FINAL

PROPOSED REMEDIAL GOAL OPTIONS FOR SOIL AT LOAD LINES 1, 2, 3, AND 4

AT THE

RAVENNA ARMY AMMUNITION PLANT, RAVENNA, OHIO

Prepared for

U.S. ARMY CORPS OF ENGINEERS
LOUISVILLE DISTRICT

Contract No. DACA45-03-D-0026
Delivery Order 0001

September 2004

Shaw® Shaw E & I

SHAW ENVIRONMENTAL, INC.
AND
SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

contributed to the preparation of this document and should not be considered eligible contractors for its review.

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Prepared by

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CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Shaw Environmental, Inc. and Science Applications International Corporation (SAIC) have completed the final version of the *Proposed Remedial Goal Options for Soil at Load Lines 1, 2, 3, and 4 at the Ravenna Army Ammunition Plant, Ravenna, Ohio*. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy.

Sharon K Robers — 9/20/04

Sharon Robers, SAIC
Study/Design Team Co-Leader — Date

Barney W. Cornaby — Sept 20, 2004

Barney Cornaby, SAIC
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Sam Stinnette — 9-20-04

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David Cobb — 9/20/04

David Cobb, Shaw Environmental, Inc.
Project Manager — Date

Significant concerns and the explanation of the resolution are as follows:

Independent technical review comments are recorded on an SAIC Document Review Record, per SAIC quality assurance procedure QAAP 3.1. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leaders.

As noted above, all concerns resulting from independent technical review of the project have been considered.

Mike Fitzgerald — 9/20/04

Principal w/ A-E firm — Date

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TABLES

ACRONYMS

ALM	Adult Lead Methodology
AOC	area of concern
bgs	below ground surface
BHHRA	baseline human health risk assessment
CFR	*Code of Federal Regulations*
CNS	central nervous system
COC	contaminant of concern
COEC	contaminant of ecological concern
DNT	dinitrotoluene
EPA	U. S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
EU	exposure unit
FFS	focused feasibility study
FPRI	fixed-price remedial investigation
FWHHRAM	*Facility-Wide Human Health Risk Assessor Manual*
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	hazard quotient
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
ppm	part per million
PRG	preliminary remediation goal
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RGO	remedial goal option
RIR	remedial investigation report
RVAAP	Ravenna Army Ammunition Plant
Shaw E&I	Shaw Environmental, Inc.
SHHRA	screening human health risk assessment
THI	target hazard index
TNT	trinitrotoluene
TR	target excess individual lifetime cancer risk

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1.0 INTRODUCTION

This remedial goal option (RGO) report documents the proposed land use and corresponding risk-based RGOs to support the remedial alternative selection process in the focused feasibility study (FFS) for soil at Load Lines 1, 2, 3, and 4 at the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio. The RGOs and conclusions presented in this report are specific to work performed by Shaw Environmental, Inc. (Shaw E&I) at Load Lines 1 through 4 as it pertains to achieving performance standards under Shaw's fixed-price remedial investigation (FPRI) contract.

The baseline human health risk assessment (BHHRA) or screening human health risk assessments (SHHRAs) and ecological risk assessments (ERAs) performed for Load Lines 1 through 4 areas of concern (AOCs) at RVAAP are available in the following documents:

- *Supplemental Baseline Human Health Risk Assessment for Load Line 1 Alternative Receptors at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (Shaw E&I 2004a);

- *Phase II Remedial Investigation Report for Load Line 1 at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* Chapter 6 (SSHRA) and Chapter 7 (ERA) (SAIC 2004);

- *Phase II Remedial Investigation Report for Load Line 2 at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* Chapter 6 (SHHRA) and Chapter 7 (ERA) (Shaw E&I 2004b);

- *Phase II Remedial Investigation Report for Load Line 3 at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* Chapter 6 (SHHRA) and Chapter 7 (ERA) (Shaw E&I 2004c); and

- *Phase II Remedial Investigation Report for Load Line 4 at the Ravenna Army Ammunition Plant, Ravenna, Ohio,* Chapter 6 (SHHRA) and Chapter 7 (ERA) (Shaw E&I 2004d).

The risk assessments included in these reports document a variety of potential human and ecological receptor populations that could be at risk and identify the contaminants of concern (COCs) and contaminants of ecological concern (COECs) that could contribute to potential risks from exposure to contaminated media within these four load lines. These risk assessments also document the calculation of risk-based RGOs for human receptors for all media (i.e., soil, surface water, sediment, and groundwater), all COCs, and all receptor populations evaluated in the remedial investigation reports (RIRs) for these load lines.

The purpose of this RGO report is to summarize the risk-based RGOs that will be used in the FFS for the interim soil remediation at Load Lines 1 through 4. This RGO report is organized into two major sections that present the approach for protection of human health (Chapter 2) and ecological receptors (Chapter 3).

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2.0 RISK-BASED REMEDIAL GOAL OPTIONS FOR PROTECTION OF HUMAN HEALTH

Risk-based RGOs are calculated medium- and chemical-specific concentrations for protection of human health. The process for calculating risk-based RGOs is a rearrangement of the equations used to calculate cancer risks or non-cancer hazards with the goal of obtaining a medium concentration that will produce a specific risk or hazard level. For example, the RGO for hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) at a cancer risk level of 10^{-5} for the National Guard trainee is the concentration of RDX that produces a risk of 10^{-5} using exposure parameters specific to the National Guard trainee receptor.

The BHHRA or SHHRAs performed for the Load Lines 1 through 4 AOCs at RVAAP in Ravenna, Ohio, are available in the RIRs, as noted previously. The risk assessments included in these RIRs document a variety of potential human receptor populations that could be at risk and identify the COCs that could contribute to potential health risks from exposure to contaminated media within these four load lines. These risk assessments also document the calculation of risk-based RGOs for all media (i.e., soil, surface water, sediment, and groundwater), all COCs, and all receptor populations evaluated in the RIRs for these load lines.

The following sections summarize the land use/receptors evaluated in this RGO report (Section 2.1), the COCs identified in the baseline/screening risk assessments for Load Lines 1 through 4 (Section 2.2), the methods used to calculate risk-based RGOs (Section 2.3), the target risk/hazard levels used to calculate risk-based RGOs (Section 2.4), the risk-based RGOs to be used in the FFS for the interim soil remediation at Load Lines 1 through 4 (Section 2.5), some notes on the application of these risk-based RGOs at Load Lines 1 through 4 (Section 2.6), and a summary (Section 2.7).

2.1 LAND USE AND POTENTIAL RECEPTORS

Potential human receptors are identified in the baseline/screening risk assessments for Load Lines 1 through 4 for three future land uses: National Guard, recreational, and residential in accordance with the RVAAP *Facility-Wide Human Health Risk Assessor Manual* (FWHHRAM) (USACE 2004a). 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 and evaluates a resident subsistence farmer (adult and child). A subset of these receptors is included in this RGO report to provide protective risk-based RGOs for the intended future land use.

The intended future land use for Load Lines 1 through 4 is for National Guard training. Specifically, these areas will be used for mounted training. This future use could include the three National Guard receptor types defined above. The National Guard trainee is exposed to soil through incidental ingestion, dermal contact, and inhalation of vapors and fugitive dust 24 hrs/day, 39 days/year for 25 years (for a total of 936 hrs/year). The other two National Guard receptors are exposed for much shorter periods of time [i.e., 4 hrs/day, 15 days/year (60 hrs/year) for 25 years for the fire/dust-suppression worker and 1 hr/day, 250 days/year (250 hrs/year) for 25 years for the security guard/maintenance worker]. Therefore, the National Guard trainee is the most conservative of the three National Guard receptors, and risk-based RGOs calculated for this receptor will also be protective of other National Guard receptors. Based on this intended future land use, risk-based RGOs for the National Guard trainee are presented here as the primary risk-based RGOs applicable to Load Lines 1 through 4 soil at RVAAP.

The National Guard trainee could also be exposed to other media (e.g., surface water and wet sediment) during training; however, these media are not included in the interim remediation of soil.

While the intended future land use for Load Lines 1 through 4 does not include recreational use of these AOCs, risk-based RGOs calculated for the National Guard trainee will be protective of a recreational receptor exposed to contaminants in soil during hunting, trapping, and fishing because these recreational activities are assumed to result in exposure 4.57 hrs/day, 7 days/year (32 hrs/year) for 30 years.

The intended future land use at Load Lines 1 through 4 for this application does not include commercial/industrial development of these areas. The National Guard trainee has similarities to a commercial/industrial receptor (e.g., 25-year adult exposure). The total exposure time for an industrial worker (2,000 hrs/year) is approximately double that of the National Guard trainee; however, exposure to airborne contaminants (i.e., fugitive dust) is greater for the National Guard trainee because of high dust generation by tracked vehicles used in training. Based on this, the National Guard trainee would be a more conservative assumption for airborne contaminants but may be less conservative for direct exposure to soil than the commercial/industrial receptor in assessing human health risks. If commercial/industrial development is proposed in future land use planning, it may be necessary to reevaluate potential receptors.

The intended future land use at Load Lines 1 through 4 does not include unrestricted residential development, nor does it include residential development by the military (e.g., a National Guard resident); however, risk-based RGOs calculated for residential receptors (adult and child) are provided in this RGO document for use in evaluating whether certain areas of Load Lines 1 through 4 could be eligible for unrestricted land use. For the purpose of this application, only RGOs associated with the proposed land use by the Ohio Army National Guard will be used in to evaluate interim remedial alternatives for impacted soils in Load Lines 1 through 4.

2.2 CONTAMINANTS OF CONCERN IN SOIL

COCs are defined as chemicals with an incremental lifetime cancer risk greater than 10^{-6} and/or a hazard index greater than 1 (in a baseline risk assessment) or 0.1 (in a screening risk assessment) for a given receptor. COCs were identified in the baseline and screening risk assessments for Load Lines 1 through 4 for each exposure medium and receptor evaluated. COCs for soil for the National Guard trainee receptor are summarized in Table 2-1.

No toxicity values are available for evaluating cancer or non-cancer effects of lead. The U. S. Environmental Protection Agency (EPA) (EPA 2003) recommends the use of the Interim Adult Lead Methodology (ALM) to support its goal of limiting risk of elevated fetal blood lead concentrations as a result of lead exposures to women of childbearing age. This model is not appropriate for exposure frequencies less than 1 day/week because the first-order elimination half-life of lead of approximately 30 days 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 as a result of absorption and subsequent clearance of lead between each exposure event (EPA 2003). Because the exposure duration of the National Guard trainee (39 days/year) is less than the time needed for lead levels to reach steady state, lead was not evaluated quantitatively in the baseline or screening risk assessments and is not identified as a COC for this receptor at these load lines. However, at the request of the Ohio Environmental Protection Agency (Ohio EPA; 2004), the ALM is used to calculate a provisional RGO value for lead with the caveat that this violates the assumptions of the model. As a result, RGOs have been calculated (Section 2.5) to serve as remediation standards that would be conservatively protective of the National Guard trainee. Because lead is not a COC and the use of the ALM to calculate an RGO for this receptor violates the assumptions of the model, the need to remediate soils in which lead is the only chemical present above RGOs will be addressed on a case-by-case basis for specific AOCs in the FFSs.

Table 2-1. Contaminants of Concern in Soil for National Guard Trainee at Load Lines 1 through 4[a]

Chemical	Contaminant of Concern			
	LL 1	LL 2	LL 3	LL 4
Inorganics				
Aluminum		X	X	X
Antimony		X		
Arsenic	X	X	X	X
Barium			X	
Cadmium			X	
Chromium, hexavalent		X		
Manganese	X	X	X	X
Explosives				
2,4,6-Trinitrotoluene	X	X	X	
RDX	X	X		
Polychlorinated Biphenyls				
Aroclor-1254	X	X	X	X
Semivolatiles				
Benz(*a*)anthracene	X			
Benzo(*a*)pyrene	X	X	X	
Benzo(*b*)fluoranthene	X			
Dibenz(*a*,*h*)anthracene	X			

[a] Deep (0 to 4 ft below ground surface) surface soil is used for National Guard trainee.
X = Chemical is a contaminant of concern for at least one soil aggregate at this load line.
LL = Load line.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

Additional COCs were identified for soil when evaluating residential receptors, as summarized in Table 2-2 below.

Using the Interim ALM and the Integrated Exposure Uptake Biokinetic Model for lead in children (both available at http://www.epa.gov/superfund/programs/lead/products.htm), lead is identified as a COC for the residential receptors (adult and/or child) at all four load lines.

2.3 METHOD FOR CALCULATING RISK-BASED REMEDIAL GOAL OPTIONS

Risk-based RGOs were developed for each chemical identified as a COC in the Load Line 1 BHHRA (Shaw E&I 2004a) and Load Lines 2 through 4 SHHRAs (Shaw E&I 2004b; Shaw E&I 2004c; Shaw E&I 2004d). The risk-based RGOs presented here were calculated using the methodology presented in the *Risk Assessment Guidance for Superfund*, Part B (EPA 1991), while incorporating site-specific exposure parameters applicable to the National Guard trainee and residential receptors for Load Lines 1 through 4.

The process for calculating risk-based RGOs was 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. For example, the risk-based RGO for RDX at the cancer risk level of 10^{-5} for the National Guard trainee is the concentration of RDX that produces a risk of 10^{-5} when using the exposure parameters specific to the National Guard trainee receptor and the cancer slope factor for RDX. Equations, exposure parameters, and toxicity values (cancer slope factors and non-cancer reference doses) are provided in the Load Line 1 BHHRA (Shaw E&I 2004a) and Load Lines 2 through 4 SHHRAs (Chapter 6 of the RIRs; Shaw E&I 2004b; Shaw E&I 2004c; Shaw E&I 2004d) and were taken from the FWHHRAM (USACE 2004a).

Table 2-2. Contaminants of Concern in Soil for Residential Receptors at Load Lines 1 through 4[a,b]

Chemical	Contaminant of Concern			
	LL 1	LL 2	LL 3	LL 4
Inorganics				
Aluminum		X	X	X
Antimony	X	X	X	
Arsenic	X	X	X	X
Barium			X	
Cadmium		X	X	
Copper		X		
Manganese		X	X	X
Thallium		X	X	X
Explosives				
1,3-Dinitrobenzene			X	
2,4,6-Trinitrotoluene	X	X	X	
2,4-Dinitrotoluene	X	X	X	
2,6-Dinitrotoluene	X			
RDX	X	X	X	
Polychlorinated Biphenyls				
Aroclor-1254	X	X	X	X
Aroclor-1260		X	X	X
Pesticides				
4,4'-DDE			X	
Dieldrin	X	X	X	
Heptachlor			X	
Semivolatiles				
Benz(*a*)anthracene	X	X	X	X
Benzo(*a*)pyrene	X	X	X	X
Benzo(*b*)fluoranthene	X	X	X	X
Dibenz(*a,h*)anthracene	X	X	X	X
Indeno(1,2,3-*cd*)pyrene	X	X	X	X

[a] Shallow surface soil (0 to 1 ft below ground surface) and subsurface soil (i.e., 1 to 13 ft below ground surface) are evaluated for the resident.
[b] Chemical is reported as a COC for an adult or child resident or both.
X = Chemical is a COC for at least one soil aggregate at this load line.
DDE = Dichlorodiphenylethylene.
LL = Load line.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.

Toxicity values (cancer slope factors and non-cancer reference doses) are also provided in the individual BHHRA and SHHRAs.

The risk-based RGOs assumed combined exposure through ingestion, inhalation of vapors and fugitive dust, and dermal contact with soil. For chemicals having both a cancer and non-cancer endpoint, risk-based RGOs were calculated for both cancer risk and non-cancer hazard, and the lower of the two values is used as the final risk-based RGO.

For the residential scenario, risk-based RGOs were calculated for both the adult and child receptors, and the lower of the two values is used as the final risk-based RGO. No risk-based RGOs were calculated for lead. EPA has defined a residential soil-lead hazard as 400 parts per million (ppm) for play areas and

1,200 ppm for bare soil in the rest of the yard [Title 40, *Code of Federal Regulations* (*CFR)*, Part 745, "Lead: Identification of Dangerous Levels of Lead: Final Rule"].

2.4 TARGET RISK

The FWHHRAM (USACE 2004a) 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 consistent with Ohio EPA guidance, with the caveat that exposure to multiple COCs might 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., more than 10) non-carcinogenic COCs with similar toxic endpoints are present, it might be appropriate to calculate chemical-specific risk-based 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 risk-based RGOs for soil at Load Lines 1 through 4 based on the small number of COCs present and the types of COCs (carcinogenic or non-carcinogenic), as summarized below for the National Guard trainee.

- Load Line 1 – Nine COCs were identified in soil for the National Guard trainee: seven carcinogens and two non-carcinogens. Of the seven carcinogens, one (arsenic) is a class A carcinogen associated with lung tumors; four polycyclic aromatic hydrocarbons (PAHs) [benz(*a*)anthracene (stomach tumors), benzo(*a*)pyrene (larynx/stomach tumors), benzo(*b*)fluoranthene (tumors), and dibenz(*a*,*h*)anthracene (immunodepressive effects)] are class B2 carcinogens that might have some similarities in target organs (mostly stomach or undefined tumors); Aroclor-1254 is also a class B2 carcinogen, but with potential effects to the liver; RDX is a class C carcinogen for liver effects. The two non-carcinogens [manganese and trinitrotoluene (TNT)] have differing toxic endpoints [central nervous system (CNS) and liver, respectively].

- Load Line 2 – Nine COCs were identified in soil for the National Guard trainee: five carcinogens and four non-carcinogens. Of the five carcinogens, two (arsenic and hexavalent chromium) are class A carcinogens and have similar target organs (lungs or respiratory system); two [Aroclor-1254 and benzo(*a*)pyrene] are class B2 carcinogens, but with differing target organs (liver and larynx/stomach); and one (RDX) is a class C carcinogen potentially associated with liver cancer. The four non-carcinogens (aluminum; antimony; manganese; and 2,4,6-TNT) have differing toxic endpoints (not defined, gastrointestinal/liver/development, CNS, and liver, respectively).

- Load Line 3 – Eight COCs were identified in soil for the National Guard trainee: three carcinogens and five non-carcinogens. Of the three carcinogens, one (arsenic) is a class A carcinogen with the lungs or respiratory system as the target organ, and two [Aroclor-1254 and benzo(*a*)pyrene] are class B2 carcinogens, but with differing target organs (liver and larynx/stomach). The five non-carcinogens (aluminum; barium; cadmium; manganese; and 2,4,6-TNT) have differing toxic endpoints (not defined, blood, kidney, CNS, and liver, respectively).

- Load Line 4 – 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 (Aroclor-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 CNS, respectively).

None of the four Load Lines has 10 carcinogenic or 10 non-carcinogenic COCs. The largest number of carcinogenic COCs (seven) was identified at Load Line 1, while the largest number of non-carcinogenic COCs (five) was identified at Load Line 3. The largest number of COCs with potentially similar endpoints was the five potentially carcinogenic PAHs identified at Load Line 1. Based on these results, a chemical-specific TR of 10^{-5} and THI of 1.0 were identified as appropriate for calculating risk-based RGOs for soil at Load Lines 1 through 4.

Additional COCs were identified for the residential receptors; however, the class of compounds with the largest number of COCs with potentially similar toxic endpoints/target organs is that of the five carcinogenic PAHs.

2.5 RISK-BASED REMEDIAL GOAL OPTIONS

Risk-based RGOs for COCs in soil are presented in Table 2-3 for the National Guard trainee. As noted previously, these risk-based RGOs assume combined exposure through ingestion, inhalation of vapors and fugitive dust, and dermal contact with soil. For chemicals having both a cancer and non-cancer endpoint, risk-based RGOs were calculated for both cancer risk and non-cancer hazard, and the lower of the two values is presented as the final risk-based RGO.

Table 2-3. Risk-Based Remedial Goal Options for National Guard Trainee in Soil at Load Lines 1 through 4[a]

Contaminant of Concern	Risk-Based RGO (mg/kg)	Background[b] (mg/kg)
Inorganics		
Aluminum	34,942	17,700
Antimony	2,458	0.96
Arsenic	31	15.4
Barium	3,483	88.4
Cadmium	109	NA
Chromium, hexavalent	16	NA
Manganese	351	1,450
Explosives		
2,4,6-Trinitrotoluene	1,646	NA
RDX	838	NA
Polychlorinated Biphenyls		
Aroclor-1254	35	NA
Semivolatiles		
Benz(*a*)anthracene	105	NA
Benzo(*a*)pyrene	10	NA
Benzo(*b*)fluoranthene	105	NA
Dibenz(*a,h*)anthracene	10	NA

[a] Deep (0 to 4 ft below ground surface) surface soil is used for National Guard trainee.
[b] Final facility-wide background values for the Ravenna Army Ammunition Plant from the *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001). Background values for soil are available for two soil depths: surface (0 to 1 ft below ground surface) and subsurface (1 to 12 ft below ground surface); the minimum value for these two aggregates is reported.
NA = Not available.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RGO = Remedial goal option.

Load Lines 1 through 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 (bgs) will be prohibited. Tracked and wheeled operations could 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; therefore, the risk-based RGOs presented for the National Guard trainee are applicable to soils from 0 to 4 ft bgs.

Estimated exposure point concentrations (EPCs) of manganese (Load Lines 1 through 4); Aroclor-1254 (Load Lines 1 and 3); benzo(*a*)pyrene (Load Line 1); hexavalent chromium (Load Line 2); and 2,4,6-TNT (Load Line 3) exceed risk-based RGOs at one or more exposure units (EUs).

As noted previously, lead is not a COC for the National Guard trainee because the exposure frequency for this receptor is close to the biological half-life of lead. Therefore, no risk-based RGO can be calculated, nor is one required. At the request of the Ohio EPA (Ohio EPA 2004), the National Guard trainee exposure parameters are used with the preliminary remediation goal (PRG) calculator for the Interim ALM (available at <http://www.epa.gov/superfund/programs/lead/products.htm>), along with the most recently recommended values for baseline blood lead concentration (PvB_0) and geometric standard deviation (GSD_i) from EPA (2002). The resulting provisional RGOs (aka PRGs) range from 1,995 to 3,663 mg/kg, as shown in Attachment 1. The estimated EPC of lead at the water tower EU at Load Line 1 exceeds the lower end of this range. However, it must be noted that use of this calculator is not recommended for receptors with less than a constant lead intake over a duration of 90 days, and the annual exposure duration for the National Guard trainee is only 39 days. For this reason, these values are referred to as provisional RGOs. The estimated EPCs of lead at all EUs at Load Lines 2 through 4 are below this provisional RGO range.

Risk-based RGOs for COCs in soil are presented in Table 2-4 for the residential receptors (adult and child). Risk-based RGOs were calculated for both the adult and child receptors, and the lower of the two values is presented as the final risk-based RGO.

No risk-based RGOs were calculated for lead. EPA has defined residential soil-lead hazards as 400 ppm for play areas and 1,200 ppm for bare soil in the rest of the yard (40 *CFR* 745, "Lead: Identification of Dangerous Levels of Lead: Final Rule").

2.6 APPLICATION OF RISK-BASED REMEDIAL GOAL OPTIONS

Risk-based RGOs for COCs in soil are presented in Tables 2-3 and 2-4. These risk-based RGOs are provided here to assist in defining the extent of contamination and to help cost various alternatives in the FFS. During the process of remedy selection for the site, final RGOs will be identified to meet risk and hazard goals. The final remedial levels could consider additional information, including the following:

- Background levels – for example, the risk-based RGO for manganese (351) is below the naturally occurring background concentration of this metal.

- Feasibility of remediating to less restrictive land use – for example, because many contaminants are collocated (i.e., multiple COCs are identified in a single soil sample), remediation of COCs for the National Guard trainee could result in remediation to residential levels with little additional effort.

- Metal speciation – risk-based RGOs are generally based on the most toxic form of each metal (e.g., As, Cr, Tl). Data could be collected to identify the actual form of the metal present.

Table 2-4. Risk-Based Remedial Goal Options for Resident in Soil at Load Lines 1 through 4[a,b]

Contaminant of Concern	Risk-Based RGO (mg/kg)	Background[c] (mg/kg)	
		Surface	Subsurface
Inorganics			
Aluminum	77,540	17,700	19,500
Antimony	31	0.96	0.96
Arsenic	5.7	15.4	19.8
Barium	5,285	88.4	124
Cadmium	72	NA	NA
Copper	3,122	17.7	32.3
Manganese	3,316	1,450	3,030
Thallium	6.2	NA	0.91
Explosives			
1,3-Dinitrobenzene	6.4	NA	NA
2,4,6-Trinitrotoluene	32	NA	NA
2,4-Dinitrotoluene	7.6	NA	NA
2,6-Dinitrotoluene	7.6	NA	NA
RDX	47	NA	NA
Polychlorinated Biphenyls			
Aroclor-1254	1.2	NA	NA
Aroclor-1260	2.0	NA	NA
Pesticides			
4,4'-DDE	15	NA	NA
Dieldrin	0.32	NA	NA
Heptachlor	1.2	NA	NA
Semivolatiles			
Benz(*a*)anthracene	5.9	NA	NA
Benzo(*a*)pyrene	0.59	NA	NA
Benzo(*b*)fluoranthene	5.9	NA	NA
Dibenz(*a*,*h*)anthracene	0.59	NA	NA
Indeno(1,2,3-*cd*)pyrene	5.9	NA	NA

[a] Reported value is the smaller of the RGOs calculated for an adult or child resident.
[b] Shallow surface soil (0 to 1 ft below ground surface) and subsurface soil (1 to 13 ft below ground surface) are evaluated for the resident.
[c] Final facility-wide background values for the Ravenna Army Ammunition Plant from the *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001). Background values for soil are available for two soil depths: surface (0 to 1 ft below ground surface) and subsurface (1 to 12 ft below ground surface).
DDE = Dichlorodiphenylethylene.
NA = Not available.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RGO = Remedial goal option.

Final remediation levels will be reviewed and approved by Ohio EPA prior to the presentation of final remedy selection for each of the load lines in the FFSs.

2.7 SUMMARY

Human health risk-based RGOs are presented for the intended land use (National Guard mounted training) for COCs identified in the BHHRA (Shaw E&I 2004a) and SHHRAs (Shaw E&I 2004b; Shaw E&I 2004c; Shaw E&I 2004d) included in the RIRs for Load Lines 1 through 4. These risk-based RGOs apply only to soil for the National Guard mounted training land use at Load Lines 1 through 4 and do not apply to other media, receptors, or AOCs.

3.0 REMEDIAL GOAL OPTIONS AND ECOLOGICAL RISK ASSESSMENT

This chapter provides a rationale for not developing quantitative RGOs for ecological risks at this time. This rationale has the following elements.

- Ecological risks were predicted based on hazard quotients (HQs) being above 1.
- Land use at the site (mounted training – no digging) is expected to destroy or significantly alter ecological habitats.
- Proposed interim remediation activities associated with reducing human health risks are expected to significantly change site conditions so that the data basis for the ERA will no longer apply and new RGOs would have to be calculated for future work/land usage anyways to reflect post-remediation conditions.
- Additional data will be provided by post-remediation confirmation sampling that will be used to more accurately develop ecological RGOs.

Each of these elements is explained below.

3.1 OVERVIEW OF ECOLOGICAL RISK ASSESSMENT FINDINGS

The Level III baseline ERAs identified multiple COECs in surface soil at Load Lines 1 through 4 (SAIC 2002; Shaw E&I 2004b; Shaw E&I 2004c; and Shaw E&I 2004d). This conclusion is based on the presence of HQs greater than 1 for one or more ecological receptors at each of the four load lines. The identification of surface soil COECs indicates that ecological risk (i.e., the probability that ecological receptors could experience adverse effects) is present at each of the four load lines. Although any HQ greater than 1 potentially indicates that adverse impacts could occur or might be occurring, larger HQs theoretically indicate higher probability of an adverse effect because they equate to higher exposure concentrations. Basic toxicological dose-response relationships for most constituents indicate that as a receptor's exposure increases, the probability (and often the severity) of adverse response also increases, at least to some upper threshold level. At the upper threshold, the probability of an adverse effect becomes 100%, and severity could be something like mortality, so increasing the dose and HQ above that level will not cause incremental adverse effects because it is already at the "maximum" level. Thus, the largest HQs are typically expected to represent the COECs that pose the largest risks, and if there are multiple COECs with large HQs, the probability of adverse effects would be even higher (assuming the COECs do not have interactions that reduce their individual toxicity).

As stated above, multiple soil COECs with large HQs were identified for multiple ecological receptors at each of the load lines (Table 3-1). For example, Aroclor-1254 and chromium were the two COECs that consistently had the largest HQs at all four load lines. Arcolor-1254 HQs ranged from a high of 110,000 for barn owls at Load Line 1 to HQs of 69 to 442 for shrews at Load Lines 2 and 3, respectively. Chromium maximum HQs above 1 were always for earthworms and ranged from a high of 626 at Load Line 1 to 88 at Load Line 4. Thus, Aroclor-1254 and chromium both had large HQs ranging between 69 and 110,000 for one or more ecological receptors at all four of the load lines. The presence of these two COECs at concentrations high enough to yield such large HQs for one or more receptors is in itself sufficient to indicate the potential for adverse ecological effects to occur from these COECs.

Table 3-1. Overview of Soil Contaminants of Ecological Concern Contributing to Ecological Risk at Load Lines 1, 2, 3, and 4

Area of Concern	COECs with Highest HQs		Other COECs with HQs >1	
	Chemicals	HQs	Chemicals	HQ Range
Load Line 1	Aroclor-1254 and chromium	(110,000 and 626, respectively)	Lead, zinc, and 16 others[a]	1.1 to 53,000
Load Line 2	Aroclor-1254 and chromium	(69 and 97, respectively)	Antimony, lead, and 5 others[a]	1.1 to 49
Load Line 3	Aroclor-1254 and chromium	(442 and 159, respectively)	Barium, zinc, and 8 others[a]	1 to 69
Load Line 4	Aroclor-1254 and chromium	(72 and 88, respectively)	Thallium, zinc, and 6 others[a]	1.1 to 45

[a] Aluminum HQs exceeded 1 for various ecological receptors at all four load lines, and iron HQs exceeded 1,000 for plants at all four load lines; however, their risks were deemed minimal, as described in the ecological risk assessments, so they are not included.
COEC = Contaminant of ecological concern.
HQ = Hazard quotient.

Although Aroclor-1254 and chromium were the two COECs with the largest HQs, each of the four load lines had an additional 7 to 10 COECs whose HQs also exceeded 1 (Table 3-1). Lead and zinc were two COECs whose HQs exceeded 1 for one or more receptors at all four load lines. The HQs for these additional COECs were generally no more than about one-half the magnitude of the maximum HQs observed for Aroclor-1254 and chromium, but they all did exceed 1, indicating the potential for adverse effects.

Aluminum and iron were two COECs whose HQs exceeded 1 for one or more ecological receptors at all four load lines. However, risks from aluminum were considered to be minimal in spite of the large HQs because it is believed to be mostly unavailable for biological uptake because of the soil pH issues as identified by EPA. Iron HQs exceeded 1 for only plants, but there is low confidence in the toxicity reference value for iron for plants, so there is low confidence in the HQ as well.

Compared to the HQs at Load Line 1, the HQs at Load Lines 2, 3, and 4 are considerably lower (Table 3-1), as evidenced by their respective HQ ranges of 1 to 110,000 (Load Line 1) and 69 to 442 (Load Lines 2, 3, and 4).

In summary, each of the four load lines had 9 to 20 soil COECs that had at least one HQ greater than 1 for one or more ecological receptors. Load Line 1 had the highest magnitude maximum HQ and range of HQs as well as the highest number of COECs whose HQs exceeded 1 among all four of the load lines. Aroclor-1254 and chromium had the highest magnitude HQs at all four load lines, ranging from 69 to 110,000. The COECs lead and zinc also had HQs exceeding 1 for one or more receptors at all four load lines. The HQs for the additional COECs were generally no more than about one-half the magnitude of the maximum HQs observed for Aroclor-1254 and chromium, but they all did exceed 1, so they indicate the potential for adverse effects. Thus, the presence of multiple COECs with HQs exceeding 1 for a variety of ecological receptors indicates that there is a potential for adverse effects to ecological receptors from chemicals at all four load lines. However, this ecological risk must be understood in conjunction with the additional elements described in the following sections.

3.2 INTENSIVE AND EXTENSIVE HABITAT ALTERATION

Habitat alteration, because of National Guard mounted-training activities, is expected to be relatively intense at any 1 acre. For example, tracked and wheeled operations are expected to be conducted frequently. Some areas at the load lines might be cleared of vegetation to permit the training. Other places

will have much soil compaction and missing or greatly harmed vegetation. Tracked and wheeled operations could result in maneuver damage up to 4 ft bgs. Subsurface activities are not planned. Digging and occupying fighting positions, tank defilade positions, tank ditches, and battle positions that extend below ground surface will be prohibited. Thus, there are many military mission activities that will result in rather intensive habitat alteration. This includes soil compaction, vegetation damage and removal, and shorter food chains. The resulting altered habitats would no longer be as desirable to vegetation and wildlife, but would be desirable for the requirements of the military training mission.

Extensiveness or the number of acres of future habitat alteration is not known at this time. It is assumed that up to 75% of the area of each load line may be altered. The load lines consist of about 1,046 acres of habitat of the following sizes:

- 466 acres at Load Line 1,
- 216 acres at Load Line 2,
- 251 acres at Load Line 3, and
- 113 acres at Load Line 4.

Thus, assumed acreage or extensiveness could be up to 780 acres for intensive change.

The area of habitat to be altered is small compared to the total facility acreage. By contrast, the load lines are part of a facility that is 22,000 acres in size; therefore, this area represents 1,046 out of 22,000 acres, or about 4.8% of the total area. If the 780 acre number is used, this would be about 3.5% of the total RVAAP area. This small percentage for the military mission means that environmental stewardship (e.g., vegetation for wildlife, timber) could be practiced in relatively large areas elsewhere at RVAAP.

Vegetation and animals are found at the load lines, descriptions of which is found in the RIRs (SAIC 2002; Shaw E&I 2004b; Shaw E&I 2004c; Shaw E&I 2004d). Briefly, vegetation consists of many old-field communities with corridors and patches of forest vegetation. Animals consist of soil invertebrates, many species of insects, mammals, and birds. However, no known threatened and endangered species or unique natural resources are present at the load lines; substantiation of this is found in Chapter 7 (ecological risk assessment, natural resources section) of the RIR for each load line. Therefore, the armored vehicle training would be carried out in an environment in which the impact would be limited to “normal” ecological resources.

Nearby habitat is available to receive wildlife that leaves the training area. Some vegetation, especially bushes and old-field vegetation, as well as some trees, is expected to be removed from within the load lines. Old-field vegetation could be mowed or cleared in another way. Wildlife is expected to be disturbed by the movement and noise of construction equipment as well as operations. Wildlife can leave and enter adjacent old fields and forest patches and vegetative corridors. As inferred earlier, RVAAP has thousands of acres of habitat like that at the load lines, and wildlife can find new home ranges there; therefore, any lack of protection from ecological RGOs would be minimal because wildlife species could move away.

3.3 MITIGATION OF ECOLOGICAL RISK

Interim soil remediation actions are expected to decrease the ecological risk at each of the load lines. These remedial activities will decrease concentrations of COECs in soil, thereby reducing ecological risks. The application of human health-based RGOs at specific locations at those load lines will protect human health and, at the same time, reduce ecological risks. The soil removals triggered by human health RGOs will directly reduce the COEC concentrations to which ecological receptors are exposed.

Ecological risks will also be reduced indirectly through remediation by reductions in the concentrations of COECs transferred to ecological receptors via the food chain. In addition to ingestion of soil, ecological receptors are exposed to soil contaminants by ingestion of plants and lower-order animals that have taken up the contaminants from the soil. Removal of contaminated soil, existing vegetation, and soil invertebrates in contaminated areas will significantly reduce EPCs.

It is expected that future land use will have a significant impact on habitat for a period of time, as discussed in the previous section. After this period, if and when land use changes, the areas may be revegetated with subsequent redevelopment of a food web. Soil and habitat conditions at that time will likely be very different from current conditions. Therefore, a revised ERA may be needed after the completion of Shaw E&I's work to more accurately evaluate the need for further remedial action based on ecological risks.

3.4 POST-REMEDIATION CONFIRMATION SAMPLING AND REASSESSMENT

As part of the remedial actions included in the proposed statement of work, post-remediation confirmation samples will be collected to verify the successful implementation of the remedial action. The intent of the confirmation sampling is to demonstrate the removal of COC-impacted soils and dry sediments to a point where remaining concentrations do not exceed approved risk-based human health RGOs. As mentioned previously, the removal of impacted soils will also serve to reduce expected risk to ecological receptors. If additional assessment of the habitat by others is required to meet future land use requirements, the confirmation sample results will provide a set of data that is more reflective of ecological habitat soil conditions after the remediation activities have been completed. Post-remediation confirmatory sampling requirements will be further discussed in subsequent Comprehensive Environmental Response, Compensation, and Liability Act documents related to the execution of work at the load lines.

3.5 RECOMMENDATION

It is recommended that no quantitative RGOs for soil to protect ecological receptors be developed at Load Lines 1 through 4. The military mission (mounted training) overrides military environmental stewardship because environmental stewardship conflicts with national security. Habitat alteration is expected to be extensive and result in soil compaction (damage to ecosystem), vegetation damage and removal (simpler or missing habitat), shorter food chains (simpler ecosystem), and lower exposure (fewer organisms). Ecological risk, already predicted to be present, is likely to continue, albeit at a lesser magnitude for the reasons stated. As part of an interim remedy, there is planned removal of soil at several locations within each load line to achieve human health RGOs; these locations are among the most contaminated of the EUs at each load line. These removals will reduce the overall concentrations of many contaminants, having the effect of lowering the low exposure and HQs at Load Lines 2, 3, and 4, and will also help reduce exposure and risk at Load Line 1 (where ecological risk could be higher). Remediation to protect populations and ecosystems that will be damaged or destroyed by future land use is not a prudent use of resources. Given the compelling reasons for lack of ecologically based remediation, RGOs are not needed for the implementation of the interim remedy for soils at Load Lines 1 through 4 by Shaw E&I, Inc. under the FPRI. Prior to final closure, it may be necessary to reevaluate the need to develop ecological RGOs for potential receptors at Load Lines 1 through 4 depending on changes in site conditions as a result of remedy implementation.

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ATTACHMENT 1

CALCULATION OF PRELIMINARY REMEDIATION GOAL FOR LEAD FOR THE NATIONAL GUARD TRAINEE USING THE ADULT LEAD MODEL

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Calculation of Preliminary Remediation Goal for Lead for the National Guard Trainee Using the Adult Lead Model

Calculations of Preliminary Remediation Goals (PRGs)
U.S. Environmental Protection Agency Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Click to Print Values | Click to Print Description | Click to return All inputs to Defaults

Exposure Variable	PRG Equation[a] 1*	PRG Equation[a] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1, GSDi = Hom	Using Equation 1, GSDi = Het	Using Equation 2, GSDi = Hom	Using Equation 2, GSDi = Het
$PbB_{fetal,\ 0.95}$	X	X	95th percentile PbB in fetus	µg/dL	10	10	10	10
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic slope factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB_0	X	X	Baseline PbB	µg/dL	1.4	1.8	1.4	1.8
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.100	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,\ D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,\ D}$	X	X	Exposure frequency (same for soil and dust)	days/year	39	39	39	39
$AT_{S,\ D}$	X	X	Averaging time (same for soil and dust)	days/year	365	365	365	365
PRG	**Preliminary Remediation Goal**			**ppm**	**3,663**	**1,995**	**3,663**	**1,995**

[a] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}). When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same PRG.

***Equation 1, based on Equation 4 in EPA 2003.**

$$PRG = \frac{([PbB_{95}fetal/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*(IR_{S+D}*AF_{S,D}*EF_{S,D})}$$

****Equation 2, alternate approach based on Equations 4 and A-19 in EPA 2003.**

$$PRG = \frac{([PbB_{fetal,0.95}/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])}$$

Source: U. S. Environmental Protection Agency 2003. *Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, Final (December 1996), EPA-540-R-03-001, OSWER Directive 9285.7-54, January, available at <http://www.epa.gov/superfund/programs/lead/products/adultpb.pdf>.

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