come from?

Most inhaled reference doses and potency slopes in the RBC table are converted from reference concentrations and unit risk values which do appear in IRIS. These conversions assume 70-kg persons inhaling 20 m^3/d. For example, the inhalation unit risk for arsenic (4.3e-3 risk per $\mu g/m^3$) is divided by 20 m^3/d and multiplied by 70 kg times 1000 μg/mg, yielding a CPSi of 15.1 risk per mg/kg/d.

4. Why does the RBC table base soil RBCs for cadmium and manganese on reference doses that apply only to drinking water?

The RBC table's use of the drinking water RfDs for cadmium and manganese reflects (1) the limited space available in the already-crowded table, and (2) the intended use of the table as a screening tool rather than a source of cleanup levels (thereby making false positives acceptable). For a formal risk assessment, Region III would use the food RfDs for soil ingestion.

At this time, only two substances (as far as we know) have distinct oral RfDs for water and food--cadmium and manganese. Adding the two food RfDs to the table would require an entire column, which would be about 99.9% blank. The table has become so crowded that it would be difficult to accommodate another column. Also, we^ve given this problem a relatively low priority because the table's primary purpose is to identify environmental problems needing further study. RBCs were never intended for uncritical use as cleanup levels, merely to identify potential problems which need a closer look.

5. What is the source of the child inhalation rate of 12 m3/d?

The calculation comes from basic physiology. It's a scaling of the mass-specific 20 m3/d rate for adults from a body mass of 70 kg to 15 kg, using the 2/3 power of mass, as follows:

Let: IRcm = mass-specific child inhalation rate (m3/kg/d)
IRc = child inhalation rate (m3/d)

$20 \text{ m3/d} \div 70\text{kg} = 0.286 \text{ m3/kg/d}$ (mass-specific adult inhalation rate)

$0.286 \text{ m3/kg/d} \times (70^{.67}) = (\text{IRcm}) \times (15^{.67})$

$\text{IRcm} = (0.286) \times (70^{.67}) \div (15^{.67}) = 0.286 \times 2.807 = 0.803 \text{ m3/kg/d}$

$\text{IRc} = \text{IRcm} \times 15\text{kg} = 0.803 \text{ m3/kg/d} \times 15\text{kg} = 12.04 \text{ m3/d}$

A short (but algebraically equivalent) way to do the conversion:

$20 \times (15 \div 70)^{.333} = 11.97$ (different from, but actually more correct than, 12.04 because of rounding error in the long form).

6. Can the oral RfDs in the RBC table be applied to dermal exposure?

Not directly. EPA's Office of Research and Development is working on dermal RfDs for some substances, but has not yet produced any final values. When dermal RfDs do appear, they will undoubtedly be based on absorbed dose rather than administered dose. Oral RfDs are (usually) based on administered dose and therefore tacitly include a GI absorption factor. Thus, any use of oral RfDs in dermal risk calculations would have to involve removing this absorption factor.

*7. The exposure variables table in the RBC background document lists the averaging time for non-carcinogens as "ED*365". What does that mean?*

ED is exposure duration, in years. Multiplying ED by 365 simply converts the duration to days. In fact, the ED term is included in both the numerator and denominator of the RBC algorithms for non-cancer risk, canceling it altogether. We expressed the algorithm this way to allow users to realize this. The total exposure is really corrected only by EF (days exposed per year) divided by 365. (Note that this explanation applies to noncarcinogenic risk only; for carcinogens, exposure is pro-rated over the number of days in a 70-year life span.)

8. Why is inorganic lead not included in the RBC table?

The reason lead is missing from the RBC table is simple, and fundamental: EPA has no reference dose or potency slope for inorganic lead, so it wasn't possible to calculate risk-based concentrations. EPA considers lead a special case because:

(1) Lead is ubiquitous in all media, so human exposure comes from multiple sources. Comparing single-medium exposures with a reference dose would be misleading.

(2) If EPA did develop a reference dose for lead by the same methods other reference doses, we would probably find that most people already exceed it. Since EPA already knows this and is moving aggressively to lower lead releases nationally, such findings at individual sites would be irrelevant and unduly alarming.

(3) EPA decided to take a new approach to separate important lead exposures from trivial ones. EPA developed a computer model (the IEUBK model) which predicts children's blood lead concentrations using lead levels in various media as inputs. The idea is to evaluate a child's entire environment, and reduce lead exposures in the most cost-effective way.

On the practical side, there are several EPA policies which effectively substitute for RBCs. The EPA Office of Solid Waste has released a detailed directive on risk assessment and cleanup of residential soil lead. The directive recommends that soil lead levels less than 400 ppm be considered safe for residential use. Above that level, the document suggests collecting certain types of data and modeling children's blood lead with the IEUBK model. For the purposes of the RBC table, the de facto residential soil number would be 400 mg/kg. For water, we suggest 15 ppb (from the national EPA Action Level), and for air, the National Ambient Air Quality Standard.

9. Where did the potency slopes for carcinogenic PAHs come from?

The source of the potency slopes for PAHs is "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons", Final Draft, EPA Environmental Criteria and Assessment Office, Cincinnati, OH. It's available from NTIS as document number ECAO-CIN-842 (March, 1993). The slopes are expressed in terms of order-of-magnitude equivalence factors relating the compounds to benzo[a]pyrene; we have converted these TEQs to potency slopes to fit the format of the table.

10. May I please have a copy of the January 1991 RBC table?

We're sorry, but no. The RBC table doesn't represent regulation or guidance, so past issues should have no legal importance. Each time we update the table we destroy all obsolete copies, electronic and paper. We do this to ensure that only one set of RBCs, that based on current information, exists at any time.

11. I've noticed that some soil RBCs are 1 million parts per million. Since some of these substances are liquids, that's obviously ridiculous. What is that basis for these calculations?

A soil RBC of 1 million parts per million means that no amount of the contaminant in soil will cause a receptor to exceed the oral reference dose by incidental ingestion of soil. In fact, some contaminants would have RBCs of more than 1 million ppm, but the algorithms cap concentrations at 100%. The reason we retain these admittedly impossible numbers is to let users see that the contaminant is not a threat via soil ingestion.

However, it's important to realize that the RBC calculations do not consider the potential of soil contaminants to leach to groundwater or escape to air by volatilization or dust entrainment. To consider these inter-media transfers, it's necessary to either monitor air and groundwater, or to use a model. Measured or modeled air and groundwater concentrations should then be compared to the RBCs for air and tap water.

We have begun to incorporate inter-media transfers into the RBC table in the form of soil screening levels (SSLs). However, EPA Headquarters has proposed only about a hundred SSLs so far, so the list is still rather short.

12. Please elaborate on the meaning of the 'W' source code in the table.

The "W" code means that a reference dose or potency slope for a contaminant is currently not present on either IRIS or HEAST, but that it once was present on either IRIS or HEAST and was removed. Such withdrawal usually indicates that consensus on the number no longer exists among EPA scientists, but not that EPA believes the contaminant to be unimportant. Older versions of the RBC table had separate codes for IRIS and HEAST withdrawals, but we changed to a single code for both because, after all, it hardly matters.

We retain withdrawn numbers in the table because we still need to deal with these contaminants during the sometimes very long delays before replacement numbers are ready. We take the position that for the purpose of screening an obsolete RBC is better than none at all. The 'W' code should serve as a clear warning that before making any serious decision involving that contaminant you will need to develop an interim value based on current scientific understanding.

If you are assessing risks at a site where a major contaminant is coded "W", consider working with your Regional EPA risk assessor to develop a current toxicity constant. If the site is being studied under CERCLA, the EPA-NCEA Regional Technical Support group may be able to assist.

13. Can I get copies of supporting documents for interim toxicity constants which are coded "E" in the RBC table?

Unfortunately, Region 3 does not have a complete set of supporting documents. The EPA-NCEA Superfund Health Risk Technical Support Center prepares these interim toxicity constants in response to site-specific requests from Regional risk assessors, and sends the documentation only to the requestor. The RBC tables contain only the interim values (those with "E" codes) that we've either requested ourselves or otherwise obtained copies of. There may be many more interim values of which we are unaware. Also, we don't receive automatic updates when NCEA revisits a contaminant, so it's likely that some interim values in the RBC table are obsolete.

It has been NCEA's policy to deny requests for documentation of interim toxicity constants. Although Region 3 has sometimes provided this documentation on request, for the above-stated reasons we have no assurance that the documentation, or even the interim numbers, are current. We've decided to discontinue distributing information that may be misleading. If one of the "E"-coded contaminants is a major risk contributor at your site, we strongly suggest that you work with EPA to develop an up-to-date reference dose or slope factor.

CHANGES IN THIS ISSUE OF THE RBC TABLE

New or revised EPA toxicity constants are now marked with "**" before the contaminant name. This is to help users quickly pick out substances with new RBCs. Formerly these contaminants were printed in underlined boldface type that copied badly. A new basis code, "M" for MCL, has been added to the upper right corner of each page. This code denotes soil screening levels for groundwater protection that are based on EPA Maximum Contaminant Levels.

If you want to raise issues or get answers to questions about the RBC table, please call the Technical Support Help Line at 215-597-1116. The line has a voice mail system to take your calls if we're not available. We'll return your call as soon as we can. Please limit calls to RBC issues; if you have a question about applying RBCs to a site, please call the EPA Regional office handling the project. Thanks for your help and cooperation, and we hope the RBC table continues to be a useful resource.

Attachment

EPA Region III Risk-Based Concentration Table

Background Information

EPA

Roy L. Smith, Ph.D.
Toxicologist
October 4, 1995

Development of Risk-Based Concentrations

General

Separate carcinogenic and non-carcinogenic risk-based concentrations were calculated for each compound for each pathway. The concentration in the table is the lower of the two, rounded to two significant figures. The following terms and values were used in the calculations:

Exposure variables	**Value**	**Symbol**
General:		
Carcinogenic potency slope oral (risk per mg/kg/d):	*	CPSo
Carcinogenic potency slope inhaled (risk per mg/kg/d):	*	CPSi
Reference dose oral (mg/kg/d):	*	RfDo
Reference dose inhaled (mg/kg/d):	*	RfDi
Target cancer risk:	1e-06	TR
Target hazard quotient:	1	THQ
Body weight, adult (kg):	70	BWa
Body weight, age 1-6 (kg):	15	BWc
Averaging time carcinogens (d):	25550	ATc
Averaging time non-carcinogens (d):	ED*365	ATn
Inhalation, adult (m3/d):	20	IRAa
Inhalation, child (m3/d):	12	IRAc
Inhalation factor, age-adjusted (m3-y/kg-d):	11.66	IFAadj
Tap water ingestion, adult (L/d):	2	IRWa
Tap water ingestion, age 1-6 (L/d):	1	IRWc
Tap water ingestion factor, age-adjusted (L-y/kg-d):	1.09	IFWadj
Fish ingestion (g/d):	54	IRF
Soil ingestion, adult (mg/d):	100	IRSa
Soil ingestion, age 1-6 (mg/d):	200	IRSc
Soil ingestion factor, age adjusted (mg-y/kg-d):	114.29	IFSadj
Residential:		
Exposure frequency (d/y):	350	EFr
Exposure duration, total (y):	30	EDtot
Exposure duration, age 1-6 (y):	6	EDc
Volatilization factor (L/m3):	0.5	K

Exposure variables	Value	Symbol
Occupational:		
Exposure frequency (d/y):	250	EFo
Exposure duration (y):	25	EDo
Fraction of contaminated soil ingested (unitless)	0.5	FC

*: Contaminant-specific toxicological constants. The priority among sources of toxicological constants was as follows: (1) IRIS, (2) HEAST, (3) HEAST alternative method, (4) EPA-NCEA Superfund Health Risk Technical Support Center, (5) withdrawn from IRIS or HEAST, and (6) other EPA documents. Each source was used only if numbers from higher-priority sources were unavailable. The EPA Superfund Health Risk Technical Support Center, part of the EPA National Center for Environmental Assessment in Cincinnati, develops provisional RfDs and CPSs on request for contaminants not in IRIS or HEAST. These provisional values are labeled "E = EPA-NCEA provisional" in the table. It is possible they may be obsolete. If one of the "E" constants is important to a Superfund risk assessment, consider requesting, through a Regional risk assessor, a new provisional value.

Age-adjusted factors

Because contact rates with tap water, ambient air, and residential soil are different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors. These factors approximated the integrated exposure from birth until age 30 by combining contact rates, body weights, and exposure durations for two age groups - small children and adults. The age-adjusted factor for soil was obtained from RAGS IB; the others were developed by analogy.

Air inhalation

$$IFAadj\ \frac{m^3\cdot y}{kg\cdot d} = \frac{EDc\cdot IRAc}{BWc} + \frac{(EDtot - EDc)\cdot IRAa}{BWa}$$

Tap water ingestion

$$IFWadj\ \frac{L\cdot y}{kg\cdot d} = \frac{EDc\cdot IRWc}{BWc} + \frac{(EDtot - EDc)\cdot IRWa}{BWa}$$

Soil ingestion

$$IFSadj\ \frac{mg\cdot y}{kg\cdot d} = \frac{EDc\cdot IRSc}{BWc} + \frac{(EDtot - EDc)\cdot IRSa}{BWa}$$

Residential water

Volatilization terms were calculated only for compounds with a mark in the "VOC" column. Compounds having a Henry's Law constant greater than 10^{-5} were considered volatile. The list may be incomplete, but is unlikely to include false positives. The equations and the volatilization factor (K, above) were obtained from RAGS IB. Oral potency slopes and reference doses were used for both oral and inhaled exposures for volatile compounds lacking inhalation values. Inhaled potency slopes were substituted for unavailable oral potency slopes only for volatile compounds; inhaled RfDs were substituted for unavailable oral RfDs for both volatile and non-volatile compounds. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

Carcinogens

$$RBC\ \tfrac{\mu g}{L} = \frac{TR \cdot ATc \cdot 1000\ \tfrac{\mu g}{mg}}{EFr \cdot ([\,K \cdot IFAadj \cdot CPSi\,] + [\,IFWadj \cdot CPSo\,])}$$

Non-carcinogens

$$RBC\ \tfrac{\mu g}{L} = \frac{THQ \cdot BWa \cdot ATn \cdot 1000\ \tfrac{\mu g}{mg}}{EFr \cdot EDtot \cdot \left(\frac{K \cdot IRAa}{RfDi} + \frac{IRWa}{RfDo}\right)}$$

Ambient air

Oral potency slopes and references were used where inhalation values were not available. RBCs for carcinogens were based on combined childhood and adult exposure; for non-carcinogens RBCs were based on adult exposure.

Carcinogens

$$RBC\ \tfrac{\mu g}{m^3} = \frac{TR \cdot ATc \cdot 1000\ \tfrac{\mu g}{mg}}{EFr \cdot IFAadj \cdot CPSi}$$

Non-carcinogens

$$RBC\ \tfrac{\mu g}{m^3} = \frac{THQ \cdot RfDi \cdot BWa \cdot ATn \cdot 1000\ \tfrac{\mu g}{mg}}{EFr \cdot EDtot \cdot IRAa}$$

Edible fish

All RBCs were based on adult exposure.

Carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{TR \cdot BWa \cdot ATc}{EFr \cdot EDtot \cdot \frac{IRF}{1000\ \tfrac{g}{kg}} \cdot CPSo}$$

Non-carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFr \cdot EDtot \cdot \frac{IRF}{1000\ \tfrac{g}{kg}}}$$

Commercial/industrial soil ingestion

RBCs were based on adult occupational exposure, including an assumption that only 50% of total soil ingestion is work-related.

Carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{TR \cdot BWa \cdot ATc}{EFo \cdot EDo \cdot \dfrac{IRSa}{10^6\ \tfrac{mg}{kg}} \cdot FC \cdot CPSo}$$

Non-carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWa \cdot ATn}{EFo \cdot EDo \cdot \dfrac{IRSa}{10^6\ \tfrac{mg}{kg}} \cdot FC}$$

Residential soil ingestion

RBCs for carcinogens were based on combined childhood and adult exposure; RBCs for non-carcinogens were based on childhood exposure only.

Carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{TR \cdot ATc}{EFr \cdot \dfrac{IFSadj}{10^6\ \tfrac{mg}{kg}} \cdot CPSo}$$

Non-carcinogens

$$RBC\ \tfrac{mg}{kg} = \frac{THQ \cdot RfDo \cdot BWc \cdot ATn}{EFr \cdot EDc \cdot \dfrac{IRSc}{10^6\ \tfrac{mg}{kg}}}$$

Development of Soil Screening Levels

General

In December 1994 the EPA Office of Solid Waste and Emergency Response proposed Soil Screening Guidance (Document 9355.4-1, PB95-963530, EPA540/R-94/101, available through NTIS at 703-487-4650). This draft document provides (1) a framework in which soil screening levels are to be used, (2) a detailed methodology for calculating soil screening levels, and (3) soil screening levels for 107 substances.

Consistent with this new guidance, the risk-based concentration table now includes two columns of generic soil screening levels (SSLs). OSWER's 107 proposed soil screening levels have been added verbatim. In addition, the proposed SSL methodology has been used to calculate soil screening levels for more substances, which are also included in the new table. The table clearly distinguishes the OSWER SSLs from the "unofficial" ones.

These SSLs provide reasonable maximum estimates of transfers of contaminants from soil to other media. One column contains soil concentrations protective of groundwater quality; the other contains soil concentrations protective of air quality. "Protective" is defined in the same terms as the risk-based concentrations for tap water and air -- that residential contact scenarios will yield a fixed upper bound risk of 10^{-6} or a fixed hazard quotient of 1 (whichever occurs at the lower concentration).

OSWER's SSLs should be used only within the framework proposed in the guidance document. The additional SSLs included in the RBC table are intended for the same uses (although they obviously carry less weight than the formally proposed numbers).

The SSLs are based on the following assumptions:

Input variables	Value	Symbol*
Surface soil moisture content (g/g)	0.1	W_s
Vadose zone soil moisture content (kg/kg)	0.2	W_v
Surface soil bulk density (g/cm^3)	1.5	ρ_{bs}
Vadose zone soil bulk density (kg/L)	1.5	ρ_{bv}
Surface soil particle density (g/cm^3)	2.65	ρ_{ss}
Vadose zone soil particle density (g/cm^3)	2.65	ρ_{sv}
Total surface soil porosity (L pore /L soil)	0.43	N_s
Total vadose zone soil porosity (L pore/L soil).	0.43	N_v
Air-filled surface soil porosity (L air/L soil)	0.28	θ_{as}
Water-filled surface soil porosity (L water/L soil)	0.15	θ_{ws}
Air-filled vadose zone soil porosity (L air/L soil)	0.13	θ_{av}
Water-filled vadose zone soil porosity (L water/L soil)	0.30	θ_{wv}
Organic carbon fraction of surface soil (g/g)	0.006	FOC_s
Organic carbon fraction of vadose zone soil (g/g)	0.002	FOC_v
Dispersion factor for 0.5 acres (g/m^{2}s per kg/m^3)	35.1	Q/C
Particulate emission factor (m^3/kg)	6.79e+08	PEF
Exposure interval (s)	9.50e+08	T
Dilution-attenuation factor (unitless)	10	DAF

*: Symbols were adjusted, variables were rearranged, and derived and chemical-specific variables were omitted for simplicity and clarity. Presentation of the input variables in a single table using the same terms as in the OSWER SSL document would have been confusing. The terms used here are generally similar to OSWER's, and can easily be compared with the SSL guidance document.

With two exceptions described in the following section, SSL calculations were based on the same algorithms presented in the OSWER draft SSL guidance document. For details of the calculations (and for general background information on SSLs), I strongly recommend consulting that document. The "unofficial" SSLs were developed under the following conditions:

Soil Screening Levels for Inhalation

Inhaled reference doses and potency slopes were used if available. If inhalation values were not available, oral RfDs and potency slopes were substituted. SSLs were calculated only for substances for which aqueous solubility, Koc, Henry's Law constant, and diffusivity in air were available. SSLs were calculated only for substances for which a volatilization factor could be calculated. This was done because OSWER's large proposed particulate emission factor rendered it pointless to estimate SSLs for particulate emissions alone. The final calculated SSL shown in the RBC table is the smaller of the risk-based SSL and the soil saturation concentration. All calculated SSLs were rounded to 2 significant figures.

The OSWER risk algorithms for inhalation were revised in order to be consistent with the rest of the RBC table. Only calculated SSLs were affected by this; SSLs proposed by OSWER are presented verbatim. Calculated SSLs for inhalation of carcinogens were based on an integrated lifetime exposure rather than adult exposure. SSLs for inhalation of noncarcinogens were based on adult exposure for 350 days per year rather than 365 days per year. The following algorithms were used to calculate inhalation SSLs:

Carcinogens

$$SSL\ \frac{mg}{kg} = \frac{TR \cdot ATc}{EFr \cdot IFAadj \cdot \left(\frac{1}{VF} + \frac{1}{PEF}\right) \cdot CPSi}$$

Non-carcinogens

$$SSL\ \frac{mg}{kg} = \frac{THQ \cdot BWa \cdot ATn \cdot RfDi}{EFr \cdot EDtot \cdot IRAa \cdot \left(\frac{1}{VF} + \frac{1}{PEF}\right)}$$

Soil Screening Levels for Groundwater Use

All algorithms were as proposed by OSWER. MCLs were used as target groundwater concentrations if available. If MCLs were unavailable the risk-based concentration in the "tap water" column of the RBC table was used as the target groundwater concentration. All SSLs for groundwater are based on a dilution-attenuation factor (DAF) of 10. Since these SSLs scale linearly with DAF, the SSLs for DAF=1 would be ten times lower. They were omitted to conserve space. All groundwater SSLs were rounded to 2 significant figures and capped at unity.

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
										Soil Ingestion			
Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Industrial mg/kg	Residential mg/kg	Air mg/kg	Groundwater mg/kg
Acephate	30560191	4.00E-03 I		8.70E-03 I			7.7 C	0.72 C	0.36 C	660 C	73 C		
Acetaldehyde	75070		2.57E-03 I		7.70E-03 I		94 N	0.81 C					
Acetochlor	34256821	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Acetone	67641	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	62000 E	8 E
Acetone cyanohydrin	75865	7.00E-02 H	4.00E-02 A				2600 N	150 N	95 N	140000 N	5500 N		
Acetonitrile	75078	6.00E-03 I	1.43E-02 A				220 N	52 N	8.1 N	12000 N	470 N		
Acetophenone	98862	1.00E-01 I	5.71E-06 W			☒	0.042 N	0.021 N	140 N	200000 N	7800 N		
Acifluorfen	62476599	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Acrolein	107028	2.00E-02 H	5.71E-06 I				730 N	0.021 N	27 N	41000 N	1600 N		
Acrylamide	79061	2.00E-04 I		4.50E+00 I	4.55E+00 I		0.015 C	0.0014 C	0.0007 C	1.3 C	0.14 C		
Acrylic acid	79107	5.00E-01 I	2.86E-04 I				18000 N	1 N	680 N	1E+06 N	39000 N		
Acrylonitrile	107131	1.00E-03 H	5.71E-04 I	5.40E-01 I	2.38E-01 I		0.12 C	0.026 C	0.0058 C	11 C	1.2 C		
Alachlor	15972608	1.00E-02 I		8.00E-02 H			0.84 C	0.078 C	0.039 C	72 C	8 C		
Alar	1596845	1.50E-01 I					5500 N	550 N	200 N	310000 N	12000 N		
Aldicarb	116063	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N	570 S	0.036 M
Aldicarb sulfone	1646884	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Aldrin	309002	3.00E-05 I		1.70E+01 I	1.71E+01 I		0.004 C	0.00037 C	0.00019 C	0.34 C	0.038 C	0.5 E	0.005 E
Ally	74223646	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Allyl alcohol	107186	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Allyl chloride	107051	5.00E-02 W	2.86E-04 I				1800 N	1 N	68 N	100000 N	3900 N		
Aluminum	7429905	1.00E+00 E					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Aluminum phosphide	20859738	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Amdro	67485294	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Ametryn	834128	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		
m-Aminophenol	591275	7.00E-02 H					2600 N	260 N	95 N	140000 N	5500 N		
4-Aminopyridine	504245	2.00E-05 H					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Amitraz	33089611	2.50E-03 I					91 N	9.1 N	3.4 N	5100 N	200 N		
Ammonia	7664417		2.86E-02 I				1000 N	100 N					
Ammonium sulfamate	7773060	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Aniline	62533		2.86E-04 I	5.70E-03 I			10 N	1 N	0.55 C	1000 C	110 C	45 N	0.031 N
Antimony and compounds	7440360	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Antimony pentoxide	1314609	5.00E-04 H					18 N	1.8 N	0.68 N	1000 N	39 N		
Antimony potassium tartrate	304610	9.00E-04 H					33 N	3.3 N	1.2 N	1800 N	70 N		
Antimony tetroxide	1332316	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
Antimony trioxide	1309644	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
Apollo	74115245	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Aramite	140578	5.00E-02 H		2.50E-02 I	2.49E-02 I		2.7 C	0.25 C	0.13 C	230 C	26 C		
Arsenic	7440382	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N	380 E	15 E
**Arsenic (as carcinogen)	7440382			1.50E+00 I	1.51E+01 I		0.045 C	0.00041 C	0.0021 C	3.8 C	0.43 C	380 E	15 E

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion			
										Industrial	Residential	Air	Groundwater
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Arsine	7784421		1.43E-05 I				0.52 N	0.052 N					
Assure	76578148	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		
Asulam	3337711	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Atrazine	1912249	3.50E-02 I		2.22E-01 H			0.3 C	0.028 C	0.014 C	26 C	2.9 C		
Avermectin B1	65195553	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Azobenzene	103333			1.10E-01 I	1.08E-01 I		0.61 C	0.058 C	0.029 C	52 C	5.8 C		
Barium and compounds	7440393	7.00E-02 I	1.43E-04 A				2600 N	0.52 N	95 N	140000 N	5500 N	350000 E	32 E
Baygon	114261	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Bayleton	43121433	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Baythroid	68359375	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Benefin	1861401	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N		
Benomyl	17804352	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Bentazon	25057890	2.50E-03 I					91 N	9.1 N	3.4 N	5100 N	200 N		
Benzaldehyde	100527	1.00E-01 I				☒	610 N	370 N	140 N	200000 N	7800 N		
Benzene	71432		1.71E-03 E	2.90E-02 I	2.90E-02 I	☒	0.36 C	0.22 C	0.11 C	200 C	22 C	0.5 E	0.02 E
Benzenethiol	108985	1.00E-05 H					0.37 N	0.037 N	0.014 N	20 N	0.78 N		
Benzidine	92875	3.00E-03 I		2.30E+02 I	2.35E+02 I		0.00029 C	0.00003 C	0.00001 C	0.025 C	0.0028 C	1.3 C	1.100E-06 C
Benzoic acid	65850	4.00E+00 I					150000 N	15000 N	5400 N	1E+06 N	310000 N	320 S	280 E
Benzotrichloride	98077			1.30E+01 I			0.0052 C	0.00048 C	0.00024 C	0.44 C	0.049 C	0.012 C	0.000073 C
Benzyl alcohol	100516	3.00E-01 H					11000 N	1100 N	410 N	610000 N	23000 N		
Benzyl chloride	100447			1.70E-01 I		☒	0.062 C	0.037 C	0.019 C	34 C	3.8 C	0.5 C	0.00036 C
Beryllium and compounds	7440417	5.00E-03 I		4.30E+00 I	8.40E+00 I		0.016 C	0.00075 C	0.00073 C	1.3 C	0.15 C	690 E	180 E
Bidrin	141662	1.00E-04 I					3.7 N	0.37 N	0.14 N	200 N	7.8 N		
Biphenthrin (Talstar)	82657043	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
1,1-Biphenyl	92524	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N	9000 S	110 N
Bis(2-chloroethyl)ether	111444			1.10E+00 I	1.16E+00 I	☒	0.0092 C	0.0054 C	0.0029 C	5.2 C	0.58 C	0.3 E	0.0003 E
Bis(2-chloroisopropyl)ether	39638329	4.00E-02 I		7.00E-02 H	3.50E-02 H	☒	0.26 C	0.18 C	0.045 C	82 C	9.1 C		
Bis(chloromethyl)ether	542881			2.20E+02 I	2.17E+02 I	☒	0.00005 C	0.00003 C	0.00001 C	0.026 C	0.0029 C	0.00004 C	1.000E-07 C
Bis(2-chloro-1-methylethyl)ether				7.00E-02 W	7.00E-02 W		0.96 C	0.089 C	0.045 C	82 C	9.1 C		
Bis(2-ethylhexyl)phthalate (DEHP)	117817	2.00E-02 I		1.40E-02 I			4.8 C	0.45 C	0.23 C	410 C	46 C	210 E	11 E
Bisphenol A	80057	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Boron (and borates)	7440428	9.00E-02 I	5.71E-03 H				3300 N	21 N	120 N	180000 N	7000 N		
Boron trifluoride	7637072		2.00E-04 H				7.3 N	0.73 N					
Bromodichloromethane	75274	2.00E-02 I		6.20E-02 I		☒	0.17 C	0.1 C	0.051 C	92 C	10 C	1800 E	0.3 E
Bromoethene	593602				1.10E-01 H	☒	0.096 C	0.057 C					
Bromoform (tribromomethane)	75252	2.00E-02 I		7.90E-03 I	3.85E-03 I	☒	2.4 C	1.6 C	0.4 C	720 C	81 C	46 E	0.5 E
Bromomethane	74839	1.40E-03 I	1.43E-03 I			☒	8.7 N	5.2 N	1.9 N	2900 N	110 N	2 E	0.1 E
4-Bromophenyl phenyl ether	101553	5.80E-02 O					2100 N	210 N	78 N	120000 N	4500 N		
Bromophos	2104963	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion			
		RfDo	RfDi	CPSo	CPSi	VOC				Industrial	Residential	Air	Groundwater
Contaminant	CAS	mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Bromoxynil	1689845	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Bromoxynil octanoate	1689992	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
1,3-Butadiene	106990				9.80E-01 I	☒	0.011 C	0.0064 C				0.0013 C	0.000072 C
1-Butanol	71363	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	9700 E	8 E
Butyl benzyl phthalate	85687	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N	530 E	68 E
Butylate	2008415	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
sec-Butylbenzene	135988	1.00E-02 E				☒	61 N	37 N	14 N	20000 N	780 N	80 S	0.27 M
tert-Butylbenzene	104518	1.00E-02 E				☒	61 N	37 N	14 N	20000 N	780 N		0.27 M
Butylphthalyl butylglycolate	85701	1.00E+00 I					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Cacodylic acid	75605	3.00E-03 H					110 N	11 N	4.1 N	6100 N	230 N		
**Cadmium and compounds	7440439	5.00E-04 I	5.71E-05 E		6.30E+00 I		18 N	0.00099 C	0.68 N	1000 N	39 N	920 E	6 E
Caprolactam	105602	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Captafol	2425061	2.00E-03 I		8.60E-03 H			7.8 C	0.73 C	0.37 C	670 C	74 C		
Captan	133062	1.30E-01 I		3.50E-03 H			19 C	1.8 C	0.9 C	1600 C	180 C		
Carbaryl	63252	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	0.34 S	23 N
Carbofuran	1563662	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
**Carbon disulfide	75150	1.00E-01 I	2.00E-01 I			☒	1000 N	730 N	140 N	200000 N	7800 N	11 E	14 E
Carbon tetrachloride	56235	7.00E-04 I	5.71E-04 E	1.30E-01 I	5.25E-02 I	☒	0.16 C	0.12 C	0.024 C	44 C	4.9 C	0.2 E	0.03 E
Carbosulfan	55285148	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Carboxin	5234684	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Chloral	75876	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Chloramben	133904	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Chloranil	118752			4.03E-01 H			0.17 C	0.016 C	0.0078 C	14 C	1.6 C		
Chlordane	57749	6.00E-05 I		1.30E+00 I	1.29E+00 I		0.052 C	0.0049 C	0.0024 C	4.4 C	0.49 C	10 E	2 E
Chlorimuron-ethyl	90982324	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Chlorine	7782505	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Chlorine dioxide	10049044		5.71E-05 I				2.1 N	0.21 N					
Chloroacetaldehyde	107200	6.90E-03 O					250 N	25 N	9.3 N	14000 N	540 N		
Chloroacetic acid	79118	2.00E-03 H					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Chloroacetophenone	532274		8.57E-06 I				0.31 N	0.031 N					
4-Chloroaniline	106478	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N	1200 S	0.3 E
Chlorobenzene	108907	2.00E-02 I	5.71E-03 A			☒	39 N	21 N	27 N	41000 N	1600 N	94 E	0.6 E
Chlorobenzilate	510156	2.00E-02 I		2.70E-01 H	2.70E-01 H		0.25 C	0.023 C	0.012 C	21 C	2.4 C		
p-Chlorobenzoic acid	74113	2.00E-01 H					7300 N	730 N	270 N	410000 N	16000 N		
4-Chlorobenzotrifluoride	98566	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N	86 N	7.5 N
2-Chloro-1,3-butadiene	126998	2.00E-02 A	2.00E-03 H			☒	14 N	7.3 N	27 N	41000 N	1600 N		
1-Chlorobutane	109693	4.00E-01 H				☒	2400 N	1500 N	540 N	820000 N	31000 N		
Chlorodibromomethane	124481	2.00E-02 I		8.40E-02 I		☒	0.13 C	0.075 C	0.038 C	68 C	7.6 C	1900 E	0.2 E
**1-Chloro-1,1-difluoroethane	75683	I	1.43E+01			☒	87000 N	52000 N					

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap	Ambient		Soil Ingestion			
		RfDo	RfDi	CPSo	CPSi	VOC	Water	Air	Fish	Industrial	Residential	Air	Groundwater
Contaminant	CAS	mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Chlorodifluoromethane	75456		1.43e+01 I			☒	87000 N	52000 N					
Chloroethane	75003	4.00E-01 E	2.86E+00 I			☒	8600 N	10000 N	540 N	820000 N	31000 N	2600 S	33 N
2-Chloroethyl vinyl ether	110758	2.50E-02 O				☒	150 N	91 N	34 N	51000 N	2000 N		
Chloroform	67663	1.00E-02 I		6.10E-03 I	8.05E-02 I	☒	0.15 C	0.078 C	0.52 C	940 C	100 C	0.2 E	0.3 E
Chloromethane	74873			1.30E-02 H	6.30E-03 H	☒	1.4 C	0.99 C	0.24 C	440 C	49 C	0.063 C	0.0066 C
4-Chloro-2,2-methylaniline hydrochloride	3165933			4.60E-01 H			0.15 C	0.014 C	0.0069 C	12 C	1.4 C		
4-Chloro-2-methylaniline	95692			5.80E-01 H			0.12 C	0.011 C	0.0054 C	9.9 C	1.1 C		
beta-Chloronaphthalene	91587	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N	2.8 S	140 N
o-Chloronitrobenzene	88733			2.50E-02 H		☒	0.42 C	0.25 C	0.13 C	230 C	26 C		
p-Chloronitrobenzene	100005			1.80E-02 H		☒	0.59 C	0.35 C	0.18 C	320 C	35 C		
2-Chlorophenol	95578	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N	53000 E	2 E
2-Chloropropane	75296		2.86E-02 H			☒	170 N	100 N				22 N	0.64 N
Chlorothalonil	1897456	1.50E-02 I		1.10E-02 H			6.1 C	0.57 C	0.29 C	520 C	58 C		
o-Chlorotoluene	95498	2.00E-02 I				☒	120 N	73 N	27 N	41000 N	1600 N	1200 N	5.6 N
Chlorpropham	101213	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Chlorpyrifos	2921882	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Chlorpyrifos-methyl	5598130	1.00E-02 H					370 N	37 N	14 N	20000 N	780 N		
Chlorsulfuron	64902723	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Chlorthiophos	60238564	8.00E-04 H					29 N	2.9 N	1.1 N	1600 N	63 N		
Chromium III and compounds	16065831	1.00E+00 I	5.71E-07 W				37000 N	0.0021 N	1400 N	1E+06 N	78000 N		
Chromium VI and compounds	18540299	5.00E-03 I			4.20E+01 I		180 N	0.00015 C	6.8 N	10000 N	390 N	140 E	19 E
Coal tar	8001589				2.20E+00 W			0.0028 C					
Cobalt	7440484	6.00E-02 E					2200 N	220 N	81 N	120000 N	4700 N		
Coke Oven Emissions	8007452				2.17E+00 I			0.0029 C					
**Copper and compounds	7440508	4.00E-02 E					1500 N	150 N	54 N	82000 N	3100 N		
Crotonaldehyde	123739	1.00E-02 W		1.90E+00 H	1.90E+00 W		0.035 C	0.0033 C	0.0017 C	3 C	0.34 C		
Cumene	98828	4.00E-02 I	2.57E-03 H				1500 N	9.4 N	54 N	82000 N	3100 N	81 N	65 N
Cyanides:													
Barium cyanide	542621	1.00E-01 W					3700 N	370 N	140 N	200000 N	7800 N		
Calcium cyanide	592018	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Copper cyanide	544923	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Cyanazine	21725462	2.00E-03 H		8.40E-01 H			0.08 C	0.0075 C	0.0038 C	6.8 C	0.76 C		
Cyanogen	460195	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Cyanogen bromide	506683	9.00E-02 I					3300 N	330 N	120 N	180000 N	7000 N		
Cyanogen chloride	506774	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Free cyanide	57125	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Hydrogen cyanide	74908	2.00E-02 I	8.57E-04 I				730 N	3.1 N	27 N	41000 N	1600 N		
Potassium cyanide	151508	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Potassium silver cyanide	506616	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Risk-Based Concentrations: Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Soil Ingestion: Industrial mg/kg	Residential mg/kg	Soil Screening Levels- Transfers from Soil to: Air mg/kg	Groundwater mg/kg
Silver cyanide	506649	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Sodium cyanide	143339	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
**Thiocyanate		2.00E-02 E					730 N	73 N	27 N	41000 N	1600 N		
Zinc cyanide	557211	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Cyclohexanone	108941	5.00E+00 I				☒	30000 N	18000 N	6800 N	1E+06 N	390000 N		
Cyclohexlamine	108918	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Cyhalothrin/Karate	68085858	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Cypermethrin	52315078	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Cyromazine	66215278	7.50E-03 I					270 N	27 N	10 N	15000 N	590 N		
Dacthal	1861321	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Dalapon	75990	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Danitol	39515418	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
DDD	72548			2.40E-01 I			0.28 C	0.026 C	0.013 C	24 C	2.7 C	37 S	0.7 E
DDE	72559			3.40E-01 I			0.2 C	0.018 C	0.0093 C	17 C	1.9 C	10 S	0.5 E
DDT	50293	5.00E-04 I		3.40E-01 I	3.40E-01 I		0.2 C	0.018 C	0.0093 C	17 C	1.9 C	80 E	1 E
Decabromodiphenyl ether	1163195	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N		
Demeton	8065483	4.00E-05 I					1.5 N	0.15 N	0.054 N	82 N	3.1 N		
Diallate	2303164			6.10E-02 H		☒	0.17 C	0.1 C	0.052 C	94 C	10 C		
Diazinon	333415	9.00E-04 H					33 N	3.3 N	1.2 N	1800 N	70 N	5400 S	2.8 N
Dibenzofuran	132649	4.00E-03 E					150 N	15 N	5.4 N	8200 N	310 N	120 S	120 N
1,4-Dibromobenzene	106376	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N		
1,2-Dibromo-3-chloropropane	96128		5.71E-05 I	1.40E+00 H	2.42E-03 H	☒	0.048 C	0.21 N	0.0023 C	4.1 C	0.46 C	1.9 N	0.00061 M
1,2-Dibromoethane	106934		5.71E-05 H	8.50E+01 I	7.70E-01 I	☒	0.00075 C	0.0081 C	0.00004 C	0.067 C	0.0075 C	0.0058 C	0.00018 M
Dibutyl phthalate	84742	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	100 E	120 E
Dicamba	1918009	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
1,2-Dichlorobenzene	95501	9.00E-02 I	4.00E-02 A			☒	270 N	150 N	120 N	180000 N	7000 N	300 E	6 E
1,3-Dichlorobenzene	541731	8.90E-02 O				☒	540 N	320 N	120 N	180000 N	7000 N		
1,4-Dichlorobenzene	106467		2.29E-01 I	2.40E-02 H		☒	0.44 C	0.26 C	0.13 C	240 C	27 C	7700 E	1 E
3,3'-Dichlorobenzidine	91941			4.50E-01 I			0.15 C	0.014 C	0.007 C	13 C	1.4 C	52 S	0.01 E
1,4-Dichloro-2-butene	764410				9.30E+00 H	☒	0.0011 C	0.00067 C					
Dichlorodifluoromethane	75718	2.00E-01 I	5.71E-02 A			☒	390 N	210 N	270 N	410000 N	16000 N	37 N	7.5 N
1,1-Dichloroethane	75343	1.00E-01 H	1.43E-01 A			☒	810 N	520 N	140 N	200000 N	7800 N	980 E	11 E
1,2-Dichloroethane (EDC)	107062		2.86E-03 E	9.10E-02 I	9.10E-02 I	☒	0.12 C	0.069 C	0.035 C	63 C	7 C	0.3 E	0.01 E
1,1-Dichloroethylene	75354	9.00E-03 I		6.00E-01 I	1.75E-01 I	☒	0.044 C	0.036 C	0.0053 C	9.5 C	1.1 C	0.04 E	0.03 E
1,2-Dichloroethylene (cis)	156592	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	1500 E	0.2 E
1,2-Dichloroethylene (trans)	156605	2.00E-02 I				☒	120 N	73 N	27 N	41000 N	1600 N	3600 E	0.3 E
1,2-Dichloroethylene (mixture)	540590	9.00E-03 H				☒	55 N	33 N	12 N	18000 N	700 N		
2,4-Dichlorophenol	120832	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N	4800 S	0.5 E
2,4-Dichlorophenoxyacetic Acid (2,4-D)	94757	1.00E-02 I				☒	61 N	37 N	14 N	20000 N	780 N	7000 S	1.7 M

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion		Air	Groundwater
										Industrial	Residential		
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
4-(2,4-Dichlorophenoxy)butyric Acid	94826	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
1,2-Dichloropropane	78875		1.14E-03 I	6.80E-02 H		☒	0.16 C	0.092 C	0.046 C	84 C	9.4 C	11 E	0.02 E
2,3-Dichloropropanol	616239	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
1,3-Dichloropropene	542756	3.00E-04 I	5.71E-03 I	1.75E-01 H	1.30E-01 H	☒	0.077 C	0.048 C	0.018 C	33 C	3.7 C	0.1 E	0.001 E
Dichlorvos	62737	5.00e-04 I	1.43E-04 I	2.90E-01 I			0.23 C	0.022 C	0.011 C	20 C	2.2 C	3.5 C	0.00072 C
Dicofol	115322			4.40E-01 W			0.15 C	0.014 C	0.0072 C	13 C	1.5 C		
Dicyclopentadiene	77736	3.00E-02 H	5.71E-05 A			☒	0.42 N	0.21 N	41 N	61000 N	2300 N		
Dieldrin	60571	5.00E-05 I		1.60E+01 I	1.61E+01 I		0.0042 C	0.00039 C	0.0002 C	0.36 C	0.04 C	2 E	0.001 E
Diesel emissions			1.43E-03 I				52 N	5.2 N					
Diethyl phthalate	84662	8.00E-01 I					29000 N	2900 N	1100 N	1E+06 N	63000 N	520 E	110 E
Diethylene glycol, monobutyl ether	112345		5.71E-03 H				210 N	21 N					
Diethylene glycol, monoethyl ether	111900	2.00E+00 H					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Diethylforamide	617845	1.10E-02 H					400 N	40 N	15 N	22000 N	860 N		
Di(2-ethylhexyl)adipate	103231	6.00E-01 I		1.20E-03 I			56 C	5.2 C	2.6 C	4800 C	530 C		
Diethylstilbestrol	56531			4.70E+03 H			0.00001 C	1E-06 C	7E-07 C	0.0012 C	0.00014 C		
Difenzoquat (Avenge)	43222486	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Diflubenzuron	35367385	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
1,1-Difluoroethane	75376		1.14E+01 I			☒	69000 N	42000 N					
Diisopropyl methylphosphonate (DIMP)	1445756	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Dimethipin	55290647	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Dimethoate	60515	2.00E-04 I					7.3 N	0.73 N	0.27 N	410 N	16 N		
3,3'-Dimethoxybenzidine	119904			1.40E-02 H			4.8 C	0.45 C	0.23 C	410 C	46 C		
Dimethylamine	124403		5.71E-06 W				0.21 N	0.021 N					
2,4-Dimethylaniline hydrochloride	21436964			5.80E-01 H			0.12 C	0.011 C	0.0054 C	9.9 C	1.1 C		
2,4-Dimethylaniline	95681			7.50E-01 H			0.09 C	0.0083 C	0.0042 C	7.6 C	0.85 C		
N-N-Dimethylaniline	121697	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
3,3'-Dimethylbenzidine	119937			9.20E+00 H			0.0073 C	0.00068 C	0.00034 C	0.62 C	0.069 C	29 C	0.00039 C
N,N-Dimethylformamide	68122	1.00E-01 H	8.57E-03 I				3700 N	31 N	140 N	200000 N	7800 N		
1,1-Dimethylhydrazine	57147			2.60E+00 W	3.50E+00 W		0.026 C	0.0018 C	0.0012 C	2.2 C	0.25 C		
1,2-Dimethylhydrazine	540738			3.70E+01 W	3.70E+01 W		0.0018 C	0.00017 C	0.00009 C	0.15 C	0.017 C		
2,4-Dimethylphenol	105679	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N	5400 S	3 E
2,6-Dimethylphenol	576261	6.00E-04 I					22 N	2.2 N	0.81 N	1200 N	47 N		
3,4-Dimethylphenol	95658	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Dimethyl phthalate	131113	1.00E+01 H					370000 N	37000 N	14000 N	1E+06 N	780000 N	1600 E	1200 E
Dimethyl terephthalate	120616	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
1,2-Dinitrobenzene	528290	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
1,3-Dinitrobenzene	99650	1.00E-04 I					3.7 N	0.37 N	0.14 N	200 N	7.8 N		
1,4-Dinitrobenzene	100254	4.00E-04 H					15 N	1.5 N	0.54 N	820 N	31 N		
4,6-Dinitro-o-cyclohexyl phenol	131895	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
										Soil Ingestion			
Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Industrial mg/kg	Residential mg/kg	Air mg/kg	Groundwater mg/kg
2,4-Dinitrophenol	51285	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N	360 N	0.1 E
Dinitrotoluene mixture				6.80E-01 I			0.099 C	0.0092 C	0.0046 C	8.4 C	0.94 C		
2,4-Dinitrotoluene	121142	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N	120 S	0.2 E
2,6-Dinitrotoluene	606202	1.00E-03 H					37 N	3.7 N	1.4 N	2000 N	78 N	370 S	0.1 E
Dinoseb	88857	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
di-n-Octyl phthalate	117840	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N	1000000 S	1000000 E
1,4-Dioxane	123911			1.10E-02 I			6.1 C	0.57 C	0.29 C	520 C	58 C		
Diphenamid	957517	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Diphenylamine	122394	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
1,2-Diphenylhydrazine	122667			8.00E-01 I	7.70E-01 I		0.084 C	0.0081 C	0.0039 C	7.2 C	0.8 C		
Diquat	85007	2.20E-03 I					80 N	8 N	3 N	4500 N	170 N		
Direct black 38	1937377			8.60E+00 H			0.0078 C	0.00073 C	0.00037 C	0.67 C	0.074 C		
Direct blue 6	2602462			8.10E+00 H			0.0083 C	0.00077 C	0.00039 C	0.71 C	0.079 C		
Direct brown 95	16071866			9.30E+00 H			0.0072 C	0.00067 C	0.00034 C	0.62 C	0.069 C		
Disulfoton	298044	4.00E-05 I					1.5 N	0.15 N	0.054 N	82 N	3.1 N		
1,4-Dithiane	505293	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Diuron	330541	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Dodine	2439103	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Endosulfan	115297	6.00E-03 I					220 N	22 N	8.1 N	12000 N	470 N	1 S	3 E
Endothall	145733	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Endrin	72208	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N	16 S	0.4 E
Epichlorohydrin	106898	2.00E-03 H	2.86E-04 I	9.90E-03 I	4.20E-03 I		6.8 C	1 N	0.32 C	580 C	65 C		
1,2-Epoxybutane	106887		5.71E-03 I				210 N	21 N					
Ethephon (2-chloroethyl phosphonic acid)	16672870	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Ethion	563122	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
2-Ethoxyethanol acetate	111159	3.00E-01 A					11000 N	1100 N	410 N	610000 N	23000 N		
2-Ethoxyethanol	110805	4.00E-01 H	5.71E-02 I				15000 N	210 N	540 N	820000 N	31000 N		
Ethyl acrylate	140885			4.80E-02 H			1.4 C	0.13 C	0.066 C	120 C	13 C		
EPTC (S-Ethyl dipropylthiocarbamate)	759944	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Ethyl acetate	141786	9.00E-01 I					33000 N	3300 N	1200 N	1E+06 N	70000 N		
Ethylbenzene	100414	1.00E-01 I	2.86E-01 I			☒	1300 N	1000 N	140 N	200000 N	7800 N	260 E	5 E
Ethylene cyanohydrin	109784	3.00E-01 H					11000 N	1100 N	410 N	610000 N	23000 N		
Ethylene diamine	107153	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Ethylene glycol	107211	2.00E+00 I					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Ethylene glycol, monobutyl ether	111762		5.71E-03 H				210 N	21 N					
Ethylene oxide	75218			1.02E+00 H	3.50E-01 H		0.066 C	0.018 C	0.0031 C	5.6 C	0.63 C		
Ethylene thiourea (ETU)	96457	8.00E-05 I		1.19E-01 H			0.57 C	0.053 C	0.027 C	48 C	5.4 C		
Ethyl ether	60297	2.00E-01 I				☒	1200 N	730 N	270 N	410000 N	16000 N		
Ethyl methacrylate	97632	9.00E-02 H					3300 N	330 N	120 N	180000 N	7000 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion		Air	Groundwater
										Industrial	Residential		
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Ethyl p-nitrophenyl phenylphosphorothioate	2104645	1.00E-05 I					0.37 N	0.037 N	0.014 N	20 N	0.78 N		
Ethylnitrosourea	759739			1.40E+02 W			0.00048 C	0.00005 C	0.00002 C	0.041 C	0.0046 C		
Ethylphthalyl ethyl glycolate	84720	3.00E+00 I					110000 N	11000 N	4100 N	1E+06 N	230000 N		
Express	10120	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
Fenamiphos	22224926	2.50E-04 I					9.1 N	0.91 N	0.34 N	510 N	20 N		
Fluometuron	2164172	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Fluoride	7782414	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Fluoridone	59756604	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Flurprimidol	56425913	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Flutolanil	66332965	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Fluvalinate	69409945	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Folpet	133073	1.00E-01 I		3.50E-03 I			19 C	1.8 C	0.9 C	1600 C	180 C		
Fomesafen	72178020			1.90E-01 I			0.35 C	0.033 C	0.017 C	30 C	3.4 C		
Fonofos	944229	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Formaldehyde	50000	2.00E-01 I			4.55E-02 I		7300 N	0.14 C	270 N	410000 N	16000 N		
Formic Acid	64186	2.00E+00 H					73000 N	7300 N	2700 N	1E+06 N	160000 N		
Fosetyl-al	39148248	3.00E+00 I					110000 N	11000 N	4100 N	1E+06 N	230000 N		
Furan	110009	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Furazolidone	67458			3.80E+00 H			0.018 C	0.0016 C	0.00083 C	1.5 C	0.17 C		
Furfural	98011	3.00E-03 I	1.43E-02 A				110 N	52 N	4.1 N	6100 N	230 N		
Furium	531828			5.00E+01 H			0.0013 C	0.00013 C	0.00006 C	0.11 C	0.013 C		
Furmecyclox	60568050			3.00E-02 I			2.2 C	0.21 C	0.11 C	190 C	21 C		
Glufosinate-ammonium	77182822	4.00E-04 I					15 N	1.5 N	0.54 N	820 N	31 N		
Glycidaldehyde	765344	4.00E-04 I	2.86E-04 H				15 N	1 N	0.54 N	820 N	31 N		
Glyphosate	1071836	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Haloxyfop-methyl	69806402	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Harmony	79277273	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
HCH (alpha)	319846			6.30E+00 I	6.30E+00 I		0.011 C	0.00099 C	0.0005 C	0.91 C	0.1 C	0.9 E	0.0004 E
HCH (beta)	319857			1.80E+00 I	1.80E+00 I		0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C	16 E	0.002 E
HCH (gamma) Lindane	58899	3.00E-04 I		1.30E+00 H			0.052 C	0.0048 C	0.0024 C	4.4 C	0.49 C	4.2 C	0.006 E
HCH-technical	608731			1.80E+00 I	1.79E+00 I		0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C		
Heptachlor	76448	5.00E-04 I		4.50E+00 I	4.55E+00 I	☒	0.0023 C	0.0014 C	0.0007 C	1.3 C	0.14 C	0.3 E	0.06 E
Heptachlor epoxide	1024573	1.30E-05 I		9.10E+00 I	9.10E+00 I	☒	0.0012 C	0.00069 C	0.00035 C	0.63 C	0.07 C	1 E	0.03 E
Hexabromobenzene	87821	2.00E-03 I				☒	12 N	7.3 N	2.7 N	4100 N	160 N		
Hexachlorobenzene	118741	8.00E-04 I		1.60E+00 I	1.61E+00 I	☒	0.0066 C	0.0039 C	0.002 C	3.6 C	0.4 C	1 E	0.8 E
Hexachlorobutadiene	87683	2.00E-04 H		7.80E-02 I	7.70E-02 I	☒	0.14 C	0.081 C	0.04 C	73 C	8.2 C	1 E	0.1 E
Hexachlorocyclopentadiene	77474	7.00E-03 I	2.00E-05 H			☒	0.15 N	0.073 N	9.5 N	14000 N	550 N	2 E	10 E
Hexachlorodibenzo-p-dioxin mixture	19408743			6.20E+03 I	4.55E+03 I		0.00001 C	1E-06 C	5E-07 C	0.0009 C	0.0001 C		
Hexachloroethane	67721	1.00E-03 I		1.40E-02 I	1.40E-02 I	☒	0.75 C	0.45 C	0.23 C	410 C	46 C	49 E	0.2 E

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion			
										Industrial	Residential	Air	Groundwater
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Hexachlorophene	70304	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Hexahydro-1,3,5-trinitro-1,3,5-triazine	121824	3.00E-03 I		1.10E-01 I			0.61 C	0.057 C	0.029 C	52 C	5.8 C		
1,6-Hexamethylene diisocyanate	822060		2.86E-06 I				0.1 N	0.01 N					
n-Hexane	110543	6.00E-02 H	5.71E-02 I			☒	350 N	210 N	81 N	120000 N	4700 N	32 N	13 N
Hexazinone	51235042	3.30E-02 I					1200 N	120 N	45 N	67000 N	2600 N		
Hydrazine, hydrazine sulfate	302012			3.00E+00 I	1.71E+01 I		0.022 C	0.00037 C	0.0011 C	1.9 C	0.21 C		
**Hydrogen chloride	7647010		5.71E-03 I				210 N	21 N					
**Hydrogen sulfide	7783064	3.00E-03 I	2.85E-04 I				110 N	1 N	4.1 N	6100 N	230 N		
Hydroquinone	123319	4.00E-02 H					1500 N	150 N	54 N	82000 N	3100 N		
Imazalil	35554440	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Imazaquin	81335377	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Iprodione	36734197	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
**Iron	7439896	3.00E-01 E					11000 N	1100 N	410 N	610000 N	23000 N		
Isobutanol	78831	3.00E-01 I				☒	1800 N	1100 N	410 N	610000 N	23000 N		
Isophorone	78591	2.00E-01 I		9.50E-04 I			71 C	6.6 C	3.3 C	6000 C	670 C	3400 E	0.2 E
Isopropalin	33820530	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Isopropyl methyl phosphonic acid	1832548	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Isoxaben	82558507	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Kepone	143500			1.80E+01 E			0.0037 C	0.00035 C	0.00018 C	0.32 C	0.035 C		
Lactofen	77501634	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Linuron	330552	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Lithium	7439932	2.00E-02 E					730 N	73 N	27 N	41000 N	1600 N		
Londax	83056996	2.00E-01 I					7300 N	730 N	270 N	410000 N	16000 N		
Malathion	121755	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Maleic anhydride	108316	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Maleic hydrazide	123331	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Malononitrile	109773	2.00E-05 H					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Mancozeb	8018017	3.00E-02 H					1100 N	110 N	41 N	61000 N	2300 N		
Maneb	12427382	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Manganese and compounds	7439965	5.00E-03 I	1.43e-05 I				180 N	0.052 N	6.8 N	10000 N	390 N		
Mephosfolan	950107	9.00E-05 H					3.3 N	0.33 N	0.12 N	180 N	7 N		
Mepiquat chloride	24307264	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
**Mercuric chloride	7487947	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Mercury (inorganic)	7439976	3.00E-04 H	8.57E-05 H				11 N	0.31 N	0.41 N	610 N	23 N	7 E	3 E
Mercury (methyl)	22967926	1.00E-04 I					3.7 N	0.37 N	0.14 N	200 N	7.8 N		
Merphos	150505	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
Merphos oxide	78488	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
Metalaxyl	57837191	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N		
Methacrylonitrile	126987	1.00E-04 I	2.00E-04 A				3.7 N	0.73 N	0.14 N	200 N	7.8 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion			
										Industrial	Residential	Air	Groundwater
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Methamidophos	10265926	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Methanol	67561	5.00E-01 I					18000 N	1800 N	680 N	1E+06 N	39000 N		
Methidathion	950378	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Methomyl	16752775	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Methoxychlor	72435	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N	41 S	62 E
2-Methoxyethanol acetate	110496	2.00E-03 A					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Methoxyethanol	109864	1.00E-03 H	5.71E-03 I				37 N	21 N	1.4 N	2000 N	78 N		
2-Methoxy-5-nitroaniline	99592			4.60E-02 H			1.5 C	0.14 C	0.069 C	120 C	14 C		
Methyl acetate	79209	1.00E+00 H					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Methyl acrylate	96333	3.00E-02 A					1100 N	110 N	41 N	61000 N	2300 N		
2-Methylaniline hydrochloride	636215			1.80E-01 H			0.37 C	0.035 C	0.018 C	32 C	3.5 C		
2-Methylaniline	95534			2.40E-01 H			0.28 C	0.026 C	0.013 C	24 C	2.7 C		
Methyl chlorocarbonate	79221	1.00E+00 W					37000 N	3700 N	1400 N	1E+06 N	78000 N		
4-(2-Methyl-4-chlorophenoxy) butyric acid	94815	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-Methyl-4-chlorophenoxyacetic acid	94746	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
2-(2-Methyl-14-chlorophenoxy)propionic acid	93652	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Methylcyclohexane	108872		8.57E-01 H				31000 N	3100 N				60 S	1500 N
Methylene bromide	74953	1.00E-02 A				☒	61 N	37 N	14 N	20000 N	780 N		
Methylene chloride	75092	6.00E-02 I	8.57E-01 H	7.50E-03 I	1.64E-03 I	☒	4.1 C	3.8 C	0.42 C	760 C	85 C	7 E	0.01 E
4,4'-Methylene bis(2-chloroaniline)	101144	7.00E-04 H		1.30E-01 H	1.30E-01 H		0.52 C	0.048 C	0.024 C	44 C	4.9 C		
4,4'-Methylenebisbenzeneamine	101779			2.50E-01 W			0.27 C	0.025 C	0.013 C	23 C	2.6 C		
4,4'-Methylene bis(N,N'-dimethyl)aniline	101611			4.60E-02 I			1.5 C	0.14 C	0.069 C	120 C	14 C		
4,4'-Methylenediphenyl isocyanate	101688		5.71E-06 I			☒	0.035 N	0.021 N					
Methyl ethyl ketone	78933	6.00E-01 I	2.86E-01 I			☒	1900 N	1000 N	810 N	1E+06 N	47000 N		
Methyl hydrazine	60344			1.10E+00 W			0.061 C	0.0057 C	0.0029 C	5.2 C	0.58 C		
Methyl isobutyl ketone	108101	8.00E-02 H	2.29E-02 A				2900 N	84 N	110 N	160000 N	6300 N		
Methyl methacrylate	80626	8.00E-02 H					2900 N	290 N	110 N	160000 N	6300 N		
2-Methyl-5-nitroaniline	99558			3.30E-02 H			2 C	0.19 C	0.096 C	170 C	19 C		
Methyl parathion	298000	2.50E-04 I					9.1 N	0.91 N	0.34 N	510 N	20 N	28 S	0.041 N
2-Methylphenol (o-cresol)	95487	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N	12000 S	6 E
3-Methylphenol (m-cresol)	103394	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
4-Methylphenol (p-cresol)	106445	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		
Methyl styrene (mixture)	25013154	6.00E-03 A	1.14E-02 A			☒	60 N	42 N	8.1 N	12000 N	470 N	100 N	1 N
Methyl styrene (alpha)	98839	7.00E-02 A				☒	430 N	260 N	95 N	140000 N	5500 N	8.8 S	7.5 N
Methyl tertbutyl ether (MTBE)	1634044	5.00E-03 E	8.57E-01 I			☒	180 N	3100 N	6.8 N	10000 N	390 N		
Metolaclor (Dual)	51218452	1.50E-01 H					5500 N	550 N	200 N	310000 N	12000 N		
Metribuzin	21087649	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Mirex	2385855	2.00E-04 I		1.80E+00 W			0.037 C	0.0035 C	0.0018 C	3.2 C	0.35 C		
Molinate	2212671	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis: C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
										Soil Ingestion			
		RfDo	RfDi	CPSo	CPSi	VOC	Tap Water	Ambient Air	Fish	Industrial	Residential	Air	Groundwater
Contaminant	CAS	mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Molybdenum	7439987	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Monochloramine	10599903	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Naled	300765	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
2-Naphthylamine	91598			1.30e+02 E			0.00052 C	0.00005 C	0.00002 C	0.044 C	0.0049 C		
Napropamide	15299997	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
Nickel refinery dust					8.40E-01 I			0.0075 C					
Nickel and compounds	7440020	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N	6900 E	21 E
Nickel subsulfide	12035722				1.70E+00 I			0.0037 C					
Nitrapyrin	1929824	1.50E-03 W					55 N	5.5 N	2 N	3100 N	120 N		
Nitrate	14797558	1.60E+00 I					58000 N	5800 N	2200 N	1E+06 N	130000 N		
Nitric Oxide	10102439	1.00E-01 W					3700 N	370 N	140 N	200000 N	7800 N		
Nitrite	14797650	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
2-Nitroaniline	88744	6.00E-05 W	5.71E-05 H				2.2 N	0.21 N	0.081 N	120 N	4.7 N		
3-Nitroaniline	99092	3.00E-03 O					110 N	11 N	4.1 N	6100 N	230 N		
4-Nitroaniline	100016	3.00E-03 O					110 N	11 N	4.1 N	6100 N	230 N		
Nitrobenzene	98953	5.00E-04 I	5.71E-04 A			☒	3.4 N	2.1 N	0.68 N	1000 N	39 N	110 E	0.09 E
Nitrofurantoin	67209	7.00E-02 H					2600 N	260 N	95 N	140000 N	5500 N		
Nitrofurazone	59870			1.50E+00 H	9.40E+00 H		0.045 C	0.00067 C	0.0021 C	3.8 C	0.43 C		
Nitrogen dioxide	10102440	1.00E+00 W					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Nitroguanidine	556887	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N		
4-Nitrophenol	100027	6.20E-02 O					2300 N	230 N	84 N	130000 N	4800 N		
2-Nitropropane	79469		5.71E-03 I		9.40E+00 H		210 N	0.00067 C					
N-Nitrosodi-n-butylamine	924163			5.40E+00 I	5.60E+00 I		0.012 C	0.0011 C	0.00058 C	1.1 C	0.12 C		
N-Nitrosodiethanolamine	1116547			2.80E+00 I			0.024 C	0.0022 C	0.0011 C	2 C	0.23 C		
N-Nitrosodiethylamine	55185			1.50E+02 I	1.51E+02 I		0.00045 C	0.00004 C	0.00002 C	0.038 C	0.0043 C		
N-Nitrosodimethylamine	62759			5.10E+01 I	4.90E+01 I		0.0013 C	0.00013 C	0.00006 C	0.11 C	0.013 C		
N-Nitrosodiphenylamine	86306			4.90E-03 I			14 C	1.3 C	0.64 C	1200 C	130 C	29 C	0.2 E
N-Nitroso di-n-propylamine	621647			7.00E+00 I			0.0096 C	0.00089 C	0.00045 C	0.82 C	0.091 C	0.014 C	0.00002 E
N-Nitroso-N-methylethylamine	10595956			2.20E+01 I			0.0031 C	0.00028 C	0.00014 C	0.26 C	0.029 C		
N-Nitrosopyrrolidine	930552			2.10E+00 I	2.13E+00 I		0.032 C	0.0029 C	0.0015 C	2.7 C	0.3 C		
m-Nitrotoluene	99081	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	460 S	0.42 N
o-Nitrotoluene	88722	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	460 S	0.42 N
p-Nitrotoluene	99990	1.00E-02 H				☒	61 N	37 N	14 N	20000 N	780 N	460 S	0.42 N
Norflurazon	27314132	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
NuStar	85509199	7.00E-04 I					26 N	2.6 N	0.95 N	1400 N	55 N		
Octabromodiphenyl ether	32536520	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Octahydro-1357-tetranitro-1357-tetrazocine	2691410	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Octamethylpyrophosphoramide	152169	2.00E-03 H					73 N	7.3 N	2.7 N	4100 N	160 N		
Oryzalin	19044883	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels: Transfers from Soil to:	
										Soil Ingestion			
Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Industrial mg/kg	Residential mg/kg	Air mg/kg	Groundwater mg/kg
Oxadiazon	19666309	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Oxamyl	23135220	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Oxyfluorfen	42874033	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Paclobutrazol	76738620	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Paraquat	1910425	4.50E-03 I					160 N	16 N	6.1 N	9200 N	350 N		
Parathion	56382	6.00E-03 H					220 N	22 N	8.1 N	12000 N	470 N	110 S	3.9 N
Pebulate	1114712	5.00E-02 H					1800 N	180 N	68 N	100000 N	3900 N		
Pendimethalin	40487421	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N		
Pentabromo-6-chloro cyclohexane	87843			2.30E-02 H			2.9 C	0.27 C	0.14 C	250 C	28 C		
Pentabromodiphenyl ether	32534819	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Pentachlorobenzene	608935	8.00E-04 I				☒	4.9 N	2.9 N	1.1 N	1600 N	63 N	570 N	48 N
Pentachloronitrobenzene	82688	3.00E-03 I		2.60E-01 H		☒	0.041 C	0.024 C	0.012 C	22 C	2.5 C		
Pentachlorophenol	87865	3.00E-02 I		1.20E-01 I			0.56 C	0.052 C	0.026 C	48 C	5.3 C	7.9 C	0.2 E
Permethrin	52645531	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		
Phenmedipham	13684634	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Phenol	108952	6.00E-01 I					22000 N	2200 N	810 N	1E+06 N	47000 N	21000 S	49 E
m-Phenylenediamine	108452	6.00E-03 I					220 N	22 N	8.1 N	12000 N	470 N		
p-Phenylenediamine	106503	1.90E-01 H					6900 N	690 N	260 N	390000 N	15000 N		
Phenylmercuric acetate	62384	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
2-Phenylphenol	90437			1.94E-03 H			35 C	3.2 C	1.6 C	3000 C	330 C		
Phorate	298022	2.00E-04 H					7.3 N	0.73 N	0.27 N	410 N	16 N		
Phosmet	732116	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
**Phosphine	7803512	3.00E-04 I	8.57E-05 H				11 N	0.31 N	0.41 N	610 N	23 N		
**Phosphoric acid	7664382	I	2.86E-03				100 N	10 N					
Phosphorus (white)	7723140	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
p-Phthalic acid	100210	1.00E+00 H					37000 N	3700 N	1400 N	1E+06 N	78000 N		
Phthalic anhydride	85449	2.00E+00 I	3.43E-02 H				73000 N	130 N	2700 N	1E+06 N	160000 N		
Picloram	1918021	7.00E-02 I					2600 N	260 N	95 N	140000 N	5500 N		
Pirimiphos-methyl	29232937	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
Polybrominated biphenyls		7.00E-06 H		8.90E+00 H			0.0076 C	0.0007 C	0.00035 C	0.64 C	0.072 C		
Polychlorinated biphenyls (PCBs)	1336363			7.70E+00 I			0.0087 C	0.00081 C	0.00041 C	0.74 C	0.083 C		
Aroclor 1016	12674112	7.00E-05 I					2.6 N	0.26 N	0.095 N	140 N	5.5 N		
Aroclor 1254	11097691	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Polychlorinated terphenyls (PCTs)				4.50E+00 E			0.015 C	0.0014 C	0.0007 C	1.3 C	0.14 C		
Polynuclear aromatic hydrocarbons												110000 S	
Acenaphthene	83329	6.00E-02 I					2200 N	220 N	81 N	120000 N	4700 N	120 S	200 E
Anthracene	120127	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N	6.8 S	4300 E
Benz[a]anthracene	56553			7.30E-01 E	6.10E-01 E		0.092 C	0.01 C	0.0043 C	7.8 C	0.88 C	27 S	0.7 E
Benzo[b]fluoranthene	205992			7.30E-01 E	6.10E-01 E		0.092 C	0.01 C	0.0043 C	7.8 C	0.88 C	23 S	4 E

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels- Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion			
		RfDo	RfDi	CPSo	CPSi	VOC				Industrial	Residential	Air	Groundwater
Contaminant	CAS	mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Benzo[k]fluoranthene	207089			7.30E-02 E	6.10E-02 E		0.92 C	0.1 C	0.043 C	78 C	8.8 C		4 E
Benzo[a]pyrene	50328			7.30E+00 I	6.10E+00 W		0.0092 C	0.001 C	0.00043 C	0.78 C	0.088 C	11 S	4 E
Carbazole	86748			2.00E-02 H			3.4 C	0.31 C	0.16 C	290 C	32 C	11 S	0.5 E
Chrysene	218019			7.30E-03 E	6.10E-03 E		9.2 C	1 C	0.43 C	780 C	88 C	3.6 S	1 E
Dibenz[ah]anthracene	53703			7.30E+00 E	6.10E+00 E		0.0092 C	0.001 C	0.00043 C	0.78 C	0.088 C	7.2 S	11 E
Fluoranthene	206440	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N	68 S	980 E
Fluorene	86737	4.00E-02 I					1500 N	150 N	54 N	82000 N	3100 N	89 S	160 E
Indeno[1,2,3-cd]pyrene	193395			7.30E-01 E	6.10E-01 E		0.092 C	0.01 C	0.0043 C	7.8 C	0.88 C	280 S	35 E
Naphthalene	91203	4.00E-02 W					1500 N	150 N	54 N	82000 N	3100 N	180 S	30 E
Pyrene	129000	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N	56 S	1400 E
Prochloraz	67747095	9.00E-03 I		1.50E-01 I			0.45 C	0.042 C	0.021 C	38 C	4.3 C		
Profluralin	26399360	6.00E-03 H					220 N	22 N	8.1 N	12000 N	470 N		
Prometon	1610180	1.50E-02 I					550 N	55 N	20 N	31000 N	1200 N		
Prometryn	7287196	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Pronamide	23950585	7.50E-02 I					2700 N	270 N	100 N	150000 N	5900 N		
Propachlor	1918167	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Propanil	709988	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Propargite	2312358	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propargyl alcohol	107197	2.00E-03 I					73 N	7.3 N	2.7 N	4100 N	160 N		
Propazine	139402	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propham	122429	2.00E-02 I					730 N	73 N	27 N	41000 N	1600 N		
Propiconazole	60207901	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Propylene glycol	57556	2.00E+01 H					730000 N	73000 N	27000 N	1E+06 N	1000000 N		
Propylene glycol, monoethyl ether	52125538	7.00E-01 H					26000 N	2600 N	950 N	1E+06 N	55000 N		
Propylene glycol, monomethyl ether	107982	7.00E-01 H	5.71E-01 I				26000 N	2100 N	950 N	1E+06 N	55000 N		
Propylene oxide	75569		8.57E-03 I	2.40E-01 I	1.29E-02 I		0.28 C	0.49 C	0.013 C	24 C	2.7 C		
Pursuit	81335775	2.50E-01 I					9100 N	910 N	340 N	510000 N	20000 N		
Pydrin	51630581	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Pyridine	110861	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Quinalphos	13593038	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
Quinoline	91225			1.20E+01 H			0.0056 C	0.00052 C	0.00026 C	0.48 C	0.053 C		
Resmethrin	10463868	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
Ronnel	299843	5.00E-02 H					1800 N	180 N	68 N	100000 N	3900 N		
Rotenone	83794	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Savey	78587050	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Selenious Acid	7783008	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Selenium	7782492	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		3 E
Selenourea	630104	5.00E-03 H					180 N	18 N	6.8 N	10000 N	390 N		
Sethoxydim	74051802	9.00E-02 I					3300 N	330 N	120 N	180000 N	7000 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

Contaminant	CAS	RfDo	RfDi	CPSo	CPSi	VOC	Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
							Tap Water	Ambient Air	Fish	Soil Ingestion		Air	Groundwater
										Industrial	Residential		
		mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg		µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Silver and compounds	7440224	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		
Simazine	122349	5.00E-03 I		1.20E-01 H			0.56 C	0.052 C	0.026 C	48 C	5.3 C		
Sodium azide	26628228	4.00E-03 I					150 N	15 N	5.4 N	8200 N	310 N		
Sodium diethyldithiocarbamate	148185	3.00E-02 I		2.70E-01 H			0.25 C	0.023 C	0.012 C	21 C	2.4 C		
Sodium fluoroacetate	62748	2.00E-05 I					0.73 N	0.073 N	0.027 N	41 N	1.6 N		
Sodium metavanadate	13718268	1.00E-03 H					37 N	3.7 N	1.4 N	2000 N	78 N		
Strontium, stable	7440246	6.00E-01 I					22000 N	2200 N	810 N	1E+06 N	47000 N		
Strychnine	57249	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Styrene	100425	2.00E-01 I	2.86E-01 I			☒	1600 N	1000 N	270 N	410000 N	16000 N	1400 E	2 E
Systhane	88671890	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
2,3,7,8-TCDD (dioxin)	1746016			1.56E+05 H	1.16E+05 H		4E-07 C	5E-08 C	C	4E-05 C	4E-06 C		
Tebuthiuron	34014181	7.00E-02 I					2600 N	260 N	95 N	140000 N	5500 N		
Temephos	3383968	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Terbacil	5902512	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Terbufos	13071799	2.50E-05 H					0.91 N	0.091 N	0.034 N	51 N	2 N		
Terbutryn	886500	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
1,2,4,5-Tetrachlorobenzene	95943	3.00E-04 I				☒	1.8 N	1.1 N	0.41 N	610 N	23 N	91 N	0.69 N
1,1,1,2-Tetrachloroethane	630206	3.00E-02 I		2.60E-02 I	2.59E-02 I	☒	0.41 C	0.24 C	0.12 C	220 C	25 C		
1,1,2,2-Tetrachloroethane	79345			2.00E-01 I	2.03E-01 I	☒	0.052 C	0.031 C	0.016 C	29 C	3.2 C	0.4 E	0.001 E
Tetrachloroethylene (PCE)	127184	1.00E-02 I		5.20E-02 E	2.03E-03 E	☒	1.1 C	3.1 C	0.061 C	110 C	12 C	11 E	0.04 E
2,3,4,6-Tetrachlorophenol	58902	3.00E-02 I					1100 N	110 N	41 N	61000 N	2300 N		
p,a,a,a-Tetrachlorotoluene	5216251			2.00E+01 H		☒	0.00053 C	0.00031 C	0.00016 C	0.29 C	0.032 C		
Tetrachlorovinphos	961115	3.00E-02 I		2.40E-02 H			2.8 C	0.26 C	0.13 C	240 C	27 C		
Tetraethyldithiopyrophosphate	3689245	5.00E-04 I					18 N	1.8 N	0.68 N	1000 N	39 N		
Tetraethyl lead	78002	1.00E-07 I					0.0037 N	0.00037 N	0.00014 N	0.2 N	0.0078 N	0.00068 N	0.000034 N
**1,1,1,2-Tetrafluoroethane	811972	I	2.29E+01			☒	140000 N	84000 N					
Thallic oxide	1314325	7.00E-05 W					2.6 N	0.26 N	0.095 N	140 N	5.5 N		
Thallium													0.4 E
Thallium acetate	563688	9.00E-05 I					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium carbonate	6533739	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thallium chloride	7791120	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thallium nitrate	10102451	9.00E-05 I					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium selenite	12039520	9.00E-05 W					3.3 N	0.33 N	0.12 N	180 N	7 N		
Thallium sulfate	7446186	8.00E-05 I					2.9 N	0.29 N	0.11 N	160 N	6.3 N		
Thiobencarb	28249776	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-(Thiocyanomethylthio)-benzothiazole	21564170	3.00E-02 H					1100 N	110 N	41 N	61000 N	2300 N		
Thiofanox	39196184	3.00E-04 H					11 N	1.1 N	0.41 N	610 N	23 N		
Thiophanate-methyl	23564058	8.00E-02 I					2900 N	290 N	110 N	160000 N	6300 N		
Thiram	137268	5.00E-03 I					180 N	18 N	6.8 N	10000 N	390 N		

Sources: *I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST E=EPA-NCEA Regional Support provisional value O=Other EPA documents.*

Basis: *C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level S=soil saturation concentration M=EPA MCL.*

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
						V	Tap	Ambient		Soil Ingestion			
		RfDo	RfDi	CPSo	CPSi	O	Water	Air	Fish	Industrial	Residential	Air	Groundwater
Contaminant	CAS	mg/kg/d	mg/kg/d	kg·d/mg	kg·d/mg	C	µg/L	µg/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Tin and compounds		6.00E-01 H					22000 N	2200 N	810 N	1E+06 N	47000 N		
Toluene	108883	2.00E-01 I	1.14E-01 I			☒	750 N	420 N	270 N	410000 N	16000 N	520 E	5 E
Toluene-2,4-diamine	95807			3.20E+00 H			0.021 C	0.002 C	0.00099 C	1.8 C	0.2 C		
Toluene-2,5-diamine	95705	6.00E-01 H					22000 N	2200 N	810 N	1E+06 N	47000 N		
Toluene-2,6-diamine	823405	2.00E-01 H					7300 N	730 N	270 N	410000 N	16000 N		
p-Toluidine	106490			1.90E-01 H			0.35 C	0.033 C	0.017 C	30 C	3.4 C		
Toxaphene	8001352			1.10E+00 I	1.12E+00 I		0.061 C	0.0056 C	0.0029 C	5.2 C	0.58 C	5 E	0.04 E
Tralomethrin	66841256	7.50E-03 I					270 N	27 N	10 N	15000 N	590 N		
Triallate	2303175	1.30E-02 I					470 N	47 N	18 N	27000 N	1000 N		
Triasulfuron	82097505	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
1,2,4-Tribromobenzene	615543	5.00E-03 I				☒	30 N	18 N	6.8 N	10000 N	390 N		
Tributyltin oxide (TBTO)	56359	3.00E-05 I					1.1 N	0.11 N	0.041 N	61 N	2.3 N		
2,4,6-Trichloroaniline hydrochloride	33663502			2.90E-02 H			2.3 C	0.22 C	0.11 C	200 C	22 C		
2,4,6-Trichloroaniline	634935			3.40E-02 H			2 C	0.18 C	0.093 C	170 C	19 C		
1,2,4-Trichlorobenzene	120821	1.00E-02 I	5.71e-02 H			☒	190 N	210 N	14 N	20000 N	780 N	240 E	2 E
1,1,1-Trichloroethane	71556	9.00E-02 W	2.86E-01 W			☒	1300 N	1000 N	120 N	180000 N	7000 N	980 E	0.9 E
1,1,2-Trichloroethane	79005	4.00E-03 I		5.70E-02 I	5.60E-02 I	☒	0.19 C	0.11 C	0.055 C	100 C	11 C	0.8 E	0.01 E
Trichloroethylene (TCE)	79016	6.00E-03 E		1.10E-02 W	6.00E-03 E	☒	1.6 C	1 C	0.29 C	520 C	58 C	3 E	0.02 E
Trichlorofluoromethane	75694	3.00E-01 I	2.00E-01 A			☒	1300 N	730 N	410 N	610000 N	23000 N	790 N	13 N
2,4,5-Trichlorophenol	95954	1.00E-01 I					3700 N	370 N	140 N	200000 N	7800 N	8200 S	120 E
2,4,6-Trichlorophenol	88062			1.10E-02 I	1.09E-02 I		6.1 C	0.57 C	0.29 C	520 C	58 C	150 C	0.06 E
2,4,5-Trichlorophenoxyacetic acid	93765	1.00E-02 I					370 N	37 N	14 N	20000 N	780 N		
2-(2,4,5-Trichlorophenoxy)propionic acid	93721	8.00E-03 I					290 N	29 N	11 N	16000 N	630 N		
1,1,2-Trichloropropane	598776	5.00E-03 I				☒	30 N	18 N	6.8 N	10000 N	390 N	13 N	0.14 N
1,2,3-Trichloropropane	96184	6.00E-03 I		7.00e+00 I		☒	0.0015 C	0.00089 C	0.00045 C	0.82 C	0.091 C	0.00003 C	6.000E-06 C
1,2,3-Trichloropropene	96195	5.00E-03 H				☒	30 N	18 N	6.8 N	10000 N	390 N		
1,1,2-Trichloro-1,2,2- trifluoroethane	76131	3.00E+01 I	8.57E+00 H			☒	59000 N	31000 N	41000 N	1E+06 N	1000000 N	2400 S	3100 N
Tridiphane	58138082	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Triethylamine	121448		2.00E-03 I				73 N	7.3 N					
Trifluralin	1582098	7.50E-03 I		7.70E-03 I			8.7 C	0.81 C	0.41 C	740 C	83 C		
**1,2,4-Trimethylbenzene	95636	5.00e-02 E				☒	300 N	180 N	68 N	100000 N	3900 N		
**1,3,5-Trimethylbenzene	108678	5.00e-02 E				☒	300 N	180 N	68 N	100000 N	3900 N	98 S	0.26 M
Trimethyl phosphate	512561			3.70E-02 H			1.8 C	0.17 C	0.085 C	150 C	17 C		
1,3,5-Trinitrobenzene	99354	5.00E-05 I					1.8 N	0.18 N	0.068 N	100 N	3.9 N		
Trinitrophenylmethylnitramine	479458	1.00E-02 H					370 N	37 N	14 N	20000 N	780 N		
2,4,6-Trinitrotoluene	118967	5.00E-04 I		3.00E-02 I			2.2 C	0.21 C	0.11 C	190 C	21 C		
Uranium (soluble salts)	7440611	3.00E-03 I					110 N	11 N	4.1 N	6100 N	230 N		
Vanadium	7440622	7.00E-03 H					260 N	26 N	9.5 N	14000 N	550 N		
Vanadium pentoxide	1314621	9.00E-03 I					330 N	33 N	12 N	18000 N	700 N		

Sources: I=IRIS H=HEAST A=HEAST alternate W=Withdrawn from IRIS or HEAST
E=EPA-NCEA Regional Support provisional value O=Other EPA documents.

Basis : C=carcinogenic effects N=noncarcinogenic effects E=EPA draft Soil Screening Level
S=soil saturation concentration M=EPA MCL.

							Risk-Based Concentrations					Soil Screening Levels-Transfers from Soil to:	
										Soil Ingestion			
Contaminant	CAS	RfDo mg/kg/d	RfDi mg/kg/d	CPSo kg·d/mg	CPSi kg·d/mg	VOC	Tap Water µg/L	Ambient Air µg/m3	Fish mg/kg	Industrial mg/kg	Residential mg/kg	Air mg/kg	Groundwater mg/kg
Vanadium sulfate	36907423	2.00E-02 H					730 N	73 N	27 N	41000 N	1600 N		
Vernam	1929777	1.00E-03 I					37 N	3.7 N	1.4 N	2000 N	78 N		
Vinclozolin	50471448	2.50E-02 I					910 N	91 N	34 N	51000 N	2000 N		
Vinyl acetate	108054	1.00E+00 H	5.71E-02 I				37000 N	210 N	1400 N	1E+06 N	78000 N	370 E	84 E
Vinyl bromide	593602		8.57E-04 I			☒	5.2 N	3.1 N				2 N	0.018 N
Vinyl chloride	75014			1.90E+00 H	3.00E-01 H	☒	0.019 C	0.021 C	0.0017 C	3 C	0.34 C	0.002 E	0.01 E
Warfarin	81812	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N	0.046 N	1800 N
m-Xylene	108323	2.00E+00 H	2.00E-01 W			☒	1400 N	730 N	2700 N	1E+06 N	160000 N	950 S	240 M
o-Xylene	9.55E+04	2.00E+00 H	2.00E-01 W			☒	1400 N	730 N	2700 N	1E+06 N	160000 N	730 S	1.50E+02 M
p-Xylene	1.06E+05		8.57E-02 W			☒	520 N	310 N				1000 S	2.20E+02 M
Xylene (mixed)	1.33E+06	2.00E+00 I				☒	12000 N	7300 N	2700 N	1E+06 N	160000 N	320 E	7.40E+01 E
Zinc	7.44E+06	3.00E-01 I					11000 N	1100 N	410 N	610000 N	23000 N		4.20E+04 E
Zinc phosphide	1.31E+06	3.00E-04 I					11 N	1.1 N	0.41 N	610 N	23 N		
Zineb	1.21E+07	5.00E-02 I					1800 N	180 N	68 N	100000 N	3900 N		

APPENDIX F
VAPOR INTRUSION INTO A BUIDLING

APPENDIX F
VAPOR INTRUSION INTO A BUILDING

Migration of trichloroethene (TCE) and 1,1,2,2-tetrachloroethane vapors from soil and from groundwater through a foundation into a building was modeled in order to evaluate whether this exposure route could potentially result in unacceptable exposure levels for future residential or commercial receptors exposed to indoor air at the Poleline Road Disposal Area (PRDA). This pathway was evaluated separately from other exposure pathways evaluated in the health risk assessment because it is conceivable that the only exposure to contaminants in soil and groundwater at this site would be through vapor intrusion into a future structure.

F1 MODELING APPROACH

The vapor intrusion model used was developed by the American Society for Testing and Materials (ASTM) for application in Risk-Based Corrective Action (RBCA) at petroleum contaminated sites (ASTM 1995). The modeling software was designed and published by Groundwater Services, Inc. (GSI) and approved for distribution by ASTM (GSI 1995). The model estimates chemical-specific volatilization factors from soil and groundwater, vapor migration through the soil column and a building foundation, and dispersion in indoor air. The output of the model are risk-based site-specific target levels (SSTLs) that represent conservative (health-protective) estimates of contaminant concentrations in soil and in groundwater that are protective of the vapor migration-indoor air pathway for residential and commercial receptors. SSTLs for Class A and B carcinogens are based on a target cancer risk level of 1E-06 (1 in 1 million); SSTLs for Class C carcinogens are based on a target cancer risk level of 1E-05 (1 in 100,000); SSTLs for noncancer effects are based on a hazard quotient of 1. Site concentrations in soil or groundwater are then compared to the SSTLs; if site concentrations exceed the SSTLs, further evaluation of this pathway may be warranted.

The ASTM model for vapor intrusion is screening-level because it uses many simplifying assumptions and default parameter values and because the model results should be used only to indicate whether further site-specific evaluation may be warranted. ASTM has stated that remediation decisions should not be based on vapor intrusion model results because of the conservative assumptions built into the model that overestimate contaminant transport and result in overly conservative target levels. If site concentrations exceed the SSTLs for this exposure route, ASTM advises that direct air or soil vapor measurements be conducted prior to proceeding with remedial measures for this pathway.

Only 1,1,2,2-tetrachloroethane and TCE were evaluated because these are the chief contributors to cancer risk from exposure to groundwater (see Table B-9 in Appendix B). Evaluating only two chemicals was considered adequate for determining whether vapor migration through the soil column and into buildings warrants further site-specific evaluation prior to future development of the site.

F2 MODEL INPUT PARAMETERS

The complexities of subsurface conditions (e.g., number of saturated zones and depth to water table) at the PRDA were simplified for modeling purposes. The simplified conceptual model and other significant site-specific model input parameters are summarized below. All model input parameters are shown in the tables in Attachment F1, Vapor Intrusion Model Output. In the model output tables, parameters shown in bold italic with underline are site-specific values that were based on the simplified conceptual model or soil characteristics estimated from information in the Remedial Investigation Report (WCFS 1996).

1. Only the area of highest contamination was evaluated, namely, in and near Areas A-3 and A-4 (see Figure F-1).

2. Depth to top of contaminated groundwater was assumed to be 8 feet, based on depth to perched zone shown in Figure F-2. This depth was selected to provide a conservative estimate of the distance of vertical vapor migration through soil.

3. Depth to top of contaminated soil was assumed to be 15 feet. Thickness of the contaminated soil layer was estimated to be 5 feet (i.e., extending to 20 feet below ground surface, which is the estimated top of the shallow saturated zone).

4. Two parameters to which the subsurface soil to enclosed space model results are particularly sensitive are soil density and air-filled soil porosity. Soil density was

estimated at 1.6 percent, based on site information on soil type and fill history. Air filled soil porosity was conservatively estimated at 0.246 cm^3air/cm^3soil.

5. Where site-specific parameters were not available (e.g., for building sizes and air exchange rates), model default values were used, with one exception (porosity of building foundation). The model default assumption is that steady state conditions exist between the vadose zone and building foundation, i.e., the foundation provides no barrier to vapor intrusion. To more realistically characterize the barrier that would be provided by a new concrete foundation, it was assumed that the air-filled pore space in the foundation was one-tenth that of the vadose zone.

6. The model default assumptions for vapor intrusion include a 1 percent open crack space in the foundation and building air exchange rates of 12/day (residential) and 20/day (commercial).

7. Vapor migration from soil and groundwater are modeled separately to estimate SSTLs for each medium.

F3 SOIL AND GROUNDWATER CONCENTRATIONS AT PRDA

Representative soil and groundwater and contaminant concentrations at the site are calculated in Tables F-1 and F-2. As noted earlier, sample results from Areas A-3 and A-4 and adjacent sample locations (shown in Figure F-1) were used to estimate the representative site concentrations for comparison to the SSTLs. Sample results used to estimate site concentrations are discussed for each medium below.

Groundwater: Sample results from the perched and shallow zones were combined to estimate the site concentrations of contaminants in groundwater because concentrations in these saturated zones were comparable (except for unusually high concentrations in MW-14, which is screened in the perched zone). Groundwater data used to calculate the site concentrations are shown in Table F-1. Both the arithmetic mean and 95% upper confidence limit (UCL) are strongly influenced by the extremely high concentrations at MW-14, which are one to two orders of magnitude higher than concentrations at other locations.

Soil: The concentration terms for soil was estimated from sample results collected in the 13 to 15-foot interval or deeper reported in the Remedial Investigation Report (WCFS 1996) as well as three excavation confirmation sample results from the Hillside Excavation collected below 13 feet (OHM 1994) (Table F-2). This data set includes the maximum concentrations detected in soil at the site (for example, two samples contain in excess of 2,000 mg/kg 1,1,2,2-tetrachloroethane, whereas the maximum concentration in soil in the 0 to 15-foot interval was 65 mg/kg).

F4 COMPARISON OF SITE CONCENTRATIONS TO SSTLs

Modeled SSTLs for soil and groundwater and contaminant concentrations at the site are shown in Table F-3. Model input and output are shown in tables in Attachment F1. As shown in Table F-3, representative site concentrations exceed SSTLs for all scenarios evaluated (commercial and residential).

For soil, 95% UCL concentrations exceed SSTLs by factors 140 or more, suggesting that site-specific measurements may be warranted prior to development of the site in the absence of remediation. Since it is possible that the soil contamination observed at depth is due to cross-contamination from shallow groundwater, groundwater remediation could have a significant effect upon the contaminant concentrations in soil.

For groundwater, 95% UCL concentrations exceed commercial SSTLs by factors of 6 (TCE) and 12 (1,1,2,2-tetrachloroethane) and they exceed residential SSTLs by factors of 19 (TCE) and 36 (1,1,2,2-tetrachloroethane). These values suggest that groundwater is probably not as significant a concern for vapor release and migration as soil, assuming soil is contaminated at the levels indicated in Table F-2.

F5 SUMMARY

The ASTM vapor migration-indoor air model calculated risk-based screening levels for soil and groundwater that are protective of the indoor air pathway. Representative site concentrations calculated for the most affected soil and groundwater areas at the PRDA exceeded the modeled SSTLs. ASTM cautions that remediation decisions should not be based on the results of this vapor intrusion model alone because of the conservative assumptions that are likely to overestimate contaminant transport. Rather, significant exceedances of the SSTLs indicate that air or soil vapor measurements should be conducted prior to making remedial decisions.

REFERENCES

American Society for Testing and Materials (ASTM). 1995. Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. ES 38-94.

Groundwater Services, Inc. (GSI). 1995. Guidance Manual for Risk-Based Corrective Action.

Woodward-Clyde Federal Services (WCFS). 1996. Remedial Investigation Report, Operable Unit B, Poleline Road Disposal Area, Fort Richardson, Alaska. Prepared for U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska.

TABLE F-1
CHEMICAL CONCENTRATIONS IN GROUNDWATER FOR COMPARING TO VAPOR MIGRATION SSTLs

Saturated Zone	Sample Location	1,1,2,2-Tetrachloroethane (mg/L)	Trichloroethylene (mg/L)
Perched	MW-14	1900	220
	SB-C1	52	15
	SB-C2	5.7	0.5
	SB-B1	68	31
Shallow	SB-D1	89	43
	SB-D2	93	46
	MW-4	71	14
	SB-O13 (a)	34	12
	SB-O14	1.6	0.7
	SB-B2	29	7.7
	SB-O1	6.1	4.5
	MW-5	21	4.8
	SB-C3	0.12	0.05
	Mean	182	31
	Std dev	517.14	58.97
	n	13	13
	t (n-1,0.05)	1.782	1.782
	95% UCL	437.94	59.86

SSTL = Site-specific target level (see Table F-3).
UCL = upper confidence limit on the mean
(a) Maximum of duplicate samples

TABLE F-2
CHEMICAL CONCENTRATIONS IN SOIL FOR COMPARING TO VAPOR MIGRATION SSTLs

Sample Location	Depth (ft bgs)	1,1,2,2-Tetrachloroethane (mg/kg)	Trichloroethylene (mg/kg)
MW-14	14-15	1.6	0.8
	16-18	2030	384
	18-20	93.2	26
	20-22	10.1	1.5
SB-C1	13-15	3.3	0.6
SB-C2	17-18	3.8	0.6
MS-10	14	121	2.5
MS-11	14	2920	134
MS-12	14	32	7
Mean		579.44	61.89
St Dev		1098.29	128.29
n		9	9
t (n-1,0.05)		1.86	1.86
95% UCL		1260.39	141.43

SSTL = Site-specific target level (see Table F-3)
UCL = upper confidence limit on the mean

Note: Boring locations within the soil area indicated on Figure F-1 but not listed here did not have samples collected below 12 feet.

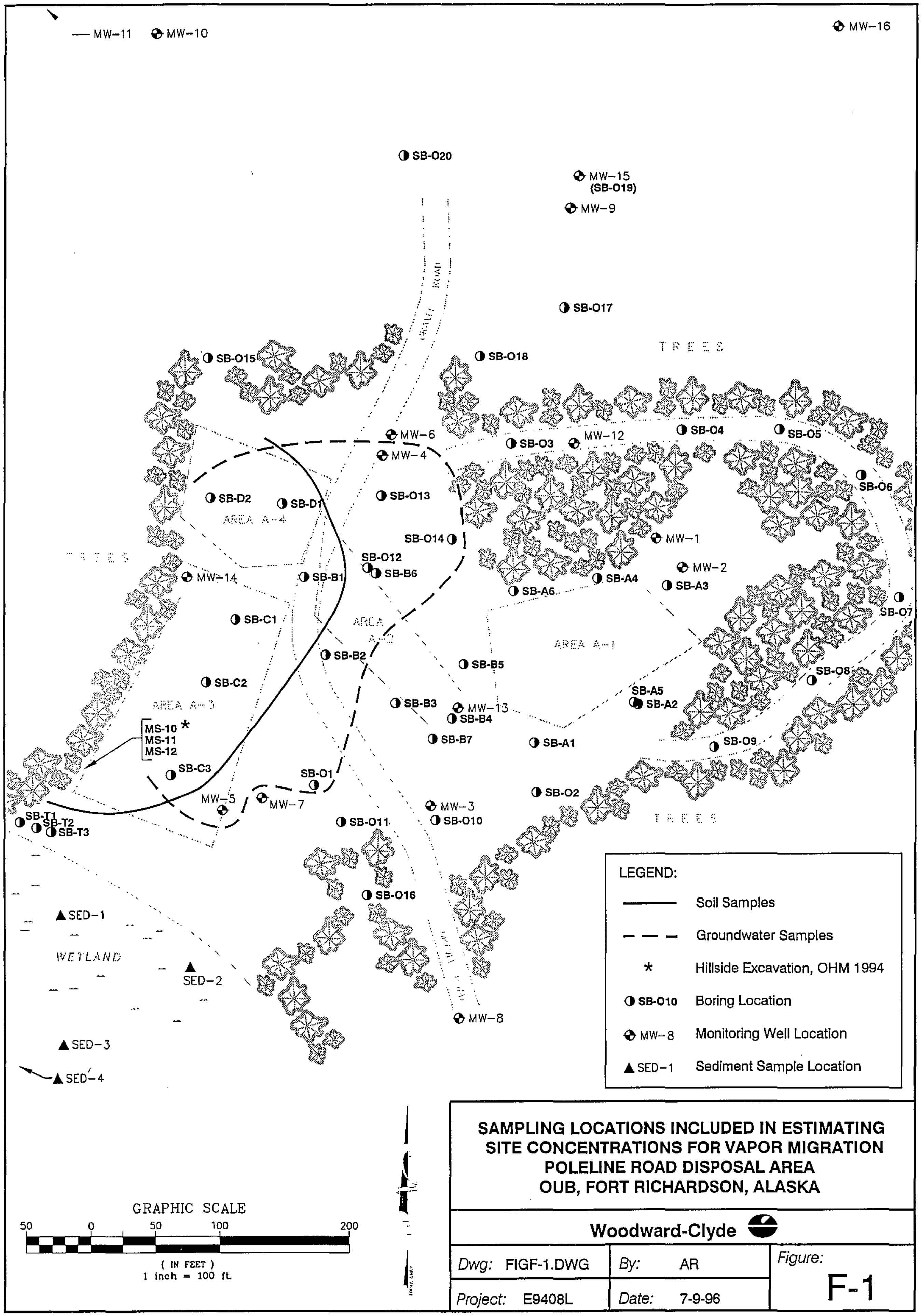
TABLE F-3
COMPARISON OF SITE CONCENTRATIONS TO SSTLs FOR VAPOR MIGRATION

	1,1,2,2-Tetrachloroethane		Trichloroethylene	
Parameter	**Conc. (mg/kg)**	**Site Conc. > SSTL?**	**Conc. (mg/kg)**	**Site Conc. > SSTL?**
Soil (15 to 20 feet bgs)				
Commercial SSTL (a)	4.1		2.7	
Residential SSTL (a)	1.3		0.87	
Mean Site Concentration (b)	579	Yes	62	Yes
95% UCL Site Concentration (b)	1260	Yes	141	Yes
Groundwater (perched and shallow)				
Commercial SSTL (a)	36		9.7	
Residential SSTL (a)	12		3.1	
Mean Site Concentration (b)	182	Yes	31	Yes
95% UCL Site Concentration (b)	438	Yes	60	Yes

(a) SSTLs are estimated target level concentrations in soil or groundwater protective of the vapor migration-indoor air exposure route. They are estimated using a model developed by ASTM (ASTM 1995; GSI 1995). SSTLs are based on conservative exposure and fate and transport assumptions. They are calculated using a 1E-06 cancer risk level for class A and B carcinogens and a 1E-05 cancer risk level for class C carcinogens. 1122-Tetrachloroethane is a class C carcinogen; TCE is unclassified, and a 1E-05 cancer risk level was used. ASTM cautions that remediation decisions should not be based on comparing site concentrations to SSTLs for the vapor migration pathway; however, the SSTLs may be used to judge whether site-specific measurements of vapor intrusion into buildings should be performed.

(b) Estimated from samples collected in and near Areas A-3 and A-4. See Tables F-1 and F-2.

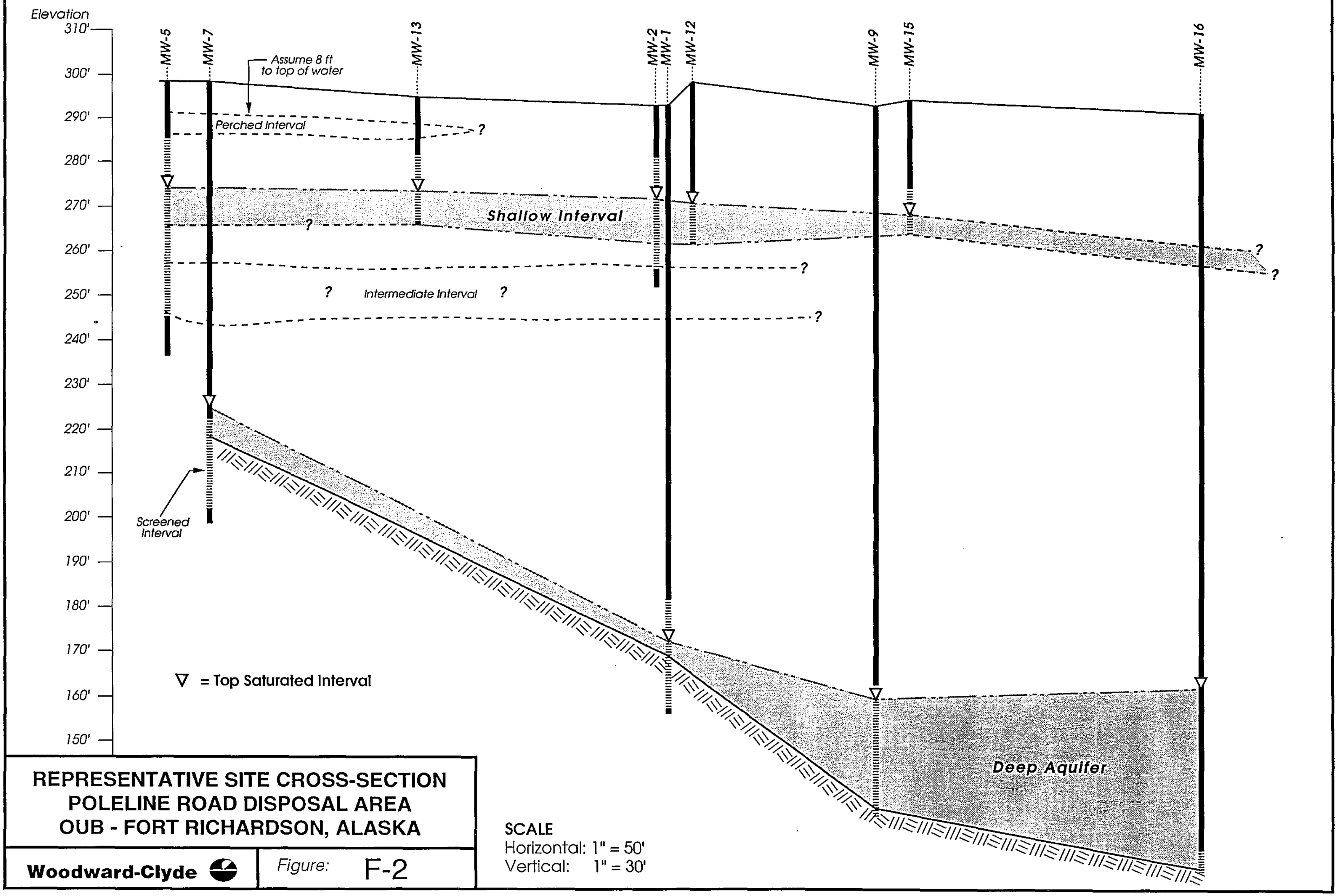
SSTL = Site-specific target level
UCL = upper confidence limit on the mean



SAMPLING LOCATIONS INCLUDED IN ESTIMATING SITE CONCENTRATIONS FOR VAPOR MIGRATION POLELINE ROAD DISPOSAL AREA OUB, FORT RICHARDSON, ALASKA

Woodward-Clyde

Dwg: FIGF-1.DWG	*By:* AR	*Figure:*
Project: E9408L	*Date:* 7-9-96	F-1



REPRESENTATIVE SITE CROSS-SECTION
POLELINE ROAD DISPOSAL AREA
OUB - FORT RICHARDSON, ALASKA

Woodward-Clyde

Figure: F-2

SCALE
Horizontal: 1" = 50'
Vertical: 1" = 30'

ATTACHMENT F1
VAPOR INTRUSION MODEL OUTPUT

RBCA TIER 1/TIER 2 EVALUA N

Output Tab

Site Name: Alaska soil:commercial
Site Location: alaska

Job Identification:
Date Completed: 7/5/96
Completed By: Denise Clendening

Software: GSI RBCA Spreadsheet
Version: v 1.0

NOTE: values which differ from Tier 1 default values are shown in bold italics and underlined.

DEFAULT PARAMETERS

Exposure Parameter	Definition (Units)	Residential Adult	Residential (1-6yrs)	Residential (1-16 yrs)	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
ATc	Averaging time for carcinogens (yr)	70				
ATn	Averaging time for non-carcinogens (yr)	30	6	16	25	1
BW	Body Weight (kg)	70	15	35	70	
ED	Exposure Duration (yr)	30	6	16	25	1
EF	Exposure Frequency (days/yr)	350			250	180
EF.Derm	Exposure Frequency for dermal exposure	350			250	
IRgw	Ingestion Rate of Water (l/day)	2			1	
IRs	Ingestion Rate of Soil (mg/day)	100	200		50	100
IRadj	Adjusted soil ing. rate (mg•yr/kg•d)	1.1E+02			9.4E+01	
IRa.in	Inhalation rate indoor (m^3/day)	15			20	
IRa.out	Inhalation rate outdoor (m^3/day)	20			20	10
SA	Skin surface area (dermal) (cm^2)	5.8E+03		2.0E+03	5.8E+03	5.8E+03
SAadj	Adjusted dermal area (cm^2•yr/kg)	2.1E+03			1.7E+03	
M	Soil to Skin adherence factor	1				
AAFs	Age adjustment on soil ingestion	FALSE			FALSE	
AAFd	Age adjustment on skin surface area	FALSE			FALSE	
tox	Use EPA tox data for air (or PEL based)	TRUE				
gwMCL?	Use MCL as exposure limit in groundwater?	FALSE				

Matrix of Exposed Persons to Complete Exposure Pathways		Residential	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
Groundwater Pathways:				
GW.i	Groundwater Ingestion	FALSE	FALSE	
GW.v	Volatilization to Outdoor Air	FALSE	FALSE	
GW.b	Vapor Intrusion to Buildings	FALSE	FALSE	
Soil Pathways				
S.v	Volatiles from Subsurface Soils	FALSE	FALSE	
SS.v	Volatiles and Particulate Inhalation	FALSE	FALSE	FALSE
SS.d	Direct Ingestion and Dermal Contact	FALSE	FALSE	FALSE
S.l	Leaching to Groundwater from all Soils	FALSE	FALSE	
S.b	Intrusion to Buildings - Subsurface Soils	FALSE	TRUE	

Matrix of Receptor Distance and Location on- or off-site		Residential Distance	Residential On-Site	Commercial/Industrial Distance	Commercial/Industrial On-Site
GW	Groundwater receptor (cm)		FALSE		FALSE
S	Inhalation receptor (cm)		FALSE		FALSE

Matrix of Target Risks		Individual	Cumulative
TRab	Target Risk (class A&B carcinogens)	1.0E-06	
TRc	Target Risk (class C carcinogens)	1.0E-05	
THQ	Target Hazard Quotient	1.0E+00	
Opt	Calculation Option (1, 2, or 3)	3	
Tier	RBCA Tier	2	

Surface Parameters	Definition (Units)	Residential	Commercial/Industrial Chronic	Commercial/Industrial Construction
t	Exposure duration (yr)	30	25	1
A	Contaminated soil area (cm^2)	2.2E+06		1.0E+06
W	Length of affected soil parallel to wind (cm)	1.5E+03		1.0E+03
W.gw	Length of affected soil parallel to groundwater (c	1.5E+03		
Uair	Ambient air velocity in mixing zone (cm/s)	2.3E+02		
delta	Air mixing zone height (cm)	2.0E+02		
Lss	Definition of surficial soils (cm)	***4.6E+02***		
Pe	Particulate areal emission rate (g/cm^2/s)	2.2E-10		

Groundwater	Definition (Units)	Value
delta.gw	Groundwater mixing zone depth (cm)	2.0E+02
I	Groundwater infiltration rate (cm/yr)	3.0E+01
Ugw	Groundwater Darcy velocity (cm/yr)	2.5E+03
Ugw.tr	Groundwater Transport velocity (cm/yr)	6.6E+03
Ks	Saturated Hydraulic Conductivity(cm/s)	
grad	Groundwater Gradient (cm/cm)	
Sw	Width of groundwater source zone (cm)	
Sd	Depth of groundwater source zone (cm)	
BC	Biodegradation Capacity (mg/L)	
BIO?	Is Bioattenuation Considered	FALSE
phi.eff	Effective Porosity in Water-Bearing Unit	3.8E-01
foc.sat	Fraction organic carbon in water-bearing unit	1.0E-03

Soil	Definition (Units)	Value		
hc	Capillary zone thickness (cm)	***3.0E+00***		
hv	Vadose zone thickness (cm)	***6.1E+02***		
rho	Soil density (g/cm^3)	***1.6***		
foc	Fraction of organic carbon in vadose zone	***0.0066***		
phi	Soil porosity in vadose zone	***0.396***		
Lgw	Depth to groundwater (cm)	***6.1E+02***		
Ls	Depth to top of affected soil (cm)	***4.6E+02***		
Lsubs	Thickness of affected subsurface soils (cm)	***1.5E+02***		
pH	Soil/groundwater pH	***6.4***		
		capillary	vadose	foundation
phi.w	Volumetric water content	***0.366***	***0.15***	***0.372***
phi.a	Volumetric air content	***0.03***	***0.246***	***0.024***

Building	Definition (Units)	Residential	Commercial
Lb	Building volume/area ratio (cm)	2.0E+02	3.0E+02
ER	Building air exchange rate (s^-1)	1.4E-04	2.3E-04
Lcrk	Foundation crack thickness (cm)	1.5E+01	
eta	Foundation crack fraction	0.01	

Dispersive Transport Parameters	Definition (Units)	Residential	Commercial
Groundwater			
ax	Longitudinal dispersion coefficient (cm)		
ay	Transverse dispersion coefficient (cm)		
az	Vertical dispersion coefficient (cm)		
Vapor			
dcy	Transverse dispersion coefficient (cm)		
dcz	Vertical dispersion coefficient (cm)		

RBCA SITE ASSESSMENT | **Tier 2 Worksheet 9.2**

Site Name: Alaska soil commercial
Site Location: alaska

Completed By: Denise Clendening
Date Completed: 7/5/1996

1 OF 1

SUBSURFACE SOIL SSTL VALUES
(> 3 FT BGS)

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 3

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		**Representative Concentration**	Soil Leaching to Groundwater			X Soil Volatilization to Indoor Air		Soil Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	**Name**	(mg/kg)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential: (on-site)	Commercial: (on-site)	(mg/kg)	"■" if yes	Only if "yes" left
79-34-5	Tetrachloroethane, 1,1,2,2-	1.3E+3	NA	NA	NA	NA	4.1E+0	NA	NA	4.1E+0	■	3.1E+02
79-01-6	Trichloroethene	1.4E+2	NA	NA	NA	NA	2.7E+0	NA	NA	2.7E+0	■	5.2E+01

Software: GSI RBCA Spreadsheet
Version: v 1.0
Serial: G-373-ZOX-798

RBCA TIER 1/TIER 2 EVALUA N

Output Ta

Site Name: Alaska soil residential
Site Location: alaska

Job Identification:
Date Completed: 7/5/96
Completed By: Denise Clendening

Software: GSI RBCA Spreadsheet
Version: v 1.0

NOTE: values which differ from Tier 1 default values are shown in bold italics and underlined.

DEFAULT PARAMETERS

Exposure Parameter	Definition (Units)	Residential			Commercial/Industrial	
		Adult	(1-6yrs)	(1-16 yrs)	Chronic	Constrctn
ATc	Averaging time for carcinogens (yr)	70				
ATn	Averaging time for non-carcinogens (yr)	30	6	16	25	1
BW	Body Weight (kg)	70	15	35	70	
ED	Exposure Duration (yr)	30	6	16	25	1
EF	Exposure Frequency (days/yr)	350			250	180
EF.Derm	Exposure Frequency for dermal exposure	350			250	
IRgw	Ingestion Rate of Water (l/day)	2			1	
IRs	Ingestion Rate of Soil (mg/day)	100	200		50	100
IRadj	Adjusted soil ing. rate (mg•yr/kg•d)	1.1E+02			9.4E+01	
IRa.in	Inhalation rate indoor (m^3/day)	15			20	
IRa.out	Inhalation rate outdoor (m^3/day)	20			20	10
SA	Skin surface area (dermal) (cm^2)	5.8E+03		2.0E+03	5.8E+03	5.8E+03
SAadj	Adjusted dermal area (cm^2•yr/kg)	2.1E+03			1.7E+03	
M	Soil to Skin adherence factor	1				
AAFs	Age adjustment on soil ingestion	FALSE			FALSE	
AAFd	Age adjustment on skin surface area	FALSE			FALSE	
tox	Use EPA tox data for air (or PEL based)	TRUE				
gwMCL?	Use MCL as exposure limit in groundwater?	FALSE				

Matrix of Exposed Persons to Complete Exposure Pathways		Residential	Commercial/Industrial	
			Chronic	Constrctn
Groundwater Pathways:				
GW.i	Groundwater Ingestion	FALSE	FALSE	
GW.v	Volatilization to Outdoor Air	FALSE	FALSE	
GW.b	Vapor Intrusion to Buildings	FALSE	FALSE	
Soil Pathways				
S.v	Volatiles from Subsurface Soils	FALSE	FALSE	
SS.v	Volatiles and Particulate Inhalation	FALSE	FALSE	FALSE
SS.d	Direct Ingestion and Dermal Contact	FALSE	FALSE	FALSE
S.l	Leaching to Groundwater from all Soils	FALSE	FALSE	
S.b	Intrusion to Buildings - Subsurface Soils	TRUE	FALSE	

Matrix of Receptor Distance and Location on- or off-site		Residential		Commercial/Industrial	
		Distance	On-Site	Distance	On-Site
GW	Groundwater receptor (cm)		FALSE		FALSE
S	Inhalation receptor (cm)		FALSE		FALSE

Matrix of Target Risks		Individual	Cumulative
TRab	Target Risk (class A&B carcinogens)	1.0E-06	
TRc	Target Risk (class C carcinogens)	1.0E-05	
THQ	Target Hazard Quotient	1.0E+00	
Opt	Calculation Option (1, 2, or 3)	3	
Tier	RBCA Tier	2	

Surface Parameters	Definition (Units)	Residential	Commercial/Industrial	
			Chronic	Construction
t	Exposure duration (yr)	30	25	1
A	Contaminated soil area (cm^2)	2.2E+06		1.0E+06
W	Length of affected soil parallel to wind (cm)	1.5E+03		1.0E+03
W.gw	Length of affected soil parallel to groundwater (c	1.5E+03		
Uair	Ambient air velocity in mixing zone (cm/s)	2.3E+02		
delta	Air mixing zone height (cm)	2.0E+02		
Lss	Definition of surficial soils (cm)	1.0E+02		
Pe	Particulate areal emission rate (g/cm^2/s)	2.2E-10		

Groundwater	Definition (Units)	Value
delta.gw	Groundwater mixing zone depth (cm)	2.0E+02
I	Groundwater infiltration rate (cm/yr)	3.0E+01
Ugw	Groundwater Darcy velocity (cm/yr)	2.5E+03
Ugw.tr	Groundwater Transport velocity (cm/yr)	6.6E+03
Ks	Saturated Hydraulic Conductivity(cm/s)	
grad	Groundwater Gradient (cm/cm)	
Sw	Width of groundwater source zone (cm)	
Sd	Depth of groundwater source zone (cm)	
BC	Biodegradation Capacity (mg/L)	
BIO?	Is Bioattenuation Considered	FALSE
phi.eff	Effective Porosity in Water-Bearing Unit	3.8E-01
foc.sat	Fraction organic carbon in water-bearing unit	1.0E-03

Soil	Definition (Units)	Value		
hc	Capillary zone thickness (cm)	***3.0E+00***		
hv	Vadose zone thickness (cm)	***6.1E+02***		
rho	Soil density (g/cm^3)	***1.6***		
foc	Fraction of organic carbon in vadose zone	***0.0066***		
phi	Soil porosity in vadose zone	***0.396***		
Lgw	Depth to groundwater (cm)	***6.1E+02***		
Ls	Depth to top of affected soil (cm)	***4.6E+02***		
Lsubs	Thickness of affected subsurface soils (cm)	***1.5E+02***		
pH	Soil/groundwater pH	***6.4***		
		capillary	vadose	foundation
phi.w	Volumetric water content	***0.366***	***0.15***	***0.372***
phi.a	Volumetric air content	***0.03***	***0.246***	***0.024***

Building	Definition (Units)	Residential	Commercial
Lb	Building volume/area ratio (cm)	2.0E+02	3.0E+02
ER	Building air exchange rate (s^-1)	1.4E-04	2.3E-04
Lcrk	Foundation crack thickness (cm)	1.5E+01	
eta	Foundation crack fraction	0.01	

Dispersive Transport Parameters	Definition (Units)	Residential	Commercial
Groundwater			
ax	Longitudinal dispersion coefficient (cm)		
ay	Transverse dispersion coefficient (cm)		
az	Vertical dispersion coefficient (cm)		
Vapor			
dcy	Transverse dispersion coefficient (cm)		
dcz	Vertical dispersion coefficient (cm)		

RBCA SITE ASSESSMENT

Tier 2 Worksheet 9.2

Site Name: Alaska soil residential
Site Location: alaska

Completed By: Denise Clendening
Date Completed: 7/5/1996

1 OF 1

SUBSURFACE SOIL SSTL VALUES
(> 3 FT BGS)

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 3

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		**Representative Concentration**	Soil Leaching to Groundwater			X Soil Volatilization to Indoor Air		Soil Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	**Name**	(mg/kg)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential: (on-site)	Commercial: (on-site)	(mg/kg)	"■" If yes	Only if "yes" left
79-34-5	Tetrachloroethane, 1,1,2,2-	1.3E+3	NA	NA	NA	1.3E+0	NA	NA	NA	1.3E+0	■	9.6E+02
79-01-6	Trichloroethene	1.4E+2	NA	NA	NA	8.7E-1	NA	NA	NA	8.7E-1	■	1.6E+02

Software: GSI RBCA Spreadsheet
Version: v 1.0

Serial: G-373-ZOX-798

RBCA TIER 1/TIER 2 EVALUA N

Output Ta

Site Name: Alaska gw commercial
Site Location: alaska

Job Identification:
Date Completed: 7/5/96
Completed By: Denise Clendening

Software: GSI RBCA Spreadsheet
Version: v 1.0

NOTE: values which differ from Tier 1 default values are shown in bold italics and underlined.

DEFAULT PARAMETERS

Exposure Parameter	Definition (Units)	Residential Adult	Residential (1-6yrs)	Residential (1-16 yrs)	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
ATc	Averaging time for carcinogens (yr)	70				
ATn	Averaging time for non-carcinogens (yr)	30	6	16	25	1
BW	Body Weight (kg)	70	15	35	70	
ED	Exposure Duration (yr)	30	6	16	25	1
EF	Exposure Frequency (days/yr)	350			250	180
EF.Derm	Exposure Frequency for dermal exposure	350			250	
IRgw	Ingestion Rate of Water (l/day)	2			1	
IRs	Ingestion Rate of Soil (mg/day)	100	200		50	100
IRadj	Adjusted soil ing. rate (mg•yr/kg•d)	1.1E+02			9.4E+01	
IRa.in	Inhalation rate indoor (m^3/day)	15			20	
IRa.out	Inhalation rate outdoor (m^3/day)	20			20	10
SA	Skin surface area (dermal) (cm^2)	5.8E+03		2.0E+03	5.8E+03	5.8E+03
SAadj	Adjusted dermal area (cm^2•yr/kg)	2.1E+03			1.7E+03	
M	Soil to Skin adherence factor	1				
AAFs	Age adjustment on soil ingestion	FALSE			FALSE	
AAFd	Age adjustment on skin surface area	FALSE			FALSE	
tox	Use EPA tox data for air (or PEL based)	TRUE				
gwMCL?	Use MCL as exposure limit in groundwater?	FALSE				

Matrix of Exposed Persons to Complete Exposure Pathways		Residential	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
Groundwater Pathways:				
GW.i	Groundwater Ingestion	FALSE	FALSE	
GW.v	Volatilization to Outdoor Air	FALSE	FALSE	
GW.b	Vapor Intrusion to Buildings	FALSE	TRUE	
Soil Pathways				
S.v	Volatiles from Subsurface Soils	FALSE	FALSE	
SS.v	Volatiles and Particulate Inhalation	FALSE	FALSE	FALSE
SS.d	Direct Ingestion and Dermal Contact	FALSE	FALSE	FALSE
S.l	Leaching to Groundwater from all Soils	FALSE	FALSE	
S.b	Intrusion to Buildings - Subsurface Soils	FALSE	FALSE	

Matrix of Receptor Distance and Location on- or off-site		Residential Distance	Residential On-Site	Commercial/Industrial Distance	Commercial/Industrial On-Site
GW	Groundwater receptor (cm)		FALSE		FALSE
S	Inhalation receptor (cm)		FALSE		FALSE

Matrix of Target Risks		Individual	Cumulative
TRab	Target Risk (class A&B carcinogens)	1.0E-06	
TRc	Target Risk (class C carcinogens)	1.0E-05	
THQ	Target Hazard Quotient	1.0E+00	
Opt	Calculation Option (1, 2, or 3)	3	
Tier	RBCA Tier	2	

Surface Parameters	Definition (Units)	Residential	Commercial/Industrial Chronic	Commercial/Industrial Construction
t	Exposure duration (yr)	30	25	1
A	Contaminated soil area (cm^2)	2.2E+06		1.0E+06
W	Length of affected soil parallel to wind (cm)	1.5E+03		1.0E+03
W.gw	Length of affected soil parallel to groundwater (c	1.5E+03		
Uair	Ambient air velocity in mixing zone (cm/s)	2.3E+02		
delta	Air mixing zone height (cm)	2.0E+02		
Lss	Definition of surficial soils (cm)	1.0E+02		
Pe	Particulate areal emission rate (g/cm^2/s)	2.2E-10		

Groundwater	Definition (Units)	Value
delta.gw	Groundwater mixing zone depth (cm)	2.0E+02
I	Groundwater infiltration rate (cm/yr)	3.0E+01
Ugw	Groundwater Darcy velocity (cm/yr)	2.5E+03
Ugw.tr	Groundwater Transport velocity (cm/yr)	6.6E+03
Ks	Saturated Hydraulic Conductivity(cm/s)	
grad	Groundwater Gradient (cm/cm)	
Sw	Width of groundwater source zone (cm)	
Sd	Depth of groundwater source zone (cm)	
BC	Biodegradation Capacity (mg/L)	
BIO?	Is Bioattenuation Considered	FALSE
phi.eff	Effective Porosity in Water-Bearing Unit	3.8E-01
foc.sat	Fraction organic carbon in water-bearing unit	1.0E-03

Soil	Definition (Units)	Value		
hc	Capillary zone thickness (cm)	***3.0E+00***		
hv	Vadose zone thickness (cm)	***2.4E+02***		
rho	Soil density (g/cm^3)	***1.6***		
foc	Fraction of organic carbon in vadose zone	***0.0066***		
phi	Soil porosity in vadose zone	***0.396***		
Lgw	Depth to groundwater (cm)	***2.4E+02***		
Ls	Depth to top of affected soil (cm)	1.0E+02		
Lsubs	Thickness of affected subsurface soils (cm)	***3.3E+02***		
pH	Soil/groundwater pH	***6.4***		
		capillary	**vadose**	**foundation**
phi.w	Volumetric water content	***0.366***	***0.15***	***0.372***
phi.a	Volumetric air content	***0.03***	***0.246***	***0.024***

Building	Definition (Units)	Residential	Commercial
Lb	Building volume/area ratio (cm)	2.0E+02	3.0E+02
ER	Building air exchange rate (s^-1)	1.4E-04	2.3E-04
Lcrk	Foundation crack thickness (cm)	1.5E+01	
eta	Foundation crack fraction	0.01	

Dispersive Transport Parameters	Definition (Units)	Residential	Commercial
Groundwater			
ax	Longitudinal dispersion coefficient (cm)		
ay	Transverse dispersion coefficient (cm)		
az	Vertical dispersion coefficient (cm)		
Vapor			
dcy	Transverse dispersion coefficient (cm)		
dcz	Vertical dispersion coefficient (cm)		

RBCA SITE ASSESSMENT | **Tier 2 Worksheet 9.3**

Site Name: Alaska gw commercial
Site Location: alaska

Completed By: Denise Clendening
Date Completed: 7/5/1996

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 3

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		**Representative Concentration**	Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		Groundwater Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	**Name**	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" If yes	Only if "yes" left
79-34-5	Tetrachloroethane, 1,1,2,2-	1.8E+2	NA	NA	NA	NA	3.6E+1	NA	NA	3.6E+1	■	5.0E+00
79-01-6	Trichloroethene	3.1E+1	NA	NA	NA	NA	9.7E+0	NA	NA	9.7E+0	■	3.0E+00

Software: GSI RBCA Spreadsheet
Version: v 1.0

Serial: G-373-ZOX-798

RBCA TIER 1/TIER 2 EVALU N

Output Ta

Site Name: Alaska gw residential
Site Location: alaska

Job Identification:
Date Completed: 7/5/96
Completed By: Denise Clendening

Software: GSI RBCA Spreadsheet
Version: v 1.0

NOTE: values which differ from Tier 1 default values are shown in bold italics and underlined.

DEFAULT PARAMETERS

Exposure Parameter	Definition (Units)	Residential Adult	Residential (1-6yrs)	Residential (1-16 yrs)	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
ATc	Averaging time for carcinogens (yr)	70				
ATn	Averaging time for non-carcinogens (yr)	30	6	16	25	1
BW	Body Weight (kg)	70	15	35	70	
ED	Exposure Duration (yr)	30	6	16	25	1
EF	Exposure Frequency (days/yr)	350			250	180
EF.Derm	Exposure Frequency for dermal exposure	350			250	
IRgw	Ingestion Rate of Water (l/day)	2			1	
IRs	Ingestion Rate of Soil (mg/day)	100	200		50	100
IRadj	Adjusted soil ing. rate (mg•yr/kg•d)	1.1E+02			9.4E+01	
IRa.in	Inhalation rate indoor (m^3/day)	15			20	
IRa.out	Inhalation rate outdoor (m^3/day)	20			20	10
SA	Skin surface area (dermal) (cm^2)	5.8E+03		2.0E+03	5.8E+03	5.8E+03
SAadj	Adjusted dermal area (cm^2•yr/kg)	2.1E+03			1.7E+03	
M	Soil to Skin adherence factor	1				
AAFs	Age adjustment on soil ingestion	FALSE			FALSE	
AAFd	Age adjustment on skin surface area	FALSE			FALSE	
tox	Use EPA tox data for air (or PEL based)	TRUE				
gwMCL?	Use MCL as exposure limit in groundwater?	FALSE				

Matrix of Exposed Persons to Complete Exposure Pathways		Residential	Commercial/Industrial Chronic	Commercial/Industrial Constrctn
Groundwater Pathways:				
GW.i	Groundwater Ingestion	FALSE	FALSE	
GW.v	Volatilization to Outdoor Air	FALSE	FALSE	
GW.b	Vapor Intrusion to Buildings	TRUE	FALSE	
Soil Pathways				
S.v	Volatiles from Subsurface Soils	FALSE	FALSE	
SS.v	Volatiles and Particulate Inhalation	FALSE	FALSE	FALSE
SS.d	Direct Ingestion and Dermal Contact	FALSE	FALSE	FALSE
S.l	Leaching to Groundwater from all Soils	FALSE	FALSE	
S.b	Intrusion to Buildings - Subsurface Soils	FALSE	FALSE	

Matrix of Receptor Distance and Location on- or off-site		Residential Distance	Residential On-Site	Commercial/Industrial Distance	Commercial/Industrial On-Site
GW	Groundwater receptor (cm)		FALSE		FALSE
S	Inhalation receptor (cm)		FALSE		FALSE

Matrix of Target Risks		Individual	Cumulative
TRab	Target Risk (class A&B carcinogens)	1.0E-06	
TRc	Target Risk (class C carcinogens)	1.0E-05	
THQ	Target Hazard Quotient	1.0E+00	
Opt	Calculation Option (1, 2, or 3)	3	
Tier	RBCA Tier	2	

Surface Parameters	Definition (Units)	Residential	Commercial/Industrial Chronic	Commercial/Industrial Construction
t	Exposure duration (yr)	30	25	1
A	Contaminated soil area (cm^2)	2.2E+06		1.0E+06
W	Length of affected soil parallel to wind (cm)	1.5E+03		1.0E+03
W.gw	Length of affected soil parallel to groundwater (c	1.5E+03		
Uair	Ambient air velocity in mixing zone (cm/s)	2.3E+02		
delta	Air mixing zone height (cm)	2.0E+02		
Lss	Definition of surficial soils (cm)	1.0E+02		
Pe	Particulate areal emission rate (g/cm^2/s)	2.2E-10		

Groundwater	Definition (Units)	Value
delta.gw	Groundwater mixing zone depth (cm)	2.0E+02
I	Groundwater infiltration rate (cm/yr)	3.0E+01
Ugw	Groundwater Darcy velocity (cm/yr)	2.5E+03
Ugw.tr	Groundwater Transport velocity (cm/yr)	6.6E+03
Ks	Saturated Hydraulic Conductivity(cm/s)	
grad	Groundwater Gradient (cm/cm)	
Sw	Width of groundwater source zone (cm)	
Sd	Depth of groundwater source zone (cm)	
BC	Biodegradation Capacity (mg/L)	
BIO?	Is Bioattenuation Considered	FALSE
phi.eff	Effective Porosity in Water-Bearing Unit	3.8E-01
foc.sat	Fraction organic carbon in water-bearing unit	1.0E-03

Soil	Definition (Units)	Value		
hc	Capillary zone thickness (cm)	***3.0E+00***		
hv	Vadose zone thickness (cm)	***2.4E+02***		
rho	Soil density (g/cm^3)	***1.6***		
foc	Fraction of organic carbon in vadose zone	***0.0066***		
phi	Soil porosity in vadose zone	***0.396***		
Lgw	Depth to groundwater (cm)	***2.4E+02***		
Ls	Depth to top of affected soil (cm)	1.0E+02		
Lsubs	Thickness of affected subsurface soils (cm)	***3.3E+02***		
pH	Soil/groundwater pH	***6.4***		
		capillary	vadose	foundation
phi.w	Volumetric water content	***0.366***	***0.15***	***0.372***
phi.a	Volumetric air content	***0.03***	***0.246***	***0.024***

Building	Definition (Units)	Residential	Commercial
Lb	Building volume/area ratio (cm)	2.0E+02	3.0E+02
ER	Building air exchange rate (s^-1)	1.4E-04	2.3E-04
Lcrk	Foundation crack thickness (cm)	1.5E+01	
eta	Foundation crack fraction	0.01	

Dispersive Transport Parameters	Definition (Units)	Residential	Commercial
Groundwater			
ax	Longitudinal dispersion coefficient (cm)		
ay	Transverse dispersion coefficient (cm)		
az	Vertical dispersion coefficient (cm)		
Vapor			
dcy	Transverse dispersion coefficient (cm)		
dcz	Vertical dispersion coefficient (cm)		

RBCA SITE ASSESSMENT | **Tier 2 Worksheet 9.3**

Site Name: Alaska gw residential
Site Location: alaska

Completed By: Denise Clendening
Date Completed: 7/5/1996

1 OF 1

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 3

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		**Representative Concentration**	☐ Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		☐ Groundwater Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	**Name**	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" If yes	Only if "yes" left
79-34-5	Tetrachloroethane, 1,1,2,2-	1.8E+2	NA	NA	NA	1.2E+1	NA	NA	NA	1.2E+1	■	1.6E+01
79-01-6	Trichloroethene	3.1E+1	NA	NA	NA	3.1E+0	NA	NA	NA	3.1E+0	■	1.0E+01

Software: GSI RBCA Spreadsheet
Version: v 1.0

Serial: G-373-ZOX-798