DEPARTMENT OF THE ARMY
U. S. ARMY ENVIRONMENTAL HYGIENE AGENCY
ABERDEEN PROVING GROUND, MARYLAND 21010-5422

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HSHB-ME-SR (40)

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HRA.DF.RCRA.CA 40.17CS

MEMORANDUM THRU HQDA (SGPS-PSP-E), 5109 Leesburg Pike,
Falls Church, VA 22041-3258

FOR Commander, U.S. Army Materiel Command, ATTN: AMCEN-A,
5001 Eisenhower Avenue, Alexandria, VA 22333-0001

SUBJECT: Health Risk Assessment No. 39-26-L138-91, Deactivation Furnace RCRA Closure Activity, Ravenna Army Ammunition Plant, Ravenna, Ohio, 26 September 1991

1. Copies of the Health Risk Assessment for the deactivation furnace at Ravenna Army Ammunition Plant with Executive Summary are enclosed.

2. Technical questions regarding this report may be directed to Bonnie J. Gaborek. Additional comments or concerns may be directed to MAJ William E. Legg, Chief, Health Risk Assessment Branch. They may be contacted at DSN 584-2953 or commercial (410) 671-2953.

FOR THE COMMANDER:

1-14-93

Encl

WILLIAM T. BROADWATER
LTC, MS
Chief, Waste Disposal Engineering
Division

TO	OFFICE	ACTION
1	GM	
	CO-COR	
	ACCTG	
	SEC	
2	ENGR	
	IR	
	S&T&O	
	P&CA	Return
3	SAF	to Engr
	UPM	
4	RETURN	

CF (w/encl)
CDR, AMCCOM, ATTN: AMSMC-EQE (COL David Lindsay)
HQDA(ENVR-E)
DA, USAEHSC, ATTN: CEHSC-FU-S
CDR, AMC, ATTN: AMCSG
CDR, HSC, ATTN: HSCL-P
CDR, MEDDAC, FT KNOX, ATTN: PVNTMED SVC (2 cy)
CDR, WRAMC, ATTN: PVNTMED SVC
✓CDR, RVAAP, ATTN: ENVR ENG OFFICE (Ms. Susan McCauslin)
CDR, USATHAMA, ATTN: CETHA-TS-S
CDR, USATHAMA, ATTN: CETHA-RM(TIC) (2 cy)
CDR, USAEHA-N

General Manager
Ravenna Arsenal, Inc.
FWD FOR
☐ Information
☐ Compliance as applicable
☐ Reply NLT

USAEHA

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40.17CS

U.S. Army
Environmental Hygiene
Agency

HEALTH RISK ASSESSMENT NO. 39-26-L138-91
DEACTIVATION FURNACE RCRA CLOSURE ACTIVITY
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
26 SEPTEMBER 1991

Distribution limited to U.S. Government agencies only; protection of privileged information evaluating another command; Nov 92. Requests for this document must be referred to Commander, Ravenna Army Ammunition Plant, ATTN: Environmental Engineering Office, Ravenna, OH 44266-9297.

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DEPARTMENT OF THE ARMY
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REPLY TO
ATTENTION OF

EXECUTIVE SUMMARY
HEALTH RISK ASSESSMENT NO. 39-26-L138-91
DEACTIVATION FURNACE RCRA CLOSURE ACTIVITY
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
26 SEPTEMBER 1991

1. PURPOSE. The Ohio Environmental Protection Agency (Ohio EPA) adopted regulations on 13 December 1987 which allow the use of a health risk assessment for closure of some Resource Conservation and Recovery Act (RCRA) facilities. The purpose of this report is to summarize the actions performed in determining whether a health risk assessment is a usable option for RCRA closure of the deactivation furnace at Ravenna Army Ammunition Plant (RVAAP).

2. CONCLUSIONS AND RECOMMENDATIONS.

a. The Ohio EPA regulations require an extremely conservative methodology in determining human health risks; therefore, using a risk assessment for closure of the deactivation furnace is not a feasible option. Both the carcinogenic and noncarcinogenic risk estimates calculated by employing Ohio EPA methodology exceed acceptable levels. The primary reasons for the high risk estimates are because an unrestricted scenario (residential scenario) is compulsory for the future use of any nonlandfill site, and the maximum concentration detected onsite is the value required for use to quantify exposure.

b. Ravenna Army Ammunition Plant is not scheduled for base realignment or closure in the foreseeable future. The deactivation furnace site, therefore, will probably be used for an industrial or commercial purpose. A future residential use is not probable. When risks values are calculated assuming an industrial scenario and in accordance with the U.S. Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund (reference 2), the carcinogenic risk still exceeds Ohio EPA's action level of $1 X 10^{-6}$ by one order of magnitude, e.g., $2 X 10^{-5}$. The noncarcinogenic risk, however, is less than unity, e.g., 0.6. Nonetheless, Ohio EPA would mandate remediation by one of the options listed below.

c. Compliance with Ohio EPA regulations must be accomplished by: "clean closure;" by closure as a landfill; or by proposing site-specific risk-based cleanup targets, because a risk assessment is not a feasible option. With clean closure, waste and contaminated soil must be removed to a level less than two standard deviations higher than the mean of natural background for inorganics, and to the method detection limit for organics. Closure as a landfill mandates post-closure care and monitoring. Proposal of site-specific risk-based cleanup levels requires acceptable documentation that all routes of exposure and risk to both human health and the environment are addressed. Both the State of New Jersey and the EPA have established a methodology for generating risk-based cleanup standards. To accomplish RCRA closure of the deactivation furnace at RVAAP, the U.S. Army Environmental Hygiene Agency (USAEHA) recommends either the proposal of risk-based cleanup standards, similar to those listed for the State of New Jersey, or clean closure, whichever is acceptable to the Ohio EPA and most cost-effective.

d. A number of metals account for the high risk values estimated for the soils at the deactivation furnace. These include antimony, arsenic, beryllium, cadmium, chromium, and copper. Lead was not quantified because toxicity values are not available. However, the toxic affects of lead are well documented; therefore, lead would also contribute to the risks associated with this site. To reduce the human health risks, mitigating activities should focus on remediation of these chemicals.

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DEACTIVATION FURNACE RCRA CLOSURE ACTIVITY
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
26 SEPTEMBER 1991

1. AUTHORITY. AEHA Form 250-R, AMC, 26 September 1991.

2. REFERENCES. See Appendix A for a list of references.

3. PURPOSE. The Ohio Environmental Protection Agency (Ohio EPA) adopted regulations on 13 December 1987 which allow the use of a health risk assessment for closure of some Resource Conservation and Recovery Act (RCRA) facilities. The purpose of this report is to summarize the actions performed in determining whether a health risk assessment is a usable option for RCRA closure of the deactivation furnace at Ravenna Army Ammunition Plant (RVAAP).

4. GENERAL.

a. The Ohio EPA has established four options to achieve closure of RCRA facilities. These options include: clean closure, which is the complete removal of waste and contaminated soil; closure as a landfill with post-closure care; proposal of site-specific risk-based cleanup levels; or performance of a risk assessment, which documents that the total carcinogenic risk is less than 1×10^{-6} and the total noncarcinogenic risk is less than unity (1).

b. The methodology required to calculate health risks for RCRA closure purposes is outlined in Section 3.11.3, Risk Assessment Cleanup Targets, in Ohio EPA's Closure Plan Review Guidance (reference 3). The requirements for closure via the risk assessment option are extremely conservative and more stringent than the techniques and policies of the EPA. The major differences between EPA methodology and Ohio EPA methodology are as follows:

MAJOR DIFFERENCES BETWEEN EPA'S AND OHIO EPA'S HUMAN HEALTH RISK ASSESSMENT POLICIES

EPA	Ohio EPA
Future Land Use-most logical and reasonable.	Future Land Use-unrestricted (residential) for nonlandfill sites.
Risk Level-acceptable range 1 X 10^{-4} to 1 X 10^{-6} (reference 4).	Risk Level-1 X 10^{-6}.
Point of Exposure-receptor.	Point of Exposure-at or within site boundary.
Exposure Pathways-all that are complete. (The phrase "complete exposure pathway" is defined in paragraph 6b.)	Exposure Pathways-minimum of ingestion, dermal contact, and inhalation of soil and ingestion and dermal contact, with water and inhalation of volatiles while showering.
Chemical Concentration in Medium-95% upper confidence interval concentration.	Chemical Concentration in Medium-maximum concentration detected.
Soil Lead Level-500 to 1,000 ppm (reference 5).	Soil Lead Level-the lower of 150 ppm or local background.

5. BACKGROUND.

a. For several years, the RVAAP operated a RCRA permitted deactivation furnace intermittently for treatment of small munitions and other reactive items that exceeded shelf life or were otherwise defective. During operations, explosive-filled components were slowly fed by conveyor toward the furnace where the elevated temperature caused burning or detonation of the explosive. The ash residues, which included metal parts, were discharged to a container for disposal (reference 6).

b. The Deactivation Furnace could not be upgraded to meet RCRA incinerator standards as required for Class A and Class B explosives. The U.S. Army, therefore, decided to discontinue operations and perform a RCRA closure. A RCRA closure plan was submitted to regulatory authorities in 1990. The approved plan for the Deactivation Furnace requires decontamination of furnace parts and mitigation of soil contaminated with heavy metals or explosives. Decontamination of the furnace parts has been accomplished. The vertical and horizontal contaminated soil boundaries, however, were not delineated with collection and analysis of numerous samples. A health risk assessment, therefore, was requested by the MACOM to fulfill RCRA closure requirements (reference 6).

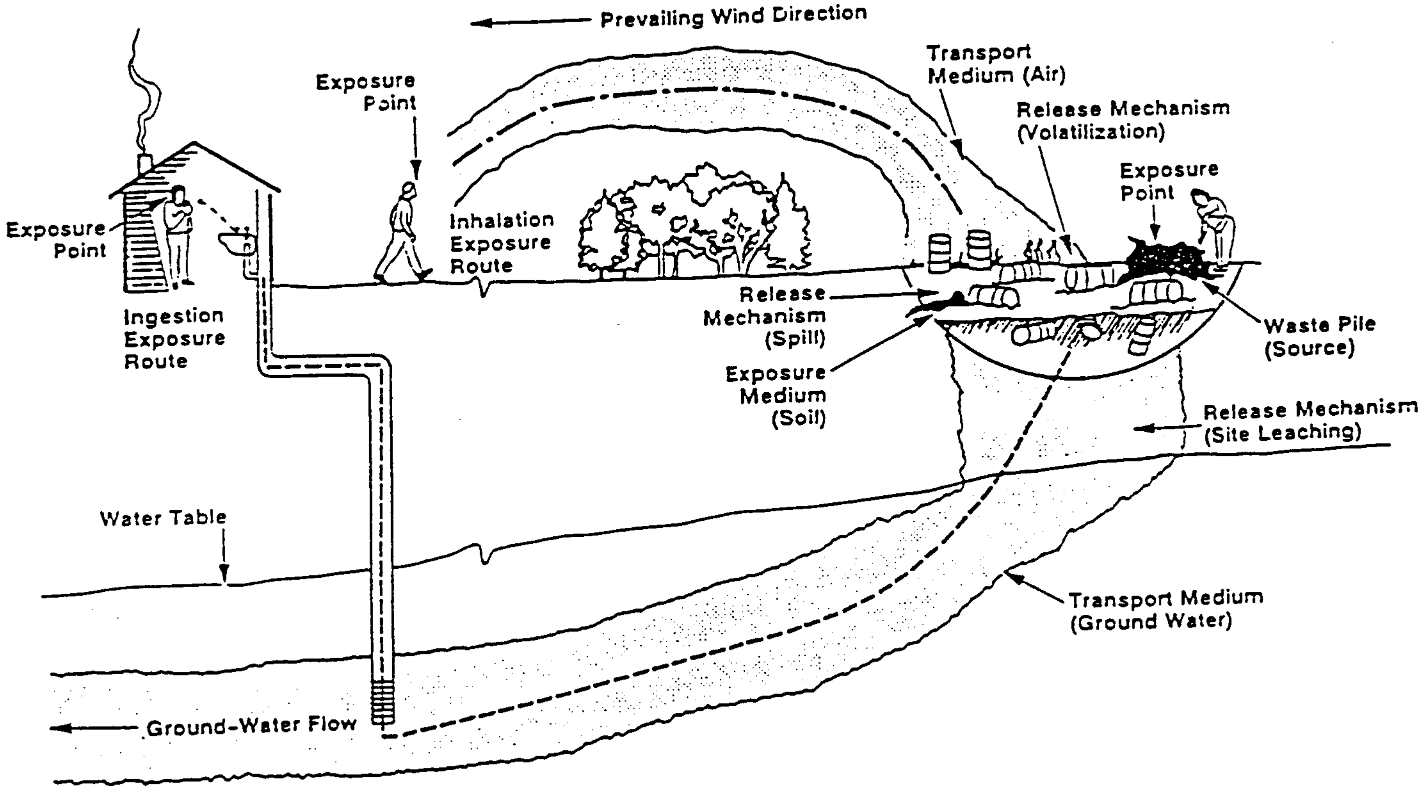
6. FINDINGS AND DISCUSSION.

a. Identification of Chemicals of Concern. The approved closure plan for the deactivation furnace identifies metal contaminants of concern (COCs) in soil as those that exceed the mean of the background samples plus two standard deviations. Explosive COCs are defined as those which exceed 1,000 mg/L. No explosives were detected in soils above this limit. Several heavy metals, however, were detected at concentrations above the defined limit. These include: Antimony (Sb), Arsenic (As), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Nickel (Ni), and Zinc (Zn). The analytical data for these chemicals are included as Appendix B. The 95% upper confidence interval concentrations and maximum concentrations are included as Appendix C.

b. Identification of Exposure Pathways. In order for contamination from a site to pose a health risk, a complete exposure pathway must exist which links the contamination source to the human population. A complete exposure pathway consists of four essential elements: a source and mechanism of chemical release; a receiving or transport medium; a point of potential human contact with the contaminated medium ("exposure point"); and an exposure route (e.g., ingestion, inhalation, or dermal contact) at the contact point. Figure 1 represents a generic illustration of the exposure pathway concept. If one or more of these elements is absent, the exposure pathway is usually considered incomplete, the pathway may be excluded from further evaluation, and a human health risk does not exist. However, Ohio EPA dictates that the baseline risk assessment include the following exposure pathways, regardless of completeness:

- Ingestion of soil and dust from contaminated soil.
- Dermal contact with contaminated soil.
- Inhalation of fugitive dust/volatiles.

Figure 1. Illustration of Exposure Pathway Concept.



- Ingestion of contaminated drinking source.
- Dermal contact with contaminated water while showering/bathing.
- Inhalation of volatiles while showering/bathing with contaminated water.

c. Quantification of Risk.

(1) Although Ohio EPA requires inclusion of the six exposure pathways listed above in the baseline risk assessment, this report only quantifies the soil exposure pathways (ingestion of and dermal contact with contaminated soil, and inhalation of fugitive dust.) The exposure pathways associated with ground water were not included because they are not complete for the deactivation furnace site, analytical data were not available, and the conclusions of the risk assessment would not be impacted if an evaluation had been performed. Presently, drinking water on the base and within the surrounding area is obtained from a municipal source. Any future-use scenario would most likely involve municipal drinking water consumption as well.

(2) Risk values for each of the three exposure pathways were estimated for three different scenarios for the most sensitive subpopulation (e.g., children or adults). The three scenarios considered were:

- a residential scenario using the maximum concentration detected. This scenario is required by Ohio EPA for RCRA closures.
- a residential scenario using the 95% upper confidence interval concentration. This scenario represents a less conservative estimate of risks than the mandated methodology. It still quantifies a highly improbable scenario, however.
- and an industrial scenario using the 95% upper confidence interval concentration. This scenario quantifies the most reasonable maximum exposure values, which is in accordance with EPA's Risk Assessment Guidance for Superfund (RAGS).

(3) Exposure Assumptions.

(a) Incidental Ingestion of Soil. This exposure pathway requires direct contact with contaminated soil via the hands or lips (as dust), followed by inadvertent hand-to-mouth contact or licking of lips. The assumptions and equation used to calculate the chronic daily intake (CDI) for each scenario for this pathway are presented in Table 1. The estimated CDIs are included as Appendix C.

TABLE 1. ASSUMPTIONS USED FOR INCIDENTAL INGESTION OF SOIL

$$\text{CDI (mg/kg-d)} = \frac{\text{CS x IR x CF x FI x EF x ED}}{\text{BW x AT}}$$

CS = Chemical Concentration in Soil, site and scenario specific in mg/kg

IR = Ingestion Rate = 200 mg/day for residential child
= 100 mg/day for residential adult
= 50 mg/day for industrial

CF = Conversion Factor = 1 X 10^{-6} kg/mg

FI = Fraction Ingested from Contaminated Source = 1

EF = Exposure Frequency = 365 days/year for residential
= 250 days/year for industrial

ED = Exposure Duration = 6 years for residential child
= 30 years for residential adult
= 25 years for industrial

BW = Body Weight = 15 kg for child
= 70 kg for adult

AT = Averaging Time = 25,550 days for carcinogenic
= 2,190 days for noncarcinogenic residential child
= 10,950 days for noncarcinogenic residential adult
= 9,125 days for noncarcinogenic industrial

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* Values obtained from RAGS and reference 7. Most selected values are required by Ohio EPA.

(b) Dermal Contact with Soil. This exposure pathway requires direct contact of exposed skin with the contaminated soil. The amount of contaminant absorbed into the bloodstream is dependent on the chemical and physical characteristics of the individual compound. The dermal pathway for soil exposure is often not evaluated because of a lack of dermal toxicity criteria. In this report, however, oral toxicity values were used to quantify dermal contact risk values. The assumptions used to estimate the absorbed dose for this pathway are presented in Table 2. Appendix C includes the calculated CDIs for this pathway.

(c) Inhalation of Fugitive Dust. This exposure pathway involves the intake of contaminants in soil by breathing air in which contaminant-bearing soil particles are suspended as wind-eroded dust. Because air sampling was not performed at the deactivation furnace site, the air model for fugitive dust emissions outlined in the document titled Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites (reference 8) was used to estimate the concentration of respirable dust in the air. Table 3 summarizes the equation and parameters used to derive the concentration of fugitive dust in the air. All the parameters used in the fugitive dust emission model are default values except the width of the contaminated area and the area of contamination. Default values were chosen because site-specific values were not available and because they are conservative. Table 4 lists the assumptions used to obtain CDI's for this exposure pathway for each scenario. The CDIs for the inhalation pathway are included as Appendix C.

d. Toxicity Assessment.

(1) Toxicity data for carcinogens are expressed as slope factors (SF). A slope factor is defined in RAGS as "a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime." The slope factors for the chemicals of concern are presented in Table 5.

(2) Toxicity data for noncarcinogens are expressed as reference doses (RfD). A RfD is defined as "an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effect during a lifetime." The reference doses for the COCs are presented in Table 6.

TABLE 2. ASSUMPTIONS USED FOR DERMAL CONTACT WITH SOIL

$$\text{absorbed dose (mg/kg-d)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical Concentration in Soil, site and scenario specific in mg/kg

CF = Conversion Factor = 1 X 10^{-6} kg/mg

SA = Skin Surface Area Available for Contact
= 3,535 cm^2/event for residential child
= 8,620 cm^2/event for residential adult
= 820 cm^2/event for industrial (hands)

AF = Soil to Skin Adherence Factor = 2.11 mg/cm^2

ABS = Absorption Factor = 1%

EF = Exposure Frequency = 365 days/year for residential
= 250 days/year for industrial

ED = Exposure Duration = 6 years for residential child
= 30 years for residential adult
= 25 years for industrial

BW = Body Weight = 15 kg for child
= 70 kg for adult

AT = Averaging Time = 25,550 days for carcinogenic
= 2,190 days for noncarcinogenic residential child
= 10,950 days for noncarcinogenic residential adult
= 9,125 days for noncarcinogenic industrial

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* Values obtained from RAGS and reference 7. Most selected values are required by Ohio EPA.

TABLE 3. FUGITIVE DUST EMISSION MODEL

$$PEF = \frac{LS \ X \ V \ X \ MH \ X \ 3600 \ sec/hr}{A} * \frac{1000 \ g/kg}{0.036 \ X \ (1-G) \ X \ (U_m/U_t)^3 \ X \ F(x)}$$

PEF = Particulate Emission Factor in m^3/kg

LS = Width of Contaminated Area = 50 meters

V = Wind Speed in Mixing Zone = 2.25 m/sec

MH = Mixing Height = 2 meters

A = Area of Contamination = 2,500 m^2

0.036 g/m^2-hour = Respirable Fraction

G = Fraction of Vegetative Cover = 0

U_m = Mean Annual Wind Speed = 4.5 m/sec

U_t = Threshold Wind Speed = 5.4 m/sec

F(x) = Function dependent on U_m/U_t = 0.9

TABLE 4. ASSUMPTIONS USED FOR INHALATION OF FUGITIVE DUST

$$\text{CDI (mg/kg-d)} = \frac{\text{CS x IR x ET x EF x ED}}{\text{PEF x BW x AT}}$$

CS = Chemical Concentration in Soil, site and scenario specific in mg/kg

IR = Inhalation Rate = 20 m^3/day = 0.83 m^3/hour

ET = Exposure Time = 24 hours/day for residential
= 8 hours/day for industrial

EF = Exposure Frequency = 365 days/year for residential
= 250 days/year for industrial

ED = Exposure Duration = 6 years for residential child
= 30 years for residential adult
= 25 years for industrial

PEF = Particulate Emission Factor = 1.73×10^7 m^3/kg

BW = Body Weight = 15 kg for child
= 70 kg for adult

AT = Averaging Time = 25,550 days for carcinogenic
= 2,190 days for noncarcinogenic residential child
= 10,950 days for noncarcinogenic residential adult
= 9,125 days for noncarcinogenic industrial

---

* Values obtained from RAGS and reference 7. Most selected values are required by Ohio EPA.

TABLE 5. SLOPE FACTORS FOR THE CHEMICALS OF CONCERN*

Metal	Weight of Evidence	Oral	Inhalation
Antimony	Not evaluated	NA	NA
Arsenic	A	1.75†	50
Beryllium	B2	4.3	8.4
Cadmium	B1	NA	6.1
Chromium(VI)	A (inhalation)	NA	41
Copper	D	--	--
Lead	B2	NA	NA
Nickel	A (inhalation)	NA	0.84‡
Zinc	D	--	--

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* The units for the values provided are in (mg/kg-day)$^{-1}$.
† This value is derived from a unit risk 5E-05 (μg/L)$^{-1}$.
‡ This value refers to nickel refinery dust.
NA = Not applicable or not available.
Values obtained from Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST), references 9 and 10, respectively.

TABLE 6. CHRONIC REFERENCE DOSES FOR THE CHEMICALS OF CONCERN*

Metal	Oral	Inhalation
Antimony	4E-04	NA
Arsenic	3E-04	NA
Beryllium	5E-03	NA
Cadmium	1E-03†	NA
Chromium(VI)	5E-03	6E-07‡
Copper	4E-02§	NA
Lead	NA	NA
Nickel	2E-02	NA
Zinc	2E-01**	NA

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* The units for the values provided are in mg/kg-day.
† RfD for food.
‡ RfD undergoing review by IRIS, value from HEAST.
§ RfD derived from a concentration of 1.3 mg/L from HEAST.
** This value obtained from HEAST.
NA = Not applicable or not available.
Values obtained from IRIS unless noted otherwise.

e. Risk Characterization.

(1) Risk estimates for carcinogenic compounds are usually expressed as a probability (i.e., $1 \text{ X } 10^{-6}$) that an individual in a population will develop cancer as a result of exposure to the contaminant. These risks are termed excess lifetime cancer risks and represent the additional risk, above the normal background level, of developing cancer. The probabilities are derived by multiplying the estimated CDI or absorbed dose by the compound's SF. The estimated excess lifetime cancer risks for each compound and scenario are presented in Appendix C.

(2) For waste sites undergoing remediation under EPA's Superfund program, carcinogenic risk values ranging from $1 \text{ x } 10^{4}$ to $1 \text{ x } 10^{-6}$ have been considered within the acceptable range, with $1 \text{ X } 10^{-6}$ as the point of departure for possible remedial action. Risk levels of $1 \text{ x } 10^{-4}$ to $1 \text{ x } 10^{-6}$ represent one excess cancer in a population of 10,000 to one excess cancer in a population of 1,000,000 as a result of exposure to the carcinogenic compound. As mentioned previously, Ohio EPA mandates remedial activities if the carcinogenic risk exceeds $1 \text{ x } 10^{-6}$.

(3) Risk characterization for noncarcinogenic effects involves calculation of a hazard quotient (HQ) which is the ratio of the CDI or absorbed dose to the RfD. Noncarcinogenic risk values (Hazard Indices) (HI) are derived in the case of multiple contaminants, by summing the HQs for each contaminant according to effect to target organs. Generally, HI values greater than one may indicate some cause for concern; the greater the HI exceeds unity, the greater the degree of concern. The HQs in this risk assessment were summed together without regard for effect to target organs, however, which represents a conservative approach. The estimated noncarcinogenic risk values for each compound and each scenario are included as Appendix C.

(4) To estimate total risks, risks values for each compound are usually summed together for each exposure pathway and across all exposure pathways for a particular scenario. In this case, risks were summed for incidental ingestion of surface soil, dermal contact with surface soil, and inhalation of fugitive dust for each of the three scenarios evaluated. The total risk values derived for the residential scenario using maximum concentrations were $3 \text{ X } 10^{-4}$, carcinogenic and 80, noncarcinogenic. The values calculated for the residential

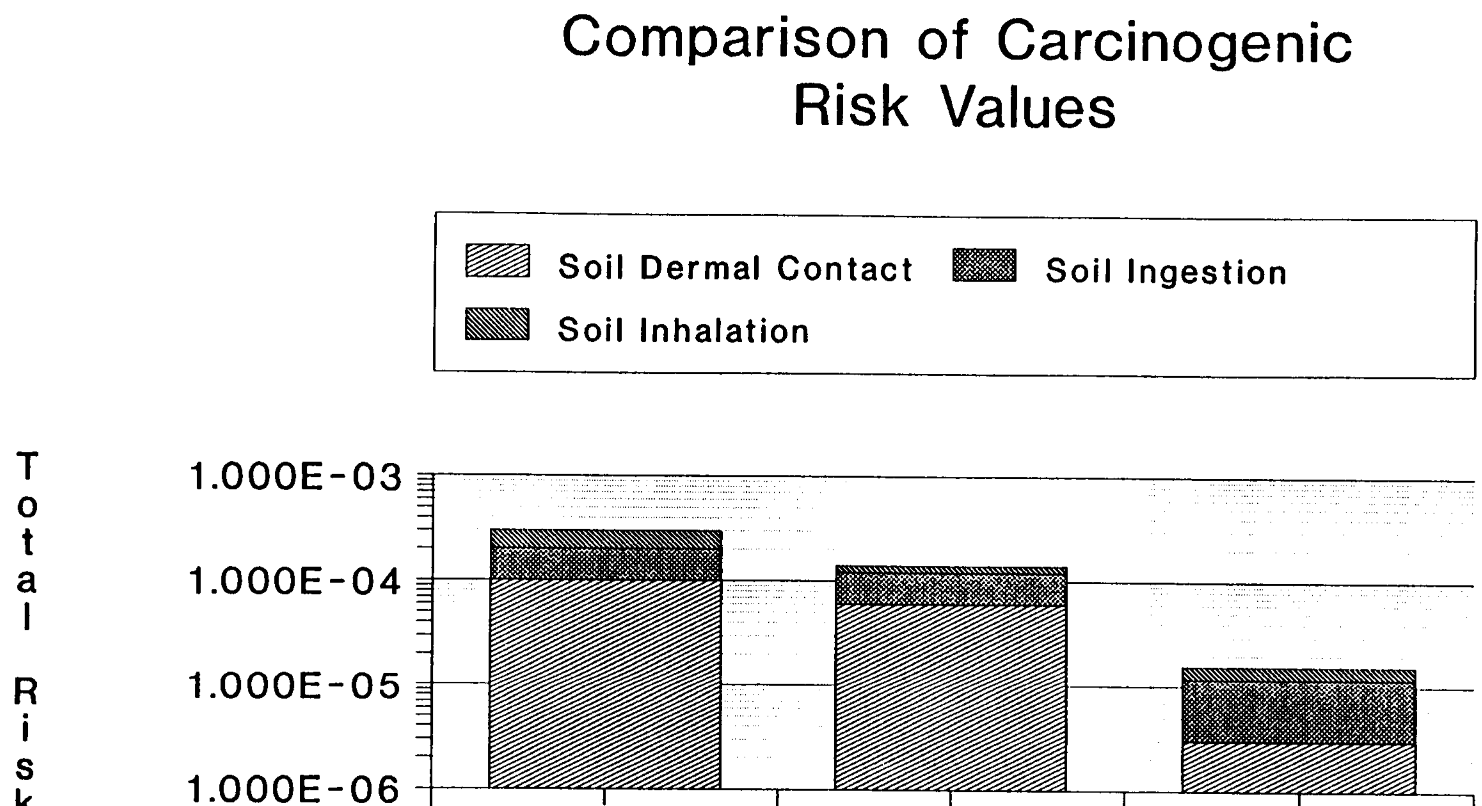
scenario using the 95% upper confidence interval were 1 X 10^{-4} and 10; the values estimated for the industrial scenario using the 95% upper confidence interval were 2 X 10^{-5} and 0.5. Arsenic, chromium, cadmium, and copper accounted for most of the risk in the residential scenario where the maximum concentration detected was used in the calculations. Antimony, arsenic, chromium, and beryllium accounted for most of the risk in the residential and industrial scenarios where the 95% upper confidence interval concentration was used for the estimates. Figures 2 and 3 graphically illustrate a comparison of the three scenarios for carcinogenic and noncarcinogenic risks, respectively.

f. Uncertainty Analysis.

(1) General. All human health risk assessments are associated with a large degree of uncertainty because risk estimates are based on a number of conservative exposure and toxicological assumptions. Exposure values calculated may not reflect actual site conditions, because standard default values are often applied. In addition, toxicity values are typically derived from animal studies, rather than human studies, causing comparisons between unrelated species. The toxicity to a human from a contaminant may or may not be similar. Also, some contaminants do not have any toxicity data at all, which may result in underestimation of risks. It is imperative, therefore, that the readers and users of risk assessments place derived risk values in the proper perspective when making decisions regarding remediation.

(2) Estimating CDIs for Inhalation of Fugitive Dust. Because air sampling data were not available for estimating CDIs for inhalation of fugitive dust, a model was employed which is based on numerous conservative assumptions. The intake values obtained, therefore, probably overestimate actual exposure conditions.

(3) Summation of HIs Disregarding Target Organ. As stated previously, HIs are generally derived by summing values which are toxic to the same target organs. The total HIs calculated in this risk assessment were summed without regard to the target organs. This conservative approach introduces a certain degree of uncertainty. Noncarcinogenic risks, therefore, are overestimated.

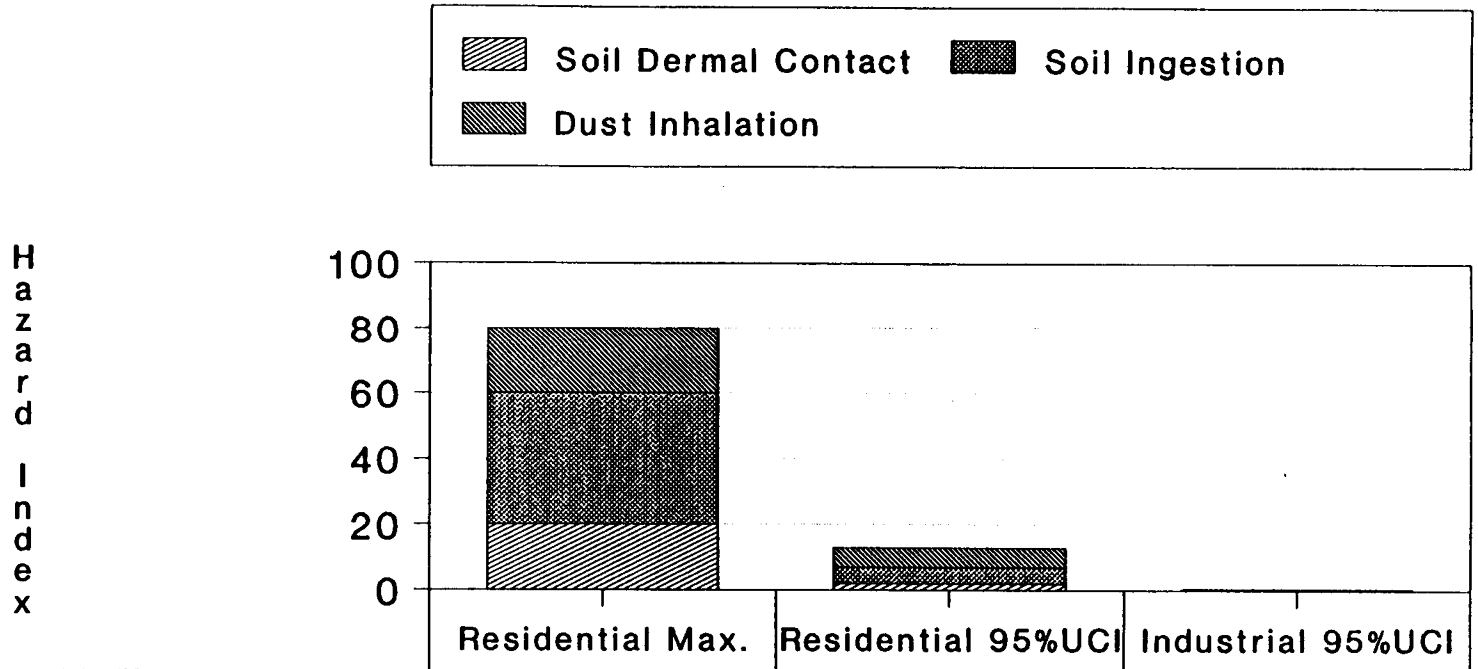


	Residential Max.	Residential 95%UCI	Industrial 95%UCI
Soil Inhalation	1.000E-04	2.000E-05	4.000E-06
Soil Ingestion	1.000E-04	6.000E-05	9.000E-06
Soil Dermal Contact	1.000E-04	6.000E-05	3.000E-06
Total Carc. Risk	3.000E-04	1.000E-04	2.000E-05

Scenario and Concentration Used

Figure 2

Comparison of Noncarcinogenic Risk Values



	Residential Max.	Residential 95%UCI	Industrial 95%UCI
Dust Inhalation	20	6	0.3
Soil Ingestion	40	5	0.2
Soil Dermal Contact	20	2	0.06
Total Hazard Index	80	10	0.6

Scenario and Concentration Used

Figure 3

g. Preliminary Remediation Goals.

(1) General. Chemical-specific preliminary remediation goals (PRGs) are concentration goals for individual chemicals for specific medium and land use combinations. There are two general sources of chemical-specific PRGs: concentrations based on applicable or relevant and appropriate requirements (ARARs) as defined in the National Contingency Plan (NCP); and concentrations based on risk assessment. The EPA has developed PRG guidance in Part B of the Human Health Evaluation Manual (reference 11). The State of New Jersey has also used a similar risk-based approach to develop proposed soil cleanup standards which are based on standard default exposure values similar to the EPA recommended exposure factors (reference 12).

(2) PRGs for the Deactivation Furnace. Table 7 lists the PRGs for the deactivation furnace using both New Jersey's methodology and EPA's methodology. Both methodologies generate numeric standards which represent the maximum concentrations that can be present in the soil medium without adverse effects from long-term exposure. The models employed in both approaches utilize typical default exposure assumptions and standard toxicity factors from accepted data bases. Proposal of risk-based cleanup levels similar to those presented in Table 7, if accepted by Ohio EPA, may reduce the remediation expenses at the deactivation furnace site.

TABLE 7. PRELIMINARY REMEDIATION GOALS*

Metal	Highest Detected Concentration	EPA Soil Cleanup Standards	Proposed NJ Soil Cleanup	
		Residential	Residential	Industrial
Antimony	159.4	108	14	340
Arsenic	48.7	0.4	20	20
Beryllium	9.2	0.2	2	2
Cadmium	1,615	270	1	100
Chromium	166	1,350	--	--
Copper	34,000	10,800	600	600
Lead	4,286	--	100	600
Nickel	123.6	5,400	250	2,400
Zinc	15,600	54,000	1,500	1,500

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* All values are given in the units mg/kg.
-- Not available.

7. CONCLUSIONS AND RECOMMENDATIONS.

a. The Ohio EPA regulations require an extremely conservative methodology in determining human health risks; therefore, using a risk assessment for closure of the deactivation furnace is not a feasible option. Both the carcinogenic and noncarcinogenic risk estimates calculated by employing Ohio EPA methodology exceed acceptable levels. The primary reasons for the high risk estimates are because an unrestricted scenario (residential scenario) is compulsory for the future use of any nonlandfill site, and the maximum concentration detected onsite is the value required for use to quantify exposure.

b. Ravenna Army Ammunition Plant is not scheduled for base realignment or closure in the foreseeable future. The deactivation furnace site, therefore, will probably be used for an industrial or commercial purpose. A future residential use is not probable. When risks values are calculated assuming an industrial scenario and in accordance with the U.S. Environmental Protection Agency's (EPA) Risk Assessment Guidance for Superfund (reference 2), the carcinogenic risk still exceeds Ohio EPA's action level of 1 X 10^{-6} by one order of magnitude, e.g., 2 X 10^{-5}. The noncarcinogenic risk, however, is less than unity, e.g., 0.6. Nonetheless, Ohio EPA would mandate remediation by one of the options listed below.

c. Compliance with Ohio EPA regulations must be accomplished by: "clean closure"; by closure as a landfill; or by proposing site-specific risk-based cleanup targets, because a risk assessment is not a feasible option. With clean closure waste and contaminated soil must be removed to a level less than two standard deviations higher than the mean of natural background for inorganics, and to the method detection limit for organics. Closure as a landfill mandates post-closure care and monitoring. Proposal of site-specific risk-based cleanup levels requires acceptable documentation that all routes of exposure and risk to both human health and the environment are addressed. Both the State of New Jersey and the EPA have established a methodology for generating risk-based cleanup standards. To accomplish RCRA closure of the deactivation furnace at RVAAP, the U.S. Army Environmental Hygiene Agency (USAEHA) recommends either the proposal of risk-based cleanup standards, similar to those listed for the State of New Jersey, or clean closure, whichever is acceptable to the Ohio EPA and most cost-effective.

d. A number of metals account for the high risk values estimated for the soils at the deactivation furnace. These include antimony, arsenic, beryllium, cadmium, chromium, and copper. Lead was not quantified because toxicity values are not available. However, the toxic affects of lead are well documented; therefore, lead would also contribute to the risks associated with this site. To reduce the human health risks, mitigating activities should focus on remediation of these chemicals.

Bonnie J. Gaborek
BONNIE J. GABOREK
Environmental Protection Specialist
Waste Disposal Engineering Division

APPROVED:

William E. Legg MAJ, MS
WILLIAM E. LEGG
MS, MAJ
Program Chief, Health Risk Assessment

APPENDIX A

REFERENCES

1. Ravenna Arsenal, Inc., Ravenna AAP Request for USAEHA Field Services to Perform a Health Risk Assessment Upon a Deactivation Furnace RCRA Closure Activity, October 1991.

2. USEPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002, December 1989.

3. Ohio Environmental Protection Agency, Closure Plan Review Guidance.

4. USEPA, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, OSWER Directive 9355.0-30, April 1991.

5. USEPA, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, OSWER Directive: 9355.4-02, 7 September 1989.

6. Bat Associates, Inc., Closure Plan for Deactivation Furnace, Ravenna Army Ammunition Plant, December 1990.

7. USEPA, Exposure Factors Handbook, EPA600/8-89/043, March 1989.

8. Cowherd, C., G.E. Muleski, P.J. Englehart, D.A. Gillette, Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites, USEPA; Office of Health and Environmental Assessment, 1985.

9. USEPA, Integrated Risk Information System (IRIS), On line data base, access 25 May 1992.

10. USEPA, Health Effects Assessment Summary Tables (HEAST), 1991.

11. USEPA, Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, (Part B, Development of Risk-based Preliminary Remediation Goals), Interim, OSWER Directive: 9285.7-01B, December 1991.

12. State of New Jersey, Proposed Cleanup Standards for Contaminated Sites, Proposed New Rule N.J.A.C. 7:26D, January 1992.

APPENDIX B

ANALYTICAL DATA FOR CHEMICALS OF CONCERN

PARAMETER	1-1	2-1	3-1	4-1	5-1	6-1	7-1	8-1	9-1	10-1	11-1	12-1	13-1	14-1	15-1	16-1	17-1	MEAN+2STD
ANTIMONY	0.50	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	22.50	10.12	5.00	5.00	11.70	0.50	0.50	0.50	2.21
ARSENIC	7.15	7.10	11.30	25.00	16.90	17.50	14.80	9.64	15.50	35.70	27.50	48.70	30.30	9.55	6.29	5.00	6.00	14.72
BERYLLIUM	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CADMIUM	5.00	5.00	25.20	34.50	38.00	27.10	5.00	5.00	19.20	199.00	1615.00	353.00	86.00	5.00	5.00	5.00	5.00	5.00
CHROMIUM	29.70	10.90	20.00	29.50	29.70	32.00	24.20	27.90	28.30	87.70	5138.00	1166.00	30.80	20.60	18.70	33.30	28.20	39.11
COPPER	74.20	29.50	1006.00	1100.00	1280.00	120.00	714.00	151.00	178.00	1470.00	34000.00	2300.00	745.00	42.70	11.50	25.70	55.90	27.35
LEAD	66.00	10.00	124.80	27.60	364.00	150.00	293.00	27.30	41.60	942.00	4286.00	1472.00	405.00	35.00	14.90	19.10	24.80	28.07
NICKEL	19.20	24.60	19.50	17.40	18.20	16.30	12.80	18.50	18.00	547.40	13.50	178.30	19.70	10.80	11.60	16.80	17.20	41.30
ZINC	169.00	51.50	607.00	1222.00	2316.00	691.00	1277.00	127.00	151.00	969.00	15600.00	1730.00	1261.00	111.00	39.60	62.10	10.20	84.35

PARAMETER	1-2	2-2	3-2	4-2	5-2	6-2	7-2	8-2	9-2	10-2	11-2	12-2	13-2	14-2	15-2	16-2	17-2	MEAN+2STD
ANTIMONY	5.00	5.00	5.91	10.00	5.00	5.00	5.00	5.00	5.00	5.00	7.00	5.00	5.00	5.00	5.00	5.00	5.00	2.21
ARSENIC	7.87	5.16	8.35	11.00	14.40	8.15	7.30	11.40	5.39	6.03	11.00	8.43	6.61	4.93	5.66	4.54	4.61	14.72
BERYLLIUM	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CADMIUM	5.00	5.00	10.20	46.60	18.80	5.00	5.00	5.00	5.00	5.00	135.00	24.00	5.00	5.00	5.00	5.00	5.00	5.00
CHROMIUM	18.10	44.50	15.30	39.70	27.60	20.30	15.50	29.40	32.40	25.70	41.90	43.40	34.30	10.00	20.00	18.30	20.20	39.11
COPPER	27.40	48.90	308.00	1060.00	243.00	182.00	192.00	5.00	27.10	254.00	4280.00	186.00	273.00	26.40	28.30	27.30	27.80	27.35
LEAD	10.00	13.40	99.30	382.00	147.00	24.90	40.00	10.00	10.00	150.00	375.00	215.00	10.00	10.00	10.00	13.00	12.90	28.07
NICKEL	33.00	31.40	20.50	32.60	34.20	18.80	15.50	38.20	35.20	19.80	35.90	27.40	31.10	16.20	34.90	38.70	43.30	41.30
ZINC	72.60	123.00	1621.00	2340.00	687.00	130.00	304.00	71.70	77.60	173.00	1350.00	635.00	77.00	77.50	83.00	81.90	78.10	84.35

PARAMETER	1-3	2-3	3-3	4-3	5-3	6-3	7-3	8-3	9-3	10-3	11-3	12-3	13-3	14-3	15-3	16-3	17-3	MEAN+2STD
ANTIMONY	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	2.21
ARSENIC	7.15	5.46	15.60	10.20	8.15	6.91	9.15	7.18	5.51	5.97	4.64	8.24	7.23	7.09	5.89	5.63	5.30	14.72
BERYLLIUM	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CADMIUM	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	120.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
CHROMIUM	14.80	16.60	21.00	22.60	24.50	22.90	24.70	29.90	30.60	27.40	51.90	30.30	24.30	16.20	18.60	19.40	19.60	39.11
COPPER	21.50	38.40	33.00	927.00	27.30	27.10	23.80	23.40	23.00	53.70	1220.00	25.90	40.40	30.60	23.10	24.30	35.40	27.35
LEAD	10.00	10.00	10.00	11.60	35.40	10.00	10.00	10.00	10.00	89.60	153.00	10.00	10.00	10.00	12.20	12.30	15.10	28.07
NICKEL	30.50	29.70	33.30	39.00	33.40	34.20	37.80	43.30	41.20	37.90	55.20	37.50	32.70	31.00	40.00	36.00	37.40	41.30
ZINC	60.80	94.70	90.00	130.00	81.30	111.00	75.10	63.50	65.90	97.00	413.00	68.00	91.10	62.40	77.80	68.90	91.40	84.35

RAVENNA ARSENAL, INC.: DEACTIVATION FURNACE CLOSURE

GRID SAMPLES: IN MG/KG

PARAMETER	18A	19A	20A	21A	22A	23A	24A	25A	26A	27A	28A	29A	30A	MEAN+2STD
ANTIMONY	5.00	5.00	5.00	5.00	5.00	5.00		5.00	5.00	5.00	5.00	5.00	5.00	2.21
ARSENIC	4.50	16.00	6.40	6.40	5.50	4.57		10.90	5.80	5.80	5.80	5.90	5.80	14.72
BERYLLIUM	5.00	5.00	5.00	5.00	5.00	5.00		5.00	5.00	5.00	5.00	5.00	5.00	5.00
CADMIUM	5.00	5.00	7.40	5.00	13.80	7.20		14.90	5.00	5.00	5.00	5.00	5.00	5.00
CHROMIUM	42.30	25.90	24.50	25.70	48.30	24.90		32.90	27.80	25.20	31.70	29.00	28.90	39.11
COPPER	50.00	197.00	120.00	729.00	153.00	344.00		162.00	38.50	106.00	28.90	55.60	59.80	27.35
LEAD	39.90	118.00	98.00	113.00	339.00	226.00		52.60	17.80	33.70	10.00	39.30	21.30	28.07
NICKEL	31.60	28.60	20.40	23.50	35.80	22.20		23.90	36.90	18.10	37.00	33.70	31.20	41.30
ZINC	132.00	414.00	268.00	596.00	2700.00	764.00		413.00	114.00	101.00	75.80	136.00	127.00	84.35

PARAMETER	18C	19C	20C	21C	22C	23C	24C	25C	26C	27C	28C	29C	30C	MEAN+2STD
ANTIMONY	80.40	137.10	102.80	91.10	67.10	77.40		90.70	85.30	63.00	100.30	73.20	98.40	2.21
ARSENIC	14.60	16.70	11.50	14.50	11.50	10.80		9.50	20.70	17.10	24.20	21.30	14.10	14.72
BERYLLIUM	5.70	5.70	5.80	5.80	5.90	5.90		5.80	5.90	6.10	5.80	5.80	5.70	5.00
CADMIUM	5.70	5.70	5.80	5.80	5.90	5.90		5.80	5.90	6.10	5.80	5.80	5.70	5.00
CHROMIUM	41.50	52.20	50.50	55.80	48.10	29.80		57.70	35.80	33.50	51.20	43.80	40.70	39.11
COPPER	20.50	21.50	7.00	20.00	21.20	17.40		25.70	7.90	16.70	16.10	16.30	20.90	27.35
LEAD	49.60	21.30	48.00	11.50	35.90	15.10		39.00	27.40	24.80	22.80	24.90	11.40	28.07
NICKEL	40.10	41.70	45.80	43.70	42.60	40.90		39.90	39.80	52.70	42.40	41.60	42.70	41.30
ZINC	62.20	68.80	71.90	67.20	72.70	77.80		107.30	74.20	87.60	68.10	82.10	61.60	84.35

RAVENNA ARSENAL, INC.: DEACTIVATION FURNACE CLOSURE

GRID SAMPLES: IN MG/KG

PARAMETER	31A	32A	33A	34A	35A	36A	37A	38A	39A	40A	41A	42A	43A	44A	45A	46A	47A	48A
ANTIMONY	13.00 13.00	98.20	167.50	80.60	126.90	95.20	96.70	92.90	150.90	1308.30	1149.00	159.40	1123.20	1139.20	88.40	1114.00	101.50	125.30
ARSENIC	4.70	13.80	16.90	13.70	10.40	14.20	19.30	12.40	9.20	19.80	16.40	17.90	16.30	14.60	84.60	12.70	15.90	15.60
BERYLLIUM	5.70	5.40	5.80	5.80	9.20	5.70	6.00	5.80	5.20	5.50	5.50	5.50	5.50	5.60	6.00	5.50	6.10	6.00
CADMIUM	11.50	65.80	5.80	5.80	5.80	5.70	6.00	5.80	5.20	5.50	7.00	5.50	5.50	5.60	6.00	5.50	6.10	6.00
CHROMIUM	27.50	20.40	43.90	35.40	60.00	36.20	43.80	37.20	20.40	82.20	50.60	54.50	52.70	39.10	68.70	59.70	69.30	44.70
COPPER	8621.40	107.10	44.80	45.00	63.10	22.90	25.50	23.00	64.80	133.20	1410.10	163.10	62.90	27.70	138.00	83.10	40.50	12.90
LEAD	617.30	172.10	11.60	55.80	11.50	11.50	11.90	11.60	26.80	57.70	159.40	55.70	39.00	63.70	34.70	70.80	35.10	11.90
NICKEL	28.30	22.50	37.50	43.20	32.20	43.50	43.90	46.80	13.70	25.90	44.10	43.10	33.60	37.40	47.20	26.10	40.30	32.30
ZINC	2797.00	980.10	57.00	240.90	131.50	81.10	77.40	73.10	148.10	301.80	3497.70	185.90	134.70	132.20	117.00	196.70	107.90	123.30

PARAMETER	49A	50A	51A	52A	53A	54A	55A	56A	57A	58A	59A	60A	61A	62A	63A	64A	65A	66A
	85.7														672			
ANTIMONY	85.70	13.70	56.80	56.10	67.50	97.80	134.60	64.10	92.00	28.60	66.10	111.60	74.30	86.00	65.10	65.90	56.20	67.60
ARSENIC	14.90	6.10	14.40	12.00	14.60	13.10	24.70	20.80	15.40	21.50	13.60	14.20	12.50	10.40	11.60	19.40	11.50	8.40
BERYLLIUM	5.80	5.60	5.80	5.40	5.50	7.20	5.90	5.70	5.70	5.70	5.90	6.00	5.70	5.90	5.50	5.60	5.40	5.50
CADMIUM	5.80	5.60	5.80	5.40	5.50	5.60	5.90	5.70	6.00	5.70	5.90	6.00	5.70	5.90	5.50	5.60	5.40	5.50
CHROMIUM	31.60	36.60	37.80	34.20	31.10	73.90	57.70	38.90	26.90	27.90	39.30	36.50	40.00	37.30	39.30	37.20	37.80	27.90
COPPER	100.30	136.30	25.90	135.40	68.60	99.40	226.30	68.60	18.40	28.80	79.20	128.50	25.60	20.60	31.80	74.00	29.90	218.80
LEAD	128.00	54.50	11.60	44.30	67.20	61.40	121.50	32.10	11.90	11.40	21.30	12.00	11.40	14.10	13.90	20.10	10.80	55.40
NICKEL	30.50	23.10	22.50	21.40	19.90	27.80	168.40	38.00	28.70	145.30	40.50	142.90	36.30	36.60	150.00	52.60	49.30	141.90
ZINC	1500.60	107.10	102.60	184.00	144.50	302.20	945.70	186.60	83.30	406.90	116.90	105.00	185.10	82.60	133.80	152.60	103.40	588.30

PARAMETER	67A	68A	69A	70A
ANTIMONY	131.20	86.40	80.90	27.80
ARSENIC	8.50	8.80	13.60	8.60
BERYLLIUM	5.80	5.60	5.70	5.60
CADMIUM	6.00	5.60	5.70	5.60
CHROMIUM	400.20	20.50	36.40	31.50
COPPER	476.40	473.60	23.80	14.00
LEAD	224.60	877.50	13.30	16.20
NICKEL	123.60	23.70	49.10	20.60
ZINC	1669.00	1236.80	82.70	78.00

Pg. 1

AMERICAN ANALYTICAL LABORATORIES, INC.

INDUSTRIAL HYGIENE AND ENVIRONMENTAL SCIENCES

840 S. MAIN STREET
AKRON, OHIO 44311
(216) 535-1300

WORK ORDER #: 91-09-155

SAMPLES RECEIVED: 09/16/91
ANALYSIS REPORTED: 10/03/91

REPORT ISSUED TO:

Simon Wakin
YWC Midwest
6490 Promler Avenue
N. Canton, Ohio 44720

WORK ID: 91-115
FACILITY: Ravenna Arsenal

SAMPLED BY: Simon Wakin
SAMPLE TYPE: Soil

SAMPLE ANALYSIS REPORT

SAMPLE ID AAL LAB #	DATE COLLECTED PARAMETER(S)	RESULT(S)	UNITS	METHOD(S)
135A 9109155-01	09/16/91			
	Antimony	< 54.2	mg/Kg	EPA_7040
	Arsenic	10.0	mg/Kg	EPA_7060
	Beryllium	< 5.4	mg/Kg	EPA_7090
	Cadmium	< 5.4	mg/Kg	EPA_7130
	Chromium	33.5	mg/Kg	EPA_7190
	Copper	33.7	mg/Kg	EPA_7210
	Lead	121.0	mg/Kg	EPA_7420
	Nickel	8.1	mg/Kg	EPA_7520
	Zinc	150.0	mg/Kg	EPA_7950
140A 9109155-02	09/16/91			
	Antimony	< 53.5	mg/Kg	EPA_7040
	Arsenic	23.1	mg/Kg	EPA_7060
	Beryllium	< 5.3	mg/Kg	EPA_7090
	Cadmium	< 5.3	mg/Kg	EPA_7130
	Chromium	39.5	mg/Kg	EPA_7190
	Copper	131.0	mg/Kg	EPA_7210
	Lead	154.0	mg/Kg	EPA_7420
	Nickel	10.3	mg/Kg	EPA_7520
	Zinc	460.0	mg/Kg	EPA_7950
146A 9109155-03	09/16/91			
	Antimony	< 57.7	mg/Kg	EPA_7040
	Arsenic	13.4	mg/Kg	EPA_7060
	Beryllium	< 5.8	mg/Kg	EPA_7090
	Cadmium	< 5.8	mg/Kg	EPA_7130
	Chromium	31.3	mg/Kg	EPA_7190
	Copper	168.0	mg/Kg	EPA_7210

AMERICAN ANALYTICAL LABORATORIES, INC.

INDUSTRIAL HYGIENE AND ENVIRONMENTAL SCIENCES

840 S. MAIN STREET
AKRON, OHIO 44311
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WORK ORDER #: 91-09-155

SAMPLES RECEIVED: 09/16/91
ANALYSIS REPORTED: 10/03/91

SAMPLE ANALYSIS REPORT

SAMPLE ID AAL LAB #	DATE COLLECTED PARAMETER(S)	RESULT(S)	UNITS	METHOD(S)
146A 9109155-03	09/16/91		**continued**	
	Lead	95.7	mg/Kg	EPA_7420
	Nickel	20.9	mg/Kg	EPA_7520
	Zinc	616.0	mg/Kg	EPA_7950
154A 9109155-04	09/16/91			
	Antimony	< 55.1	mg/Kg	EPA_7040
	Arsenic	15.0	mg/Kg	EPA_7060
	Beryllium	< 5.5	mg/Kg	EPA_7090
	Cadmium	< 5.5	mg/Kg	EPA_7130
	Chromium	45.8	mg/Kg	EPA_7190
	Copper	56.0	mg/Kg	EPA_7210
	Lead	137.0	mg/Kg	EPA_7420
	Nickel	23.5	mg/Kg	EPA_7520
	Zinc	304.0	mg/Kg	EPA_7950
161A 9109155-05	09/16/91			
	Antimony	< 50.9	mg/Kg	EPA_7040
	Arsenic	12.3	mg/Kg	EPA_7060
	Beryllium	< 5.1	mg/Kg	EPA_7090
	Cadmium	< 5.1	mg/Kg	EPA_7130
	Chromium	41.0	mg/Kg	EPA_7190
	Copper	67.2	mg/Kg	EPA_7210
	Lead	151.0	mg/Kg	EPA_7420
	Nickel	22.4	mg/Kg	EPA_7520
	Zinc	395.0	mg/Kg	EPA_7950
166A 9109155-06	09/16/91			
	Antimony	< 57.6	mg/Kg	EPA_7040
	Arsenic	22.5	mg/Kg	EPA_7060
	Beryllium	< 5.8	mg/Kg	EPA_7090
	Cadmium	< 5.8	mg/Kg	EPA_7130
	Chromium	42.3	mg/Kg	EPA_7190

AMERICAN ANALYTICAL LABORATORIES, INC.

INDUSTRIAL HYGIENE AND ENVIRONMENTAL SCIENCES

840 S. MAIN STREET
AKRON, OHIO 44311
(216) 535-1300

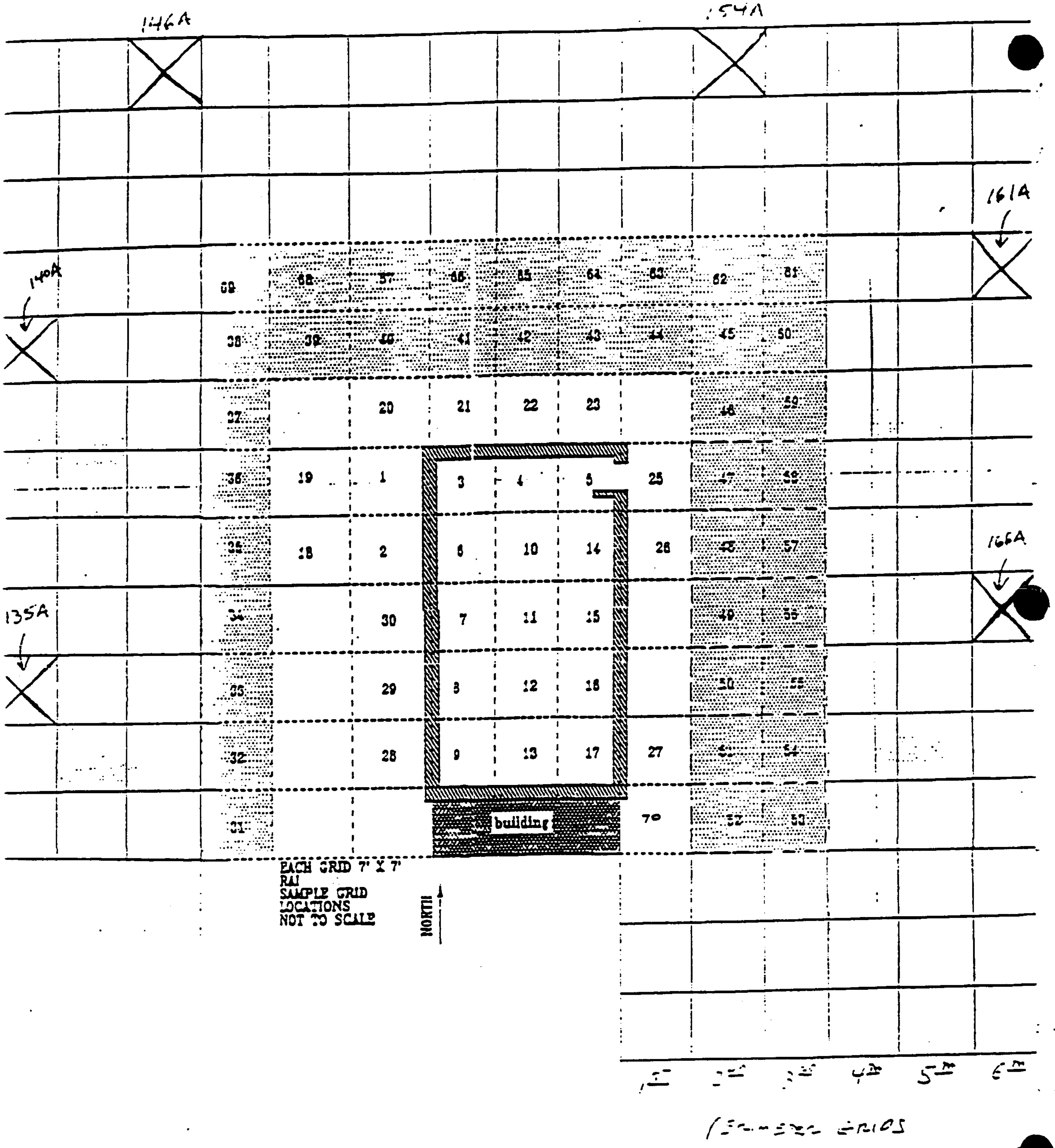
WORK ORDER #: 91-09-155

SAMPLES RECEIVED: 09/16/91
ANALYSIS REPORTED: 10/03/91

SAMPLE ANALYSIS REPORT

SAMPLE ID AAL LAB #	DATE COLLECTED PARAMETER(S)	RESULT(S)	UNITS	METHOD(S)
166A 9109155-06	09/16/91		**continued**	
	Copper	52.0	mg/Kg	EPA_7210
	Lead	93.1	mg/Kg	EPA_7420
	Nickel	20.4	mg/Kg	EPA_7520
	Zinc	249.0	mg/Kg	EPA_7950

ANALYSIS REVIEWED AND APPROVED BY ______________________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APPENDIX C

EXPOSURE ASSESSMENT CALCULATIONS AND RISK CHARACTERIZATION CALCULATIONS

RAVENNA ARMY AMMUNITION PLANT-DEACTIVATION FURNACE

SOIL	95% UCI []	Maximum []
Antimony	62.811	159.4
Arsenic	15.526	48.700
Beryllium	5.616	9.200
Cadmium	88.087	1615.000
Chromium	46.796	166.000
Copper	1743.165	34000.000
Lead	305.124	4296.000
Nickel	36.823	123.600
Zinc	1205.705	15600

MULTIPLICATION FACTORS FOR EACH SCENARIO AND EXPOSURE PATHWAY

SOIL	Non-carcinogenic			Carcinogenic		
	Ingestion	Dermal Contact	Inhalation	Ingestion	Dermal Contact	Inhalation
Res. Child	1.33E-05	4.97E-06	7.70E-08	1.14E-06	4.26E-07	6.60E-09
Res. Adult	1.43E-06	2.60E-06	1.66E-08	6.12E-07	1.11E-06	7.12E-09
Industrial/Commercial	4.89E-07	1.69E-07	3.77E-09	1.75E-07	6.05E-08	1.35E-09

Chronic Daily Intake-Incidental Ingestion of Soil-95% UCI []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	8.37E-04	8.97E-05	3.07E-05
Arsenic	2.07E-04	2.22E-05	7.60E-06
Beryllium	7.49E-05	8.02E-06	2.75E-06
Cadmium	1.17E-03	1.26E-04	4.31E-05
Chromium	6.24E-04	6.69E-05	2.29E-05
Copper	2.32E-02	2.49E-03	8.53E-04
Lead	4.07E-03	4.36E-04	1.49E-04
Nickel	4.91E-04	5.26E-05	1.80E-05
Zinc	1.61E-02	1.72E-03	5.90E-04

Chronic Daily Intake-Incidental Ingestion of Soil-95% UCI []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	7.18E-05	3.85E-05	1.10E-05
Arsenic	1.77E-05	9.51E-06	2.71E-06
Beryllium	6.42E-06	3.44E-06	9.81E-07
Cadmium	1.01E-04	5.39E-05	1.54E-05
Chromium	5.35E-05	2.87E-05	8.18E-06
Copper	1.99E-03	1.07E-03	3.05E-04
Lead	3.49E-04	1.87E-04	5.33E-05
Nickel	4.21E-05	2.25E-05	6.43E-06
Zinc	1.38E-03	7.38E-04	2.11E-04

Chronic Daily Intake-Incidental Ingestion of Soil-Maximum []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	2.13E-03	2.28E-04	7.80E-05
Arsenic	6.49E-04	6.96E-05	2.38E-05
Beryllium	1.23E-04	1.31E-05	4.50E-06
Cadmium	2.15E-02	2.31E-03	7.90E-04
Chromium	2.21E-03	2.37E-04	8.12E-05
Copper	4.53E-01	4.86E-02	1.66E-02
Lead	5.71E-02	6.12E-03	2.10E-03
Nickel	1.65E-03	1.77E-04	6.05E-05
Zinc	2.08E-01	2.23E-02	7.63E-03

Chronic Daily Intake-Incidental Ingestion of Soil-Maximum []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	1.82E-04	9.76E-05	2.79E-05
Arsenic	5.57E-05	2.98E-05	8.51E-06
Beryllium	1.05E-05	5.63E-06	1.61E-06
Cadmium	1.85E-03	9.89E-04	2.82E-04
Chromium	1.90E-04	1.02E-04	2.90E-05
Copper	3.89E-02	2.08E-02	5.94E-03
Lead	4.90E-03	2.62E-03	7.49E-04
Nickel	1.41E-04	7.57E-05	2.16E-05
Zinc	1.78E-02	9.55E-03	2.73E-03

Chronic Daily Intake-Dermal Contact with Soil-95% UCI []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	3.12E-04	1.63E-04	1.06E-05
Arsenic	7.72E-05	4.03E-05	2.63E-06
Beryllium	2.79E-05	1.46E-05	9.51E-07
Cadmium	4.38E-04	2.29E-04	1.49E-05
Chromium	2.33E-04	1.22E-04	7.92E-06
Copper	8.67E-03	4.53E-03	2.95E-04
Lead	1.52E-03	7.93E-04	5.17E-05
Nickel	1.83E-04	9.57E-05	6.23E-06
Zinc	6.00E-03	3.13E-03	2.04E-04

Chronic Daily Intake-Dermal Contact with Soil-95% UCI []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	2.68E-05	6.99E-05	3.80E-06
Arsenic	6.62E-06	1.73E-05	9.39E-07
Beryllium	2.39E-06	6.25E-06	3.40E-07
Cadmium	3.75E-05	9.81E-05	5.33E-06
Chromium	1.99E-05	5.21E-05	2.83E-06
Copper	7.43E-04	1.94E-03	1.05E-04
Lead	1.30E-04	3.40E-04	1.84E-05
Nickel	1.57E-05	4.10E-05	2.23E-06
Zinc	5.14E-04	1.34E-03	7.29E-05

Chronic Daily Intake-Dermal Contact with Soil-Maximum []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	7.93E-04	4.14E-04	2.70E-05
Arsenic	2.42E-04	1.27E-04	8.24E-06
Beryllium	4.57E-05	2.39E-05	1.56E-06
Cadmium	8.03E-03	4.20E-03	2.73E-04
Chromium	8.25E-04	4.31E-04	2.81E-05
Copper	1.69E-01	8.83E-02	5.76E-03
Lead	2.13E-02	1.11E-02	7.26E-04
Nickel	6.15E-04	3.21E-04	2.09E-05
Zinc	7.76E-02	4.05E-02	2.64E-03

Chronic Daily Intake-Dermal Contact with Soil-Maximum []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	6.79E-05	1.78E-04	9.64E-06
Arsenic	2.08E-05	5.42E-05	2.94E-06
Beryllium	3.92E-06	1.02E-05	5.56E-07
Cadmium	6.89E-04	1.80E-03	9.76E-05
Chromium	7.08E-05	1.85E-04	1.00E-05
Copper	1.45E-02	3.79E-02	2.06E-03
Lead	1.83E-03	4.77E-03	2.59E-04
Nickel	5.27E-05	1.38E-04	7.47E-06
Zinc	6.65E-03	1.74E-02	9.43E-04

Chronic Daily Intake-Inhalation of Dust-95% UCI []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	4.84E-06	1.04E-06	2.37E-07
Arsenic	1.20E-06	2.58E-07	5.85E-08
Beryllium	4.32E-07	9.32E-08	2.12E-08
Cadmium	6.78E-06	1.46E-06	3.32E-07
Chromium	3.60E-06	7.77E-07	1.76E-07
Copper	1.34E-04	2.89E-05	6.57E-06
Lead	2.35E-05	5.07E-06	1.15E-06
Nickel	2.84E-06	6.11E-07	1.39E-07
Zinc	9.28E-05	2.00E-05	4.55E-06

Chronic Daily Intake-Inhalation of Dust-95% UCI []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	4.15E-07	4.47E-07	8.48E-08
Arsenic	1.02E-07	1.11E-07	2.10E-08
Beryllium	3.71E-08	4.00E-08	7.58E-09
Cadmium	5.81E-07	6.27E-07	1.19E-07
Chromium	3.09E-07	3.33E-07	6.32E-08
Copper	1.15E-05	1.24E-05	2.35E-06
Lead	2.01E-06	2.17E-06	4.12E-07
Nickel	2.43E-07	2.62E-07	4.97E-08
Zinc	7.96E-06	8.58E-06	1.63E-06

Chronic Daily Intake-Inhalation of Dust-Maximum []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	1.23E-05	2.65E-06	6.01E-07
Arsenic	3.75E-06	8.08E-07	1.84E-07
Beryllium	7.08E-07	1.53E-07	3.47E-08
Cadmium	1.24E-04	2.68E-05	6.09E-06
Chromium	1.28E-05	2.76E-06	6.26E-07
Copper	2.62E-03	5.64E-04	1.28E-04
Lead	3.30E-04	7.11E-05	1.62E-05
Nickel	9.52E-06	2.05E-06	4.66E-07
Zinc	1.20E-03	2.59E-04	5.88E-05

Chronic Daily Intake-Inhalation of Dust-Maximum []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	1.05E-06	1.13E-06	2.15E-07
Arsenic	3.21E-07	3.47E-07	6.57E-08
Beryllium	6.07E-08	6.55E-08	1.24E-08
Cadmium	1.07E-05	1.15E-05	2.18E-06
Chromium	1.10E-06	1.18E-06	2.24E-07
Copper	2.24E-04	2.42E-04	4.59E-05
Lead	2.83E-05	3.05E-05	5.79E-06
Nickel	8.16E-07	8.80E-07	1.67E-07
Zinc	1.03E-04	1.11E-04	2.11E-05

Risk Characterization-Incidental Ingestion of Soil-95% UCI []

Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	2.1E+00	2.2E-01	7.7E-02
Arsenic	6.9E-01	7.4E-02	2.5E-02
Beryllium	1.5E-02	1.6E-03	5.5E-04
Cadmium	1.2E+00	1.3E-01	4.3E-02
Chromium	1.2E-01	1.3E-02	4.6E-03
Copper	5.8E-01	6.2E-02	2.1E-02
Lead			
Nickel	2.5E-02	2.6E-03	9.0E-04
Zinc	8.0E-02	8.6E-03	2.9E-03
TOTAL HI	4.78	0.51	0.18

Risk Characterization-Incidental Ingestion of Soil-95% UCI []

Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	3.1E-05	1.7E-05	4.7E-06
Beryllium	2.8E-05	1.5E-05	4.2E-06
Cadmium	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	5.9E-05	3.1E-05	9.0E-06

Risk Characterization-Incidental Ingestion of Soil-Maximum []

Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	5.3E+00	5.7E-01	1.9E-01
Arsenic	2.2E+00	2.3E-01	7.9E-02
Beryllium	2.5E-02	2.6E-03	9.0E-04
Cadmium	2.2E+01	2.3E+00	7.9E-01
Chromium	4.4E-01	4.7E-02	1.6E-02
Copper	1.1E+01	1.2E+00	4.2E-01
Lead			
Nickel	8.2E-02	8.8E-03	3.0E-03
Zinc	1.0E+00	1.1E-01	3.8E-02
TOTAL HI	41.93	4.49	1.54

Risk Characterization-Incidental Ingestion of Soil-Maximum []

Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	9.7E-05	5.2E-05	1.5E-05
Beryllium	4.5E-05	2.4E-05	6.9E-06
Cadmium	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	1.4E-04	7.6E-05	2.2E-05

Risk Characterization-Dermal Contact with Soil-95% UCI []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	7.8E-01	4.1E-01	2.7E-02
Arsenic	2.6E-01	1.3E-01	8.8E-03
Beryllium	5.6E-03	2.9E-03	1.9E-04
Cadmium	4.4E-01	2.3E-01	1.5E-02
Chromium	4.7E-02	2.4E-02	1.6E-03
Copper	2.2E-01	1.1E-01	7.4E-03
Lead			
Nickel	9.2E-03	4.8E-03	3.1E-04
Zinc	3.0E-02	1.6E-02	1.0E-03
TOTAL HI	1.78	0.93	0.06

Risk Characterization-Dermal Contact with Soil-95% UCI []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	1.2E-05	3.0E-05	1.6E-06
Beryllium	1.0E-05	2.7E-05	1.5E-06
Cadmium	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	2.2E-05	5.7E-05	3.1E-06

Risk Characterization-Dermal Contact with Soil-Maximum []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	2.0E+00	1.0E+00	6.7E-02
Arsenic	8.1E-01	4.2E-01	2.7E-02
Beryllium	9.1E-03	4.8E-03	3.1E-04
Cadmium	8.0E+00	4.2E+00	2.7E-01
Chromium	1.7E-01	8.6E-02	5.6E-03
Copper	4.2E+00	2.2E+00	1.4E-01
Lead			
Nickel	3.1E-02	1.6E-02	1.0E-03
Zinc	3.9E-01	2.0E-01	1.3E-02
TOTAL HI	15.64	8.17	0.53

Risk Characterization-Dermal Contact with Soil-Maximum []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	3.6E-05	9.5E-05	5.2E-06
Beryllium	1.7E-05	4.4E-05	2.4E-06
Cadmium	0.0E+00	0.0E+00	0.0E+00
Chromium	0.0E+00	0.0E+00	0.0E+00
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	0.0E+00	0.0E+00	0.0E+00
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	5.3E-05	1.4E-04	7.5E-06

Risk Characterization-Inhalation of Dust-95% UCI []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony			
Arsenic			
Beryllium			
Cadmium			
Chromium	6.0E+00	1.3E+00	2.9E-01
Copper			
Lead			
Nickel			
Zinc			
TOTAL HI	6.01	1.29	0.29

Risk Characterization-Inhalation of Dust-95% UCI []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	5.1E-06	5.5E-06	1.0E-06
Beryllium	3.1E-07	3.4E-07	6.4E-08
Cadmium	3.5E-06	3.8E-06	7.3E-07
Chromium	1.3E-05	1.4E-05	2.6E-06
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	2.0E-07	2.2E-07	4.2E-08
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	2.2E-05	2.4E-05	4.5E-06

Risk Characterization-Inhalation of Dust-Maximum []
Non-carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony			
Arsenic			
Beryllium			
Cadmium			
Chromium	2.1E+01	4.6E+00	1.0E+00
Copper			
Lead			
Nickel			
Zinc			
TOTAL HI	21.30	4.59	1.04

Risk Characterization-Inhalation of Dust-Maximum []
Carcinogenic

	Res. Child	Res. Adult	Ind/Com
Antimony	0.0E+00	0.0E+00	0.0E+00
Arsenic	1.6E-05	1.7E-05	3.3E-06
Beryllium	5.1E-07	5.5E-07	1.0E-07
Cadmium	6.5E-05	7.0E-05	1.3E-05
Chromium	4.5E-05	4.8E-05	9.2E-06
Copper	0.0E+00	0.0E+00	0.0E+00
Lead	0.0E+00	0.0E+00	0.0E+00
Nickel	6.9E-07	7.4E-07	1.4E-07
Zinc	0.0E+00	0.0E+00	0.0E+00
TOTAL RISK	1.3E-04	1.4E-04	2.6E-05