Crow's Nest Munitions Response Site
Remedial Investigation
Human Health Risk Assessment
West Point Military Reservation, West Point, NY

Prepared for

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ALM	Adult Lead Methodology
Am	Amino
AT	Averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BG	Background
BKSF	Biokinetic slope factor
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COPC	Contaminant of Potential Concern
CSM	Conceptual Site Model
DNT	Dinitrotoluene
DU	decision unit
EF	exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
GSD	Geometric standard deviation
HHRA	Human Health Risk Assessment
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IR_s	soil ingestion rate
MC	munition constituent
MDC	maximum detected concentration
µg/dL	micrograms per deciliter
mg/kg	milligrams per kilogram
NA	not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
Pb	lead
PbB	lead blood concentration
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
RSL	regional screening level
SD	standard deviation
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan

The human health risk assessment (HHRA) addresses the soil and sediment incremental sampling results collected in November 2015 at the Crow's Nest Munitions Response Site (MRS)". U.S. Environmental Protection Agency (EPA) regional screening levels that are protective of a residential scenario were used to screen the soil and sediment data. The risk-based screening results identified lead as the primary soil and sediment Contaminant of potential concern (COPC) at decision units (DU) -01 and DU-02, respectively. Explosives were eliminated from further evaluation. The risk-based screening results and background evaluation eliminated DU-03 from further evaluation.

EPA's Adult Lead Methodology (ALM) model (version date 6/21/09) was used to estimate risk from exposure to lead in soil at DU-01 and sediment at DU-02. In accordance with 2003 EPA guidance, the mean concentration of lead was used as the exposure point concentration for DU-01 (690.8 milligrams per kilogram [mg/kg]) and DU-02 (3,433 mg/kg). The following non-residential exposure scenarios were evaluated:

- Current and future installation personnel and contractor
- Current and future relic hunter and trespasser
- Future recreational wild game hunter and hiker
- Future recreational camper

EPA's target threshold for lead is to limit the risk to no more than a 5 percent chance fetuses exposed to lead would exceed a lead blood concentration (PbB) of 10 micrograms per deciliter (µg/dL) (EPA, 2010). The ALM results for all scenarios were below the target PbB and probability thresholds. The HHRA indicates that there is minimal risk to human receptors if the MRS is converted to recreational use.

SECTION ONE: INTRODUCTION

The human health risk assessment (HHRA) was prepared pursuant to the U.S. Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS), Part A (EPA, 1989) and subsequent RAGS guidance (Parts B through F). A risk assessment can be a qualitative or quantitative process that characterizes site conditions and determines applicable risk to human health and the environment, based on potential exposure scenarios. This Section describes the purpose of the HHRA and the report's organization.

1.1 PURPOSE OF THE REPORT

The HHRA addresses potential human exposure to any munitions constituents (MC) detected at the Crow's Nest Munitions Response Site (MRS). The HHRA addresses soil and sediment data collected by incremental methods only.

The HHRA is part of the Remedial Investigation (RI) report that is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by Title 42 of the United States Code Sections 9601 through 9675.

1.2 REPORT ORGANIZATION

The HHRA report consists of the following Sections:

- Section 2.0 - Data Handling and Evaluation
- Section 3.0 - Identification of Constituents of Potential Concern (COPCs)
- Section 4.0 - Exposure Assessment
- Section 5.0 - Toxicity Assessment
- Section 6.0 - Risk Characterization
- Section 7.0 - Uncertainty Assessment
- Section 8.0 - HHRA Conclusions
- Section 9.0 - References

SECTION TWO: DATA HANDLING AND EVALUATION

In November 2015, incremental samples were collected and analyzed for the Target list of explosives and lead. The HHRA addresses the incremental soil sampling results from Decision Units (DU)-01 and DU -03 as well as the incremental sediment sampling results of DU-02. DU-02 is primarily a heavily vegetated wetlands area; DU-01 and DU-03 are also heavily vegetated, but are more easily accessed via trails and roadways.

The incremental sampling results from background sediment (WPIS00SA01-03) and soil (WPIS00SB01-03) are also used as lines of evidence in the risk characterization discussion. The HHRA does not address soil discrete sampling results collected within DU-01; these results are used in the RI for specific MRS characterization purposes.

Table 2-1 presents the summary statistics for the incremental sample results. Tables 4-3 through 4-6 in of the RI present the incremental soil and sediment sample results for DU-01, DU-02, DU-03, and background soil and sediment analysis that are addressed in the HHRA. All results were used in the HHRA, including those flagged during data validation. No rejected ("R"-flag) data were identified during data validation. Flagged results are further discussed in the Uncertainty Assessment Section of the HHRA.

Table 2-1: Incremental Sampling Summary Statistics

Constituent	CAS No	Number of Detects	Number of Sample Points	Method Detection Limit Range (mg/kg)	Limit of Quantitation Range (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Maximum Sample Location	Mean (mg/kg)	Standard Deviation
Decision Unit 1 (DU-01)										
Lead	7439-92-1	33	33	0.008-0.03	0.11-0.43	113	2220	WPIS01SI03	690.8	576.4
2-Am-DNT	35572-78-2	1	33	0.018-0.023	0.084-0.11	0.034	0.034	WPIS01SK01	0.034	na
2,4-Dinitrotoluene	121-14-2	1	33	0.012-0.016	0.084-0.11	0.041	0.041	WPIS01SK01	0.041	na
2,6-Dinitrotoluene	606-20-2	0	33	0.023-0.029	0.084-0.11	na	na	na	na	na
2,4,6-Trinitrotoluene	118-96-7	5	33	0.0056-0.0072	0.084-0.11	0.0074	0.084	WPIS01SK03	0.0319	0.0306
4-Am-DNT	19406-51-0	6	33	0.014-0.018	0.084-0.11	0.031	0.12	WPIS01SK02	0.0798	0.0318
Decision Unit 2 (DU-02)										
Lead	7439-92-1	0	3	0.043-0.09	0.62-1.3	2250	4470	WPIS02SA01	3433	1117
Decision Unit 3 (DU-03)										
Lead	7439-92-1	6	6	0.0056-0.012	0.08-0.18	64.1	90.6	WPIS03SB03	73.73	9.516
2-Am-DNT	35572-78-2	0	6	0.017-0.022	0.08-0.1	na	na	na	na	na
2,4-Dinitrotoluene	121-14-2	0	6	0.012-0.015	0.08-0.1	na	na	na	na	na
2,6-Dinitrotoluene	606-20-2	0	6	0.022-0.028	0.08-0.1	na	na	na	na	na
2,4,6-Trinitrotoluene	118-96-7	0	6	0.0054-0.0069	0.08-0.1	na	na	na	na	na
4-Am-DNT	19406-51-0	0	6	0.014-0.017	0.08-0.1	na	na	na	na	na
Background Sediment										
Lead	7439-92-1	0	3	0.0062-0.0076	0.089-0.11	68.4	78.6	WPIS00SA02	74.53	5.405
Background Soil										
Lead	7439-92-1	3	3	0.011-0.014	0.15-0.2	77.1	92.4	WPIS00SB03	86.7	8.362
2-Am-DNT	35572-78-2	0	3	0.019-0.022	0.092-0.1	na	na	na	na	na

Constituent	CAS No	Number of Detects	Number of Sample Points	Method Detection Limit Range (mg/kg)	Limit of Quantitation Range (mg/kg)	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Maximum Sample Location	Mean (mg/kg)	Standard Deviation
2,4-Dinitrotoluene	121-14-2	0	3	0.014-0.016	0.092-0.1	na	na	na	na	na
2,6-Dinitrotoluene	606-20-2	0	3	0.025-0.028	0.092-0.1	na	na	na	na	na
2,4,6-Trinitrotoluene	118-96-7	0	3	0.0062-0.007	0.092-0.1	na	na	na	na	na
4-Am-DNT	19406-51-0	0	3	0.016-0.018	0.092-0.1	na	na	na	na	na

Notes:
- = no value; Am=amino; BG=background; COPC=constituent of potential concern; DNT=dinitrotoluene; DU=decision unit; mg/kg=milligrams per kilogram;
na = not applicable

SECTION THREE: IDENTIFICATION OF CONSTITUENTS OF POTENTIAL CONCERN

Identifying the constituents of potential concern (COPC) at the MRS is a critical step in the risk assessment process. Screening criteria, such as those used in this HHRA, serve to focus the HHRA on COPCs that have the potential to significantly contribute to the calculated risks. Constituents that cannot be eliminated by screening are identified as COPC and are then quantitatively evaluated in the HHRA. This Section describes the risk-based screening as well as the background and lead evaluations conducted to identify COPCs at the MRS.

3.1 RISK-BASED SCREENING RESULTS

Table 3-1 presents the maximum detected concentrations (MDCs) in soil and sediment that were compared to the EPA's residential soil regional screening levels (RSLs). The residential soil RSLs are protective of a target cancer risk of 1×10^{-6} and a hazard quotient (HQ) of 0.1 (EPA, 2015). Residential RSLs were selected for the risk-based screening because they are protective of any type of public receptors that may access the MRS. If a constituent's MDC exceeded the residential soil RSL, then it was carried forward as a COPC in the HHRA.

The risk-based screening results in Table 3-1 indicate that explosives were eliminated from further evaluation for all the DUs. However, lead was identified as a soil COPC at DU-01 and DU-02.

Table 3-1: Human Health Risk-Base Screening Results

Detected Constituent	CAS No	Maximum Detection (mg/kg)	Maximum Sample Location	EPA Residential Soil RSL(1) (mg/kg)	COPC? (Yes/No)	Lead Mean (mg/kg)	Mean Exceeds Action Level?
Decision Unit 1 (DU-01)							
Lead	7439-92-1	2220	WPIS01SI03	400	Yes	690.8	Yes
2-Am-DNT	35572-78-2	0.034	WPIS01SK01	15	no	-	-
2,4-Dinitrotoluene	121-14-2	0.041	WPIS01SK01	1.7	no	-	-
2,4,6-Trinitrotoluene	118-96-7	0.084	WPIS01SK03	3.6	no	-	-
4-Am-DNT	19406-51-0	0.12	WPIS01SK02	15	no	-	-
Decision Unit 2 (DU-02)							
Lead	7439-92-1	4470	WPIS02SA01	400	Yes	3433	Yes
Decision Unit 3 (DU-03)							
Lead	7439-92-1	90.6	WPIS03SB03	400	no	-	-
Background Sediment							
Lead	7439-92-1	78.6	WPIS00SA02	400	no	-	-
Background Soil							
Lead	7439-92-1	92.4	WPIS00SB03	400	no	-	-

Notes:
- = no value; Am = amino; BG = background; COPC = constituent of potential concern; DNT = dinitrotoluene; DU = decision unit; mg/kg = milligrams per kilogram; RSL = regional screening level
(1) EPA, 2015. Residential Soil Regional Screening Level (RSL) Table, Dated November 2015. Protective of a target cancer risk of 1×10^{-6} and hazard quotient of 0.1.

3.2 BACKGROUND EVALUATION

RI field activities collected incremental samples from two background locations: WPIS00SA01-03 (sediment) and WPIS00SB01-03 (soil). The background incremental sampling results are used to distinguish lead concentrations related to past munitions use at the MRS from those that are naturally occurring at the MRS. When the MDC and the calculated mean concentration are close values, it indicates that the high number of increments collected for each replicate produced a homogeneous aliquot and is a representative concentration. As shown below in Table 3-2, the background sampling units have representative concentrations.

Table 3-2: Background Lead Results

Background Sample	Lead MDC (mg/kg)	Lead Mean (mg/kg)
WPIS00SA01 (Sediment)	78.6	74.53
WPIS00SB01 (Soil)	92.4	86.7

Explosives were also analyzed in background soil, but no detections were identified. Detections of explosives are considered MRS-related concentrations and are not attributed to organic anthropogenic concentrations.

The soil MDC and mean concentrations of DU-01 and DU-03 are compared with the corresponding concentrations of background soil to determine whether lead concentrations are likely associated with MC releases or attributed to background in Table 3-3.

Table 3-3: Site to Background Lead in Soil Comparison

Decision Unit	Lead MDC (mg/kg)	Lead Mean (mg/kg)	Background Soil Lead MDC (mg/kg)	Background Soil Lead Mean (mg/kg)
DU-01	2,220	690.8	92.4	86.7
DU-03	90.6	73.73		

The DU-01 concentrations of lead are higher than the background soil lead concentrations indicating that site-related activities have contributed to lead concentrations at the DU. DU-03 lead concentrations are similar to the background soil concentrations indicating that the presence of lead at DU-03 may be attributed to background.

For DU-02, the sediment MDC and mean concentrations for lead are higher than the sediment MDC and mean concentrations for background sediment (Table 3-4). The lead concentrations at DU-02 are likely attributed to a MC release rather than background.

Table 3-4: Site to Background Lead in Sediment Comparison

Decision Unit	Lead MDC (mg/kg)	Lead Mean (mg/kg)	Background Sediment Lead MDC (mg/kg)	Background Sediment Lead Mean (mg/kg)
DU-02	4,470	3,433	78.6	74.53

Lead is carried forward as a COPC at DU-01 and DU-02 following the background evaluation.

3.3 LEAD EVALUATION

Because most human health effects data for lead are correlated with concentrations in the blood rather than an external dose, the standard cancer risk and non-cancer hazard approach for evaluating health effects cannot be applied to lead. Lead's residential soil RSL of 400 mg/kg was derived using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (IEUBKwin v1.1 build 11).

The IEUBK model predicts the chance that a typical child (ages 0 to 6 years) would have a lead blood concentration (PbB) exceeding 10 micrograms per deciliter (µg/dL) from background sources (e.g., diet, lead-based paint, drinking water, and indoor dust) as well as an exposure to lead related to the MRS. If all default parameters are used to run the IEUBK model, it produces a soil action level of 400 milligrams per kilogram (mg/kg) which EPA has adopted as lead's residential soil RSL (EPA, 2015).

EPA (2010) guidance recommends using the mean concentration for estimating risk from exposure to lead; as shown in Table 3-1, the mean concentrations for lead at DU-01 and DU-02 still exceed the 400 mg/kg action level. Lead is carried forward as a COPC for DU-01 and DU-02 for MRS-specific lead modeling.

SECTION FOUR: EXPOSURE ASSESSMENT

The Exposure Assessment presents the mechanisms by which human receptors may come into contact with medium-specific COPCs and the magnitude, frequency, and duration of these exposures. This Section describes the potentially exposed human populations, the MRS-specific lead modeling parameters, and the exposure point concentrations (EPCs) used to estimate risk.

4.1 POTENTIALLY EXPOSED POPULATIONS

The HHRA MC conceptual site model (CSM) (Figure 4-1) identifies the following current/future exposed populations or scenarios for the MRS: Installation personnel and contractors, and the public (e.g., trespassers, relic hunters, wild game hunters, hikers, and campers).

The Installation personnel and contractors, and the public receptors are assumed to be exposed to the following soil-related exposure pathways: incidental ingestion, dermal contact, and inhalation of vapors and/or wind-blown particulates from soil. For DU-02, incidental ingestion and dermal contact with sediment are the primary exposure pathways since wet conditions reduce the likelihood of wind-blown vapors and/or particulates.

The current and future Installation personnel and contractors are adults who visit the MRS periodically to conduct outdoor inspections, maintenance activities, and/or environmental studies. The current and future trespasser and relic hunter are likely to be adults and/or teens who dig up relics or play at the MRS.

The future wild game hunter and hiker are likely to be an older teen or adult who like to go hunting or hiking at the MRS. The wild game food consumption pathway for the hunter scenario is not quantitatively evaluated because biomagnification of lead is not expected to occur with terrestrial food chains (Agency for Toxic Substances and Disease Registry [ATSDR], 2007). As noted earlier, lead is the primary soil COPC for this MRS. Also, a future recreational camper is evaluated; he/she is a teen or an adult that spends his/her family vacation camping at the MRS.

It is assumed that a young child (less than 6 years old) is unlikely to frequently visit the MRS due to its heavy vegetation and steep slopes; therefore EPA's IEUBK model will not be used in the HHRA. Instead, EPA's adult lead methodology (ALM) (version date 6/21/09) is used to assess lead exposure to the teen and adult receptors at the MRS (EPA, 2009).

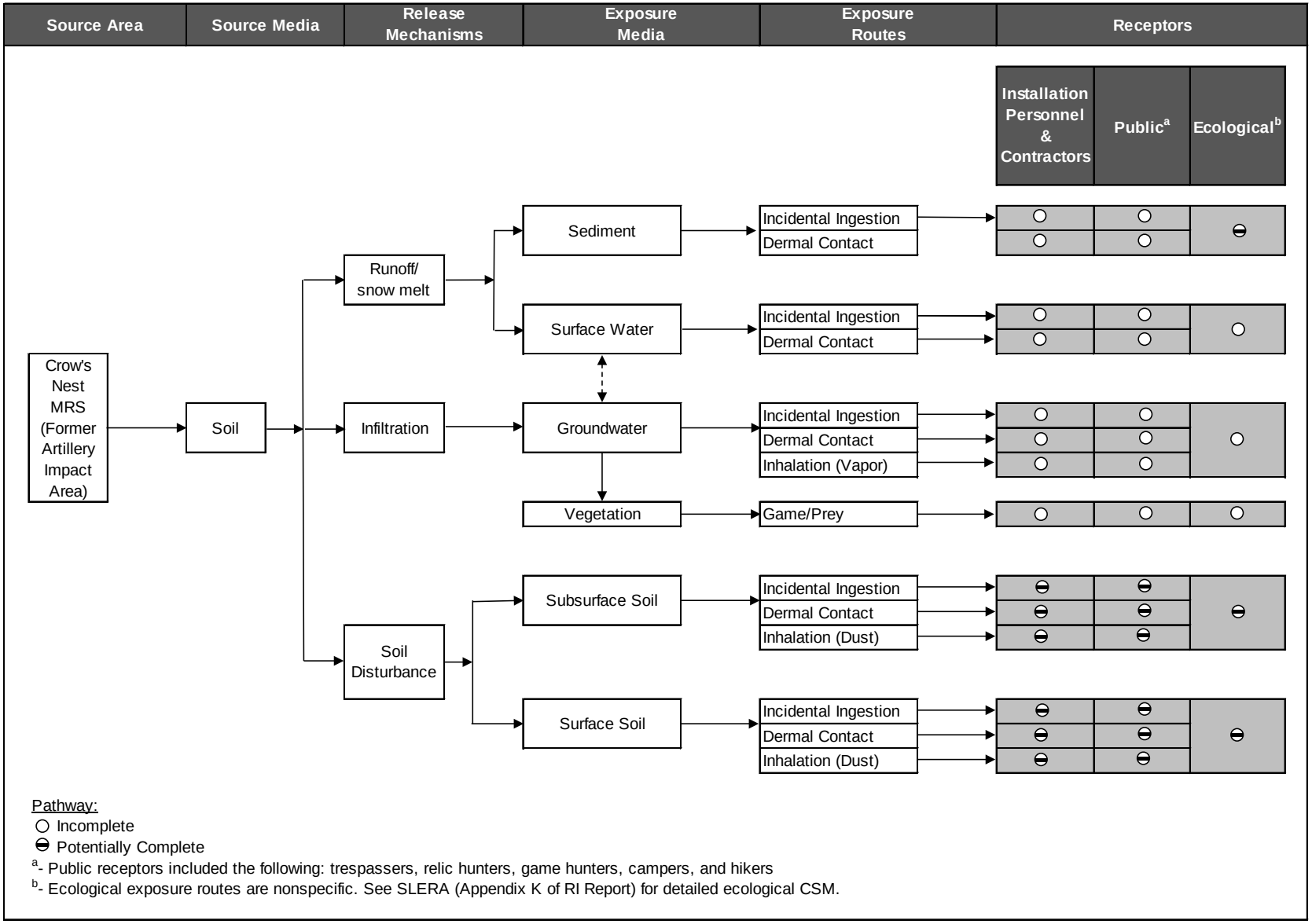

Figure 4-1: MC Exposure Pathway Analysis

4.2 LEAD EXPOSURE PARAMETERS

Table 4-1 presents the model input parameters used to run the ALM. The ALM predicts the chance that a fetus of a pregnant female worker would have a PbB exceeding 10 µg/dL. The protection of a fetus is considered protective of any male or female adult workers and/or recreational receptors at the MRS.

The Centers for Disease Control and Prevention (CDC) estimates that about a half million US children (ages 1-5) have blood lead levels above 5 µg/dL; CDC has adopted a PbB threshold of 5µg/dL or lower to be protective of children (CDC, 2015). The new toxicity information for lead however has not been incorporated into any EPA methodologies for evaluating the exposure of children or adults to lead (EPA, 2006 and 2010). The HHRA uses the existing EPA PbB threshold of 10 µg/dL (EPA, 2010).

ALM default values were used for the general parameters (Table 4-1). The ALM guidance recommends using central tendency values for soil ingestion and exposure frequency (EPA, 2010). The receptor-specific model parameters are described in further detail below.

Installation Personnel and/or Contractor: Installation personnel and contractor represent current and future outdoor worker exposure scenarios at the MRS. These workers visit the MRS roughly once a month to inspect it or collect environmental samples. A central tendency soil ingestion rate (IR_s) of 0.05 grams/day is used for the adult workers (EPA, 2011); it is also the ALM default value (EPA, 2009). A minimum exposure frequency for soil and dust exposure ($EF_{S,D}$) of 13 days per year is used; three months is considered to be the model's minimum exposure to produce a quasi-steady-state PbB concentration (EPA, 2003). The EF is calculated using the following equation:

$EF_{S,D}$ (days/year) = 1 day/week x 4.3 weeks/month x 3 months/year

EPA (2003) guidance recommends that the averaging time ($AT_{S,D}$) not be annualized for intermittent exposure scenarios so that a quasi-steady state PbB concentration (minimum of 3 months) can be achieved. A determination must be made whether the duration of exposure could reasonably produce a body burden of lead that would result in an adverse health effect. The $AT_{S,D}$ is calculated for a shorter-term exposure duration using the following equation:

$AT_{S,D}$ (days/year) = 7 days/week x 4.3 weeks/month x 3 months/year

In the model's EF/AT relationship, the conversion factors of 4.3 weeks/month and 3 months/year drop out of the calculation resulting in an $EF_{S,D}$ of 1 day/year and an $AT_{S,D}$ of 7 days/year. The risk calculation for the installation personnel and/or contractor would be based on 1 day of exposure out of 7 days as if the exposure occurred for the entire year and ignores the effect of the 5 months of the year when MRS exposure does not occur.

Relic Hunter and/or Trespasser: The relic hunter and trespasser represent current and future trespasser scenarios at the MRS. Because these receptors are likely to engage in more intense soil contact-related activities (e.g., digging for relics, playing, etc.), a higher central tendency IR_s of 0.1 grams/day is used (EPA, 2011). The relic hunter or trespasser is likely to visit the MRS on intermittent days during the warmer months. Using the same $EF_{S,D}$ and $AT_{S,D}$ equations provided above:

$EF_{S,D}$ (days/year) = 1 day/week x 4.3 weeks/month x 6 months/year = 26 days/year

$AT_{S,D}$ (days/year) = 7 days/week x 4.3 weeks/month x 6 months/year = 181 days/year

The model's EF/AT relationship is converted into an $EF_{S,D}$ of 1 day/year and an $AT_{S,D}$ of 7 days/year when the similar conversion factors are eliminated.

Table 4-1: Adult Lead Methodology Model Parameters

Variable	Description of Variable	Units	Model Input Values	Notes
General Parameters				
PbS	Lead exposure point concentration (mean)	mg/kg	DU-01 = 690.8 DU-02 = 3433	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal lead blood (PbB) ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB concentration	µg/dL	1.0	EPA, 2009
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
PbBt	Target PbB level of concern	µg/dL	10	EPA, 2010
Receptor-Specific Parameters				
$IR_{S, D}$	**Soil ingestion rate (including soil-derived indoor dust)**			
	Installation Personnel and Contractor (adult)	grams/day	0.05	EPA, 2011
	Relic Hunter and Trespasser (teen/adult)	grams/day	0.1	EPA, 2011
	Wild Game Hunter and Hiker (adult)	grams/day	0.05	EPA, 2011
	Camper (teen/adult)	grams/day	0.1	EPA, 2011
$EF_{S, D}$	**Exposure frequency (same for soil and dust)**			
	Installation Personnel and Contractor (adult)	days/year	1	a
	Relic Hunter and Trespasser (teen/adult)	days/year	1	b
	Wild Game Hunter and Hiker (adult)	days/year	2	c
	Camper (teen/adult)	days/year	14	d
$AT_{S, D}$	**Averaging time (same for soil and dust)**			
	Installation Personnel and Contractor (adult)	days/year	7	e
	Relic Hunter and Trespasser (teen/adult)	days/year	7	f
	Wild Game Hunter and Hiker (adult)	days/year	7	g
	Camper (teen/adult)	days/year	365	h

Notes:
ALM = Adult Lead Methodology; B = blood; EPA = U.S. Environmental Protection Agency; DU = decision unit; µg/day = micrograms per day; µg/dL = micrograms per deciliter; mg/kg = milligrams per kilogram; Pb = lead

EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.

a. Minimum exposure frequency of 1 day/week x 4.3 months x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 1 day/year.
b. Intermittent exposure frequency is 1 day/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 1 day/year.
c. Intermittent exposure frequency is 2 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 1 day/year.
d. Receptor spends his/her annual 2-week vacation time (14 days/year) camping.
e. Minimum averaging time of 7 days/week x 4.3 weeks/month x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 7 days/year.
f. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 7 days/year.
g. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 7 days/year.
h. The annual vacation time represents consecutive days of exposure. The averaging time is normalized over the year (365 days/year).

Wild Game Hunter and/or Hiker: The wild game hunter and hiker represent future recreational exposure scenarios at the MRS. A central tendency IRs of 0.05 grams/day is used (EPA, 2011). As noted earlier, the consumption of wild game exposure pathway for the future hunter is not quantitatively evaluated because lead is not likely to biomagnify in terrestrial food chains (ATSDR, 2007).

The 2015-2016 West Point Hunting Season (http://www.westpointmwr.com/outdoor/daily_bag_limit.pdf) indicates that hunting seasons can last roughly a week to 7 months long. Conservatively, it is assumed that this receptor spends his/her weekends either hunting or hiking at the MRS; an EF of 60 days per year for 7 months out of the year is assumed.

$EF_{S,D}$ (days/year) = 2 day/week x 4.3 weeks/month x 7 months/year = 60 days/year

$AT_{S,D}$ (days/year) = 7 days/week x 4.3 weeks/month x 7 months/year = 211 days/year

The model's EF/AT relationship is converted into an $EF_{S,D}$ of 2 days/year and an $AT_{S,D}$ of 7 days/year when the similar conversion factors are eliminated.

Camper: The camper represents a future recreational exposure scenario at the MRS. The camper is likely to be a teen or an adult that engages in some intensive soil contact-related activities (e.g., digging fire pits or bathroom trenches). For conservatism, a central tendency IRs of 0.1 grams/day is used (EPA, 2011). It is assumed that the camper spends his/her annual 2-week vacation time camping at the MRS. Since the exposure consists of consecutive days of exposure and is not intermittent, an $EF_{S,D}$ of 14 days/year and an $AT_{S,D}$ of 365 days/year are used.

4.3 EXPOSURE POINT CONCENTRATION

EPA guidance recommends using the mean concentration as the EPC for lead modeling (EPA, 2010). Table 4-1 presents the mean concentrations used to evaluate exposure to lead at DU-01 and DU-02. Microsoft® Office Excel was used as the calculation tool to derive the mean concentrations.

SECTION FIVE: TOXICITY ASSESSMENT

Toxicity assessments provide the basis for evaluating what is acceptable exposure and what level of exposure may adversely affect human health. A toxicity assessment involves

- Determining whether exposures to a constituent can increase the incidence of a specific adverse effect (e.g., cancer, kidney damage) in humans
- Characterizing the nature and strength of evidence of causation
- Quantifying the relationship between the dose of the constituent and the incidence of adverse health effects in the exposed population

The increase in PbBs at the MRS for each receptor is estimated using a linear biokinetic slope factor (BKSF). EPA guidance recommends using a BKSF of 0.4 µg/dL per µg/day for the ALM (EPA, 2003). The estimated lead uptake is multiplied by the BKSF to determine the MRS related increase in PbBs for each receptor.

SECTION SIX: RISK CHARACTERIZATION

Risk characterization summarizes the nature and magnitude of the potential for occurrence of adverse health effects under a specific set of conditions. The Exposure Assessment and the Toxicity Assessment are integrated into quantitative estimates of health risks to potential receptors.

The ALM model uses the exposure parameter described in the Exposure Assessment (Section 4.0) to estimate lead uptake which is multiplied by the BKSF presented in the Toxicity Assessment (Section 5.0) to estimate risk from exposure to lead for each receptor.

EPA's target threshold for lead is to limit the risk to no more than a 5 percent chance fetuses exposed to lead would exceed a PbB of 10 µg/dL (EPA, 2010). Table 6-1 summarizes the ALM results for DU-01 and DU-02. Tables 6-2 through 6-9 present the ALM model runs for each receptor at DU-01 and DU-02.

The ALM results for all scenarios at DU-01 and DU-02 are below EPA's target PbB for the fetus threshold of 10 µg/dL and the probability threshold of 5 percent.

Table 6-1: Summary of the Adult Lead Methodology Results

Receptor	Receptor PbB Geometric Mean PbB_{adult} (µg/dL)	95th Percentile PbB among Fetuses of Adult Receptor $PbB_{fetal, 0.95}$ (µg/dL)	Target PbB Level of Concern [(1)] PbB_t (µg/dL)	Probability that fetal PbB > PbBt, assuming lognormal distribution $P(PbB_{fetal} > PbB_t)$ (%)	Probability Threshold of Concern [(1)] (%)
Decision Unit 1 (DU-01)					
Installation Personnel and Contractor (adult)	1.2	2.9	10	0.009	5
Relic Hunter and Trespasser (teen/adult)	1.5	3.5	10	0.03	5
Wild Game Hunter and Hiker (adult)	1.5	3.5	10	0.03	5
Camper (teen/adult)	1.1	2.7	10	0.005	5
Decision Unit 1 (DU-02)					
Installation Personnel and Contractor (adult)	2.2	5.2	10	0.3	5
Relic Hunter and Trespasser (teen/adult)	3.4	7.9	10	2	5
Wild Game Hunter and Hiker (adult)	3.4	7.9	10	2	5
Camper (teen/adult)	1.6	3.9	10	0.06	5

Notes:
ALM = Adult Lead Methodology; EPA = U.S. Environmental Protection Agency; DU = decision unit; µg/dL = micrograms per deciliter;
PbB = lead blood concentration
(1) EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.

Table 6-2: Adult Lead Methodology Model Run Installation Personnel and Contractor at Decision Unit 01

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	690.8	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**1.2**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.9	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	EPA, 2010
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.009%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Minimum intermittent exposure frequency of 1 day/week x 4.3 months x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 1 day/year.
b. Minimum intermittent averaging time of 7 days/week x 4.3 weeks/month x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 7 days/year.

Table 6-3: Adult Lead Methodology Model Run Relic Hunter and Trespasser at Decision Unit 01

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	690.8	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.1	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**1.5**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	3.5	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	EPA, 2010
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.03%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Intermittent exposure frequency is 1 day/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 1 day/year.
b. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 7 days/year.

Table 6-4: Adult Lead Methodology Model Run Wild Game Hunter and Hiker at Decision Unit 01

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	690.8	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	2	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**1.5**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	3.5	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	See text
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.03%**	PASS

Notes:
Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Intermittent exposure frequency is 2 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 1 day/year.
b. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 7 days/year.

Table 6-5: Adult Lead Methodology Model Run Camper at Decision Unit 01

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	690.8	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.1	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	14	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**1.1**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	2.7	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	See text
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.005%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Receptor spends his/her annual 2-week vacation time (14 days/year) camping.
b.The annual vacation time represents consecutive days of exposure. The averaging time is normalized over the year (365 days/year).

Table 6-6: Adult Lead Methodology Model Run Installation Personnel and Contractor at Decision Unit 02

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	3433	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**2.2**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	5.2	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	See text
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.3%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Minimum intermittent exposure frequency of 1 day/week x 4.3 months x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 1 day/year.
b. Minimum intermittent averaging time of 7 days/week x 4.3 weeks/month x 3 months/year (EPA, 2003). The EF/AT relationship conversion is 7 days/year.

Table 6-7: Adult Lead Methodology Model Run Relic Hunter and Trespasser at Decision Unit 02

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	3433	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.1	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	1	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**3.4**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	7.9	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	EPA, 2010
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**2%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Intermittent exposure frequency is 1 day/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 1 day/year.
b. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 6 months/year. The EF/AT relationship conversion is 7 days/year.

Table 6-8: Adult Lead Methodology Model Run Wild Game Hunter and Hiker at Decision Unit 02

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	3433	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.05	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	2	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	7	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**3.4**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	7.9	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	EPA, 2010
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**2%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Intermittent exposure frequency is 2 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 1 day/year.
b. Intermittent averaging time is 7 days/week x 4.3 weeks/month x 7 months/year. The EF/AT relationship conversion is 7 days/year.

Table 6-9: Adult Lead Methodology Model Run Camper at Decision Unit 02

Variable	Description of Variable	Units	Lead Model Value	Notes
PbS	Soil lead concentration	µg/g or ppm	3433	DU-Specific
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	unitless	0.9	EPA, 2003
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	EPA, 2003
GSD_i	Geometric standard deviation PbB	unitless	1.8	EPA, 2009
PbB_0	Baseline PbB	µg/dL	1.0	EPA, 2009
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.10	EPA, 2011
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	NA	NA
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	unitless	NA	NA
K_{SD}	Mass fraction of soil in dust	unitless	NA	NA
$AF_{S, D}$	Absorption fraction (same for soil and dust)	unitless	0.12	EPA, 2003
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	14	a
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	b
PbB_{adult}	**PbB of receptor, geometric mean**	**µg/dL**	**1.6**	Calculated
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	3.9	Calculated
PbB_t	Target PbB level of concern (e.g., 10 ug/dL)	µg/dL	**10**	EPA, 2010
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbB_t, assuming lognormal distribution**	**%**	**0.06%**	PASS

Notes:
DU = Decision Unit; NA = not applicable; PASS = below target threshold of 5%
EPA, 2003. Assessing Intermittent or Variable Exposure at Lead Sites. EPA-540-R-03-008, OSWER 9285.7-76. November.
EPA, 2009. Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters. OSWER 9200.2-82. June.
EPA, 2010. Frequent Questions from Risk Assessors on the Adult Lead Methodology (ALM). March.
EPA, 2011. Exposure Factors Handbook: 2011 Edition, National Center for Environmental Assessment, Office of Research and Development. EPA/600/R-09/052F, September.
a. Receptor spends his/her annual 2-week vacation time (14 days/year) camping.
b.The annual vacation time represents consecutive days of exposure. The averaging time is normalized over the year (365 days/year).

SECTION SEVEN: UNCERTAINTY ASSESSMENT

Uncertainties are inherent in every aspect of a quantitative HHRA. Certain assumptions are made as part of the HHRA process, and these assumptions may lead to an over- or underestimation of the actual risks associated with the MRS. Table 7-1 presents the uncertainties associated with each step of the HHRA process.

Table 7-1: HHRA Uncertainty Assessment Summary

Source of Uncertainty	Effect on Risk Estimates	Potential Magnitude	Rationale for Assumptions
Data Collection and Evaluation/Identification of COPCs			
Samples Representing Munitions Response Site (MRS) Media – If the samples did not adequately represent media at the MRS, the risk estimates could be overestimated or underestimated.	over- or underestimate	low	The Work Plan (URS, 2015) was designed to confirm expected locations of MC and delineate areas of concern. Also, a Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) was prepared for the MRS. Uncertainty was reduced due to the approval of the Final RI Work Plan and UFP-QAPP.
Analytical Methods Used to Test Samples – If the analytical methods used did not apply to some constituents at the MRS, risk could be underestimated.	underestimate	low	Since the analytical methods at the MRS were selected to address all constituents known or suspected to be present on the basis of the history of the MRS, the level of uncertainty was reduced.
Qualified Data for COPCs – The data validation process did not reject any of the measurement results. Data validation identified 9 sample points out of 33 that were “J”-flagged data for lead at DU-01, indicating the results were estimated and were between the limit of detection and the limit of quantitation. The same data points were also "f"-flagged indicating field duplicate imprecision. These results were still carried forward into the HHRA. One sample point for DU-01 and one sample point at DU-02 were "N"-flagged, indicating that lead was a tentatively identified compound. These results were carried forward into the HHRA. No data flags were identified for DU-03.	overestimate	low	For conservatism, the estimated and tentatively identified compound results were carried forward into the HHRA. Lead mean concentrations used as EPCs may be overestimated.
Detection Limit Adequacy – The soil and sediment minimum detection limits (See Table 2-1) are protective of the residential screening levels (See Table 3-1) used for the explosives and lead.	underestimate	low	The uncertainty associated with the COPC selection process is reduced because the detection limits likely caught any detections of potential COPCs during the MRS investigation.

Source of Uncertainty	Effect on Risk Estimates	Potential Magnitude	Rationale for Assumptions
Exposure Assessment			
Pathways Not Evaluated or Conservatively Included – The HHRA assessed the primary exposure pathways (i.e., ingestion, dermal contact, and inhalation) for soil and sediment media. However, the ingestion of wild game was not quantified for the wild game hunter scenario. Also, inhalation of dust was factored into the DU-02 receptor calculations even though the DU is a wetlands area.	overestimate	moderate	The risk estimates for DU-02 are likely biased high with the inclusion of the inhalation of dust. DU-02 is a wetland area and the wet conditions would inhibit any wind-blown dust.
	underestimate	low	The consumption of wild game exposure pathway is likely to be an infrequent exposure pathway and lead is not likely to biomagnify in terrestrial food chains (ATSDR, 2007). However, the risk estimates for this scenario may be underestimated.
Estimation of Exposure Point Concentration – EPA (2010) guidance recommends using lead's mean concentration for lead modeling.	over- or underestimate	low	Generally the calculated mean and MDC for lead were close values for each DU, indicating that the high number of increments (minimum of 30) collected for each replicate produced a homogeneous aliquot and representative MRS concentration. Using the mean concentration as the EPC for HHRA calculations is appropriate for characterizing risk exposure at the MRS.
Exposure Parameter Estimation – Model default values were used for the general parameters in the ALM modeling. EPA guidance recommends using central tendency values for receptor-specific parameters. However, the ALM is typically used to address adult exposure to lead.	overestimate	moderate	ALM model default parameters are conservative values. Also, a higher central tendency soil ingestion rate of 0.1 grams/day was used to be protective of young teens at the MRS. Receptor-specific exposure parameters were developed based upon likely current and future use of the MRS; this reduces the level of uncertainty with the exposure estimates.
	over- or underestimate	moderate	EPA's Technical Review Workgroup (TRW) has noted that it is reasonable to apply the ALM to non-residential adolescent receptors, provided appropriate parameter values can be identified for PbB_0, GSDi, AFs, and BKSF (EPA, 2010). The EPA TRW also states that it is reasonable to apply the ALM to non-residential scenarios with older children, since exposure during these years may result in a body burden of lead that is available to transfer to the fetus later in life (EPA, 2010).
Toxicity Assessment			
Basis for Selecting Toxicity Values – ALM model default for the BKSF was used in the risk calculations.	over- or underestimate	moderate	ALM model default BKSF is a conservative value.
New Toxicity Information Regarding PbB levels in Children – CDC recommends using a lower PbB threshold (5 µg/dL or lower) due to number of US children with PbB levels above 5 µg/dL.	underestimate	moderate-high	If EPA accepts CDC (2015) findings and adopts a PbB threshold of 5 µg/dL or lower for the IEUBK and ALM. If a PbB threshold of 5 µg/dL is used, the DU-01 ALM results remain acceptable for all receptors. However, the DU-02 ALM results for the installation personnel/contractor, relic hunter/trespasser, and wild game hunter/hiker exceed the probability threshold of 5 percent.

Source of Uncertainty	Effect on Risk Estimates	Potential Magnitude	Rationale for Assumptions
Risk Characterization			
Use of Modeled Results to Estimate Risk - ALM model was used to estimate risk from exposure to lead at the MRS.	overestimate	moderate	There is uncertainty associated with using the ALM to predict PbBs at the MRS. However, conservative assumptions (including using time-weighted $EF_{S,D}$ and $AT_{S,D}$ versus the actual exposure for the receptors) were used throughout the process that likely resulted in an overestimation of PbBs for receptors at the MRS.

SECTION EIGHT: HHRA CONCLUSIONS

The HHRA identified lead as the primary COPC at DU-01 and DU-02. The risk-based screening results and background evaluation eliminated DU-03 from further evaluation.

EPA's ALM model was used to estimate risk from exposure to lead in soil at DU-01 and sediment at DU-02. Using lead's mean concentration as the soil EPC for DU-01 (690.8 mg/kg) and sediment EPC for DU-02 (3,433 mg/kg), the following non-residential exposure scenarios were evaluated:

- Current and future installation personnel and contractor
- Current and future relic hunter and trespasser
- Future recreational wild game hunter and hiker
- Future recreational camper

EPA's target threshold for lead is to limit the risk to no more than a 5 percent chance fetuses exposed to lead would exceed a PbB of 10 µg/dL (EPA, 2010). The uncertainty assessment supports the results of the HHRA; in most cases, conservative assumptions were used to assess the risk and the receptor results are likely overestimated.

The DU-01 and DU-02 ALM results for all scenarios were below the target PbB and probability thresholds. The HHRA indicates that there is minimal risk to human receptors if the MRS is converted to recreational use.

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