

6.0 SCREENING HUMAN HEALTH RISK ASSESSMENT

6.1 INTRODUCTION

This screening human health risk assessment (SHHRA) documents the chemicals of concern (COCs) that may contribute to potential health risks to humans from exposure to contamination within the Load Line 4 AOC at RVAAP in Ravenna, Ohio. Load Line 4 was used to melt and load TNT into large-caliber shells, bombs, and anti-tank mines. The line operated briefly during World War II and again from 1951 to 1957. During its operation history, Load Line 4 produced about 1.2 million munitions. No significant demolition activities have occurred at Load Line 4. Rail lines within the AOC have been removed as part of facility-wide reclamation efforts. This screening risk assessment is prepared in accordance with the *RVAAP's Facility-Wide Human Health Risk Assessor's Manual (FWHHRAM)* (USACE 2004) as part of the Phase II RI report for the Load Line 4 AOC.

The purpose of this SHHRA is to define the potential for health risks to be associated with various current and future uses of the land at Load Line 4 by identifying COCs and to identify the appropriate RGOs for use in evaluating potential remedial actions.

The process used to accomplish the objectives of this SHHRA is

- identify all chemicals of potential concern (COPCs) at Load Line 4,
- identify appropriate receptor populations and exposure scenarios for current and future land use at Load Line 4,
- develop screening RGOs for these exposure scenarios for all COPCs identified at Load Line 4,
- identify COCs by comparing Load Line 4 concentrations to screening RGOs, and
- calculate risk-based RGOs for the COCs to move forward to the FS.

The Load Line 4 SHHRA identifies COCs and presents RGOs for five environmental media: groundwater, surface water, sediment, surface soil, and subsurface soil.

This risk assessment is organized into six major sections. The screening process used to identify COPCs is discussed in Section 6.2. The exposure assessment, which is performed to identify the exposure pathways by which receptors may be exposed to contaminants and calculate potential intakes, is presented in Section 6.3. The toxicity assessment for the Load Line 4 COPCs is presented in Section 6.4. The results of the risk characterization (i.e., COCs and RGOs) are presented in Section 6.5. An assessment of the uncertainties associated with the risk characterization is provided in Section 6.6, and the conclusions of the SHHRA are summarized in Section 6.7.

6.2 DATA EVALUATION

This section provides a description of the data evaluation process used to identify COPCs for Load Line 4. The data evaluation process is conducted in accordance with the FWHHRAM (USACE 2004). The purpose of the SHHRA data evaluation screening process is to eliminate chemicals for which no further risk evaluation is needed. Data collected at Load Line 4 are aggregated by environmental medium (i.e., surface water, soil, sediment, and groundwater). Soil data are further aggregated by depth interval—shallow surface soils from 0 to 0.3 m (0 to 1 ft) bgs, deep surface soils from 0 to 1.2 m (0 to 4 ft), and subsurface soil greater than 0.3 m (1 ft) bgs. Subsurface soil samples were taken to a maximum depth of 0.9 m (3 ft) bgs because field screening did not identify any explosives in samples collected at this depth at Load Line 4.

Data for surface and subsurface soils are aggregated into EUs based on historical use and geographic proximity, as described in Section 4.1.2. The purpose of combining areas with similar use and geography is to allow an appropriate assessment of similar exposures over a given EU. If areas with dissimilar histories are aggregated, there is a potential to screen out contaminants that should be carried through the process. The aggregates selected to divide the Load Line 4 AOC into EUs achieve the intent of being protective of human and environmental health. Soil data are grouped into the following six EUs, which are shown on [Figure 4-1](#):

- Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16),
- Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse),
- Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A),
- Change Houses,
- Melt-Pour Drainage Ditches, and
- Perimeter Area.

Surface soil samples were collected from all six EUs; subsurface soil samples were collected from four of the six EUs (all except the Change Houses and Melt-Pour Drainage Ditches).

Data collected from buildings and structures are not included in the SHHRA. These samples were collected at the same time as the Phase II RI, but were collected for use by decontamination and decommissioning contractors. See Section 4.8 for a detailed discussion of these data.

Surface water and sediment data are aggregated by conveyance. Three aggregates were identified

- Main Stream Segment Upstream of Perimeter Road Bridge at G-19/-19A,
- Main Stream Segment Downstream of Perimeter Road Bridge at G-19/-19A and the Settling Pond, and
- Exit Drainage – From Settling Pond to PF-8.

Surface water and sediment aggregates are shown in [Figure 4-1](#). Dry sediment collected from ditches that are primarily dry is addressed as soil. Water samples from small intermittent ditch lines or puddles do not represent viable habitat and do not fit the exposure models for human receptors to water. Samples collected from manholes, sanitary sewers, and storm sewers are not included in the SHHRA.

Groundwater data are represented by a single aggregate, as described in Section 4.1.2.

Section 6.2.1 provides a summary of the COPC selection process and the data assumptions used during that process. Section 6.2.2 presents the results of the COPC screening process.

6.2.1 Chemical of Potential Concern Screening

SRCs that exceed screening levels and potentially pose a risk to human health are called COPCs. This section provides a description of the screening process used to identify COPCs and the data assumptions used in the process.

COPCs are identified for each EU data set for each medium. This data evaluation consists of five steps: (1) a DQA, (2) frequency-of-detection/ WOE screening, (3) screening of essential human nutrients, (4) risk-based screening, and (5) background screening.

1. **Data Quality Assessment** – Analytical results were reported by the laboratory in electronic form and loaded into a Load Line 4 database. Site data were then extracted from the database so that only one result is used for each station and depth sampled. QC data, such as sample splits and duplicates, and laboratory re-analyses and dilutions were not included in the determination of COPCs for this risk assessment. Field screening data that were considered in the evaluation of nature and extent of contamination at Load Line 4 are not included in the data set for the risk assessment. Samples rejected in the validation process are also excluded from the risk assessment. The percentage of rejected data is approximately 1%. A complete summary of data quality issues is presented in the DQA appendix of this report (see Appendix H).
2. **Frequency-of-Detection/Weight-of-Evidence Screen** – Each chemical for each environmental medium was evaluated to determine its frequency of detection. Chemicals that were never detected were eliminated as COPCs. For sample aggregations with at least 20 samples and a frequency of detection of less than 5%, a WOE approach was used to determine if the chemical is AOC-related. The magnitudes and locations (clustering) of the detections and potential source of the chemical were evaluated. If the detected results showed no clustering, the chemical is not a COPC in another medium at that location, the concentrations are not substantially elevated relative to the detection limit, and the chemical was not used in the area under investigation, they are considered spurious, and the chemical was eliminated from further consideration. This screen is applied to all organic and inorganic chemicals with the exception of explosives and propellants. All detected explosives and propellants are included in the list of COPCs regardless of their frequency of detection.
3. **Essential Nutrients** – Chemicals that are considered essential nutrients (i.e., calcium, chloride, iodine, iron, magnesium, potassium, phosphorus, and sodium) are an integral part of the human food supply and are often added to foods as supplements. EPA (1989a) recommends that these chemicals not be evaluated as COPCs so long as they are (1) present at low concentrations (i.e., only slightly elevated above naturally occurring levels) and (2) toxic at very high doses (i.e., much higher than those that could be associated with contact at the site). Recommended daily allowance (RDA) and recommended daily intake (RDI) values are available for seven of these metals. Based on these RDA/RDI values, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI of calcium, magnesium, phosphorous, potassium, and sodium, even if the soil consisted of the pure mineral (i.e., soil concentrations > 1,000,000 mg/kg). Receptors ingesting 100 mg of soil per day would require soil concentrations of 1,500 mg/kg of iodine and 100,000 to 180,000 mg/kg of iron to meet their RDA/RDI for these metals. Concentrations of essential nutrients do not exceed these levels at Load Line 4; thus, these constituents are not addressed as COPCs.
4. **Risk-based Screen** – The objective of this evaluation is to identify COPCs that may pose a potentially significant risk to human health. The risk-based screening values are conservative values

published by EPA. The MDC of each chemical in each environmental medium is compared against the appropriate risk-based screening value. Chemicals detected below these concentrations are screened from further consideration. Detected chemicals without risk-based screening values are not eliminated from the COPC list. The risk-based screening values for each environmental medium are described in Section 6.2.1.1.

5. **Background Screen** – For each inorganic constituent detected, concentrations in Load Line 4 samples are screened against available, naturally occurring background levels. This screening step, which applies only to the inorganics, is used to determine if detected inorganics are site related or naturally occurring. If the MDC of a constituent exceeds the background value, the constituent is considered AOC-related. All detected organic compounds are considered to be above background. Inorganic chemicals whose MDCs are below background levels are eliminated from the COPC list. Background screening values are described in Section 6.2.1.2.

6.2.1.1 Risk-based screening values

The risk-based screening values are conservative values published by EPA.

- For surface soil, subsurface soil, and sediment, a conservative screen is performed using the most current residential preliminary remediation goals (PRGs) published by EPA Region 9 (EPA 2002a). To account for the potential effects of multiple chemicals, PRGs based on non-cancer endpoints are divided by 10. These screening values are very conservative [based on a 10^{-6} risk level and a hazard quotient (HQ) of 0.1]. For information purposes only, data from these same media are also compared against the Region 9 industrial soil PRGs. Region 9 PRGs can be found on the EPA Region 9 world wide web site (<http://www.epa.gov/region09/waste/sfund/prg/index.html>).
- Surface water and groundwater data are screened using the EPA Region 9 tap water PRGs, which are also available at <http://www.epa.gov/region09/waste/sfund/prg/index.html>.

6.2.1.2 Background screening values

This Load Line 4 Phase II RI does not include determination of Load Line 4-specific background data. Analytical results are screened against the final facility-wide background values for RVAAP, published in the *Phase II Remedial Investigation Report for Winklepeck Burning Grounds at Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1999). Background values for soil are available for two soil depths: surface (0 to 1 ft bgs) and subsurface (1 to 12 ft bgs). Soil data at Load Line 4 are aggregated into three depth intervals: shallow surface soil (0 to 1 ft bgs), deep surface soil (0 to 4 ft bgs), and subsurface soil (greater than 1 ft bgs). The following background depth intervals are used for identifying COPCs in Load Line 4 soil.

- For shallow surface soil (0 to 1 ft bgs), the background screen is performed using background values for surface soil (0 to 1 ft bgs).
- For deep surface soil (0 to 4 ft bgs), the background screen is performed using background values for either surface soil (0 to 1 ft bgs) or subsurface soil (1 to 12 ft bgs), whichever is lower.
- For subsurface soil (greater than 1 ft bgs), the background screen is performed using background values for subsurface soil (1 to 12 ft bgs).

6.2.1.3 COPC screening assumptions

The data set used to determine COPCs may include data collected from both Phase I (as appropriate, see Section 4.1) and Phase II RIs. Specific assumptions applied to these data can be found in Chapter 4.0 (Nature and Extent of Contamination). The following assumptions, used in the development of COPCs for the SHHRA, are noted.

- Physical chemical data (e.g., alkalinity, pH, etc.) are not considered to be COPCs for Load Line 4.
- Filtered data are not used in the determination of surface water COPCs (i.e., only unfiltered data are evaluated for surface water). Unfiltered data include both soluble and insoluble chemicals. These data represent untreated/unprocessed water drawn from a surface water sampling station. However, due to problems with the groundwater samples having high turbidity, filtered metals data for groundwater are used in this risk assessment (Mohr 1998). See Section 4.6 for a detailed discussion on filtered groundwater data.
- Soil data are subdivided into three data sets—shallow surface soil, deep surface soil, and subsurface soil—based on sampling depths used for Load Line 4. Shallow surface soils were collected from 0 to 1 ft bgs, deep surface soils from 0 to 3 ft bgs, and subsurface soil from 1 to 3 ft bgs.
- Chemicals not detected in a medium are not considered to be COPCs for that medium.
- Alpha-chlordane and gamma-chlordane are evaluated by screening against the EPA Region 9 PRGs for chlordane.

COPCs are determined for each medium in each EU using all available data after the data assumptions listed above are applied.

6.2.2 Chemical of Potential Concern Screening Results

The COPC screening process and results are summarized in Tables Q-1 through Q-6. These tables include

- summary statistics, including frequency of detection, range of detected concentrations, arithmetic average concentration, and UCL_{95} on the mean concentration;
- all screening values (background concentrations and PRGs, as appropriate); and
- final COPC status.

Table 6-1 summarizes the resulting COPCs for each medium/AOC combination. COPCs are categorized as quantitative (based on available toxicity values, these chemicals will be further evaluated quantitatively in this SHHRA) and qualitative (due to a lack of toxicity values these chemicals will be further evaluated quantitatively in this SHHRA); see the Toxicity Assessment (Section 6.4) for more details on toxicity.

6.2.2.1 COPCs for groundwater

As shown in Table 6-1, two metals were identified as groundwater COPCs at Load Line 4: arsenic and manganese.

Table 6-1. COPCs for each Medium at Load Line 4^a

COPC	Groundwater	Surface Water	Sediment	Shallow Surface Soil	Deep Surface Soil	Subsurface Soil
Quantitative COPCs^b						
<i>Inorganics</i>						
Aluminum			MS	EH	EH,PR	PR
Arsenic	LL4	MU		EH,MP,PR	EH,MP,PR	
Barium				EH	EH	
Cadmium				EH,PR,PS	EH,PR,PS	
Copper				PR	PR	
Lead				EH,PA,PR,PS	EH,PA,PR,PS	
Manganese	LL4	MU		EH,PA,PR,PS	EH,PA,PR,PS	PR
Mercury				PR	PR	
Thallium			MS	CH,EH,MP,PA,PR,PS	CH,EH,MP,PA,PR,PS	
Zinc				EH	EH	
<i>Organics</i>						
2-Methylnaphthalene				CH	CH	
4,4'-DDT		MS				
Aldrin				EH	EH	
Benz(a)anthracene				EH	EH	
Benzo(a)pyrene				CH,EH,PA,PS	CH,EH,PA,PS	
Benzo(b)fluoranthene				CH,EH	CH,EH	
Dibenz(a,h)anthracene				CH,EH	CH,EH	
Dieldrin				EH	EH	
Heptachlor				EH	EH	
Indeno(1,2,3-cd)pyrene				EH	EH	
PCB-1254				EH,PR,PS	EH,PR,PS	
PCB-1260				EH,PR,PS	EH,PR,PS	
RDX				EH	EH	
Qualitative COPCs^c						
<i>Organics</i>						
Acenaphthylene				EH	EH	
Benzo(g,h,i)perylene				CH,EH,PA,PS	CH,EH,PA,PS	
Nitrocellulose				PR,PS	PR,PS	
Phenanthrene				CH,EH,MP,PR,PS	CH,EH,MP,PR,PS	

^a COPCs are shown for all medium/area of concern combinations. Area of concern codes are as follows:

- LL4 = Load Line 4.
- CH = Change Houses Aggregate.
- ED = Exit Drainage Aggregate.
- EH = Explosives Handling Areas. Aggregate
- MP = Melt-Pour Area Drainage Ditches Aggregate.
- MS = Main Stream Segment and Settling Pond Aggregate.
- MU = Main Stream Segment Upstream of Perimeter Road Aggregate.
- PA = Perimeter Area Aggregate.
- PR = Preparation and Receiving Areas Aggregate.
- PS = Packaging and Shipping Areas Aggregate.

^b Quantitative COPCs have approved toxicity values that allow for further quantitative evaluation in the human health risk assessment.

^c Qualitative COPCs do not have approved toxicity values that allow for further quantitative evaluation in the human health risk assessment.

- COPC = Chemical of potential concern.
- DDT = Dichlorodiphenyltrichloroethane.
- PCB = Polychlorinated biphenyl.
- RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

6.2.2.2 COPCs for surface water

As shown in [Table 6-1](#), two metals were identified as surface water COPCs for the Main Stream Segment Upstream of Perimeter Road Bridge aggregate: arsenic and manganese. 4,4'-DDT was the one COPC identified in the surface water in the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate. No surface water COPCs were identified in the Exit Drainage Aggregate.

6.2.2.3 COPCs for sediment

As shown in [Table 6-1](#), two sediment COPCs were identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate: aluminum and thallium. No sediment COPCs were identified for Main Stream Segment Upstream of Perimeter Road Bridge or Exit Drainage Aggregates.

6.2.2.4 COPCs for shallow surface soil

As seen in [Table 6-1](#), a total of 26 COPCs were identified within the six shallow surface soil aggregates. The 26 shallow surface soil COPCs include the following:

- 10 metals (aluminum, arsenic, barium, cadmium, copper, lead, manganese, mercury, thallium, and zinc);
- 2 explosives (nitrocellulose and RDX);
- 3 pesticides (aldrin, dieldrin, and heptachlor);
- 2 PCBs (PCB-1254 and PCB-1260);
- 7 PAHs [benz(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)fluoranthene, benzo(*g,h,i*)perylene, dibenz(*a,h*)anthracene, indeno(1,2,3-*cd*)pyrene, and phenanthrene]; and
- 2 SVOCs (2-methylnaphthalene and acenaphthylene).

Based on lack of toxicity information, 4 of these 26 shallow surface soil COPCs are classified as qualitative COPCs [nitrocellulose, benzo(*g,h,i*)perylene, phenanthrene, and acenaphthylene]; RGO screening cannot be performed for these 4 COPCs.

6.2.2.5 COPCs for deep surface soil

As seen in [Table 6-1](#), a total of 26 COPCs were identified within the six deep surface soil aggregates. The 26 deep surface soil COPCs include the following:

- 10 metals (aluminum, arsenic, barium, cadmium, copper, lead, manganese, mercury, thallium, and zinc);
- 2 explosives (nitrocellulose and RDX);
- 3 pesticides (aldrin, dieldrin, and heptachlor);
- 2 PCBs (PCB-1254 and PCB-1260);

- 7 PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and phenanthrene]; and
- 2 SVOCs (2-methylnaphthalene and acenaphthylene).

Based on lack of toxicity information, 4 of these 26 deep surface soil COPCs are classified as qualitative COPCs [nitrocellulose, benzo(g,h,i)perylene, phenanthrene, and acenaphthylene]; RGO screening cannot be performed for these 4 COPCs.

6.2.2.6 COPCs for subsurface soil

Two metal COPCs were identified in one subsurface soil aggregate: aluminum and manganese in the Preparation and Receiving Areas; no subsurface soil COPCs were identified in the other three subsurface soil aggregates (Explosives Handling Areas, Packaging and Shipping Areas, and Perimeter Area; see [Table 6-1](#)).

6.3 EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to estimate the magnitude, frequency, and duration of potential human exposure to COPCs. The four primary steps of the exposure assessment for this SHHRA are listed below.

1. Characterize the proposed land use to identify the potentially exposed human receptors, their activity patterns, and any other characteristics that might increase or decrease their likelihood of exposure.
2. Identify each exposure pathway by which a receptor may be exposed to the COPCs (e.g., surface water ingestion).
3. Identify exposure parameters (e.g., ingestion rate) for each receptor's potential intake of each COPC.
4. Identify the concentrations of COPCs to which the receptors may be exposed.

In this SHHRA the output of the exposure assessment is used in conjunction with the output of the toxicity assessment (Section 6.4) for the development of screening RGOs to identify COCs in the risk characterization (Section 6.5).

6.3.1 Land Use and Potential Receptors

The RVAAP installation is located in two counties of northeastern Ohio, Portage County and Trumbull County, with a majority of the facility lying in Portage County. According to the 2000 Census, the total population of Portage and Trumbull counties was 152,061 and 225,116, respectively. The largest population centers in the area are the city of Ravenna (population 11,771), which is located approximately 2 miles to the west, and the town of Newton Falls (population 5,002), which is located approximately 1 mile to the southwest.

The land use immediately surrounding the facility is primarily rural. Approximately 55% of Portage County is either woodland or farmland (Portage County Soil and Water Conservation District Resources Inventory 1985; Census Bureau 1992). To the south of the facility is the Michael J. Kirwan Reservoir, which is used for recreational purposes. The Reservoir is south of the site, across State Route 5. The Reservoir is fed by the West Branch of the Mahoning River, which flows south along the western edge of the installation. Hinkley Creek flows south across the western portion of the facility and eventually flows

into the West Branch of the Mahoning River. The major surface drainages at RVAAP—Sand Creek and the South Fork of Eagle Creek—exit the facility property and eventually flow east to the Mahoning River.

Residential groundwater use occurs outside of the facility, with most of the residential wells tapping into either the Sharon Conglomerate or the surficial unconsolidated aquifer. Groundwater from on-site production wells was used during operations at the facility (USACE 1996); however, all but two of these production wells have been abandoned. Two wells, located in the central portion of the facility, provide sanitary water to the facility. A third well located at Building T-5301 may be utilized for future IRP projects for sanitary water. The Sharon Conglomerate is the major producing aquifer at the facility. The chemicals detected in the soils at Load Line 4 during Phase I and Phase II are generally explosives and metals. Fate and transport modeling results indicate that none of these metals or explosives, except for RDX, is expected to migrate to any of the receptor locations (see Chapter 5.0 for more information). In addition, groundwater sampling of selected residential wells adjacent to RVAAP, conducted by the Ohio EPA during 1997, found no indications of explosives in groundwater at the locations sampled.

Currently, surface water at Load Line 4 is used primarily by wildlife. None of the settling ponds in Load Line 4 are included in the catch and release fishing program at RVAAP (Morgan 2003b and 2004).

Land use within the facility is restricted access. In 1993, the land use changed from “maintained caretaker” status to “inactive-modified (un-maintained) caretaker” status (Department of the Army, Environmental Assessment 1993). This new status indicated that the facility was no longer needed to mobilize for war efforts. The only remaining federally mandated mission for the facility was identified as ammunition and bulk explosives storage. Funding decreased for building maintenance and maintenance activities such as mowing. Load Line 4, which lies in the eastern portion of the facility, is outside of any of the existing ammunition storage areas. The facility is currently maintained by a contracted caretaker, Tol-Test, Inc. Site workers infrequently visit the load line; however, mowing no longer takes place. RVAAP occupies parts of the RTLS. OHARNG conducts training exercises in parts of the RTLS, but training is restricted to areas outside of AOCs. No training is conducted within Load Line 4.

RVAAP is located in a rural area, is not accessible to the general public, and is not near any major industrial or developed areas. The facility is completely fenced and patrolled by security personnel. Army and full-time operating contractor staff (i.e., security and grounds and maintenance workers) are located on-site. Additional subcontractor staff are on-site for varying periods of time, ranging from several weeks to more than 12 months, to complete specific demolition/decommissioning projects. Training activities under OHARNG involve an average of 4,500 personnel during the course of a month, who are on-site for periods of 3 days (inactive duty or weekend training) to 2 weeks (annual training).

Load Line 4 is located in the southeastern corner of RVAAP and is not currently used for OHARNG training activities. Some workers will be present during future demolition activities, which are currently suspended pending additional funding and desensitization of buildings for explosive compounds. The former production area is surrounded by a security fence and locked gates. Groundskeeping activities are limited to infrequent mowing and brush clearing along the perimeter areas outside of the AOC boundary fence. Six to 12 deer hunts take place at RVAAP during weekends in October and November each year. Load Line 4 is not presently included in the deer hunting program. Security activities consist of gate checks and surveillance along South Service Road.

As described above, there is currently no human activity at Load Line 4 beyond occasional visits by remediation contractors. Therefore, this SHHRA focuses on the potential future land use at Load Line 4. Per

the FWHHRAM (USACE 2004), the following potential human receptors are identified for three future land uses at Load Line 4.

- National Guard use includes three receptor types: National Guard Trainee, National Guard Security Guard/Maintenance Worker, and National Guard Fire/Dust Suppression Worker.
- Recreational use includes a receptor engaged in hunting, trapping, and fishing.
- Residential use is included to provide a baseline scenario for unrestricted re-use and evaluates a Resident Subsistence Farmer (adult and child).

6.3.2 Exposure Pathways

An exposure pathway is made up of the following components:

- source,
- release mechanism (e.g., volatilization),
- transport pathway,
- exposure point,
- exposure route, and
- receptor.

Potential exposure pathways associated with each receptor and land use category are identified in [Table 6-2](#). For a BERA, ingestion of food (including fish, waterfowl, venison, beef, and vegetables) raised on-site is included for additional information in the exposure assessment for some of these receptors. However, these indirect pathways are extremely conservative and are not used in the calculation of RGOs.

A discussion of each land use/receptor/pathway combination is provided below. The exposure parameters for each pathway are provided in [Table 6-3](#).

6.3.2.1 National Guard land use

National Guard receptors are assumed to be exposed to four media: soil, surface water, sediment, and groundwater.

Three receptor categories have been identified under this land use. Each of these receptors is described below. Parameter values used to evaluate the National Guard receptors in this SHHRA are provided in [Table 6-3](#).

National Guard Trainee

National Guard Trainees may be present at the site up to 24 hr/d for 24 d/year on inactive duty training and/or 24 hr/d for 15 d/year during annual training. As a conservative estimate for this SHHRA, it is assumed that the same individual is present at Load Line 4 for both inactive duty training (24 d/year) and annual training (15 d/year) for a total exposure frequency of 39 d/year.

Table 6-2. Receptors and Exposure Pathways for RVAAP Load Line 4

Exposure Pathways	Exposure Media					
	Groundwater	Surface Water	Sediment	Surface Soil		Subsurface Soil ^c
				Shallow ^a	Deep ^b	
<i>National Guard – Trainee</i>						
Ingestion	✓	✓	✓	--	✓	--
Dermal	✓	✓	✓	--	✓	--
Inhalation						
Vapor	✓	-- ^d	✓	--	✓	--
Dust	--	--	✓	--	✓	--
<i>National Guard – Security Guard/Maintenance Worker</i>						
Ingestion	--	--	--	✓	--	--
Dermal	--	--	--	✓	--	--
Inhalation						
Vapor	--	--	--	✓	--	--
Dust	--	--	--	✓	--	--
<i>National Guard – Fire/Dust Suppression Worker</i>						
Ingestion	--	✓	✓	✓	--	--
Dermal	--	✓	✓	✓	--	--
Inhalation						
Vapor	--	-- ^d	✓	✓	--	--
Dust	--	--	✓	✓	--	--
<i>Hunter/Trapper/Fisher</i>						
Ingestion	--	✓	✓	✓	--	--
Dermal	--	✓	✓	✓	--	--
Inhalation						
Vapor	--	-- ^d	✓	✓	--	--
Dust	--	--	✓	✓	--	--
<i>Resident Subsistence Farmer (adult and child)</i>						
Ingestion	✓	✓	✓	✓	--	✓
Dermal	✓	✓	✓	✓	--	✓
Inhalation						
Vapor	✓	-- ^d	✓	✓	--	✓
Dust	--	--	✓	✓	--	✓

✓ = Receptor is exposed to chemicals of potential concern (COPCs) in this exposure medium.

-- = Receptor is not exposed to COPCs in this exposure medium.

^a Shallow surface soil is defined as 0 to 1 ft below ground surface (bgs).

^b Deep surface soil is defined as 0 to 4 ft bgs. However, the maximum sampling depth is 3 ft bgs due to shallow bedrock.

^c Subsurface soil is defined as 1 to 3 ft bgs.

^d No volatile organic compounds are COPCs in Load Line 4 surface water.

RVAAP = Ravenna Army Ammunition Plant.

Table 6-3. Parameters Used to Quantify Exposures for Each Medium and Receptor at Load Line 4^a

Exposure Pathway and Parameter	Units	Potential Receptor					
		National Guard Personnel			Recreator	Resident Subsistence Farmer	
		Security Guard/ Maintenance Worker	Dust/Fire Control	Trainee	Hunter/ Fisher	Adult	Child
Surface Soil^b							
<i>Incidental Ingestion</i>							
Soil ingestion rate	kg/d	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Exposure time	hr/d	1	4	24	4.57	24	24
Exposure frequency	d/year	250	15	39	7	350	350
Exposure duration	years	25	25	25	30	30	6
Body weight	kg	70	70	70	70	70	15
Carcinogen averaging time	d	25,550	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	9,125	9,125	9,125	10,950	10,950	2,190
Fraction ingested	Unitless	1	1	1	1	1	1
Conversion factor	d/hr	0.042	0.042	0.042	0.042	0.042	0.042
<i>Dermal Contact</i>							
Skin area	m ² /event	0.33	0.33	0.33	0.57	0.57	0.22
Adherence factor	mg/cm ²	0.7	0.3	0.3	0.3	0.4	0.2
Absorption fraction	Unitless	Chemical Specific – See Table Q-7					
Exposure frequency	events/year	250	15	39	7	350	350
Exposure duration	years	25	25	25	30	30	6
Body weight	kg	70	70	70	70	70	15
Carcinogen averaging time	d	25,550	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	9,125	9,125	9,125	10,950	10,950	2,190
Conversion factor	(kg-cm ²)/(mg-m ²)	0.01	0.01	0.01	0.01	0.01	0.01
<i>Inhalation of VOCs and Dust</i>							
Inhalation rate	m ³ /d	20	44.4	44.4	20	20	10
Exposure time	hr/d	1	4	24	4.57	24	24
Exposure frequency	d/year	250	15	39	7	350	350
Exposure duration	years	25	25	25	30	30	6

Table 6-3. Parameters Used to Quantify Exposures for Each Medium and Receptor at Load Line 4^a (continued)

Exposure Pathway and Parameter	Units	Potential Receptor					
		National Guard Personnel			Recreator	Resident Subsistence Farmer	
		Security Guard/ Maintenance Worker	Dust/Fire Control	Trainee	Hunter/ Fisher	Adult	Child
Body weight	kg	70	70	70	70	70	15
Carcinogen averaging time	d	25,550	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	9,125	9,125	9,125	10,950	10,950	2,190
Conversion factor	d/hr	0.042	0.042	0.042	0.042	0.042	0.042
Subsurface Soil							
<i>Incidental Ingestion</i>							
Soil ingestion rate	kg/d	NA	NA	NA	NA	0.0001	0.0002
Exposure time	hr/d	NA	NA	NA	NA	24	24
Exposure frequency	d/year	NA	NA	NA	NA	350	350
Exposure duration	years	NA	NA	NA	NA	30	6
Body weight	kg	NA	NA	NA	NA	70	15
Carcinogen averaging time	d	NA	NA	NA	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	NA	NA	10,950	2,190
Fraction ingested	Unitless	NA	NA	NA	NA	1	1
Conversion factor	d/hr	NA	NA	NA	NA	0.042	0.042
<i>Dermal Contact</i>							
Skin area	m ² /event	NA	NA	NA	NA	0.57	0.22
Adherence factor	mg/cm ²	NA	NA	NA	NA	0.4	0.2
Absorption fraction	Unitless	NA	NA	NA	NA	Chem. Spec. See Table Q-7	
Exposure frequency	events/year	NA	NA	NA	NA	350	350
Exposure duration	years	NA	NA	NA	NA	30	6
Body weight	kg	NA	NA	NA	NA	70	15
Carcinogen averaging time	d	NA	NA	NA	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	NA	NA	10,950	2,190
Conversion factor	(kg-cm ²)/(mg-m ²)	NA	NA	NA	NA	0.01	0.01
<i>Inhalation of VOCs and Dust</i>							
Inhalation rate	m ³ /d	NA	NA	NA	NA	20	10
Exposure time	hr/d	NA	NA	NA	NA	24	24
Exposure frequency	d/year	NA	NA	NA	NA	350	350
Exposure duration	years	NA	NA	NA	NA	30	6

Table 6-3. Parameters Used to Quantify Exposures for Each Medium and Receptor at Load Line 4^a (continued)

Exposure Pathway and Parameter	Units	Potential Receptor					
		National Guard Personnel			Recreator	Resident Subsistence Farmer	
		Security Guard/ Maintenance Worker	Dust/Fire Control	Trainee	Hunter/ Fisher	Adult	Child
Body weight	kg	NA	NA	NA	NA	70	15
Carcinogen averaging time	d	NA	NA	NA	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	NA	NA	10,950	2,190
Conversion factor	d/hr	NA	NA	NA	NA	0.042	0.042
Sediment							
<i>Incidental Ingestion</i>							
Soil ingestion rate	kg/d	NA	0.0001	0.0001	0.0001	0.0001	0.0002
Exposure time	hr/d	NA	4	24	4.57	24	24
Exposure frequency	d/year	NA	15	39	7	350	350
Exposure duration	years	NA	25	25	30	30	6
Body weight	kg	NA	70	70	70	70	15
Carcinogen averaging time	d	NA	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	NA	9,125	9,125	10,950	10,950	2,190
Fraction ingested	Unitless	NA	1	1	1	1	1
Conversion factor	d/hr	NA	0.042	0.042	0.042	0.042	0.042
<i>Dermal Contact</i>							
Skin area	m ² /event	NA	0.33	0.33	0.52	0.57	0.22
Adherence factor	mg/cm ²	NA	0.3	0.3	0.3	0.4	0.2
Absorption fraction	Unitless	NA	Chemical Specific – See Table Q-7				
Exposure frequency	events/year	NA	15	39	7	350	350
Exposure duration	years	NA	25	25	30	30	6
Body weight	kg	NA	70	70	70	70	15
Carcinogen averaging time	d	NA	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	NA	9,125	9,125	10,950	10,950	2,190
Conversion factor	(kg-cm ²)/(mg-m ²)	NA	0.01	0.01	0.01	0.01	0.01
<i>Inhalation of VOCs and Dust</i>							
Inhalation rate	m ³ /d	NA	44.4	44.4	20	20	10
Exposure time	hr/d	NA	4	24	4.57	24	24
Exposure frequency	d/year	NA	15	39	7	350	350
Exposure duration	years	NA	25	25	30	30	6
Body weight	kg	NA	70	70	70	70	15

Table 6-3. Parameters Used to Quantify Exposures for Each Medium and Receptor at Load Line 4^a (continued)

Exposure Pathway and Parameter	Units	Potential Receptor					
		National Guard Personnel			Recreator	Resident Subsistence Farmer	
		Security Guard/ Maintenance Worker	Dust/Fire Control	Trainee	Hunter/ Fisher	Adult	Child
Carcinogen averaging time	d	NA	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	NA	9,125	9,125	10,950	10,950	2,190
Conversion factor	d/hr	NA	0.042	0.042	0.042	0.042	0.042
Surface Water							
<i>Incidental Ingestion</i>							
Incidental water ingestion rate	L/d	NA	0.1	0.1	0.05	0.1	0.1
Exposure frequency	d/year	NA	15	39	7	350	350
Exposure duration	years	NA	25	25	30	30	6
Body weight	kg	NA	70	70	70	70	15
Carcinogen averaging time	d	NA	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	NA	9,125	9,125	10,950	10,950	2,190
<i>Dermal Contact</i>							
Skin area	m ²	NA	0.33	0.33	0.52	0.57	0.22
Permeability constant	cm/hr	NA	Chemical Specific – See Table Q-7				
Exposure time	hr/d	NA	4	24	4.57	2.5	2.5
Exposure frequency	d/year	NA	15	39	7	350	350
Exposure duration	years	NA	25	25	30	30	6
Body weight	kg	NA	70	70	70	70	15
Carcinogen averaging time	d	NA	25,550	25,550	25,550	25,550	25,550
Non-carcinogen averaging time	d	NA	9,125	9,125	10,950	10,950	2,190
Conversion factor	(m/cm)/(L/m ³)	NA	10	10	10	10	10
Groundwater							
<i>Drinking Water Ingestion</i>							
Drinking water ingestion rate	L/d	NA	NA	2	NA	2	1.5
Exposure frequency	d/year	NA	NA	39	NA	350	350
Exposure duration	years	NA	NA	25	NA	30	6
Body weight	kg	NA	NA	70	NA	70	15
Carcinogen averaging time	d	NA	NA	25,550	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	9,125	NA	10,950	2,190
<i>Dermal Contact While Showering</i>							
Skin area	m ²	NA	NA	1.94	NA	1.94	0.866

Table 6-3. Parameters Used to Quantify Exposures for Each Medium and Receptor at Load Line 4^a (continued)

Exposure Pathway and Parameter	Units	Potential Receptor					
		National Guard Personnel			Recreator	Resident Subsistence Farmer	
		Security Guard/ Maintenance Worker	Dust/Fire Control	Trainee	Hunter/ Fisher	Adult	Child
Permeability constant	cm/hr	NA	NA	Chem. Spec. – See Table Q-7	NA	Chem. Spec. – See Table Q-7	
Exposure time	hr/d	NA	NA	0.25	NA	0.25	0.25
Exposure frequency	d/year	NA	NA	39	NA	350	350
Exposure duration	years	NA	NA	25	NA	30	6
Body weight	kg	NA	NA	70	NA	70	15
Carcinogen averaging time	d	NA	NA	25,550	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	9,125	NA	10,950	2,190
Conversion factor	(m/cm)/(L/m ³)	NA	NA	10	NA	10	10
<i>Inhalation of VOCs During Household Water Use</i>							
Inhalation rate	m ³ /d	NA	NA	20	NA	20	10
Exposure frequency	d/year	NA	NA	39	NA	350	350
Exposure duration	years	NA	NA	25	NA	30	6
Body weight	kg	NA	NA	70	NA	70	15
Carcinogen averaging time	d	NA	NA	25550	NA	25,550	25,550
Non-carcinogen averaging time	d	NA	NA	9125	NA	10,950	2,190 ^{b1}
Volatilization factor	L/m ³	NA	NA	0.5	NA	0.5	0.5

^a Exposure parameter from RVAAP's Facility-Wide Human Health Risk Assessor's Manual (USACE 2004).

^b Deep (0 to 4 ft bgs) surface soil is used for National Guard Trainee; shallow (0 to 1 ft bgs) surface soil is used for all other receptors.

bgs = Below ground surface.

NA = Not applicable for this scenario.

RVAAP = Ravenna Army Ammunition Plant.

USACE = United States Army Corps of Engineers.

VOC = Volatile organic compound.

This receptor is assumed to belong to the National Guard for 25 years (default worker exposure duration) and to use Load Line 4 for training every year of his/her enlistment.

It is assumed that Load Line 4 will be used for mounted training. Digging and occupying fighting positions, tank defilade positions, tank ditches, and battle positions that extend below ground surface will be prohibited. Tracked and wheeled operations may result in maneuver damage up to 4 ft bgs. Because of this maneuver damage, the National Guard Trainee is assumed to be exposed to deep surface soil defined as 0 to 4 ft bgs. Soil samples were taken to a maximum depth of 3 ft bgs because field screening did not identify any explosives in samples collected at this depth at Load Line 4. This receptor is exposed to soil via incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust.

The National Guard Trainee is also assumed to be exposed to surface water and sediment during training. Exposure to these media is assumed to occur daily (i.e., 39 d/year) via incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust. According to RTLS staff, all potable water will come from the local municipal water supply. There are currently no plans to obtain potable water from groundwater wells. However, groundwater may be used in the future at vehicle wash points. Groundwater is included as a conservative assumption since the municipal water supply is not currently in place.

National Guard Security Guard/Maintenance Worker

The Load Line 4 area is not mowed. Security patrols occur daily across the installation, but not within Load Line 4; patrolmen usually remain within their vehicles during these patrols. Although the security guard is not currently exposed to contaminated media at Load Line 4 on a daily basis, the potential exposure of this receptor is evaluated in this SHHRA. Therefore, as a worst-case assumption, it is assumed that a security guard leaves his or her vehicle on a daily basis and is exposed to surface soil. Parameter values used to assess exposure to this receptor in the SHHRA are provided in [Table 6-3](#).

National Guard Fire/Dust Suppression Worker

National Guard personnel may use surface water for fire suppression with a frequency of 4 hr/d for 5 d/year (for a total of 20 hr/year), as well as dust suppression for up to 40 hr/year. It is assumed that both of these activities will be conducted by the same individual for a total exposure period of 60 hr/year or approximately 4 hr/d for 15 d/year.

Use of surface water for fire and dust suppression is assumed to result in exposure to surface water via incidental ingestion and dermal contact while setting pumps and hoses in the surface water body and while spraying water. While no VOCs were identified as COPCs in surface water for Load Line 4, it is possible that some inhalation of airborne surface water may occur as a result of spraying. Inhalation is not included in the surface water exposure model; however, the surface water ingestion rate (100 mL/d) is assumed to include potential incidental inhalation exposure.

This receptor is also assumed to be exposed to shallow surface soil and sediment via incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust.

6.3.2.2 Recreational land use

In the future, permitted recreational activities at Load Line 4 may include waterfowl hunting, trapping, and fishing. These activities are evaluated for a single recreational receptor, as described below. Parameter values used to evaluate the Recreational receptor in this SHHRA are provided in [Table 6-3](#).

Hunting and Trapping

Permitted waterfowl hunting is managed jointly by the facility staff and the State Division of Wildlife. Waterfowl hunters may be on-site to hunt 4 hr/d for 2 d/year and to check and clean wood duck boxes 1 hr/d for 1 d/year for a total of approximately 9 hr/year.

Trapping takes place 3 months of the year (November through January), primarily to control beaver and raccoon populations. Trappers are assumed to be present at Load Line 4 for 2 hr at the start of the season to scout and set traps and 0.5 hr/d for 6 d/year to check traps, for a total of approximately 5 hr/year. Traps are generally set near ponds (near existing dams) and along roadsides. According to Tim Morgan, OSC forester, the most common catches include beaver, mink, muskrat, weasel, raccoon, possum, rabbit, and squirrel (Morgan 2002).

It is assumed that waterfowl hunting and trapping are conducted by the same individual for a total exposure period of approximately 12 hr/year (evaluated as 6 hr/d for 2 d/year). This receptor is assumed to be exposed to shallow surface soil, surface water, and sediment via incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust.

Fishing

Catch and release fishing is allowed at some areas, although currently not at Load Line 4, for personnel permanently assigned to RTLS and their guests (OHARNG 2001). Fishers are assumed to be present up to 4 hr/d for 5 d/year. This receptor is assumed to be exposed to shallow surface soil, surface water, and sediment via incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust. It is the goal, when the installation restoration program is done, to have unrestricted fishing and taking of fish from all ponds.

For this SHHRA it is assumed that hunting, trapping, and fishing are conducted by the same individual for a total exposure period of 4.57 hr/d, 7 d/year (i.e., 6 hr/d for 2 d/year to hunt and trap plus 4 hr/d for 5 d/year to fish).

6.3.2.3 Residential land use

This land use scenario represents a true baseline assessment against which all decisions, including decisions to maintain institutional controls, can be made. The residential scenario was evaluated for unrestricted re-use of the site and to address OHARNG concerns of not wanting any restrictions on the re-use of the property. The adult and child resident farmer are assumed to be exposed chronically to all media: groundwater, surface water, sediment, and soil. It is assumed that the farmer lives on Load Line 4 land and digs into subsurface soils (see [Table 6-3](#)). Parameters used to represent activity patterns are listed in [Table 6-3](#) and generally come from standard default values defined by the EPA (1991a).

6.3.3 Exposure Equations

Intake is defined as the amount of contaminant that could be in contact with the body (e.g., lungs and gut) per unit body weight per unit time. Dose is defined as the amount of contaminant that could be absorbed into the bloodstream per unit body weight per unit time. For this SHHRA, intake is not quantified, rather the intake equations as presented in the FWHHRAM (USACE 2004) are modified as shown below to serve as the basis for determining screening RGOs (see more details on the process of determining RGOs in Section 6.5). The exposure parameters used in these equations are provided in [Table 6-3](#). Parameter values, based on EPA guidance with input from the OHARNG and RVAAP facility staff, are taken from the FWHHRAM (USACE 2004).

In general, intake is calculated as shown in Equation 6-1:

$$\text{Intake (mg/kg-d)} = C \times E, \quad (6-1)$$

where

- C = chemical concentration in exposure medium (mg/kg in soil and sediment or mg/L in groundwater and surface water),
- E = chemical exposure (l/d in soil and sediment or L/kg-d in groundwater and surface water).

The exposure (E) term in this equation is calculated per the equations presented in the FWHHRAM (USACE 2004) for intake, with the concentration term (C) removed. These exposure equations are shown below as Equations 6-2 through 6-7; these exposure equations will subsequently be used in the development of RGOs.

Because RGOs are quantified for direct exposure pathways only, exposure equations are not provided in this SHHRA for the ingestion of food pathways (i.e., fish ingestion by the hunter/trapper/fisher and resident, as well as the ingestion of beef, milk, vegetables, and venison by the resident).

6.3.3.1 Soil and sediment exposure equations

Exposure from the incidental ingestion of soil and sediment is quantified in the RGO calculations using Equation 6-2:

$$\text{Chemical Exposure (1/d)} = \frac{IR_s \times EF \times ED \times FI \times ET \times CF}{BW \times AT}, \quad (6-2)$$

where

- IR_s = ingestion rate (kg/d),
- EF = exposure frequency (d/year),
- ED = exposure duration (years),
- FI = fraction ingested (value of 1, unitless),
- ET = exposure time (hr/d),
- CF = conversion factor for ET (d/hr),
- BW = body weight (kg),
- AT = averaging time (days) for carcinogens or non-carcinogens.

Exposure for the dermal contact with soils and sediment pathway is quantified in the RGO calculations using Equation 6-3.

$$\text{Chemical Exposure (1/d)} = \frac{CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}, \quad (6-3)$$

where

- CF = conversion factor [(10⁻⁶ kg/mg) × (10⁴ cm²/m²)],
- SA = skin surface area exposed to soil or sediment (m²/event),

- AF = soil to skin adherence factor (mg/cm²),
- ABS = chemical-specific absorption factor [(unitless) Table Q-7; when chemical-specific values are not available, the following defaults are used: 0.1% for inorganics, 1.0% for VOCs, and 10% for SVOCs],
- EF = exposure frequency (events/year),
- ED = exposure duration (years),
- BW = body weight (kg),
- AT = averaging time (days) for carcinogens or non-carcinogens.

Exposure for the inhalation of soil or dry sediment is quantified in the RGO calculations using Equation 6-4:

$$\text{Chemical Exposure (l/d)} = \frac{IR_a \times EF \times ED \times (VF^{-1} + PEF^{-1}) \times ET \times CF}{BW \times AT}, \quad (6-4)$$

where

- IR_a = inhalation rate (m³/d),
- EF = exposure frequency (d/year),
- ED = exposure duration (years),
- VF = chemical-specific volatilization factor (Table Q-7; m³/kg),
- PEF = particulate emission factor (m³/kg),
- ET = exposure time (hr/d),
- CF = conversion factor for ET (d/hr),
- BW = body weight (kg),
- AT = averaging time (days) for carcinogens or non-carcinogens.

The general particulate emissions factor (PEF) value used for all Load Line 4 receptors, except the National Guard Trainee, is the default value for Cleveland, Ohio, assuming a 0.5-acre source area (9.24E+08 m³/kg). This PEF value was calculated using the EPA Soil Screening Guidance (EPA 1996a), found on-line at <http://risk.lsd.ornl.gov/epa/ssl1.shtml>. While some of the EUs are smaller than 0.5 acres and some are larger than 0.5 acres, the contamination tends to be limited to small areas around the buildings. Therefore, a 0.5-acre contaminated source area is considered appropriate. A smaller PEF value (1.67 × 10⁶) is used for the National Guard Trainee scenario because the activities of this receptor are assumed to generate more dust. This PEF value was calculated from a dust-loading factor (DLF) of 600 µg/m³ (DOE 1983) as: PEF = 1/(DLF × Conversion Factor) = 1/(600 µg/m³ × 1E-09 kg/µg) = 1.67E+06 m³/kg.

6.3.3.2 Groundwater and surface water exposure equations

Exposure for the ingestion of water is quantified in the RGO calculations using Equation 6-5:

$$\text{Chemical Exposure (L/kg-d)} = \frac{IR_w \times EF \times ED}{BW \times AT}, \quad (6-5)$$

where

- IR_w = ingestion rate (L/d),
- EF = exposure frequency (d/year),
- ED = exposure duration (years),

BW = body weight (kg),
 AT = averaging time (days) for carcinogens or non-carcinogens.

Exposure for the dermal contact with chemicals in water is quantified in the RGO calculations using Equation 6-6:

$$\text{Chemical Exposure (L/kg-d)} = \frac{CF \times PC \times SA \times ET \times EF \times ED}{BW \times AT}, \quad (6-6)$$

where

CF = conversion factor [(m/100 cm) × (1,000 L/m³)],
 PC = chemical-specific permeability constant (Table Q-7; cm/hr),
 SA = skin surface area exposed to soil (m²),
 ET = exposure time (hr/d),
 EF = exposure frequency (days/year),
 ED = exposure duration (years),
 BW = body weight (kg),
 AT = averaging time (days) for carcinogens and non-carcinogens.

Inhalation of VOCs from surface water is not evaluated because no volatile COPCs have been identified in surface water for Load Line 4. Exposure for the inhalation of VOCs from groundwater during household water use is quantified in the RGO calculations using Equation 6-7:

$$\text{Chemical Exposure (L/kg-d)} = \frac{IR_w \times K \times EF \times ED \times ET \times CF}{BW \times AT}, \quad (6-7)$$

where

IR_w = inhalation rate (m³/d),
 K = volatilization factor (0.0005 × 1,000 L/m³),
 EF = exposure frequency (d/year),
 ED = exposure duration (years),
 ET = exposure time adjustment (hr/d),
 CF = conversion factor for ET (d/hr),
 BW = body weight (kg),
 AT = averaging time (days) for carcinogens or non-carcinogens.

6.3.4 Exposure Point Concentrations

The exposure point concentration (EPC) represents the chemical concentration a receptor is likely to come in contact with over the duration of exposure. Exposure concentrations from direct contact with environmental media (i.e., soil, sediment, surface water, and groundwater) are based on the sampling results of the media, as described below.

Exposure from direct contact pathways represents exposure to media at the source, and the EPC is based on data collected at the source. Current measured concentrations of chemicals were used to represent future concentrations in the media of interest.

The EPCs developed for each COPC represent an UCL₉₅ on the mean or the maximum detected value for all locations within the EU. If the UCL₉₅ is greater than the MDC, then the default EPC is the MDC for that constituent. EPCs were calculated using EPA guidance, *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992a). The data were tested using the Shapiro-Wilk test to determine distribution, normal or lognormal, of the concentrations. The UCL₉₅ on the mean was calculated using the normal distribution equation (see Equation 6-8) when the concentrations are normally distributed, when concentrations are not judged to be normally or lognormally distributed, when the data set contains fewer than five detections, or when the frequency of detection is less than 50%. For these situations, the UCL₉₅ on the mean is calculated using the following equation:

$$UCL_{95}(normal) = \bar{x}_n + \frac{(t)(s_x)}{\sqrt{n}}, \quad (6-8)$$

where

- \bar{x}_n = mean of the untransformed data,
- t = student-t statistic,
- s_x = standard deviation of the untransformed data,
- n = number of sample results available.

For lognormally distributed concentrations, the UCL₉₅ on the mean is calculated using the following equation:

$$UCL_{95}(log\ normal) = e \left[\bar{x}_l + 0.5(s_l^2) + \frac{(s_l)(H)}{\sqrt{n-1}} \right], \quad (6-9)$$

where

- e = constant (base of the natural log, equal to 2.718),
- \bar{x}_l = mean of the transformed data [$l = \log(x)$],
- s_l = standard deviation of the transformed data,
- H = H-statistic,
- n = number of sample results available.

6.4 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to provide the toxicity data to evaluate the potential for COPCs to cause adverse health effects in exposed individuals. Where possible, it provides an estimate of the relationship between the intake or dose of a COPC and the likelihood or severity of adverse health effects as a result of that exposure. Toxic effects have been evaluated extensively by EPA. This section provides the results of the EPA evaluation of the chemicals identified as COPCs at Load Line 4.

6.4.1 Toxicity Information and U. S. Environmental Protection Agency Guidance for Non-carcinogens

Non-carcinogenic effects are evaluated by comparing an exposure or intake/dose with a reference dose (RfD) or reference concentration (RfC). The RfD and RfCs are determined using available dose-response data for individual chemicals. Scientists determine the exposure concentration or intake/dose below which no adverse effects are seen and add a safety factor (from 10 to 1,000) to determine the RfD or RfC. RfDs

and RfCs are identified by scientific committees supported by EPA. The RfDs available for the COPCs present in Load Line 4 media are listed in Table Q-8 (EPA 1997b, 2004). In this SHHRA, RfCs, measured in milligrams per cubic meter, were converted to RfDs expressed in units of milligrams per kilogram body weight per day by using the default adult inhalation rate and body weight [i.e., $(\text{RfC} \times 20 \text{ m}^3/\text{d})/70 \text{ kg} = \text{RfD}$] (EPA 1989a).

Chronic RfDs are developed for protection from long-term exposure to a chemical (from 7 years to a lifetime); subchronic RfDs are used to evaluate short-term exposure (from 2 weeks to 7 years) (EPA 1989a). Since the potential receptors at Load Line 4 are not considered to have short-term exposures, a conservative approach has been taken for this SHHRA by using only chronic RfDs [chronic RfDs generally result in HQs that are at least as large as (sometimes larger than) HQs calculated from subchronic RfDs].

Toxic effects are diverse and measured in various target body organs (e.g., they range from eye irritation to kidney or liver damage). EPA is currently reviewing methods for accounting for the difference in severity of effects; however, existing RfDs do not address this issue.

6.4.2 Toxicity Information and U. S. Environmental Protection Agency Guidance for Carcinogens

For carcinogens, risks are estimated as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as excess or incremental cancer risk, which is cancer occurrence in addition to normally expected rates of cancer development. Excess cancer risk is estimated using a cancer slope factor (CSF). The CSF is defined as a plausible upper-bound estimate of the probability of a response (i.e., cancer) per unit intake of a chemical over a lifetime (EPA 1989a).

EPA expresses inhalation cancer potency as the unit risk based on the chemical concentration in air [i.e., risk per microgram (μg) of chemical per cubic meter (m^3) of ambient air]. These unit risks were converted to CSFs expressed in units of risk per mg of chemical per kg body weight per day by using the default adult inhalation rate and body weight [i.e., $(\text{Unit Risk} \times 70 \text{ kg} \times 1,000 \mu\text{g}/\text{mg})/20 \text{ m}^3/\text{d}$].

CSFs used in the evaluation of risk from carcinogenic COPCs are listed in Table Q-9 (EPA 1997b, 2004).

6.4.3 Estimated Toxicity Values for Dermal Exposure

Oral and inhalation RfDs and CSFs are currently available. Dermal RfDs and CSFs were estimated from oral toxicity values using chemical-specific gastrointestinal absorption factors (GAFs) to calculate total absorbed dose. This conversion is necessary because most oral RfDs and CSFs are expressed as the amount of chemical administered per time and body weight; however, dermal exposure is expressed as an absorbed dose. Dermal toxicity factors are calculated from oral toxicity factors as shown below (EPA 1992b):

$$\text{RfD}_{\text{dermal}} = \text{RfD}_{\text{oral}} \times \text{GAF}$$

$$\text{CSF}_{\text{dermal}} = \text{CSF}_{\text{oral}}/\text{GAF}$$

Per the FWHHRAM (USACE 2004), dermal CSFs and RfDs are estimated from the oral toxicity values using chemical-specific GAFs to calculate the total absorbed dose only for chemicals with GAF values < 0.5 . Chemical-specific GAF values available from EPA's *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (EPA 2002b) are used whenever possible. Not all COPCs have specific GAF values. When quantitative data are insufficient, a default GAF is used. A default value of 1.0 for organic and inorganic

chemicals is used (EPA 2002b). The GAF and resulting dermal toxicity values used in this SHHRA are listed in Tables Q-8 and Q-9.

6.4.4 Assumptions Used in the Toxicity Assessment

Assumptions made in assigning toxicity values for COPCs at Load Line 4 are listed below.

- Thallium, as a metal, is evaluated using the toxicity values for thallium carbonate. This is the form of thallium with the most conservative toxicity values.
- Total chromium is evaluated using the toxicity values for Chromium III. This is the form of chromium, other than Chromium VI (which is evaluated as a separate COPC), with the most conservative toxicity values.
- Toxicity equivalency factors (TEFs) are applied to carcinogenic polycyclic aromatic hydrocarbons (cPAHs). The following TEFs are used to convert the cPAHs identified as COPCs at Load Line 4 to an equivalent concentration of benzo(*a*)pyrene.

<u>cPAH</u>	<u>TEF</u>
Benzo(<i>a</i>)pyrene	1
Benz(<i>a</i>)anthracene	0.1
Benzo(<i>b</i>)fluoranthene	0.1
Benzo(<i>k</i>)fluoranthene	0.01
Chrysene	0.001
Dibenzo(<i>a,h</i>)anthracene	1
Indeno(1,2,3- <i>cd</i>)pyrene	0.1

6.4.5 Chemicals Without U. S. Environmental Protection Agency Toxicity Values

No RfDs or CSFs are available for some detected chemicals at Load Line 4 because the non-carcinogenic and/or carcinogenic effects of these chemicals have not yet been determined. Although these chemicals may contribute to health effects from exposure to contaminated media at Load Line 4, their effects cannot be quantified at the present time. As seen from Table 6-1, COPCs falling into this category for Load Line 4 include one explosive (nitrocellulose), two PAHs [benzo(*g,h,i*)perylene and phenanthrene], and one SVOC (acenaphthylene).

Previously withdrawn or provisional toxicity values are used for one COPC at Load Line 4: benzo(*a*)pyrene uses a provisional inhalation CSF. Without this provisional value, the inhalation pathway could not be quantitatively evaluated for this chemical.

No RfDs or CSFs are available for lead. EPA (1999) recommends the use of the Interim Adult Lead Methodology to support its goal of limiting risk of elevated fetal blood lead concentrations due to lead exposures to women of child-bearing age. This model is used to estimate the probability that the fetal blood lead level will exceed 10 µg/dL as a result of maternal exposure. This model is not appropriate for exposure frequencies less than 1 d/week because the first order elimination half-life of lead of approximately 30 d requires a constant lead intake over a duration of 90 days to reach quasi-steady state. Shorter exposures are expected to produce oscillations in blood lead concentrations due to absorption and subsequent clearance of lead between each exposure event (EPA 2003). Because of this limitation, lead exposures are evaluated for the Security Guard/Maintenance Worker and Resident Subsistence Farmer only. Complete documentation of the model is available at <http://www.epa.gov/superfund/programs/lead/prods.htm>. The model-supplied default values were used for all parameters, with the exception of the site-specific media

concentration and exposure frequency. Input parameters and results of this model are provided in Tables Q-22 through Q-25.

The Integrated Exposure Uptake Biokinetic (IEUBK) model for lead in children (available at <http://www.epa.gov/superfund/programs/lead/ieubk.htm>) was used to evaluate the On-Site Resident Farmer child. The IEUBK model is used to predict the risk of elevated blood lead levels in children (under the age of seven) that are exposed to environmental lead from many sources. The model also predicts the risk (e.g., probability) that a typical child, exposed to specified media lead concentrations, will have a blood lead level greater or equal to the level associated with adverse health effects (10 µg/dL). Results of this model are provided in Tables Q-22 through Q-25.

6.5 RISK CHARACTERIZATION

Risk characterization for this SHHRA consists of (1) development of screening RGOs for Load Line 4 COPCs, (2) comparison of EPCs versus screening RGOs for Load Line 4 COPCs to determine Load Line 4 COCs, and (3) development of risk-based RGOs for use in the FS for Load Line 4 COCs.

This section is divided into three subsections: methodology (Section 6.5.1), results of COC selection (Section 6.5.2), and risk-based RGOs for COCs (Section 6.5.3).

6.5.1 Methodology for Identifying Chemicals of Concern

The four-step process for identifying COCs for Load Line 4 is illustrated in [Figure 6-1](#). Each of these steps is described below.

6.5.1.1 Step 1 – Determine COPCs for each medium

Four environmental media were evaluated at Load Line 4: soil, surface water, sediment, and groundwater. Soil data are further aggregated by depth interval—shallow surface soils from 0 to 1 ft bgs, deep surface soils from 0 to 4 ft bgs, and subsurface soil greater than 1 ft bgs. Load Line 4 COPCs were identified for each exposure medium as described in Section 6.2; see also [Table 6-1](#).

6.5.1.2 Step 2 – Determine EPCs for each COPC

EPCs were developed for each Load Line 4 COPC in each exposure medium as described in Section 6.3.4; see also Tables Q-1 to Q-6.

6.5.1.3 Step 3 – Determine screening RGOs for each COPC for each medium/receptor combination

Screening RGO are conservative risk-based concentrations used to identify COCs for Load Line 4. These screening RGOs may be more conservative than the risk-based RGOs calculated for this AOC (for the FS) because they are designed to identify all possible COCs at the site. Risk-based RGOs for the FS may take into account the number of COCs present.

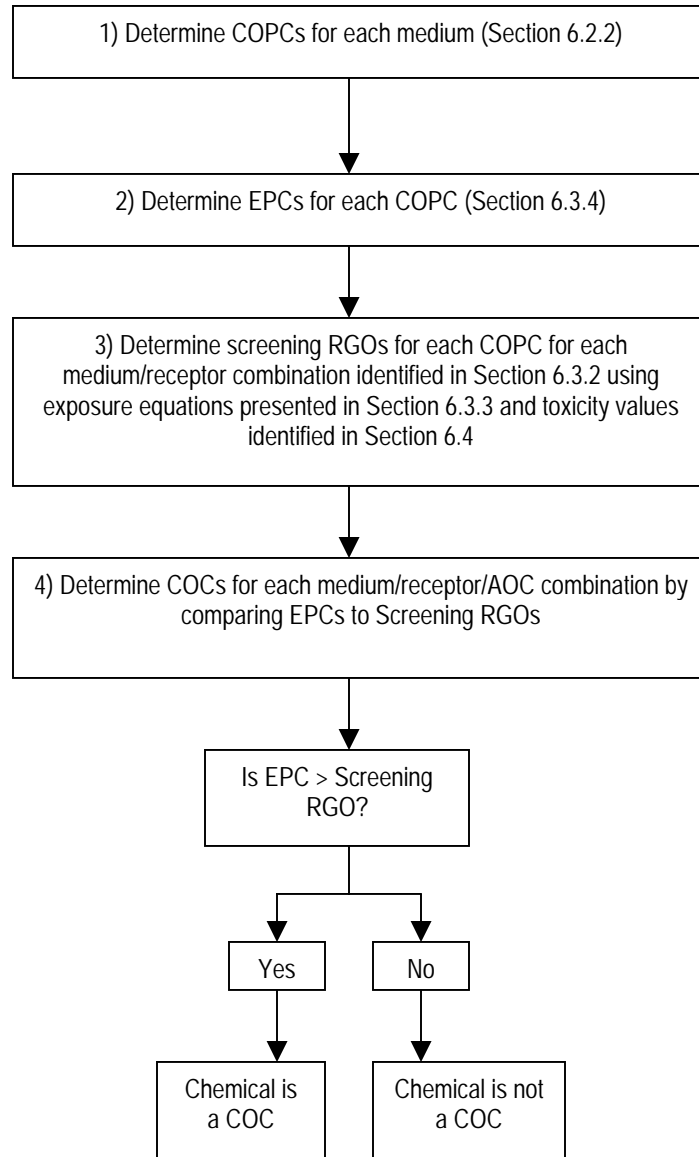


Figure 6-1. Human Health COC Determination Method for Load Line 4

Cancer risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the incremental lifetime cancer risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the United States, the background chance of contracting cancer is a little more than 3 in 10, or 3×10^{-1} (American Cancer Society 2003). The National Oil and Hazardous Substances Pollution Contingency Plan identifies a risk range of 10^{-6} to 10^{-4} , or 1-in-1 million to 1-in-10,000 exposed persons developing cancer (EPA 1990b) for remediation of contaminated sites. ILCRs below 10^{-6} are considered acceptable; ILCRs above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address ILCRs further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates.

The formula for calculating ILCR is shown below (EPA 1989a):

$$\text{ILCR} = I \times \text{CSF} \quad (6-10)$$

where

- I = Intake (mg/kg-d) and $I = C \times E$ (as shown in Equation 6-1),
- C = Exposure concentration in an environmental medium (mg/kg or mg/L),
- E = Exposure as calculated using the exposure equations shown in Section 6.3.3 (d^{-1} or L/kg-d),
- CSF = Cancer slope factor (mg/kg-d)⁻¹ (Table Q-9).

To calculate an RGO at a specific risk level (e.g., 10^{-6}), the above risk equation is rearranged so that the equation is solved for C, the concentration term, as shown in Equation 6-11 for carcinogens.

$$\text{RGO at ILCR of } 10^{-6} = \frac{10^{-6}}{E \times \text{CSF}}, \quad (6-11)$$

where

- RGO = Remedial goal option (mg/kg or mg/L),
- E = Exposure as calculated using the exposure equations shown in Section 6.3.3 (d^{-1} or L/kg-d),
- CSF = Cancer slope factor (mg/kg-d)⁻¹ (Table Q-9).

Thus, to obtain the ingestion of soil RGOs at the 10^{-6} risk level for the National Guard Trainee receptor exposed to arsenic, the parameter values for the National Guard Trainee receptor (from Table 6-3) and the chemical-specific parameter (oral CSF, from Table Q-9) for arsenic are used to calculate an RGO for soil ingestion of 12.2 mg/kg, which will produce a soil ingestion risk of 10^{-6} for the National Guard Trainee receptor exposed to arsenic. RGOs are calculated for each exposure pathway and for total exposure by all pathways for each medium.

Non-carcinogenic hazards associated with toxic (i.e., non-carcinogenic) effects are evaluated by comparing an estimated intake or dose from site media to an acceptable exposure expressed as an RfD. The RfD is the threshold level below which no toxic effects are expected to occur in a population, including sensitive subpopulations. The ratio of intake over the RfD is the HQ (EPA 1989a) and is calculated as:

$$\text{HQ} = I/\text{RfD} \quad (6-12)$$

where

- I = Intake (mg/kg-d) and $I = C \times E$ (as shown in Equation 6-1),
- C = Exposure concentration in an environmental medium (mg/kg or mg/L),
- E = Exposure (d-1 or L/kg-d) as calculated using the exposure equations shown in Section 6.3.3,
- RfD = Reference dose (mg/kg-d) (Table Q-8).

HQs may be summed to obtain a hazard index (HI) for all chemicals present at a site. An HI greater than 1 has been defined as the level of concern for potential adverse non-carcinogenic health effects (EPA 1989a). This approach differs from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1-in-100 chance of an adverse effect but indicates only that the estimated intake is 100 times less than the threshold level at which adverse health effects may occur.

To calculate an RGO at a specific hazard level (e.g., 0.1), the above hazard equation is rearranged so that the equation is solved for C, the concentration term, as shown in Equation 6-13 for non-carcinogens.

$$\text{RGO at HQ of 0.1} = \frac{0.1 \times \text{RfD}}{E}, \quad (6-13)$$

where

- RGO = Remedial goal option (mg/kg or mg/L),
- RfD = Reference dose (mg/kg-d) (Table Q-8),
- E = Exposure as calculated using the exposure equations shown in Section 6.3.3 (d-1 or L/kg-d).

The FWHHRAM (USACE 2004) identifies cumulative goals of 1×10^{-5} for cancer risk and 1.0 for non-cancer hazards for Load Line 4. To ensure that these goals for cumulative risk and hazard are met, a chemical-specific cancer risk goal of 1×10^{-6} was chosen to estimate screening RGOs; this risk level will ensure that any chemicals with risk $> 1 \times 10^{-6}$ are COCs and will provide for meeting the cumulative risk goal of 1×10^{-5} for Load Line 4 if multiple COCs are present. Likewise, a conservative chemical-specific hazard level of 0.1 was chosen to estimate screening RGOs; this hazard level will provide for meeting the cumulative hazard goal of 1.0 for Load Line 4 if multiple COCs are present.

For this SHHRA, screening RGOs are calculated for each exposure route (e.g., ingestion), as well as for the total chemical risk or hazard across all appropriate exposure routes. Note that if a calculated RGO is not physically possible (e.g., more than the pure chemical), then the RGO is adjusted accordingly. For example, if the calculated RGO is 5.5E+06 mg/kg, then the RGO is adjusted downward to 1.0E+06 mg/kg.

As described previously, COPCs were identified for groundwater, surface water, sediment, surface soil (shallow and deep), and subsurface soil. Screening RGOs are calculated for all COPCs in this SHHRA, for each appropriate receptor/medium combination evaluated. For COPCs with both cancer and non-cancer effects, the smallest RGO between the carcinogenic RGO (across all pathways) and the non-carcinogenic RGO (across all pathways) is chosen as the screening RGO; this is done for each COPC for each receptor/medium combination. The resulting screening RGOs are shown in Tables Q-10 to Q-15 for groundwater, surface water, sediment, shallow surface soil, deep surface soil, and subsurface soil, respectively.

6.5.1.4 Step 4 – Determine COCs for each medium/receptor combination

The method used in this SHHRA to determine human health COCs is to compare the EPCs (see Step 2 in Section 6.5.1.2) with the screening RGOs (see Step 3 in Section 6.5.1.3), for each COPC for each receptor/medium combination. Any COPC whose EPC is larger than its screening RGO is a human health COC for that particular receptor/medium combination; COPCs whose EPCs are smaller than their screening RGOs are not human health COCs for that particular receptor/medium combination.

It is important to note and understand that although HQs and ILCRs are not quantified in this SHHRA, the process of comparing the EPCs to screening RGOs at specific risk and hazard levels for specific receptors is equivalent to determining if the specific risk and hazard levels have been exceeded. For example, if the EPC for arsenic in shallow surface soil exceeds the screening RGO based on a risk of 10^{-6} for the Resident Farmer Adult, then the total risk across the ingestion, inhalation, and dermal pathways for the Resident Farmer Adult exposed to arsenic will be greater than 10^{-6} . Similarly, if the EPC for aluminum in shallow surface soil exceeds the screening RGO based on a hazard of 0.1 for the Resident Farmer Child, then the total hazard across the ingestion, inhalation, and dermal pathways for the Resident Farmer Child exposed to aluminum will be greater than 0.1. This comparison method allows one to categorize exposures to COPCs as being above or below the 10^{-6} risk level or 0.1 hazard level; chemicals that exceed these risk or hazard levels are deemed COCs in this SHHRA.

6.5.2 Risk Characterization Results

COCs are identified as COPCs whose EPC exceeds the screening RGO at a risk level of 10^{-6} or HQ of 0.1, whichever is smaller. COCs for Load Line 4 are identified in the following sections by EU and exposure medium. A summary of these results is presented for each medium/receptor/AOC combination in [Table 6-4](#).

6.5.2.1 Groundwater

Two COPCs were identified for the single groundwater aggregate at Load Line 4 (see Table Q-1). Screening RGOs were developed for these two groundwater COPCs, for the three receptors (National Guard Trainee, Resident Farmer Adult, and Resident Farmer Child) exposed to groundwater in this SHHRA (see Table Q-10). Table Q-16 shows the actual screening to determine groundwater COCs for these three receptors. A summary of the resulting COCs is shown in [Table 6-4](#).

Both COPCs were identified as COCs for the one groundwater aggregate: arsenic and manganese were COCs for the National Guard Trainee, Resident Farmer Adult, and Resident Farmer Child. Risk-based RGOs were developed for both of these COCs, for all three receptors exposed to groundwater (see Section 6.5.3).

6.5.2.2 Surface water

Three surface water COPCs were identified – two for the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate and one for the aggregate designated as Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond; no COPCs were identified for the Exit Drainage Aggregate (see Tables Q-2 and 6-1). Screening RGOs were developed for these three surface water COPCs, for the five receptors (National Guard Fire/Dust Suppression Worker, National Guard Trainee, Hunter/Trapper/Fisher, Resident Farmer Adult, and Resident Farmer Child) exposed to surface water in this SHHRA (see Table Q-11). Table Q-17 shows the actual screening to determine surface water COCs for these five receptors. A summary of the resulting COCs is shown in [Table 6-4](#); results are discussed below for each aggregate.

Table 6-4. Receptor/Medium/Exposure Unit Combinations with COCs at Load Line 4

COC	Groundwater			Surface Water					Sediment				
	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/Trapper/Fisher	Resident Farmer Adult	Resident Farmer Child	Dust/Fire Control Worker	National Guard Trainee	Hunter/Trapper/Fisher	Resident Farmer Adult	Resident Farmer Child
<i>Inorganics</i>													
Aluminum										MS			MS
Arsenic	LL4	LL4	LL4		MU		MU	MU					
Manganese	LL4	LL4	LL4		MU		MU	MU					
Thallium													MS
<i>Organic PCBs</i>													
PCB-1254													
PCB-1260													
<i>Organic Pesticides</i>													
4,4'-DDT					MS		MS	MS					
<i>Organic Semivolatiles</i>													
Benz(a)anthracene													
Benzo(a)pyrene													
Benzo(b)fluoranthene													
Dibenz(a,h)anthracene													
Indeno(1,2,3-cd)pyrene													

Table 6-4. Receptor/Medium/Exposure Unit Combinations with COCs at Load Line 4 (continued)

COC	Shallow Surface Soil					Deep Surface Soil	Subsurface Soil	
	Security Guard/ Maintenance Worker	Dust/Fire Control Worker	Hunter/ Trapper/ Fisher	Resident Farmer Adult	Resident Farmer Child	National Guard Trainee	Resident Farmer Adult	Resident Farmer Child
<i>Inorganics</i>								
Aluminum					EH	EH,PR		PR
Arsenic	EH,MP,PR			EH,MP,PR	EH,MP,PR	EH,MP,PR		
Manganese					EH,PA,PR,PS	EH,PA,PR,PS	PR	PR
Thallium					CH,EH,MP,PR			
<i>Organic PCBs</i>								
PCB-1254	EH,PR			EH,PR,PS	EH,PR,PS	PR		
PCB-1260	EH,PR			EH,PR,PS	EH,PR,PS			
<i>Organic Pesticides</i>								
4,4'-DDT								
<i>Organic Semivolatiles</i>								
Benz(a)anthracene				EH				
Benzo(a)pyrene	CH,EH,PA			CH,EH,PA,PS	CH,EH,PA,PS			
Benzo(b)fluoranthene	EH			CH,EH	EH			
Dibenz(a,h)anthracene	EH			CH,EH	EH			
Indeno(1,2,3-cd)pyrene				EH				

COCs are shown for each medium/receptor/area of concern combination. Chemicals whose exposure point concentration exceeds its screening risk-based RGO are COCs. Area of concern codes are as follows:

LL4 = Load Line 4.

CH = Change Houses Aggregate.

ED = Exit Drainage Aggregate.

EH = Explosives Handling Areas Aggregate.

MP = Melt-Pour Area Drainage Ditches Aggregate.

MS = Main Stream Segment and Settling Pond Aggregate.

MU = Main Stream Segment Upstream of Perimeter Road Aggregate.

PA = Perimeter Area Aggregate.

PR = Preparation and Receiving Areas Aggregate.

PS = Packaging and Shipping Areas Aggregate.

COC = Chemical of concern.

DDT = Dichlorodiphenyltrichloroethane.

PCB = Polychlorinated biphenyl.

RGO = Remedial goal option. Screening risk-based RGOs are based on a cancer risk level of 10^{-6} or a hazard level of 0.1 (whichever is smaller) and are shown in Tables Q-10 through Q-15. Screening of Load Line 4 data to determine COCs is shown in Tables Q-16 through Q-21.

Main Stream Segment Upstream of Perimeter Road Bridge

Both surface water COPCs were identified as COCs at the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate: arsenic and manganese, both for the National Guard Trainee, Resident Farmer Adult, and Resident Farmer Child.

Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond

One pesticide was identified as a surface water COC at the aggregate designated as Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond: 4,4'-DDT, a COC for the National Guard Trainee, Resident Farmer Adult, and Resident Farmer Child.

Exit Drainage Aggregate

No COPCs, and consequently no COCs, were identified from exposure to surface water at the Exit Drainage Aggregate.

Across all three aggregates, a total of three COCs were identified for surface water (two metals and one pesticide); see [Table 6-4](#). Risk-based RGOs were developed for all three of these COCs, for all five receptors exposed to this medium (see Section 6.5.3).

6.5.2.3 Sediment

Two sediment COPCs were identified for the aggregate designated as Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond; no COPCs were identified for the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate or the Exit Drainage Aggregate (see Table Q-3). Screening RGOs were developed for these two sediment COPCs, for the five receptors (National Guard Fire/Dust Suppression Worker, National Guard Trainee, Hunter/Trapper/Fisher, Resident Farmer Adult, and Resident Farmer Child) exposed to sediment in this SHHRA (see Table Q-12). Table Q-18 shows the actual screening to determine sediment COCs for these five receptors. A summary of the resulting COCs is shown in [Table 6-4](#); results are discussed below for each aggregate.

Main Stream Segment Upstream of Perimeter Road Bridge

No COPCs, and consequently no COCs, were identified from exposure to sediment at the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate.

Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond

Two metals were identified as sediment COCs at the aggregate designated as Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond: aluminum, for the National Guard Trainee and Resident Farmer Child; and thallium, for the Resident Farmer Child only.

Exit Drainage

No COPCs, and consequently no COCs, were identified from exposure to sediment at the Exit Drainage Aggregate.

Across all three aggregates, a total of two COCs were identified for sediment (two metals); see [Table 6-4](#). Risk-based RGOs were developed for both of these COCs, for all five receptors exposed to this medium (see Section 6.5.3).

6.5.2.4 Shallow surface soil

Shallow surface soil is defined by the following six aggregates:

- Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16),
- Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse),
- Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A),
- Change Houses,
- Melt-Pour Drainage Ditches, and
- Perimeter Area.

A total of 26 shallow surface soil COPCs were identified within the six soil aggregates (see Table Q-4). Twenty-one of these 26 shallow surface soil COPCs have approved toxicity values and, thus, were determined to be quantitative COPCs (see Table 6-1). Lead was also a shallow surface soil COPC in four of the six soil aggregates (Explosives Handling Areas, Preparation and Receiving Areas, Packaging and Shipping Areas, and Perimeter Area); lead is discussed separately below.

Screening RGOs were developed for the 21 shallow surface soil quantitative COPCs, for the 5 receptors (National Guard Security Guard/Maintenance Worker, National Guard Fire/Dust Suppression Worker, Hunter/Trapper/Fisher, Resident Farmer Adult, and Resident Farmer Child) exposed to shallow surface soil in this SHHRA (see Table Q-13). Table Q-19 shows the actual screening to determine shallow surface soil COCs for these five receptors. A summary of these COCs is shown in Table 6-4; results are discussed below for each aggregate.

Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16)

Eleven shallow surface soil COCs were identified for the Explosives Handling Areas. These COCs included the following:

- 4 metals: aluminum, manganese, and thallium, all for the Resident Farmer Child only; and arsenic, for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child;
- 2 PCBs: PCB-1254 and PCB-1260, both for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child; and
- 5 PAHs: benz(*a*)anthracene and indeno(1,2,3-*cd*)pyrene, both for the Resident Farmer Adult only; and benzo(*a*)pyrene, benzo(*b*)fluoranthene, and dibenz(*a,h*)anthracene, all for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child.

Preparation and Receiving Areas (Buildings EB-3, DB-803)

Five shallow surface soil COCs were identified for the Preparation and Receiving Areas Aggregate. These COCs included the following:

- 3 metals: manganese and thallium, both for the Resident Farmer Child only; and arsenic, for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child; and
- 2 PCBs: PCB-1254 and PCB-1260, both for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child.

Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A)

Four shallow surface soil COCs were identified for the Packaging and Shipping Areas Aggregate. These COCs included the following:

- 1 metal: manganese, for the Resident Farmer Child only;
- 2 PCBs: PCB-1254 and PCB-1260, both for the Resident Farmer Adult and Resident Farmer Child; and
- 1 PAH: benzo(*a*)pyrene, a COC for the Resident Farmer Adult and Resident Farmer Child.

Change Houses

Four shallow surface soil COCs were identified for the Change Houses Aggregate. These COCs included the following:

- 1 metal: thallium, for the Resident Farmer Child only; and
- 3 PAHs: benzo(*b*)fluoranthene and dibenz(*a,h*)anthracene, both for Resident Farmer Adult only; and benzo(*a*)pyrene, for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child.

Melt-Pour Drainage Ditches

Two metals were identified as shallow surface soil COCs for the Melt-Pour Drainage Ditches Aggregate: arsenic, for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child; and thallium, for the Resident Farmer Child only.

Perimeter Area Aggregate

Two shallow surface soil COCs were identified for the Perimeter Area Aggregate. These COCs included the following:

- 1 metal: manganese, for the Resident Farmer Child only; and
- 1 PAH: benzo(*a*)pyrene, for the Security Guard/Maintenance Worker, Resident Farmer Adult, and Resident Farmer Child.

Across all six aggregates, a total of 11 COCs were identified for shallow surface soil (4 metals, 2 PCBs, and 5 PAHs); see [Table 6-4](#). Risk-based RGOs were developed for all 11 of these COCs, for all 5 receptors exposed to this medium (see Section 6.5.3).

Evaluation of Lead in Shallow Surface Soil

Lead was identified as a COPC in shallow surface soil at the following EUs: Explosives Handling Areas Aggregate (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16), Preparation and Receiving Areas Aggregate (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse), Packaging and Shipping Areas Aggregate (Buildings G-17, G-18, and B-19/-19A), and Perimeter Area Aggregate.

Two adult receptors were evaluated for exposure to lead in the shallow surface soil using the adult lead model: the Security Guard/Maintenance Worker and Resident Farmer Adult (all other receptors had exposure frequencies too short to be evaluated with the adult lead model). The estimated probability of fetal blood lead concentrations exceeding acceptable levels was less than 4% at the Explosives Handling

Areas Aggregate (Table Q-22); 3% or less at both the Packaging and Shipping Areas (Table Q-23) and the Perimeter Area Aggregates (Table Q-24); and less than 6% at the Preparation and Receiving Areas Aggregate (Table Q-25).

For the child receptor (Resident Farmer Child), the estimated probabilities of exceeding target blood lead levels were as follows: 19% at the Explosives Handling Areas Aggregate (Table Q-22); 7% at the Packaging and Shipping Areas Aggregate (Table Q-23); 12% at the Perimeter Area Aggregate (Table Q-24); and 35% at the Preparation and Receiving Areas Aggregate (Table Q-25).

Based on these results, lead may be considered a COC at the Explosives Handling Areas, Perimeter Area, and Preparation and Receiving Areas Aggregates.

6.5.2.5 Deep surface soil

Deep surface soil is defined by the following six aggregates:

- Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16),
- Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse),
- Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A),
- Change Houses,
- Melt-Pour Drainage Ditches, and
- Perimeter Area.

A total of 26 deep surface soil COPCs were identified in the six soil aggregates (see Table Q-5). Twenty-one of these 26 deep surface soil COPCs have approved toxicity values and, thus, were determined to be quantitative COPCs (see Table 6-1). Lead was also a deep surface soil COPC in four of the six aggregates (Explosives Handling Areas, Preparation and Receiving Areas, Packaging and Shipping Areas, and Perimeter Area); however, because the exposure frequency for the National Guard Trainee (the only receptor with exposures to deep surface soils) is relatively short, the adult blood lead modeling was not appropriate.

Screening RGOs were developed for the 21 deep surface soil quantitative COPCs, for the one receptor (National Guard Trainee) exposed to deep surface soil in this SHHRA (see Table Q-14). Table Q-20 shows the actual screening to determine deep surface soil COCs for this receptor. A summary of these COCs is shown in Table 6-4; results are discussed below for each aggregate.

Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16)

Three metals were identified as deep surface soil COCs for the Explosives Handling Areas: aluminum, arsenic, and manganese.

Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse)

Four deep surface soil COCs were identified for the Preparation and Receiving Areas Aggregate. These COCs included

- 3 metals: aluminum, arsenic, and manganese; and
- 1 PCB: PCB-1254.

Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A)

One metal was identified as a deep surface soil COC for the Packaging and Shipping Areas Aggregate: manganese.

Change Houses

No deep surface soil COCs were identified for the Change Houses Aggregate, as all EPCs were less than their respective screening RGOs.

Melt-Pour Drainage Ditches

One metal was identified as a deep surface soil COC for the Melt-Pour Drainage Ditches Aggregate: arsenic.

Perimeter Area Aggregate

One metal was identified as a deep surface soil COC for the Perimeter Area Aggregate: manganese.

Across all six aggregates, a total of four COCs were identified for deep surface soil (three metals and one PCB); see [Table 6-4](#). Risk-based RGOs were developed for all four of these COCs, for the National Guard Trainee exposed to this medium (see Section 6.5.3).

6.5.2.6 Subsurface soil

Subsurface soil is defined by the following four aggregates:

- Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16),
- Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse),
- Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A), and
- Perimeter Area.

Two subsurface soil COPCs were identified in the Preparation and Receiving Areas Aggregate; no COPCs were identified in the other subsurface soil aggregates (see Tables Q-6 and [6-1](#)).

Screening RGOs were developed for these two subsurface soil COPCs, for the two receptors (Resident Farmer Adult and Resident Farmer Child) exposed to subsurface soil in this SHHRA (see Table Q-15). Table Q-21 shows the actual screening to determine subsurface soil COCs for these two receptors. A summary of the subsurface soil COCs is shown in [Table 6-4](#); results are discussed below for each aggregate.

Explosives Handling Areas (Buildings G-8, G-9, G-11, G-12/-12A, G-13, G-15, and G-16)

No COPCs, and consequently no COCs, were identified from exposure to subsurface soil at the Explosives Handling Areas Aggregate.

Preparation and Receiving Areas (Buildings G-1/-1A, G-2, G-3, and G-4 powerhouse)

Two metals were identified as subsurface soil COCs at the Preparation and Receiving Areas Aggregate: aluminum, for the Resident Farmer Child only; and manganese, for both the Resident Farmer Adult and Resident Farmer Child.

Packaging and Shipping Areas (Buildings G-17, G-18, and B-19/-19A)

No COPCs, and consequently no COCs, were identified from exposure to subsurface soil at the Packaging and Shipping Areas Aggregate.

Perimeter Area Aggregate

No COPCs, and consequently no COCs, were identified from exposure to subsurface soil at the Perimeter Area Aggregate.

Across all four aggregates, two metals were identified as subsurface soil COCs; see [Table 6-4](#). Risk-based RGOs were developed for both of these COCs, for both receptors exposed to this medium (see Section 6.5.3).

6.5.3 Remedial Goal Options for Chemicals of Concern

To support the remedial alternative selection process, RGOs were developed for each chemical identified as a COC in the direct exposure pathways for this Load Line 4 SHHRA. These RGOs are risk-based concentrations that will be used in the FS to assist in defining the extent of contamination to be remediated and, thus, will help cost various alternatives. RGOs are media- and chemical-specific concentrations and are calculated for COCs within each land use/receptor scenario for a given medium. The RGOs presented in this chapter are for protection of human health and may or may not be protective of ecological receptors. The process for calculating RGOs for this SHHRA is a rearrangement of the cancer risk or non-cancer hazard equations, with the goal of obtaining the concentration that will produce a specific risk or hazard level.

Section 6.5.1.3 presented the methods for determining RGOs. Section 6.5.1.3 indicated how to estimate RGOs at the 10^{-6} risk level and 0.1 hazard level; these levels were levels for screening the Load Line 4 data in order to determine COCs. In this section, different risk and hazard levels are used to determine risk-based RGOs for the COCs, but the methods detailed in Section 6.5.1.3 apply here as well.

The FWHHRAM (USACE 2004) identifies a 10^{-5} target excess individual lifetime cancer risk (TR) for carcinogens and an acceptable Target Hazard Index (THI) of 1 for non-carcinogens, with the caveat that exposure to multiple COCs may require downward adjustment of these targets. The TR and THI are dependent on several factors, including the number of carcinogenic and non-carcinogenic COCs and the target organs and toxic endpoints of these COCs.

For example, if numerous (i.e., approaching or greater than 10) non-carcinogenic COCs with similar toxic endpoints are present, it may be appropriate to calculate chemical-specific RGOs with a THI of 0.1 to account for exposure to multiple contaminants. A TR of 10^{-5} and THI of 1.0 are identified as appropriate for calculating RGOs for Load Line 4 based on the small number of COCs identified for each exposure medium, as described below for the National Guard Trainee (the most likely receptor at Load Line 4)], and the type of COCs (carcinogenic or non-carcinogenic).

- Groundwater – Only two COCs were identified for the National Guard Trainee. One COC (arsenic) is a carcinogen and the other COC (manganese) is a non-carcinogen.
- Surface water – Only three COCs were identified for the National Guard Trainee exposed to surface water. Two of the COCs are carcinogens; one (arsenic) is a class A carcinogen with the lungs or respiratory system as the target organ, while the other (4,4'-DDT) is a class B2 carcinogen with the liver as the target organ. The one non-carcinogenic COC in surface water is manganese.

- Sediment – Only one non-carcinogenic COC (aluminum) was identified for the National Guard Trainee exposed to sediment.
- Surface soil – A total of four COCs were identified for the National Guard Trainee, two carcinogens and two non-carcinogens. Of the two carcinogens, one (arsenic) is a class A carcinogen with the lungs or respiratory system as the target organ and the other one (PCB-1254) is a class B2 carcinogen with a different target organ (liver). The two non-carcinogens (aluminum and manganese) have differing toxic endpoints (not defined and central nervous system, respectively).

Risk-based RGOs for COCs in groundwater, surface water, sediment, surface soil, and subsurface soil are presented in [Tables 6-5](#) through [6-10](#). These RGOs are provided here to assist in defining the extent of contamination and to help cost various alternatives in the FS. During the process of remedy selection for the site, final RGOs will be identified to meet risk and hazard goals. The final RGOs may consider additional information such as background concentrations and will be reviewed by Ohio EPA prior to remedy selection.

6.6 UNCERTAINTY ANALYSIS

This section identifies the uncertainties associated with each step of the SHHRA process used for Load Line 4. Uncertainties are not cumulative and are not mutually exclusive.

6.6.1 Uncertainties Associated with the Data Evaluation

Although the data evaluation process used to select COPCs adheres to established procedures and guidance, it also requires making decisions and developing assumptions on the basis of historical information, disposal records, process knowledge, and best professional judgment about the data. Uncertainties are associated with all such assumptions. The background concentrations and PRGs used to screen analytes are also subject to uncertainty.

In addition, the determination of the chemical for certain analytes is subject to various assumptions. For example, it is assumed that all metallic thallium is present as the most toxic form (thallium carbonate).

Another area of uncertainty involves the qualitative evaluation (and elimination from further consideration) of essential nutrients, many of which have no available toxicity values. In addition, the toxicity values used in the derivation of PRGs are subject to change as additional information becomes available from scientific research. These periodic changes in toxicity values may cause the PRG values to change as well.

Uncertainty can be introduced in the data aggregation process. Any changes to criteria governing how data are grouped affect the summary statistics. For example, if data from a single sample are removed from an aggregate, the MDC could change for that aggregate. This change could effect whether an analyte remains on, or is removed from, the COPC list for that aggregate (since the MDC is used in the PRG screening process). Other summary statistics could be affected as well.

Load Line 4 has remained relatively undisturbed between the Phase I and Phase II RIs. No demolition of structures or extensive disturbance of soil has occurred. Accordingly, soil data obtained during the Phase I RI in 1996 were deemed to still represent current conditions at the AOC. Phase I RI soil data collected from the 0 to 2-ft bgs interval were incorporated into the appropriate data aggregates and evaluated in conjunction with Phase II surface soil collected from the 0 to 1-ft bgs interval.

Table 6-5. Risk-based RGOs (mg/L) for Groundwater COCs at Load Line 4

COC	Total RGO ^a National Guard Trainee		Total RGO ^a Resident Farmer Adult		Total RGO ^a Resident Farmer Child	
	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵
	<i>Inorganics</i>					
Arsenic	9.8E-02	6.1E-03	1.1E-02	5.7E-04	3.1E-03	8.1E-04
Manganese	1.4E+01	--	1.6E+00	--	4.6E-01	--

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).
 COC = Chemical of concern.
 HQ = Hazard quotient.
 RGO = Remedial goal option.
 -- = No RGO could be quantified, based on lack of approved toxicity value.

Table 6-6. Risk-based RGOs (mg/L) for Surface Water COCs at Load Line 4

COC	Total RGO ^a Dust/Fire Control		Total RGO ^a National Guard Trainee		Total RGO ^a Hunter/Trapper		Total RGO ^a Resident Farmer Adult		Total RGO ^a Resident Farmer Child	
	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵
	<i>Inorganics</i>									
Arsenic	4.1E+00	2.5E-01	7.8E-01	4.8E-02	1.1E+01	5.9E-01	1.7E-01	8.9E-03	4.2E-02	1.1E-02
Manganese	1.5E+02	--	1.1E+01	--	2.1E+02	--	6.0E+00	--	2.6E+00	--
<i>Organic Pesticides</i>										
4,4'-DDT	6.0E-02	1.0E-02	3.9E-03	6.4E-04	7.2E-02	9.9E-03	2.4E-03	3.3E-04	1.3E-03	9.1E-04

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).
 COC = Chemical of concern.
 DDT = Dichlorodiphenyltrichloroethane.
 HQ = Hazard quotient.
 RGO = Remedial goal option.
 -- = No RGO could be quantified, based on lack of approved toxicity value.

Table 6-7. Risk-based RGOs (mg/kg) for Sediment COCs at Load Line 4

COC	Total RGO ^a Dust/Fire Control		Total RGO ^a National Guard Trainee		Total RGO ^a Hunter/Trapper		Total RGO ^a Resident Farmer Adult		Total RGO ^a Resident Farmer Child	
	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵
	<i>Inorganics</i>									
Aluminum	1.0E+06	--	3.5E+04	--	1.0E+06	--	7.0E+05	--	7.8E+04	--
Thallium	7.7E+03	--	5.2E+02	--	1.4E+04	--	5.7E+01	--	6.2E+00	--

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).
 COC = Chemical of concern.
 HQ = Hazard quotient.
 RGO = Remedial goal option.
 -- = No RGO could be quantified, based on lack of approved toxicity value.

Table 6-8. Risk-based RGOs (mg/kg) for Shallow Surface Soil COCs at Load Line 4

COC	Total RGO ^a		Total RGO ^a		Total RGO ^a		Total RGO ^a		Total RGO ^a	
	Security Guard/ Maintenance Worker		Dust/Fire Control		Hunter/Trapper		Resident Farmer Adult		Resident Farmer Child	
	HQ =	Risk =	HQ =	Risk =	HQ =	Risk =	HQ =	Risk =	HQ =	Risk =
	1.0	10 ⁻⁵	1.0	10 ⁻⁵	1.0	10 ⁻⁵	1.0	10 ⁻⁵	1.0	10 ⁻⁵
<i>Inorganics</i>										
Aluminum	1.0E+06	--	1.0E+06	--	1.0E+06	--	7.0E+05	--	7.8E+04	--
Arsenic	4.2E+02	2.6E+01	1.1E+04	6.9E+02	1.6E+04	8.1E+02	1.3E+02	6.7E+00	2.2E+01	5.7E+00
Manganese	7.5E+04	--	1.0E+06	--	1.0E+06	--	2.0E+04	--	3.3E+03	--
Thallium	1.3E+03	--	7.7E+03	--	1.4E+04	--	5.7E+01	--	6.2E+00	--
<i>Organic PCBs</i>										
PCB-1254	6.2E+00	4.4E+00	2.2E+02	1.5E+02	2.8E+02	1.6E+02	3.5E+00	2.0E+00	1.2E+00	3.5E+00
PCB-1260	--	4.4E+00	--	1.5E+02	--	1.6E+02	--	2.0E+00	--	3.5E+00
<i>Organic Semivolatiles</i>										
Benz(<i>a</i>)anthracene	--	1.3E+01	--	4.5E+02	--	4.8E+02	--	5.9E+00	--	9.7E+00
Benzo(<i>a</i>)pyrene	--	1.3E+00	--	4.5E+01	--	4.8E+01	--	5.9E-01	--	9.7E-01
Benzo(<i>b</i>)fluoranthene	--	1.3E+01	--	4.5E+02	--	4.8E+02	--	5.9E+00	--	9.7E+00
Dibenz(<i>a,h</i>)anthracene	--	1.3E+00	--	4.5E+01	--	4.8E+01	--	5.9E-01	--	9.7E-01
Indeno(1,2,3- <i>cd</i>)pyrene	--	1.3E+01	--	4.5E+02	--	4.8E+02	--	5.9E+00	--	9.7E+00

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).

COC = Chemical of concern.

HQ = Hazard quotient.

PCB = Polychlorinated biphenyl.

RGO = Remedial goal option.

-- = No RGO could be quantified, based on lack of approved toxicity value.

Table 6-9. Risk-based RGOs (mg/kg) for Deep Surface Soil COCs at Load Line 4

COC	Total RGO ^a	
	HQ = 1.0	Risk = 10 ⁻⁵
<i>Inorganics</i>		
Aluminum	3.5E+04	--
Arsenic	1.5E+03	3.1E+01
Manganese	3.5E+02	--
<i>Organic PCBs</i>		
PCB-1254	5.5E+01	3.5E+01

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).

COC = Chemical of concern.

HQ = Hazard quotient.

PCB = Polychlorinated biphenyl.

RGO = Remedial goal option.

-- = No RGO could be quantified, based on lack of approved toxicity value.

Table 6-10. Risk-based RGOs (mg/kg) for Subsurface Soil COCs at Load Line 4

COC	Total RGO ^a Resident Farmer Adult		Total RGO ^a Resident Farmer Child	
	HQ = 1.0	Risk = 10 ⁻⁵	HQ = 1.0	Risk = 10 ⁻⁵
	<i>Inorganics</i>			
Aluminum	7.0E+05	--	7.8E+04	--
Manganese	2.0E+04	--	3.3E+03	--

^a Total RGO is the RGO across all pathways (ingestion, dermal, and inhalation).

COC = Chemical of concern.

HQ = Hazard quotient.

RGO = Remedial goal option.

-- = No RGO could be quantified, based on lack of approved toxicity value.

Inclusion of this older Phase I data introduces uncertainty due to age, changes in analytical methods and detection limits, and limited TALs for many samples. However, the Phase I RI data provide valuable information regarding the extent of contamination related to source areas.

Representative exposure concentrations are calculated in this SHHRA based on the assumption that the samples collected from each EU are truly random samples. In fact, only the samples collected from the perimeter EU were collected randomly. Sample locations for all other EUs were biased to identify areas of highest contaminant concentrations. Seasonal variations in the data may also exist (especially with the surface water and groundwater data), which may not have been captured in the calculation of the EPCs.

In addition, in the evaluation of the various media, environmental concentrations are assumed to be constant (i.e., concentrations are not reduced by loss due to natural removal processes such as volatilization, leaching, and/or biodegradation). Since the source of contamination (i.e., production and demilitarization of munitions) no longer exists at Load Line 4, this assumption is a source of uncertainty.

Some unavoidable uncertainty is associated with the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment depends on the adequacy of the set of procedures that specifies how samples are selected and handled and how strictly these procedures are followed. QA/QC procedures within the laboratories are used to minimize uncertainties; however, sampling errors, laboratory analysis errors, and data analysis errors can occur.

Water data from intermittent ditches have not been quantitatively evaluated in this SHHRA. One water sample from intermittent ditches was available, but these data were not evaluated because water is rarely available for exposure to potential receptors; therefore, the associated risk is expected to be very small.

Some current analytical methods are limited in their ability to achieve detection limits at or below risk-based screening levels (i.e., PRG concentrations). Under these circumstances, it is uncertain whether the true concentration is above or below the PRGs, which are protective of human health. When analytes are on the COPC list and have a mixture of detected and non-detected concentrations, the determination of the EPC, and ultimately whether the chemical is a COC or not, may be affected by these detection limits. The number of COCs may be overestimated as a result of some sample concentrations being reported as non-detected at the MDL, which may be greater than the PRG concentration (when the actual concentration may be much smaller than the MDL). The number of COCs may also be underestimated because some analytes that are not detected in any sample are removed from the COPC list. If the concentrations of these analytes are below the MDL but are above the PRG, the chemicals are not included in the risk screening results.

The selection of COPCs in this SHHRA relied primarily on analyte concentrations obtained as the result of field sampling for the RI. The sources of COPCs are addressed in the selection of contaminants in exposure media for current environmental conditions. However, under future land use conditions, other contaminants not currently accounted for, particularly those that have slow transport velocities, may appear in secondary media at concentrations that could contribute to the calculated risk.

6.6.2 Uncertainties Associated with the Exposure Assessment

Moderate uncertainty can be introduced in the data aggregation process for estimating a representative exposure concentration in the exposure media. A statistical test (the Shapiro-Wilk test) is performed to determine whether the concentration data are best described by a normal or lognormal distribution. Each COPC's mean and UCL₉₅ on the mean concentrations are calculated using both detected values and one-half of the reported detection limit for samples without a detected concentration. The EPC is the smaller of the MDC or the calculated UCL₉₅. This method may moderately overestimate the exposure concentration.

As described previously, some uncertainty is associated with the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment depends on the adequacy of the set of procedures that specifies how samples are to be selected and handled and how strictly these procedures are followed. QA/QC procedures are used to minimize uncertainties; however, sampling errors, laboratory analysis errors, and data analysis errors can and do occur. Moreover, some current analytical methods are limited in their ability to achieve detection limits appropriate for use in risk assessment. Therefore, EPCs, and ultimately the number of COCs, may be overestimated as a result of analyte concentrations being reported at the MDL, which may be greater than the concentration at which adverse health effects could occur. Additional uncertainties are introduced by detection limits that differ among the various data sets; these uncertainties are especially noticeable in the historical (i.e., Phase I) data sets. In addition, EPCs (and ultimately the number of COCs) may be underestimated if chemical concentrations are above risk criteria but below detection limits and reported as non-detects.

At best, quantification of exposure provides an estimate of the chemical intake for various exposure pathways identified at the site. Several uncertainties associated with the various components of the exposure assessment include uncertainties about the exposure pathway equations, exposure parameters, land use scenarios, representative exposure concentrations, and sampling and analysis of the media.

For each primary exposure pathway chosen for inclusion in the RGO calculation for this SHHRA, assumptions are made concerning the exposure parameters (e.g., amount of contaminated media a receptor can be exposed to and intake rates for different routes of exposure) and the routes of exposure. In the absence of site-specific data, the assumptions used are taken from the FWHHRAM (USACE 2004) and are consistent with EPA-approved default values, which are assumed to be representative of potentially exposed populations (EPA 1989a, 1991a). All contaminant exposures are assumed to be from site-related exposure media (i.e., no other sources contribute to the receptor's health risk).

Note that for the dermal contact with soil and sediment pathway, no exposure time is included in the equation. This is based on the assumption that the receptor may not bathe (i.e., remove the soil in contact with the skin surface) for 24 hr following the initial exposure; therefore, the receptor is actually exposed to soil contaminants for 24 hr/d. This may overestimate the exposure associated with dermal contact with soil or sediment. This fact is especially important when the dermal pathway is the major contributor to the RGO concentration used for determining COCs.

Most exposure parameters have been selected so that errors occur on the side of conservatism. When several of these upper-bound values are combined in estimating exposure for any one pathway, the

resulting exposures can be in excess of the 99th percentile and, therefore, outside of the range that may be reasonably expected. Therefore, the consistent conservatism employed in the estimation of these parameters generally leads to overestimation of the potential risks, or in the case of this SHHRA, to an overly conservative RGO concentration used to determine COCs.

6.6.3 Uncertainties Associated with Toxicity Information

The methodology used to develop a non-carcinogenic toxicity value (RfD or RfC) involves identifying a threshold level below which adverse health effects are not expected to occur. The RfD and RfC values are generally based on studies of the most sensitive animal species tested (unless adequate human data are available) and the most sensitive endpoint measured. Uncertainties exist in the experimental data set for such animal studies. These studies are used to derive the experimental exposure representing the highest dose level tested at which no adverse effects are demonstrated [i.e., the no-observed-adverse-effect level (NOAEL)]; in some cases, however, only a lowest-observed-adverse-effect level (LOAEL) is available. The RfD and/or RfC are derived from the NOAEL (or LOAEL) for the critical toxic effect by dividing the NOAEL (or LOAEL) by uncertainty factors. These factors usually are in multipliers of 10, with each factor representing a specific area of uncertainty in the extrapolation of the data. For example, an uncertainty factor of 100 is typically used when extrapolating animal studies to humans. Additional uncertainty factors are sometimes necessary when other experimental data limitations are found. Because of the large uncertainties (10 to 10,000) associated with some RfD or RfC toxicity values, exact safe levels of exposure for humans are not known. For non-carcinogenic effects, the amount of human variability in physical characteristics is important in determining the risks that can be expected at low exposures and in determining the NOAEL (EPA 1989a).

The uncertainty associated with the toxicity factors for non-carcinogens is measured by the uncertainty factor, the modifying factor, and the confidence level. The toxicological data (CSFs and RfDs) for dose-response relationships of chemicals are frequently updated and revised, which can lead to overestimation or underestimation of risks. These values are often extrapolations from animals to humans, and this can also cause uncertainties in toxicity values because differences can exist in chemical absorption, metabolism, excretion, and toxic response between animals and humans.

EPA considers differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize the potential to underestimate the dose-response relationship; as a result, more conservatism is usually incorporated into these steps. In particular, toxicity factors that have high uncertainties may change as new information is evaluated. Therefore, a number of the COCs—particularly those with high uncertainties—may be subject to change. Finally, the toxicity of a contaminant may vary significantly with the chemical form present in the exposure medium. For example, some metals may be deemed as COCs because they are conservatively assumed to be in their most toxic forms (by using conservative screening RGOs to determine COCs).

The carcinogenic potential of a chemical can be estimated through a two-part evaluation involving (1) a WOE assessment to determine the likelihood that a chemical is a human carcinogen, and (2) a slope factor assessment to determine the quantitative dose-response relationship. Uncertainties occur with both assessments. Chemicals fall into one of five groups on the basis of WOE studies of humans and laboratory animals (EPA 2004): (1) Group A – known human carcinogen; (2) Group B – probable human carcinogen based on limited human data or sufficient evidence in animals, but inadequate or no evidence in humans; (3) Group C – possible human carcinogens; (4) Group D – not classified as to human carcinogenicity; and (5) Group E – evidence of no carcinogenic effects in humans.

The CSF for a chemical is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. It is used to estimate an upper-bound lifetime probability of an

individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The slope factor is derived by applying a mathematical model to extrapolate from a relatively high administered dose to animals to the lower exposure levels expected for humans. The slope factor represents the UCL₉₅ on the linear component of the slope (generally the low-dose region) of the tumorigenic dose-response curve. A number of low-dose extrapolation models have been developed, and EPA generally uses the linearized multi-stage model in the absence of adequate information to support other models.

For several analytes, no toxicity information for either the non-carcinogenic or carcinogenic health effects to humans is available in EPA's IRIS (EPA 2004) or HEAST (EPA 1997b). The carcinogenic potential has not been evaluated for some chemicals lacking EPA-approved toxicity values. In addition, some analytes have been assigned a WOE classification for carcinogenicity (EPA 1989a) but have not been assigned a slope factor. Therefore, until and unless additional toxicity information allows the derivation of toxicity factors, potential risk from certain analytes cannot be quantified.

Uncertainties are associated with the GAF values used to modify the oral toxicity values to evaluate dermal toxicity. Similar uncertainties are associated with the TEF values used to evaluate exposure to PAHs. Many potential uncertainties are associated with the toxicity data used in this SHHRA and can affect the RGOs and the COC determinations.

In the absence of EPA-approved toxicity values for benzo(*a*)pyrene, withdrawn or provisional values have been used in the risk characterization for this COPC. The toxicity values for this chemical have larger uncertainties than other approved values. Because this COPC is identified as a COC in this SHHRA, caution should be used, and a closer look at the withdrawn/provisional value(s) is appropriate when making remediation decisions for this COC.

6.6.4 Uncertainties and Assumptions in the Risk Characterization

Risk assessment, as a scientific activity, is subject to uncertainty. This is true even though the methodology used in this SHHRA follows EPA guidelines. As noted previously, the risk evaluation in this report is subject to uncertainty pertaining to sampling and analysis, selection of COPCs, exposure estimates, and availability and quality of toxicity data.

For this SHHRA, the method for determining COCs is the main uncertainty for the risk characterization. Note that HQs and ILCRs are not quantified in this SHHRA. However, the process of comparing the EPCs to screening RGOs at specific risk and hazard levels for specific receptors is equivalent to determining if the specific risk and hazard levels are exceeded. The use of a hazard level of 0.1 to determine the screening RGO is conservative. This process (using the 0.1 hazard level for screening) is used to conservatively guard against the possibility of missing non-carcinogenic COCs, which could potentially result in a cumulative hazard of greater than 1 if present in large numbers with similar toxic effects. Similarly, a 10⁻⁶ risk level is used for screening to guard against the possibility of missing carcinogenic COCs, which could potentially result in a cumulative risk of greater than 10⁻⁵ if present in large numbers.

Four COPCs [acenaphthylene, benzo(*g,h,i*)perylene, nitrocellulose, and phenanthrene] could not be evaluated quantitatively due to the lack of toxicity information and/or values. This results in another uncertainty for this SHHRA.

6.7 SUMMARY AND CONCLUSIONS

This SHHRA was conducted to identify COCs and RGOs for contaminated media at the RVAAP Load Line 4 AOC for three potential future use scenarios: National Guard use, recreational use, and residential use. Results have been presented for all scenarios and exposure pathways. The following steps were used to generate conclusions regarding human health risks and hazards associated with contaminated media at Load Line 4:

- identification of COPCs,
- calculation of EPCs for COPCs,
- calculation of screening RGOs,
- identification of COCs, and
- calculation of risk-based RGOs to move forward to the FS.

COCs are determined for National Guard receptors (Trainee, Security Guard/Maintenance Worker, and Fire/Dust Suppression Worker), recreational receptors (Hunter/Trapper/Fisher), and residential receptors (Resident Subsistence Farmer Adult and Child). A COC summary is presented in [Table 6-4](#), with results discussed below for each medium. Risk-based RGOs have been calculated and presented for all medium-specific COCs (see [Tables 6-5](#) through [6-10](#)). Risk-based RGOs are calculated for all chemicals identified as COCs for any receptor [e.g., arsenic is identified as a COC in surface water for the National Guard Trainee and for the Resident Farmer (adult and child), but not for the Fire/Dust Suppression Worker or the Hunter/Trapper/Fisher; however, risk-based RGOs are calculated for this metal for all five receptors exposed to surface water]. For each medium, ratios of EPCs to RGOs are used to provide an estimate of cancer risk; similar estimates are not provided for non-carcinogenic hazards, as an exceedance of the non-carcinogenic RGO is an indication of a hazard greater than one (the non-carcinogenic threshold).

6.7.1 Groundwater

Two COCs (arsenic and manganese) were identified for the National Guard Trainee exposed via potable use of groundwater; these COCs were also identified for the On-Site Residential Farmer scenarios. For these groundwater COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be slightly greater than 10^{-5} for the National Guard Trainee and slightly greater than 10^{-4} for the residential farmer scenarios. These are hypothetical future scenarios; no receptors are currently using groundwater from the AOC for any purpose.

6.7.2 Surface Water and Sediment

Exposure to surface water and sediment was evaluated for five receptor scenarios: National Guard Fire/Dust Suppression Worker, National Guard Trainee, Hunter/Trapper/Fisher, and Resident Farmer (adult and child). The following summarizes the resulting COCs in surface water and sediment at Load Line 4.

- Three Load Line 4 COCs were identified for the National Guard Trainee exposed to surface water, including two metals (arsenic and manganese) and one pesticide (4,4'-DDT). All three COCs were also identified for the On-Site Residential Farmer scenarios. Two COCs (arsenic and manganese) were identified for the Main Stream Segment Upstream of Perimeter Road Bridge Aggregate and one COC (4,4'-DDT) was identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate; no surface water COCs were identified for the Exit Drainage Aggregate. For the surface water COCs, ratios of EPCs to RGOs indicate that estimated cancer risks would be less than 10^{-6} for the Fire/Dust Suppression Worker and the

Hunter/Trapper/Fisher and between 10^{-6} and 10^{-5} for the National Guard Trainee and the residential farmer scenarios.

- Aluminum was the only COC identified for the National Guard Trainee exposed to sediment; this COC and thallium were also identified for the On-Site Residential Farmer Child. Both COCs were identified for the Main Stream Segment Downstream of Perimeter Road Bridge and the Settling Pond Aggregate; no sediment COCs were identified for the Main Stream Segment Upstream of Perimeter Road Bridge or Exit Drainage Aggregates. Aluminum and thallium are both non-carcinogenic chemicals.

6.7.3 Soil

Surface soil was evaluated at six EUs; subsurface soil was evaluated at four EUs. Direct contact (ingestion, dermal contact, and inhalation) with surface and subsurface soils was evaluated for six receptors: National Guard Security Guard/Maintenance Worker (shallow surface soil), National Guard Fire/Dust Suppression Worker (shallow surface soil), National Guard Trainee (deep surface soil), Hunter/Trapper/Fisher (shallow surface soil), and Resident Farmer (adult and child) (shallow surface soil and subsurface soil). The following summarizes the resulting COCs in soil at Load Line 4.

- Eleven Load Line 4 COCs were identified for shallow surface soil, including 4 metals (aluminum, arsenic, manganese, and thallium), 2 PCBs (PCB-1254 and PCB-1260), and 5 PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene]. The number of shallow surface soil COCs varied for each receptor: none for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher; six COCs for the Security Guard/Maintenance Worker; eight COCs for the Resident Farmer Adult; and nine COCs for the Resident Farmer Child. The number of shallow surface soil COCs identified for each EU also varied: 2 for both the Melt-Pour Drainage Ditches and Perimeter Area Aggregates; 4 for both the Packaging and Shipping Areas and the Change Houses Aggregates; 5 for the Preparation and Receiving Areas Aggregate; and 11 for the Explosives Handling Areas Aggregate.

Ratios of EPCs to RGOs provide an indication of estimated cancer risks. All estimated risks for shallow surface soil COCs would be less than 10^{-6} for the Fire/Dust Suppression Worker and Hunter/Trapper/Fisher. For the Security Guard/Maintenance Worker, most COCs would produce a cancer risk at or slightly above 10^{-6} , with one exception: the estimated cancer risk would be slightly larger than 10^{-5} for PCB-1254 in the Preparation and Receiving Areas Aggregate. For the resident farmer scenarios, estimated cancer risks would exceed 10^{-5} for several shallow surface soil COCs, including: arsenic in the Explosives Handling Areas, Preparation and Receiving Areas, and Melt-Pour Drainage Ditches Aggregates; PCB-1254 in the Preparation and Receiving Areas Aggregate; PCB-1260 in the Explosives Handling Areas Aggregate; and benzo(a)pyrene in the Explosives Handling Areas Aggregate.

- Four Load Line 4 COCs were identified for the National Guard Trainee exposed to deep surface soil, including three metals (aluminum, arsenic, and manganese), and one PCB (PCB-1254). The number of deep surface soil COCs identified for each EU varied: none for the Change Houses Aggregate; one for the Melt-Pour Drainage Ditches, Packaging and Shipping Areas, and Perimeter Area Aggregates; three for the Explosives Handling Areas Aggregate; and four for the Preparation and Receiving Areas Aggregate.

Ratios of EPCs to RGOs indicate that estimated cancer risks would be below 10^{-6} for most deep surface soil COCs; two COCs would result in estimated cancer risk to the National Guard Trainee of slightly larger than 10^{-6} at the Explosives Handling Areas Aggregate (arsenic); at the Preparation and

Receiving Areas Aggregate (arsenic and PCB-1254); and at the Melt-Pour Drainage Ditches Aggregate (arsenic).

- Two metals were identified as Load Line 4 subsurface soil COCs for the resident farmer scenarios: aluminum and manganese. The COCs were identified for the Preparation and Receiving Areas Aggregate only; no subsurface soil COCs were identified for the Explosives Handling Areas, Packaging and Shipping Areas, or Perimeter Area Aggregates. Aluminum and manganese are both non-carcinogenic chemicals.

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