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E-MAIL TRANSMITTING REVISED TEXT FOR SECTION 6 OF HUMAN HEALTH RISK
ASSESSMENT SITE 28 NSWC INDIAN HEAD MD
2/11/2005
CH2MHILL

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Sent: Friday, February 11, 2005 11:04 AM

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Subject: NDWIH Site 28 Lead Hot Spot analysis

Team,

Sorry for the delay on this deliverable... Attached is the analysis of lead for the Swale 3 area, including the revised text for Section 6 (HHRA) and relevant conclusions, new Figure 6-2, and new Appendix H. All changes to the text have been highlighted in yellow for ease of review. The analysis was conducted in response to the following comment:

PAGE 6-18 According to the last paragraph in Section 6.6.2.6, risks from lead in soil were not calculated because the average concentration was less than the residential soil screening level. The text further indicates that, despite this, surface and subsurface samples near the NE quadrant of the site contained lead concentrations that "would likely be a concern for residents." Given the observed presence of lead at up to 17,000 mg/kg, outliers should be separated from the remaining data, and a hot spot analysis of risk should be performed for lead. The following receptors should be included in this evaluation: Current Construction Workers, Future Commercial Workers, and Future Child Residents.

Response: A hot spot analysis of lead for the area of swale 3, in the north quadrant of the site, will be performed. Risks associated with lead will be evaluated using the IEUBK model for a child resident, and the adult lead model for a "site worker" (i.e., the only model available to evaluate lead exposure to adults).

Although the intent of the adult lead model for a "site worker" is to evaluate blood levels for fetuses of industrial workers, it was used to determine risks for utility workers, adult trespassers, and construction workers (by adjusting the ingestion rate and exposure frequency variables) since no other adult lead model is available. In addition, the rationale for not including commercial workers in the risk assessment has been added to the text.

Please review the attached and provide comments by March 4, 2005, so that this information can be incorporated into the final RI report. If you have any questions or need further information, please feel free to call me.

Thank you,

Chris

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Andrew raised a good point re: use of significant figures in calculations. Care should be taken to ensure the correct number of sig. fig is used in calcs & the result.

2/14/2005

Baseline Human Health Risk Assessment

6.1 Executive Summary

The following receptors had total RME noncarcinogenic hazards or carcinogenic risks that exceeded USEPA's target levels:

- Future adult resident exposed to groundwater
- Future child resident exposed to groundwater
- Future lifetime resident exposed to groundwater
- Future adult resident exposed to soil
- Future child resident exposed to soil
- Future lifetime resident exposed to soil
- Future construction worker exposed to groundwater
- Future construction workers exposed to soil

This section presents the results of an assessment of potential human health risks associated with the presence of site-related soil, surface water, sediment, and groundwater at Site 28 at Indian Head. The baseline risk assessment, which characterizes the human health risks at Site 28 if no additional remediation is implemented, was conducted to assess the potential human health impacts from the site under current conditions, as well as to determine if any further actions are needed at the site to be sufficiently protective of human health. This risk assessment has been prepared utilizing conservative assumptions, and all feasible exposure pathways have been considered based on current site conditions and current and potential future site usage.

The results of the Site 28 baseline human health risk assessment (HHRA) will be used to document the potential for endangerment to human health, to assist in identifying media that may need to be addressed through remedial action, and to provide a basis to select action levels.

6.2 Scope of Risk Assessment

The HHRA for Site 28 is comprised of the following components:

- **Identification of Chemicals of Potential Concern (COPCs)**—identifies and characterizes the distribution of COPCs found on the site. COPCs are the focus of the subsequent evaluation in the risk assessment.
- **Exposure Assessment**—identifies contaminated media and potential pathways by which exposure could occur, characterizes the potentially exposed populations (e.g., residents), and estimates the magnitude, frequency, and duration of exposures.

- **Toxicity Assessment**—identifies the types of adverse health effects associated with exposure to COPCs and summarizes the relationship between magnitude of exposure and occurrence of adverse health effects (toxicity factors).
- **Risk Characterization**—integrates the results of the exposure assessment and toxicity assessment to estimate the potential risks to human health. Both cancer and noncancer human health effects are evaluated. Pathways that pose an unacceptable risk are identified.
- **Uncertainty Assessment**—identifies sources of uncertainty associated with the data, methodology, and the values used in the risk assessment.

These components are described in the following sections. The spreadsheets used to screen for COPCs, and calculate estimated exposures and health risks associated with the COPCs, are presented in Appendix G.

6.3 Identification of Chemicals of Potential Concern

The identification of COPCs includes data collection, data evaluation, and data screening steps. The data collection and evaluation steps involve gathering and reviewing the available site data and identifying a set of data that is of acceptable quality for the risk assessment. This data set is then further screened against concentrations that are protective of human health to reduce the data set to those chemicals and media of potential concern.

6.3.1 Data Selection and Evaluation

Section 1.4 summarizes the previous investigations at Site 28.

There are few site historical data, most of which are several years old. Data collected during the RI were evaluated in the risk assessment. Only analytical results that were fully validated were used in the human health risk assessment. The following bullets discuss how validated, qualified results were evaluated in the risk assessment:

- Data qualified with a J (estimated) were treated as detected concentrations.
- Data qualified with an R (rejected) were excluded from the risk assessment.
- Data qualified with a B (blank contamination) was used in the risk assessment as if they were not detected, and one-half the value was used as the sample concentration.
- For duplicate samples, the higher of the two concentrations was used.
- One-half the sample quantitation limit (SQL), also referred to as the method reporting limit, was used in place of undetected results in calculating summary statistics for analytes having one or more positive results in a particular medium.
- Analytes for which no positive results are reported for a particular medium were not considered contaminants of potential concern for that medium.

6.3.2 Data Summary

All of the data used in the risk assessment have been fully validated and are assumed to represent current conditions. Soil, surface water, and groundwater data that were used in the risk assessment are presented in this section. There is also a discussion on sediment data, however, as discussed in Section 6.3, exposure to sediment was not quantified in the risk

assessment. For each medium, chemical-specific summary statistics are presented in Appendix F for the data set used for risk calculations. Methods for calculating exposure point concentrations and 95 percent UCL values for the COPCs are discussed in Section 6.3.3.

6.3.2.1 Soil

During the RI, surface soil samples were collected from 0 to 6 in. bgs, and subsurface soil samples were collected from 1 to 3 ft bgs at 27 locations in Zone A and eight locations in Zone B (see Figure 2-1). A Geoprobe was used at locations accessible by a track mounted Geoprobe, at other locations a hand Geoprobe was utilized.

The soil samples were analyzed for TCL VOCs, TCL SVOCs, TAL metals, and chemicals used in the manufacturing of explosives: the SW-846 method 8330 list of nitroaromatics and nitroamines, NG, NQ, PETN, and perchlorate.

Table 6-1 summarizes each sample and the corresponding analysis. Analytical results for the soil samples are summarized in Tables 4-1, 4-2, 4-7, and 4-8 and Appendix C.

6.3.2.2 Groundwater

Five monitoring wells were installed in August of 2003 and sampled in September of 2003. The monitoring well locations were selected based on the results of direct push groundwater sample results collected in May 2003. Following standard USEPA risk assessment practice, the Geoprobe groundwater samples were not evaluated in the risk assessment. These samples are typically very turbid and not necessarily representative of actual groundwater concentrations. Groundwater samples collected from the monitoring wells were analyzed for TCL VOCs, TCL SVOCs, TAL metals, and chemicals used in the manufacturing of explosives.

Following USEPA Region III guidance (USEPA, 1992), dissolved inorganic groundwater data were used for the residential exposure scenario. Total inorganic groundwater data were used for the construction worker scenario because the construction worker would be exposed directly to the groundwater water in the excavation pit.

Figure 4-7 identifies the locations of the Site 28 monitoring wells. Table 6-1 summarizes the groundwater samples evaluated in the risk assessment and the corresponding laboratory analysis. Analytical results for the groundwater samples are summarized in Table 4-5 and Appendix C.

6.3.2.3 Surface Water

Three surface water samples were collected from the swales during the RI. Surface water samples were analyzed for TCL VOCs, TCL SVOCs, chemicals used in the manufacturing of explosives, and TAL metals (total and dissolved).

Figure 4-8 identifies the surface water sample locations. Table 6-1 summarizes the surface water samples evaluated in the risk assessment and the corresponding laboratory analysis. Analytical results for the surface water samples are presented in Table 4-6, and Appendix C.

6.3.2.4 Sediment

Exposure to sediment was not quantitatively evaluated in the risk assessment. As discussed in Section 6.3.2, exposure to sediment is not a complete exposure pathway. However, a brief discussion of the sediment data is included here.

High zinc concentrations were detected in sediment collected from Mattawoman Creek during the TIE and Mattawoman Creek study. Human health risks associated with exposure to sediment were evaluated in the Mattawoman Creek study (Tetra Tech NUS, 2002). The Mattawoman Creek study considered risk for current/future construction workers, adult recreational users, and adolescent recreational users. The study concluded the following:

Incremental cancer risks and hazard indices for exposure to sediment and surface water by construction workers, adolescent recreational users, and adult recreational users were within acceptable levels for the RME and CTE scenarios. The incremental cancer risk for the ingestion of fish by adolescent and adult recreational users exceeded EPA's target risk range of 10^{-4} and 10^{-6} for both the RME and CTE scenarios. Arsenic and Aroclor-1260 were the major contributors to the incremental cancer risk for ingestion of fish from Mattawoman Creek. The Hazard indices for ingestion of fish by adolescent and adult recreational users exceeded the acceptable level of 1. Arsenic, 2-amino-4,6-dinitrotoluene, and 4-methylphenol were the major contributors to the HI for the ingestion of fish from Mattawoman Creek. [TTNUS, 2002a, pp. 6-34-6-35.]

Zinc was not a primary risk driver for the Mattawoman Creek study, but at localized areas of Mattawoman Creek (such as the zinc recovery furnace) zinc was detected as high as 71,000 mg/kg.

For the Site 28 RI, 15 sediment samples were collected at depth intervals of 0–6 in. and 6–12 in. Three of these samples were collected from the swale, and the remaining twelve samples were collected from Mattawoman Creek. All locations were sampled for TAL metals; three locations were also sampled for TCL SVOCs and chemicals used in the manufacturing of explosives. However, as mentioned above, this data was not evaluated in the human health risk assessment.

6.3.3 Selection of Chemicals of Potential Concern

All of the detected constituents were screened to select the COPCs in accordance with USEPA Region III guidelines (USEPA, 1993), using the steps described below. The COPC selection process was conservative to ensure selection of the constituents comprising the majority of the potential risk associated with the site. The maximum detected concentration of each constituent in each medium was compared to a screening value to select the COPCs for the media. If the maximum concentration exceeded the screening value, the constituent was selected as a COPC and retained for the risk evaluation. The only variance from this COPC selection procedure applied to lead. Due to the different approach adapted by USEPA for estimating potential health risks posed by exposure to environmental lead, the mean lead concentrations were compared to the appropriate lead screening levels.

- **Comparison with Health-based Criteria for Soil:** The maximum detected chemical concentrations in soil were compared with USEPA Region III risk-based concentrations (RBCs) for residential soil (USEPA, 2003). RBCs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. RBCs based

on carcinogenic effects were used as present in the RBC table. Mean lead soil concentrations were compared to the USEPA residential child soil screening value of 400 ppm (OSWER Directive 9355.4-12, issued on July 14, 1994).

- **Comparison with Health-based Criteria for Air:** The maximum detected air concentrations calculated from soil were compared with USEPA Region III ambient air RBCs (USEPA, 2003a). RBCs that are based on noncarcinogenic effects were divided by 10 to account for exposure to multiple constituents. RBCs based on carcinogenic effects were used as presented in the RBC table (USEPA, 2003a). Air concentrations were estimated on the basis of the maximum detected soil concentrations using USEPA methodology (USEPA, 1996).
- **Comparison with Health-based Criteria for Groundwater:** The maximum detected chemical concentrations in groundwater were compared with USEPA Region III tap water RBCs (USEPA, 2003a). RBCs that are based on noncarcinogenic effects were divided by ten to account for exposure to multiple constituents. RBCs based on carcinogenic effects were used as present in the RBC table. The mean lead groundwater concentration was compared to the Safe Drinking Water Act lead action level of 15 parts per billion (ppb).
- **Comparison with Health-based Criteria for Surface Water:** RBC values are not available for surface water. In addition, tap water RBCs are based on exposure assumptions that are not applicable for contact with surface water. As such, screening of COPCs in surface water was based on a comparison of maximum detected surface water concentrations to 10 times the tap water RBCs. The use of 10 times the tap water RBC is a conservative estimate because a receptor is in contact with surface water at exposure parameters (ingestion rate, skin surface area, exposure frequency, and exposure duration) much lower than those for groundwater. Tap water RBCs that are based on noncarcinogenic effects were used as presented in the most current RBC table (USEPA, 2003a). USEPA Region III tap water RBCs based on carcinogenic effects were multiplied by 10 for surface water COPC screening. Lead concentrations in surface water were compared to the Safe Drinking Water Act action level for lead of 15 µg/L.
- **Comparison with Recommended Dietary Allowances (RDAs):** Chemicals that are human nutrients, present at low concentrations (i.e., only slightly elevated above naturally occurring levels), and toxic only at very high doses were eliminated from the quantitative risk analysis. These constituents are calcium, magnesium, potassium, and sodium.

6.3.4 Chemicals of Potential Concern

Table 6-2 identifies the chemicals that were selected as COPCs based on the above screening methodology for soil, surface water, and groundwater. Details of the screening process are shown in the screening tables, Tables 2.1 through 2.9, in Appendix G. The COPCs for soil are primarily PAHs and metals. Although lead was not selected as a COPC for surface soil or combined surface and subsurface soil based on a comparison of the mean lead concentration to the screening value, it was retained as a COPC because the lead concentrations within the central area of the site are much higher than the concentrations across the remainder of the site, and are above the lead screening level. This is discussed in Section 6.4.3. There were no COPCs retained for inhalation of volatile and fugitive emissions from surface soil or combined surface and subsurface soil, and therefore, this pathway was not quantified in the risk assessment. The COPCs for the surface water are two metals, arsenic, and lead. The COPCs for groundwater are metals and one SVOC, bis(2-ethylhexyl)phthalate.

6.4 Exposure Assessment

Exposure refers to the potential contact of an individual with a chemical. The exposure assessment identifies pathways and routes by which an individual may be exposed to the COPCs and estimates the magnitude, frequency, and duration of potential exposure. Contaminant fate and transport is evaluated in Section 7, which discusses the potential release mechanisms at the site. A conceptual exposure model showing potential exposure scenarios identified under current and potential future conditions is presented in Figure 6-1. The following subsections discuss the three components of exposure assessment:

- Characterization of exposure setting
- Identification of exposure pathways
- Quantification of exposure

6.4.1 Characterization of Exposure Setting

Characterizing an exposure setting consists of two parts: (1) identifying the physical characteristics of the site as they relate to exposure, and (2) characterizing human populations on or near the site.

Basic facility characteristics such as physical setting, climate, groundwater hydrology, and the presence and location of surface water were summarized in the Section 2.

Potentially exposed populations are identified based on their locations relative to the site, their activity patterns, and the presence of potentially sensitive subpopulations. Table 6-3 summarizes the potentially exposed populations evaluated in this risk assessment.

6.4.1.1 Current Land Use

Currently, Site 28 is not used, and vehicle access to the site is restricted. Utility workers may repair and maintain the fence that surrounds the site and be exposed to surface and subsurface soil. Although in some locations at the site, the groundwater is close to the ground surface, the utility workers would not be expected to be working in these areas and would most likely not contact the shallow groundwater. Although the site is mostly fenced,

it may be possible for adult and adolescent trespassers to access the site and be exposed to surface soil.

Mattawoman Creek is used for boating and fishing, and therefore, recreational users may be exposed to Mattawoman Creek surface water adjacent to Site 28. The surface water data collected from the swales was conservatively assumed to represent the potential surface water concentrations in Mattawoman Creek associated with Site 28. The banks of Mattawoman Creek adjacent to Site 28 are very steep, and therefore, any sediment contacted by the recreational user would be rinsed off the skin while exiting the creek to land or re-entering a boat. Additionally, the swales are very small, and exposure to sediment in the swales would be expected to be insignificant. Therefore, exposure to sediment was not quantified in the risk assessment. The fisherman and their families may ingest the fish that they catch from the creek. However, fish tissue samples were not collected from Mattawoman Creek for this study and this pathway was evaluated qualitatively. As noted above, fish consumption was identified as a human health risk in the Mattawoman Creek Study performed by Tetra Tech NUS (2002). This study assessed the creek as a whole.

There is no current exposure to groundwater beneath Site 28. Groundwater is not currently used as a water supply for potable or other uses at Indian Head.

6.4.1.2 Potential Future Land Use

Site 28 is located in an area of the facility that could potentially be used recreationally (e.g., for fishing) but would not likely be used for residential, commercial², or industrial purposes. The future recreational user could be exposed to surface water while fishing or boating in the creek, the same exposures that are considered for the current recreational user. Swimming is not likely to take place at the site. The shoreline is overgrown for all of Zone B, and the creek itself is mostly wetland vegetation for the first 50 ft off the shore.

The potential future uses of the site assume that the subsurface soil will be excavated and placed on the ground surface. Therefore, future exposure to soil includes exposure to combined surface and subsurface soil. It was assumed a future trespasser (adult and adolescent) might be exposed to this soil. Although unlikely, it was assumed the site could be used for future residential development, and future residents could contact site surface and subsurface soil. Excavation activities at the site may also expose the construction worker to the soil.

Groundwater is not anticipated to be used as a future potable water supply at the base. However, the groundwater data from the site was used as a conservative assessment of groundwater quality for the future residential exposure scenario. The construction worker may also be exposed to the shallow groundwater during the excavation/construction activities.

6.4.2 Identification of Exposure Pathways

An exposure pathway can be described as a mechanism that moves a COPC from its source to an exposed population or individual, referred to as a receptor. An exposure pathway

² The commercial and industrial worker exposure routes were not evaluated quantitatively in this risk assessment because the residential evaluation should provide a conservative upper-bound estimate of risk for these receptors.

must be complete or exposure cannot occur. A complete exposure pathway has five elements:

- Source (e.g., chemical residues in soil)
- Mechanism for release and migration of chemical (e.g., runoff, leaching)
- Environmental transport medium (e.g., soil, surface water)
- Point or site of potential human contact (exposure point, e.g., contact with soil)
- Route of intake (e.g., incidental ingestion of soil)

All five elements must be present for a pathway to be considered complete. If one or more elements are not present, then the pathway is incomplete and there is no possibility of exposure. The following subsections discuss the elements as they pertain to Site 28.

6.4.2.1 Contaminant Sources

Sources at Site 28 include contaminated soil associated with the former zinc recovery furnace and the shoreline burning cage. The constituents detected in site media are primarily SVOCs and metals.

6.4.2.2 Release and Transport Mechanisms

The fate and transport of chemicals in surface soil, soil (combined surface and subsurface soil), groundwater, surface water, and sediment are determined by physical characteristics of the site as well as by the chemical and physical properties of the constituents. A detailed description of the fate and transport of contaminants is presented in Section 5 of this report.

The primary transport mechanisms from sources at Site 28 appear to be fugitive dust and volatile emissions from soil, leaching from soil to groundwater, and surface erosion caused by runoff to the river. Carbon tetrachloride is believed to be coming from upgradient of the site.

6.4.2.3 Potential Exposure Points and Exposure Routes

Exposure points are locations where humans could come in contact with contamination. On-site exposure points include surface soil, soil (combined surface and subsurface soil), surface water, and groundwater.

Potential exposure routes are evaluated for potential current and future site use. Existing and potential exposure pathways are illustrated in the conceptual exposure model (Figure 6-1). Exposure scenarios and potentially complete pathways of exposure evaluated in this risk assessment are presented in Table 6-3.

6.4.2.4 Current Exposure Routes

The only contaminated media currently accessible at the site are surface soil, combined surface and subsurface soil, and surface water. Based on current site use, potential receptors at the site are utility workers (combined surface and subsurface soil exposure), adult and adolescent trespassers (surface soil), and adult and adolescent recreational users (surface water, fish). Table 6-3 identifies the current exposure routes for each of these receptors.

6.4.2.5 Future Exposure Routes

The probable future use of the site is the same as the current use. In that case, the most likely future receptors would be utility workers (soil), adult and adolescent trespassers (soil), and adult and adolescent recreational users (surface water). The potential future exposure scenario assumes that the subsurface soil will be excavated and become surface soil. Additionally, a future residential child and adult scenario (soil and groundwater) was conservatively included in this evaluation to account for an unrestricted use scenario. Table 6-3 identifies the potential future exposure routes for each of these receptors.

The exposure pathways listed above were selected in consultation with USEPA Region III and the Navy. The exposure concentrations used to calculate potential risks to each of the receptors are presented in Appendix G, Tables 3.1 through 3.6 (reasonable maximum exposure (RME) and central tendency exposure (CTE)). The exposure parameters and equations used to calculate the risks are presented in Appendix G, Tables 4.1 through 4.9 (RME and CTE).

6.4.3 Quantification of Exposure

Exposure is quantified by estimating the exposure point concentrations and chemical intake by the receptors for both RME and CTE scenarios.

6.4.3.1 Exposure Point Concentrations (EPCs)

Exposure point concentrations are estimated chemical concentrations that a receptor may contact and are specific to each exposure medium. Exposure point concentrations may be directly monitored or estimated using environmental fate and transport models. For this assessment, fate and transport modeling was used to estimate constituent concentrations in fugitive dust emissions from soils.

Fugitive dust and volatile emissions from soil were estimated as part of the COPC screening process (Appendix G, Tables 2.2, 2.2.A, 2.4, 2.4.A, and 2.7) following USEPA's Soil Screening Guidance Document (USEPA, 1996). There were no COPCs retained for inhalation of volatile and fugitive emissions from surface soil or combined surface and subsurface soil, and therefore, the inhalation pathway was not quantified in this risk assessment.

The reasonable maximum exposure (RME) EPCs were calculated as the 95 percent upper confidence limit (95 percent UCL), the 97.5 percent UCL, or the 99 percent UCL of the arithmetic mean concentration. The maximum detected concentration was used in place of the UCL as the EPC when the calculated UCL was greater than the maximum detected value or less than five samples were available for the data grouping.

ProUCL, version 2.1 (USEPA, 2003c), was used to calculate the UCLs and determine the distribution the data fit. The ProUCL model uses the Shapiro-Wilk *W*-test to determine if the data fit a lognormal or normal distribution for data sets with less than 50 samples. For data sets with greater than 50 samples, Lilliefors test was used to determine the distribution of the data. The distribution that the data fit was then used to choose the method that ProUCL uses to calculate the UCL. The recommendations outlined in the ProUCL model documentation were used to select the appropriate UCL. For data that were determined to fit a normal distribution, the student's *t*-statistic was used to calculate the 95 percent UCL.

For data determined to fit a lognormal distribution, either Land's H-statistic was used to calculate the 95 percent UCL, or the Chebyshev Theorem using the MVUE of the parameters was used to calculate the 95 percent UCL, 97.5 percent UCL, or 99 percent UCL, depending on the standard deviation of the population. For data that fit neither a lognormal or normal distribution, the Chebyshev Theorem using the arithmetic mean and standard deviation was used to calculate the 95 percent UCL, 97.5 percent UCL, or 99 percent UCL, depending on the population standard deviation. For data sets that fit both a lognormal and normal distribution, the methods described above for the distribution with the higher W-value was used to calculate the UCL.

The average concentration was used as the CTE exposure point concentrations (EPC). For data that fit a lognormal distribution (based on the discussion above), the average of the log-transformed data was used as the CTE EPC. For data that fit a normal distribution, the average of the nontransformed data was used as the CTE EPC. For data sets that fit both lognormal and normal distributions or fit neither, the distribution with the higher W-value was used to calculate the UCL.

Due to the limited number of surface water samples that were collected, UCLs were not calculated for this media. The maximum detected concentrations were selected as the RME EPCs for the surface water COPCs.

The data qualifiers were handled as discussed in Section 6.2.1, to calculate the RME and CTE EPCs. The RME EPCs are included in Appendix G, Tables 3.1.RME through 3.5.RME and the CTE EPCs are included in Appendix G, Tables 3.1.CTE through 3.5.CTE.

The filtered inorganic data were used to evaluate the residential scenario following USEPA guidance (USEPA, 1992). Unfiltered inorganic data were used to evaluate the construction worker scenario.

6.4.3.2 Estimation of Chemical Intakes for Individual Pathways

Chemical intake is the amount of a chemical contaminant entering the receptor's body. Chemical intakes are generally expressed as follows:

$$I = \frac{C \times CR \times EF \times ED}{BW \times AT} \text{ (mg/kg/day)}$$

Where:

- I = intake (mg/kg-day)
- C = chemical concentration at exposure point (mg/L, mg/kg, mg/m³)
- CR= contact rate, or amount of contaminated medium contacted per unit time or event (L/day, mg/event, m³/day)
- EF= exposure frequency (days/year)
- ED= exposure duration (years)
- BW= body weight of exposed individual (kg)
- AT= averaging time, or period over which exposure is averaged (days)

The intake equation requires specific exposure parameters for each exposure pathway. Appendix G, Tables 4.1 through 4.9 (RME and CTE) present the exposure factors used for different scenarios at the site. Both RME and CTE intakes were included in this evaluation. CTE intakes were calculated for exposure scenarios with RME cumulative cancer risks greater than 1×10^{-4} or cumulative noncancer hazards greater than 1.

For residential exposure to soil and groundwater, lifetime age-adjusted intakes were calculated for carcinogenic constituents. Age-adjusted exposure factors were calculated using the equations presented in the USEPA Region III RBC table (USEPA, 2003a) and shown in Tables 4.6 and 4.8 (RME and CTE) in Appendix G.

A dermal absorption factor is required for the dermal exposure to soil pathway. Dermal absorption factors were obtained from USEPA's RAGS, Part E (USEPA, 2001, Exhibit 3-4). For the inorganic constituents not included in this reference, one percent was used as the default value (USEPA, 1995).

The methods presented in USEPA's RAGS, Part E (USEPA, 2001), for estimating dermal exposure to water were used to evaluate dermal exposure to groundwater during bathing and showering, dermal exposure to groundwater in an open excavation, and dermal exposure to surface water in Mattawoman Creek. The non-steady state model or pseudo steady-state model was used to estimate the dermally absorbed dose per event for organic constituents (USEPA, 2001). If the exposure time (or event time, t_{event}) was shorter than the time to reach steady-state (t^*), the non-steady-state model was used. If t_{event} was greater than t^* , the pseudo-steady state model was used. For inorganics, the absorbed dose was calculated using a steady-state approach. These models are shown in Tables 4.5 (RME and CT) and 4.8 (RME and CT), in Appendix G.

6.5 Toxicity Assessment

Toxicity assessment defines the relationship between the magnitude of exposure and possible severity of adverse effects, and weighs the quality of available toxicological evidence. Toxicity assessment generally consists of two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining the potential adverse effects from exposure to the chemical along with the type of health effect involved. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. Toxicity criteria (e.g., reference doses and slope factors) are derived from the dose-response relationship. USEPA has performed the toxicity assessment step for many chemicals and has published the results in IRIS, NCEA issue papers, and HEAST databases.

Health effects are divided into two broad groups: noncarcinogenic and carcinogenic effects. This division is based on the different mechanisms of action currently associated with each category. Chemicals causing noncarcinogenic health effects are evaluated independently from those having carcinogenic effects. Some chemicals may produce both noncarcinogenic and carcinogenic effects, and are therefore evaluated in both groups.

The primary source of toxicity values is the USEPA's IRIS database, which contains up-to-date health risk and USEPA regulatory information. IRIS includes only RfDs and CSFs that have been verified by USEPA work-groups. The IRIS database is the USEPA's preferred source of toxicity information. If data were not available from IRIS, data from NCEA were used. If data were not available from either of these sources, HEAST, which are issued by USEPA's Office of Research and Development, were consulted. If no appropriate toxicity values were available, an appropriate surrogate constituent was selected for the COPC screening, or the chemical was evaluated qualitatively.

6.5.1 Toxicity Information for Noncarcinogenic Effects

Noncarcinogenic health effects include a variety of toxic effects on body systems, ranging from renal toxicity (toxicity to the kidneys) to central nervous system disorders.

Noncarcinogenic health effects are grouped into two basic categories: acute toxicity and chronic toxicity. Acute toxicity can occur after a single exposure (usually at high doses), and the effect is most often seen immediately. Chronic toxicity generally occurs after repeated exposure (usually at low doses) and is seen weeks, months, or years after the initial exposure. The toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) animal studies, long-term (chronic) animal studies, and epidemiological investigations.

USEPA (1989) defines the chronic RfD as a dose that is likely to be without appreciable risk of deleterious effects during a lifetime of exposure. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (for example, 7 years to a lifetime), and consider uncertainty in the toxicological data base and sensitive receptors. Chronic RfDs may be overly protective if used to evaluate the potential for adverse health effects resulting from short-term exposure. USEPA's NCEA develops subchronic RfDs for short-term exposure (2 weeks to 7 years). Subchronic RfDs have been peer-reviewed by Agency and outside reviewers, but they have not undergone verification by an intra-Agency workgroup, and as a result are considered interim rather than verified toxicity values. Chronic and subchronic RfDs are developed for both the inhalation and oral exposures. Subchronic RfDs were used for the construction worker scenario because the exposure duration is 1 year.

In the development of RfDs, all available studies examining the toxicity of a chemical following exposure are considered based on their scientific merit. The lowest dose level at which an observed toxic effect is occurring is identified as the "lowest-observed-adverse-effect level" (LOAEL) and the dose at which no effect is observed is identified as the "no-observed-adverse-effect level" (NOAEL). Several uncertainty factors (UFs) may be applied to account for uncertainty. UFs account for uncertainties such as poor data quality, extrapolation of data from animal studies to human exposures, or the use of subchronic studies to develop chronic criteria. These UFs range between 10 to 10,000, and are based on professional judgment. Therefore, there are varying degrees of uncertainty in the toxicity criteria.

USEPA-derived oral and inhalation RfDs, and associated UFs and MFs for the COPCs at the Site 28 are listed in Tables 5.1 and 5.2 in Appendix G.

Per USEPA guidance, oral RfDs were adjusted from administered doses to absorbed doses for evaluating dermal toxicity, when deemed appropriate. The RfDs were adjusted using oral absorption factors from USEPA (2001). The adjusted dermal RfDs are summarized in Table 5.1 in Appendix G.

6.5.2 Toxicity Information for Carcinogenic Effects

Potential carcinogenic effects are quantified using oral and inhalation CSFs. CSFs are expressed in units of per milligram per kilogram of body weight per day (mg/kg/day)⁻¹.

CSFs may be derived from the results of chronic animal bioassays, human epidemiological studies, or both. Animal bioassays are usually conducted at dose levels that are much higher than are likely to be encountered in the environment. This study design detects possible adverse effects in the relatively small test populations used in the studies.

A number of mathematical models and procedures have been developed to extrapolate from the high doses used in laboratory studies to the low doses typically associated with environmental exposures. The USEPA-preferred linearized multistage (LMS) model is usually used to estimate the largest linear slope (within the upper 95 percent UCL) at low extrapolated doses that is consistent with the data. The 95 percent UCL slope of the dose-response curve is subjected to various adjustments, and an inter-species scaling factor is usually applied to derive a cancer slope factor or inhalation unit risk factor for humans. It is assumed that if a cancer response occurs at the dose level in the study, there is some probability that a response will occur at all lower exposure levels (i.e., a dose-response relationship with no threshold is assumed). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an ad hoc basis. In both types of analyses, conservative (e.g., health protective) assumptions are applied and the models are believed to provide rough estimates of the upper limits on potential lifetime risk.

USEPA-derived oral and inhalation CSFs are listed in Tables 6.1 and 6.2 in Appendix G. In accordance with USEPA guidance, certain oral CSFs were adjusted from administered doses to absorbed doses to evaluate dermal toxicity. When appropriate, the CSFs were adjusted using oral absorption factors from USEPA (2001). The adjusted dermal CSFs are summarized in Table 6.1 in Appendix G.

6.5.3 Chemicals for Which no USEPA Toxicity Values Are Available

Most of the chemicals detected at the site have toxicity factors and USEPA Region III RBCs. Detected constituents that did not have RBCs were compared to RBCs for appropriate surrogate constituents. Surrogates were based on previous recommendations from USEPA Region III, and their RBCs were used to screen these constituents. The surrogates used are identified in the screening tables, Tables 2.1 through 2.9 in Appendix G.

Lead and mercury are the only constituents identified as COPCs that do not have toxicity values, and therefore, required other considerations for the risk characterization. For mercury, the analytical results for mercury in soil were for total mercury. However, mercury has three valence states and is found in the environment in the metallic form, and in the form of various inorganic and organic complexes. For the purposes of this HHRA, the oral RfD for mercuric chloride was used as a surrogate for elemental mercury.

Lead does not have available published toxicity factors. Lead is regulated by USEPA based on the concentration of lead in blood. The blood-lead concentration is estimated by using a physiologically based pharmacokinetic model (the Integrated Exposure Uptake Biokinetic (IEUBK) Model). As a conservative soil screening value, 400 mg/kg lead in soil was considered appropriate for residential land use scenarios (OSWER Directive 9355.4-12, issued on July 14, 1994). Lead concentrations in groundwater and surface water were compared to the Safe Drinking Water Act action level of 15 µg/L.

The average site-wide concentrations of lead in surface soil (142 mg/kg) and combined surface and subsurface soil (58.5 mg/kg) were below the lead soil screening level of 400 mg/kg. Therefore, the site-wide lead concentrations were not evaluated further in the risk characterization. However, detected concentrations of lead in 12 of the 70 soil samples were above the soil screening value of 400 mg/kg, some of them greater than 25 times the soil screening value. These samples were collected near Swale 3 in Zone A, forming a relatively continuous geographic extent (Figure 6-2). An assessment of risk associated with exposure to lead in this area was performed using the results from those sample locations where the surface and/or subsurface soil sample results were detected above the soil screening value of 400 mg/kg (see Table 1 in Appendix H and Figure 6-2). An average soil lead concentration of 2,126 mg/kg was calculated for these samples and subsequently used as the lead exposure point concentration.

The IEUBK model was used to quantitatively assess the potential impacts of lead exposure to the residential child (see Appendix H). Risks associated with non-residential adult exposure to lead were evaluated based on *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil* (USEPA, 2003d). This approach uses a methodology that relates soil lead intake to blood lead concentrations in women of child-bearing age. The methodology focuses on estimating fetal blood lead concentrations in women exposed to lead-contaminated soil.

The IEUBK evaluation predicted a geometric mean blood lead concentration of 15.8 micrograms per deciliter of blood (µg/dL) for children 0 to 84 months old, as a result of ingestion of soil from the Swale 3 area. This blood lead concentration exceeds the USEPA's target level of concern of 10 µg/dL. According to the IEUBK model, this represents approximately 83 percent of this population. Thus, exposure to soil in this area would be a potential concern for future child residents.

In general, the Adult Lead Model is intended to be used to determine blood lead levels for fetuses of industrial workers; however, it was used to determine risks for fetuses of the current utility worker, current and future adult trespasser, and future construction worker because no other model is available (see Appendix H). As a result, the ingestion rate and exposure frequency variables of the model input were adjusted to reflect each exposure population, which introduced an uncertainty into the lead risk estimations. Below is a discussion of the Adult Lead Model results for each of the exposure populations.

For the current utility worker, the model predicted a geometric mean blood lead concentration in the range of 2.8 to 3.0 µg/dL using an adjusted ingestion rate of 0.48 g/day and an exposure frequency of 10 days/year. The 95th percentile blood lead level for fetuses of the utility worker is predicted to be in the range of 8.7 µg/dL to 10.8 µg/dL, as a result of ingestion of soil from the Swale 3 area. These results are in the range of USEPA's

percent?
recommended level of 10 $\mu\text{g}/\text{dL}$. The probability that the fetal lead blood concentration would be greater than the target blood lead concentration of 10 $\mu\text{g}/\text{dL}$ ranges from less than to slightly greater than 5. Therefore, exposure to lead in soil could be potential health concern for the fetuses of pregnant female utility workers, if they are exposed at the upper end of the estimated range of parameter values.

For the future construction worker, the model predicted a geometric mean blood level concentration of approximately 35 $\mu\text{g}/\text{dL}$ using an adjusted ingestion rate of 0.48 g/day and an exposure frequency of 250 days/year. The 95th percentile blood lead level for fetuses of the construction worker is predicted to be in the range of 107 $\mu\text{g}/\text{dL}$ to 125 $\mu\text{g}/\text{dL}$, as a result of ingestion of soil from the Swale 3 area. These results exceed USEPA's recommended level of 10 $\mu\text{g}/\text{dL}$. The probability that the fetal lead blood concentration would be greater than the target blood lead concentration of 10 $\mu\text{g}/\text{dL}$ is greater than 5 percent (the calculated probability is greater than 90 percent). Therefore, exposure to lead in soil would be a potential health concern for the fetuses of pregnant female construction workers.

For the adult trespasser (current and future), the model predicted a geometric mean blood level concentration in the range of 3.0 to 3.2 $\mu\text{g}/\text{dL}$ using an adjusted ingestion rate of 0.1 g/day and an exposure frequency of 52 days/year. The predicted 95th percentile blood level for fetuses of the adult trespasser is in the range of 9.0 $\mu\text{g}/\text{dL}$ to 11.2 $\mu\text{g}/\text{dL}$, as a result of ingestion of soil from the Swale 3 area. The results are in the range of USEPA's recommended level of 10 $\mu\text{g}/\text{dL}$. The probability that the fetal lead blood concentration would be greater than the target blood lead concentration of 10 $\mu\text{g}/\text{dL}$ ranges from less than to slightly greater than 5. Therefore, exposure to lead in soil could be potential health concern for the fetuses of adult trespassers, if they are exposed at the upper end of the estimated range of parameter values.

The one detected concentration (in three samples) of lead in the surface water (61.5 $\mu\text{g}/\text{L}$) slightly exceeded the Safe Drinking Water Act action level for lead of 15 $\mu\text{g}/\text{L}$. Exposure to lead in surface water by recreational users cannot be evaluated quantitatively. However, since recreational exposure is much less than drinking water exposure (the basis for the action level), exposure to lead in the surface water is not expected to be a concern for human health.

The maximum detected concentration (30 $\mu\text{g}/\text{L}$) and the average concentration (17.1 $\mu\text{g}/\text{L}$) of lead in unfiltered groundwater exceed the Safe Drinking Water Act action level for lead of 15 $\mu\text{g}/\text{L}$. Exposure to lead in groundwater by construction workers during excavation cannot be evaluated quantitatively. However, since construction worker exposure to groundwater is much less than drinking water exposure, exposure to lead in the groundwater by a construction worker is not expected to be a concern for human health.

The maximum detected concentration of lead in the filtered groundwater was below the Safe Drinking Water Act action level for lead of 15 $\mu\text{g}/\text{L}$, and therefore exposure to lead in drinking water is not expected to be a concern for future residents.

6.6 Risk Characterization

Risk characterization is the process of integrating the previous elements of the risk assessment into quantitative and semiquantitative expressions of risk. The calculated risk is then used as an integral component in remedial decision-making and selection of potential remedies or actions.

6.6.1 Noncarcinogenic and Carcinogenic Risk Estimation Methods

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic contaminants because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. The noncarcinogenic health impacts from carcinogens are also assessed.

6.6.1.1 Noncarcinogenic Risk Estimation

Noncarcinogenic health risks are estimated by comparing actual or expected exposure levels to threshold concentrations (or RfDs). The expected intake divided by the RfD is equal to the hazard quotient (HQ):

$$\text{Hazard Quotient (HQ)} = \text{Intake} / \text{RfD}$$

The intake and RfD are expressed in the same units and represent the same exposure period (i.e., chronic or subchronic). The intake and RfD also represent the same exposure route, (i.e., inhalation intakes are divided by the inhalation RfD). When the HQ exceeds one (i.e., exposure exceeds the RfD), a certain degree of health risk is indicated. To assess the potential for noncarcinogenic health effects posed by exposure to multiple chemicals and multiple exposure pathways a "hazard index" approach is used (USEPA, 1989). This approach assumes that noncarcinogenic hazards associated with exposure to more than one chemical and pathway are additive. Synergistic or antagonistic interactions between chemicals are not accounted for. The hazard index (HI) may exceed one even if all of the individual HQs are less than one. The chemicals may then be segregated by similar mechanisms of toxicity and toxicological effects, and separate HIs derived based on mechanism and target organs affected.

6.6.1.2 Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related contamination is evaluated by estimating excess lifetime cancer risk. Excess lifetime carcinogenic risk is the incremental increase in the probability of developing cancer during one's lifetime in addition to the background probability of developing cancer. The background incidence of cancer in the U.S. population is approximately 30 percent (including both lethal and non-lethal forms). Therefore, a 2×10^{-6} excess lifetime carcinogenic risk means that an individual's probability of developing cancer in his or her lifetime changes from approximately 0.300000 to 0.300002. Or, expressed another way, for every 1 million people exposed to the carcinogen throughout their lifetime, the incidence of cancer *may* increase by two cases.

The carcinogenic risk is calculated by multiplying the intake by the CSF.

$$\text{CR} = \text{Intake} \times \text{CSF}$$

The combined risk from exposure to multiple chemicals at a site was evaluated by adding the risks from individual chemicals. Risks were also added across the pathways, if an individual would be exposed through multiple pathways. For example, a person contacting the soil could be exposed by both the oral and dermal pathways.

When a cumulative carcinogenic risk to an individual receptor under the assumed exposure conditions at the site exceeds 100 in a million (10^{-4} excess cancer risk), CERCLA generally requires remedial action to reduce risks at the site (USEPA, 1991). If the cumulative risk is less than 10^{-4} , action generally is not required, but may be warranted if a risk-based chemical-specific standard, for example, maximum contaminant level (MCL), is exceeded. A risk-based remedial decision could be superseded by the presence of an environmental impact requiring action at the site.

6.6.2 Risk Assessment Results

A summary of the results is shown in Table 6-4 for the RMEs and Table 6-5 for the CTEs. CTE risks were calculated when the RME hazards exceeded 1 or the cancer risks exceeded 10^{-4} .

The noncarcinogenic and carcinogenic risks are calculated in Appendix G, Tables 7.1.RME through 7.11.RME, and 7.1.CTE through 7.4.CTE. Tables 9.1.RME through 9.11.RME in Appendix G summarize the RME total potential risks to each receptor. Tables 9.1.CTE through 9.4.CTE in Appendix G summarize the CTE total potential risks to each receptor that had risks that exceeded an HI of 1.0 or a carcinogenic risk of 1×10^{-4} . Tables 10.1.RME through 10.9.RME and Tables 10.1.CTE through 10.3.CTE in Appendix G summarize only the chemicals that contribute an HI above 0.1 to a total HI greater than 1.0, or a cancer risk greater than 10^{-6} to a total carcinogenic risk greater than 10^{-4} .

6.6.2.1 Current Utility Worker

The risk assessment assumed that a current utility worker could be exposed to Site 28 combined surface and subsurface soil. The total current RME noncarcinogenic hazard to an adult utility worker exposed to soil (0.16) is below USEPA's target noncarcinogenic hazard level (Appendix G, Table 9.1 RME). The carcinogenic risk to an adult utility worker exposed to soil (1.4×10^{-5}) is within the USEPA's target carcinogenic risk range of 1×10^{-4} to 1×10^{-6} .

As discussed in Section 6.5.3, the Adult Lead Model was used to evaluate potential impacts of exposure to lead in the combined surface and subsurface soil in the area of Swale 3. The results indicated that exposure to surface and subsurface soil at the upper end of the estimated range of parameter values would be a potential concern for the fetuses of female utility workers.

6.6.2.2 Current Adult Trespasser

The risk assessment assumed that a current adult trespasser might be exposed to surface soil at Site 28. The total RME noncarcinogenic hazard (0.34) and carcinogenic risk (2.6×10^{-5}) for an adult trespasser exposed to surface soil are below USEPA's target levels (Appendix G, Table 9.2.RME).

As discussed in Section 6.5.3, the Adult Lead Model was used to evaluate potential impacts of exposure to lead in the combined surface and subsurface soil in the area of Swale 3. The

results indicated that exposure to surface and subsurface soil at the upper end of the estimated range of parameter values would be a potential concern for the fetuses of female adult trespassers.

6.6.2.3 Current Adolescent Trespasser

The risk assessment assumed that a current adolescent trespasser might be exposed to surface soil at Site 28. The total RME noncarcinogenic hazard (0.42) and carcinogenic risk (1.2×10^{-5}) for an adolescent trespasser exposed to surface soil are below USEPA's target levels (Appendix G, Table 9.3.RME).

Potential impact of exposure to lead in surface and subsurface soil in the area of Swale 3 was not evaluated for the adolescent trespasser because the Adult Lead Model does not assume a reasonable exposure scenario for this receptor.

6.6.2.4 Current/Future Recreational Adult

This risk assessment assumed that a current and/or potential future recreational adult might be exposed to surface water in the swales at Site 28. The total RME noncarcinogenic hazard (0.0019) and carcinogenic risk (2.9×10^{-7}) for a current/future adult recreational user exposed to surface water are below USEPA's target levels (Appendix G, Table 9.4.RME).

Current and/or potential future recreational adults may ingest the fish caught from the Mattawoman Creek. This pathway was not evaluated quantitatively since no fish tissue samples were collected. Section 9.6 and Table 9.27 present information regarding potential uptake of constituents in Mattawoman Creek sediment by fish. Since some of the constituents detected in the sediment could accumulate in fish tissue (e.g., arsenic, lead, and mercury), it can not be concluded that there is no exposure to constituents via fish ingestion for current/future recreational adults. Additional site-specific information would be necessary to quantitatively evaluate this potential exposure route.

6.6.2.5 Current/Future Recreational Adolescent

This risk assessment assumed that a current and/or potential future recreational adolescent might be exposed to surface water in the Mattawoman Creek at Site 28. The total RME noncarcinogenic hazard (0.0025) and carcinogenic risk (1.5×10^{-7}) for a current/future adolescent recreational user exposed to surface water are below USEPA's target levels (Appendix G, Table 9.4.RME).

Current and/or potential future recreational adolescents may ingest the fish caught from the Mattawoman Creek. This pathway was not evaluated quantitatively since no fish tissue samples were collected.

6.6.2.6 Future Resident

It was assumed that potential future adult and child residents living on-site might be exposed to the site groundwater and soil.

Exposure to groundwater would result in a hazard greater than USEPA's target level for adult (HI=40) and child (HI =94) residents (Appendix G, Tables 9.6.RME and 9.7.RME). The main hazard contributors are arsenic, iron, and vanadium, all contributing individual HQs over 1. Both the ingestion and dermal contact routes contribute hazards above 1. The main

contributors to the noncancer hazard indices for the child are aluminum, arsenic, cadmium, iron, manganese, and vanadium, all contributing individual HQs over 1.

The maximum detected constituent concentrations were used as the EPCs for groundwater due to the limited number of samples available. This may result in an overestimation of the risk. The maximum detected concentrations of cadmium, iron, and vanadium were not much higher than the 95 percent upper tolerance limit (UTL) of the background groundwater data presented in the Background Investigation Report (Appendix E). The maximum detected concentrations of aluminum and manganese in the site related groundwater was less than that of the 95 percent UTL of the background groundwater data. Therefore, all of the COPCs, and calculated hazard, may not be solely associated with Site 28, but may also be associated with background groundwater conditions. However, based on arsenic alone, which was not detected in the background groundwater samples, the hazard would still be above 1 for the adult and child resident. Exposure to groundwater through potable use by a lifetime resident would result in a carcinogenic risk (7.8×10^{-3}) above USEPA's target risk range, based on RME exposure assumptions (Appendix G, Table 9.8.RME). The groundwater risk driver is arsenic.

A CTE hazard analysis was conducted for exposure to groundwater for an adult and child resident (Appendix G, Tables 9.1.CTE and 9.2.CTE). The resulting CTE hazard for both a residential adult (7.0) and child (16.9) exposed to groundwater is greater than 1.0. Arsenic and iron are the main contributors to the CTE hazard. A CTE risk evaluation was conducted for groundwater for a lifetime resident. The CTE carcinogenic risk for groundwater (8.2×10^{-4}) is also above 1×10^{-4} .

The RME noncarcinogenic hazard to adult (HI = 1.3) and child (HI = 11) residents exposed to soil exceeds USEPA's target noncarcinogenic hazard level (Appendix G, Tables 9.6.RME and 9.7.RME). These hazards are associated with the ingestion of inorganics, mainly arsenic and zinc, from the soil. Future lifetime resident (Appendix G, Table 9.8.RME) exposure to soil at Site 28 would result in a carcinogenic risk (3.3×10^{-4}) that is above the USEPA target carcinogenic risk levels. This risk is associated with ingestion and dermal contact with arsenic in soil.

CTE hazards were calculated for the adult and child resident for exposure to soil. The CTE hazards for the adult (0.10) and child (0.83) resident are below USEPA's target HI (Appendix G, Tables 9.1.CTE and 9.2.CTE). A CTE risk for the future lifetime resident was calculated. The CTE risk for the lifetime resident (1.4×10^{-5}) is within the USEPA target carcinogenic risk range (Appendix G, Table 9.3.CTE).

As discussed in Section 6.5.3, the IEUBK model was used to quantitatively assess potential impacts of exposure to lead in soil in the area of Swale 3 by the residential child. The results indicated that exposure to soil would potentially be a health concern for future child residents.

6.6.2.7 Future Construction Worker

Exposure to soil through incidental ingestion and dermal contact, and to groundwater through dermal contact was evaluated for a future construction worker. The total potential future RME noncarcinogenic hazard exceeds USEPA's target hazard level (Appendix F, Table 9.9.RME). The hazard due to exposure to soil is 3.9, mainly due to arsenic, and the

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hazard associated with groundwater is 2.0. For groundwater, there are no individual constituents contributing HIs above 1. The RME carcinogenic risks for a construction worker exposed to soil (1.4×10^{-5}) and groundwater (5.3×10^{-6}) are within the USEPA's target range.

A CTE risk calculation was performed for noncarcinogenic and carcinogenic risks for soil and groundwater (Appendix G, Table 9.4.CTE). The CTE hazards and risks for exposure to soil and groundwater are all below USEPA's target risk levels.

As discussed in Section 6.5.3, the Adult Lead Model was adjusted and used to evaluate potential impacts of exposure to lead in surface and subsurface soil in the area of Swale 3 to a future construction worker. The results indicated that exposure to lead in this area would potentially be a health concern for fetuses of pregnant female construction workers.

Subsurface or Combination?

6.6.2.8 Future Adult Trespasser

The risk assessment assumed that a potential future adult trespasser might be exposed to soil at Site 28. The total RME noncarcinogenic hazard (0.29) and carcinogenic risk (2.1×10^{-5}) for an adult trespasser exposed to soil are below or within USEPA's target levels (Appendix G, Table 9.10.RME).

As discussed in Section 6.5.3, the Adult Lead Model was adjusted and used to evaluate potential impacts of exposure to lead in surface and subsurface soil in the area of Swale 3 for the adult trespasser. The results indicated that exposure to surface and subsurface soil at the upper end of the estimated range of parameter values would be a potential concern for the fetuses of female adult trespassers.

How would such a receptor be exposed to SSB of a 52 deep?

6.6.2.9 Future Adolescent Trespasser

The risk assessment assumed that a potential future adolescent trespasser might be exposed to soil at Site 28. The total RME noncarcinogenic hazard (0.36) and carcinogenic risk (9.8×10^{-6}) for an adolescent trespasser exposed to soil are below or within USEPA's target levels (Appendix G, Table 9.11.RME).

Potential impact of exposure to lead in surface and subsurface soil in the area of Swale 3 was not evaluated for the adolescent trespasser because the Adult Lead Model does not assume a reasonable exposure scenario for this receptor.

6.7 Uncertainty Associated with Human Health Assessment

The risk measures used in site risk assessments are not fully probabilistic estimates of risk but are conditional estimates given that a set of assumptions about exposure and toxicity are realized. Thus it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective.

6.7.1 General Uncertainty in COPC Selection

The uncertainty in sampling and possibility of missing a contaminated location is expected to be minimal at this site because of the amount of sampling data available for the site. The quantitative uncertainty associated with the other factors is also minimal because the data were validated prior to use in the risk assessment. The general assumptions used in the COPC selection are conservative to ensure the estimation of highest possible risk.

6.7.3 Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the noncarcinogenic toxicity factors is included in Appendix G, Tables 5.1 and 5.2. Several UFs were applied to extrapolate dose points from animal studies to humans. The UFs range between 1 and 300. Therefore, there is a degree of uncertainty in the noncarcinogenic toxicity criteria, based on the available scientific data for each compound. The noncarcinogenic toxicity factors are most likely an overestimate of actual toxicity.

Use of provisional toxicity factors increases the degree of uncertainty associated with the Site 28 risk assessment. Provisional RfDs for aluminum and iron were used in this assessment. The USEPA does not include an RfD for aluminum or iron in IRIS or HEAST, so a provisional value from NCEA was used.

Iron is an essential human nutrient, which complicates the derivation of an RfD (USEPA, January 1999). The future child resident had an estimated HQ from ingestion of iron in soil of 0.96, which is below the USEPA target value of 1. Therefore, exposure to iron in soil by child residents should not be considered a health concern. However, the future child resident had an estimated HQ from ingestion of iron in groundwater of 14, which is above the USEPA target value of 1. The RME intake of iron via incidental ingestion of groundwater (4.2 mg/kg-day; Appendix G, Table 7.7) also exceeds the RDA range for children ages 6 months to 10 years (0.36–1.11 mg/kg-day) (USEPA, 1999). Therefore, exposure to iron in groundwater by child residents should be considered a health concern since it exceeds the range associated with levels that meet the known nutrient needs of healthy individuals.

Although the oral RfD for manganese is not provisional (that is, the RfD has been approved by a USEPA workgroup), the derivation of toxicity factors for essential nutrients is complicated, and therefore, warrants further discussion. Manganese is an essential human nutrient responsible for activating several enzymes (USEPA, 2003b). Disease states have been documented in humans associated with both deficiencies and excess intakes of manganese (USEPA, 2003b). The IRIS profile for manganese states, "The reference dose is estimated to be an intake for the general population that is not associated with adverse health effects; this is not meant to imply that intakes above the reference dose are necessarily associated with toxicity. Some individuals may, in fact, consume a diet that contributes more than 10 mg Mn/day without any cause for concern," (USEPA, 2003b). Exposure to manganese in groundwater resulted in an HQ of 1.4 for future child residents. However, the National Research Council has determined an "estimated safe and adequate daily dietary intake" (ESADDI) of manganese to be 2–5 mg/day for adults (USEPA, 2003b). The highest dissolved manganese concentration was 441 µg/L, so at least 5 liters of water from that location would have to be consumed per day to intake just 2 mg/day of manganese. An ESADDI for children was not provided, and therefore, this comparison can not be made. However, the essential human requirement should be considered when reviewing the manganese HQ.

Carcinogenic slope factors developed by the USEPA represent upper bound estimates. Any carcinogenic risks generated in this assessment should be regarded as an upper bound estimate on the potential carcinogenic risks rather than an accurate representation of carcinogenic risk. The true carcinogenic risk is likely to be less than the predicted value.

A number of SVOCs were detected in only one of the 70 soil samples collected at Site 28. These SVOCs were all detected in sample IS28SS36-0001 at concentrations around 100 µg/kg and qualified with a J. SVOCs were not detected in most of the samples collected around sample IS28SS36-0001. As discussed in Appendix C, Section J.1.4, the SVOCs detected in IS28SS36-0001 are likely the result of erroneous laboratory results. After discussion with the data validator, the validator agreed that the samples should be rejected, see Appendix C, Attachment B. However, none of the SVOCs that were detected in only this sample were retained as a COPC, and therefore, this sample does not impact the results of the risk assessment.

Comparison of the site data to background data was not used as a criterion in the selection of the COPCs. Therefore, some of the constituents that have been retained as COPCs and carried through the risk assessment may be present at concentrations consistent with background conditions at Indian Head.

6.7.2 Uncertainty Associated with Exposure Assessment

The most significant source of uncertainty associated with the exposure assessment is the underlying assumption that contact with affected media would occur under current land use conditions, and that the land use and human activity patterns assumed for the hypothetical future scenarios would occur. There is no information to suggest that recreationalists, trespassers, or utility workers currently at Indian Head routinely come into contact with affected media in the course of their daily activities (or will in the future); therefore, the generic exposure assumptions used to evaluate exposure are likely to overestimate current (and future) exposure.

Most of the exposure pathways analyzed are assumed, and exposure factors used for quantitation of exposure are conservative and reflect worst-case or upper-bound assumptions on the exposure. Most of the exposure pathways evaluated for Site 28 are hypothetical and are not likely to occur in the future. Site 28 is not expected to be used for residential use, so the inclusion of this receptor in the assessment is conservative.

The future soil exposure scenario adds additional conservatism by assuming that the subsurface soil will become surface soil during any future construction activities. During many construction projects, clean fill material is placed over the soil that is disturbed during excavation projects. The clean fill material is generally needed to support growth of grass and other landscape plants.

The percent of a chemical absorbed through the skin is likely to be affected by many parameters. Some of the parameters include soil loading, soil moisture content, organic content, pH, and presence of other constituents. The availability of a chemical depends on site-specific fate and transport properties of the chemical species available for eventual absorption of skin. Chemical concentrations, specific properties of the chemical, and soil release kinetics all impact the amount of a chemical that is absorbed. These factors contribute to the uncertainty associated with these estimates and make quantitation of the amount of certain chemicals absorbed from soil difficult.

The RfD for vanadium used in the risk assessment is derived from human data (NCEA, 2000). The same reference (NCEA, 2000) also lists a RfD derived from animal data, which is lower. Based on a review of the NCEA document and discussions with USEPA toxicologists, it is appropriate to use the higher, human-based RfD.

6.7.4 Uncertainty in Risk Characterization

The uncertainties identified in each component of risk assessment ultimately contribute to uncertainty in risk characterization. The addition of risks and HIs across pathways and chemicals contributes to uncertainty based on the interaction of chemicals such as additivity, synergism, potentiation, susceptibility of exposed receptors, etc.

One essential nutrient, iron, was identified as a potential risk driver for the child resident. However, the receptor-specific intake was consistent with established safe or recommended daily doses. Therefore the RME risk characterization for these constituents should be reviewed in conjunction with important toxicological information regarding daily intakes estimated to prevent conditions related with deficiencies of these constituents.

Sufficient information was not available to quantitatively characterize current/future recreational adult exposure to site-constituents via ingestion of fish from Mattawoman Creek. However, this is addressed in the Mattawoman Creek Study for the creek as a whole (Tetra Tech NUS, 2002). This is a potentially complete exposure pathway and the Ecological Risk Assessment (Section 7) indicates that sediment constituents could be taken up by fish in Mattawoman Creek. Since neither fish population or tissue data was available, the exposure was not quantified and the qualitative risk characterization only provides tentative conclusions regarding exposure rather than risk.

The use of the Adult Lead Model to evaluate risks associated with exposure to lead in soil by utility workers, construction workers, and adult trespassers results in uncertainty in the risk characterization. The Adult Lead Model was developed to evaluate risks to industrial workers, based on standard worker exposure assumptions. Use of this model for other ~~than~~ industrial receptors may result in an underestimate or overestimate of risks to these receptors.

6.8 Summary

This risk assessment was conducted to evaluate the potential human health risks associated with the presence of site-related surface soil, combined surface and subsurface soil, groundwater, sediment, and surface water at Site 28, Indian Head. Potential risks were calculated for a current utility worker, current and future adult and adolescent trespasser, current/future adult and adolescent recreational user, future adult resident, future child resident, future lifetime resident, and future construction worker. This baseline risk assessment was conducted to characterize the potential future human health risks at Site 28 if no additional remediation is implemented.

Appendix G, Tables 9.1.RME through 9.11.RME and Tables 9.1.CTE through 9.4.CTE summarize the RME and CTE potential hazards and risks to each receptor. Appendix G, Tables 10.1.RME through 10.9.RME, and 10.1.CT through 10.3.CT show only the chemicals

What about the duration of risk, etc? esp for trespassers

that contributed HIs greater than 0.1 to total HIs greater than 1.0, or carcinogenic risks greater than 10^{-6} to total carcinogenic risks greater than 10^{-4} .

There are no risks or hazards that exceed USEPA target levels for the utility worker exposed to site soil, adult and adolescent trespassers exposed to site soil (current or future), or adult and adolescent recreationalists exposed to surface water. All potential exposures to surface soil and surface water result in hazards and risks within USEPA target levels. Exposure to sediment was not quantified since it is not a complete exposure pathway.

The following receptors had total RME noncarcinogenic hazards or carcinogenic risks that exceeded USEPA's target levels:

- Future adult resident exposed to groundwater
- Future child resident exposed to groundwater
- Future lifetime resident exposed to groundwater
- Future adult resident exposed to soil
- Future child resident exposed to soil
- Future lifetime resident exposed to soil
- Future construction worker exposed to groundwater
- Future construction workers exposed to soil

Future exposure to combined surface and subsurface soil by a child and adult resident, and construction worker may result in a noncarcinogenic hazard above USEPA's target hazard index of 1.0. Arsenic and zinc are the only constituents which contribute individual HIs above 1 (arsenic for the child resident and construction worker, and zinc for the child resident) to the total HI. The CTE noncarcinogenic hazards are below USEPA's target HI for all three receptors. Future exposure to combined surface and subsurface soil by a lifetime resident may result in a carcinogenic risk above USEPA's target range of 1×10^{-6} to 1×10^{-4} . Exposure to arsenic in the combined soil contributes to the cancer risk for future lifetime residents. The CTE carcinogenic risk to the lifetime resident is within USEPA's target risk range.

While exposure to combined surface and subsurface soil by a future commercial worker was not quantitatively evaluated in this risk assessment, the noncarcinogenic hazard is expected to be below USEPA's target hazard index of 1.0. The RME noncarcinogenic hazard to an adult resident exposed to soil (HI=1.3), which is the most directly analogous receptor, of those evaluated, to a commercial worker, only marginally exceeds USEPA's target hazard level. Therefore, the RME hazard to the less-exposed commercial worker would likely be less than the target HI of 1.0, and thus would result in an acceptable risk. In addition, the CTE noncarcinogenic hazards and CTE carcinogenic risks to residential exposure to soil are below USEPA's target HI or within USEPA's target risk range. Therefore, the CTE hazards and risks to future commercial workers will result in an acceptable risk.

The average concentrations of lead in surface soil and combined surface and subsurface soil (142 and 58.5, respectively) were below the USEPA recommended level. However, detected concentrations of lead in 12 of the 70 soil samples were above the soil screening value of 400 mg/kg, some of them greater than 25 times the soil screening value. These samples were collected in the northeast quadrant of the site, near Swale 3. Based on the lead analysis in the vicinity of Swale 3, exposure to surface and subsurface soil in this area would potentially be

a concern for fetuses of expectant construction workers, fetuses of expectant utility workers (if they are exposed at the upper end of the estimated range of parameter values), fetuses of expectant adult trespassers (if they are exposed at the upper end of the estimated range of parameter values), and future child residents.

It is extremely unlikely that the surficial groundwater at Site 28 will be used as a future source of potable water, due to the low yield and availability of better water supplies. However, future potable use of the groundwater was evaluated in the risk assessment. Future potable use of the groundwater would result in a noncarcinogenic hazard above USEPA's target hazard index of 1.0 to child and adult residents. The hazard is associated with a number of inorganic constituents. The majority of these constituents, excluding arsenic, were also detected in the background groundwater at concentrations that appear to be similar to those on site. However, even if they are considered background-related, arsenic alone would pose a hazard above USEPA's target hazard index of 1.0. The CTE hazards are also above 1.0. Future exposure to groundwater by a lifetime resident may result in a carcinogenic risk above USEPA's target range. This risk is also driven by arsenic in the groundwater. The CTE risk is also above USEPA's target range.

Future construction work involving unprotected contact with the groundwater would result in risks within USEPA target levels. The noncarcinogenic hazard is above the USEPA target of 1.0 for the RME scenario. The CTE scenario results in an HI within the target range.

In summary, there would be potentially unacceptable risks to future residents if the site is used for future residential purposes. Additionally, construction workers involved in excavation activities at the site may also face potential unacceptable risks associated with exposure to soil and groundwater.

Trespassers?

6.9 References

Foster, S. A. and P. C. Chrostowski. *Inhalation Exposures to Volatile Organic Contaminants in the Shower*. ICF-Clement Associates, Inc. Washington, D.C. 1987.

NCEA, May 2000 – vanadium profile

Tetra Tech NUS. 2002. *Mattawoman Creek Study*. Indian Head Division Naval Surface Warfare Center, Indian Head, Maryland. July 2002.

USEPA, 1989. *Risk Assessment Guidance for Superfund, Vol. I, Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. December. USEPA, 1991. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part B, Interim Final*. Office of Solid Waste and Emergency Response. March. USEPA, 1992. *Draft Guidance on the Selection of Analytical Metal Results from Monitoring Well Samples for Use in the Quantitative Assessment of Risk*. USEPA Region III. August 10.

USEPA, 1993. *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening*. Region III, Hazardous Waste Management Division, Office of Superfund Programs. EPA/903/R-93-001. January 1993.

USEPA, 1994. *1994 Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*, OSWER Directive 9355.4-12. July 14.

USEPA, 1995. *Assessing Dermal Exposure from Soil*. Region III Technical Guidance Manual, Risk Assessment. Hazardous Waste Management Division, Office of Superfund Programs. EPA/903-K-003. December.

USEPA, 1996. *Soil Screening Guidance: Technical Background Document*. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-95/128. May 1996.

USEPA, 2001. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim*. EPA/540/R/99/005. OSWER 9285.7-02EP. September.

USEPA, December 2002. *Calculating Upper Confidence Limits For Exposure Point Concentrations at Hazardous Waste Sites*. OSWER 9285.6-10. Office of Emergency and Remedial Response, Washington, D.C.

USEPA, 2003a. *Region III Updated Risk-Based Concentration Table*. October 15.

USEPA, 2003b. *Integrated Risk Information System*. U.S. Environmental Protection Agency, Office of Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH.

USEPA, 2003c. *ProUCL User's Guide. Version 2.1*. February.

USEPA, 2003d. *Recommendations of the Technical Review Workgroup for Lead for an interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. January 2003.

Conclusions and Recommendations

The objectives of the RI, presented in the work plan (CH2M HILL, 2003) were to:

- Verify the presence of contamination in soil, groundwater, surface water, and sediment resulting from past activities at the site
- Define the extent of contamination
- Evaluate the need for remediation based on the critical information developed in the human health and ecological risk assessments

8.1 Conclusions

The analytical results have adequately defined the nature and extent of the contamination for each media. The number of samples taken was adequate to determine concentration trends at the site, as discussed in Section 6. None of the media contain VOCs, SVOCs, or chemicals used in explosive devices in significant quantities to be of concern. All of the risk drivers at the site are metals.

Disparities?

The human health risk assessment determined that potentially unacceptable risk was present for future adults, children, lifetime residents, and construction workers exposed to soil and groundwater. Risks to commercial and industrial workers from soil were not quantitatively evaluated in the risk assessment. However, based on the calculated risk to an adult resident exposed to soil (i.e., a noncarcinogenic hazard that only marginally exceeded the USEPA target hazard level), which is the most directly analogous receptor to a commercial worker, the potential risk to this receptor is likely acceptable. The analysis of the elevated lead concentrations in the Swale 3 area concluded that exposure to surface and subsurface soil in this area would potentially be a concern for fetuses of expectant construction workers, utility workers (if they are exposed at the upper end of the estimated range of parameter values), adult trespassers (if they are exposed at the upper end of the estimated range of parameter values), and future child residents.

None of these receptors are presently at the site, nor are they expected to be present at the site in the near future. The ecological risk assessment determined that unacceptable risk was present in the soil and sediment. A Baseline Ecological Risk Assessment is already funded, and will be performed for Site 28.

8.2 Recommendations

The recommendations for Site 28 are to proceed to the feasibility study. Remediation alternatives need to be studied to address human health and ecological risk caused by the soil at Site 28. Sediment remediation will also be needed to address the ecological risk at the site.

While risks from groundwater to human receptors are estimated to be potentially unacceptable, groundwater is not recommended for advancement in the CERCLA process to the feasibility study stage. Given the proximity of Site 28 to Mattawoman Creek, low hydraulic conductivity, and the very thin saturated thickness (less than 15 feet; shown on cross-sections in Figures 2-2 and 2-3), shallow groundwater in the vicinity of Site 28 is not a potable resource. One could not build a legal well in this unit, given Maryland well construction regulations, which require a minimum of 20 feet of isolation casing from ground surface. This unit is also not capable of meeting sustained yield requirements of Maryland well construction regulations; a well casing greater than 200 feet would likely be required.

Risk from groundwater to ecological receptors will be evaluated in the Site 28 Baseline Ecological Risk Assessment, since groundwater does migrate to surface water swales and the Mattawoman Creek system. Groundwater is also a potential source of metals to the nearshore sediments and surface water and thus will be considered in the management of ecological risk for these media. The Baseline Ecological Risk Assessment will be completed prior to the Site 28 Feasibility Study.

Also, shoreline habitat is expected to be restored as part of any remedial action, as the current conditions are degraded and active erosion is occurring.

Table 1
 Samples Included in Lead Hot Spot Analysis
 Site 28 RI Report, NDWIH
 Indian Head, Maryland

StationID	IS28MM06		IS28MM11			IS28MM14	
SampleID	IS28SS06-0001	IS28SB06-0103	IS28SS11-0001	IS28SS11-0001P	IS28SB11-0103	IS28SS14-0001	IS28SB14-0103
SampleDate	05/15/03	05/15/03	05/13/03	05/13/03	05/13/03	05/15/03	05/15/03
Total Metals (MG/KG)							
Lead	430	15	731	836	14.1	189	1090

StationID	IS28MM23		IS28MM42		IS28SO08	
SampleID	IS28SS23-0001	IS28SB23-0103	IS28SS42-0001	IS28SB42-0103	IS28SS08-0001	IS28SB08-0103
SampleDate	05/15/03	05/15/03	05/14/03	05/14/03	05/13/03	05/13/03
Total Metals (MG/KG)						
Lead	346	1020	2800	410	3540 J	6 J

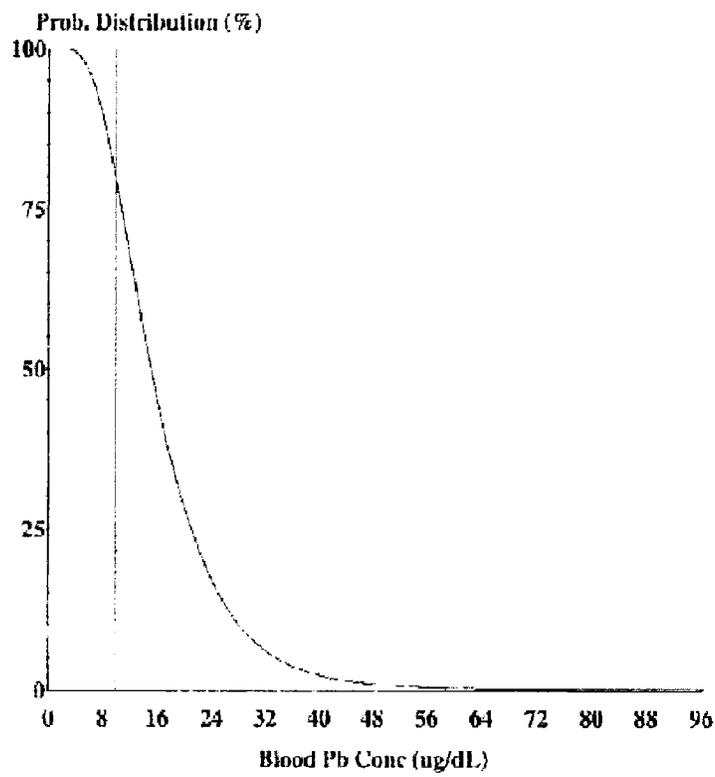
StationID	IS28SO09		IS28SO10		IS28SO15	
SampleID	IS28SS09-0001	IS28SB09-0103	IS28SS10-0001	IS28SB10-0103	IS28SS15-0001	IS28SB15-0103
SampleDate	05/12/03	05/12/03	05/13/03	05/13/03	05/13/03	05/13/03
Total Metals (MG/KG)						
Lead	526	3.7	1180 J	1640 J	3650 J	28.2 J

StationID	IS28SO18		IS28SO19	
SampleID	IS28SS18-0001	IS28SB18-0103	IS28SS19-0001	IS28SB19-0105
SampleDate	05/13/03	05/13/03	05/13/03	05/13/03
Total Metals (MG/KG)				
Lead	1990	149	10300 J	16600 J

Mean Value: 2125.59

IEUBK Model Results

Indian Head Site 28 - Lead Hot Spot Analysis



Cutoff = 10.000 ug/dl
Geo Mean = 15.800
GSD = 1.600
% Above = 83.478

Age Range = 0 to 84 months
Time Step = Hourly
Run Mode = Research

Model Version: 1.0 Build 253

User Name:

Date:

Site Name:

Operable Unit:

Run Mode: Research

=====
The time step used in this model run: 3 - Hourly (24 times a day).

***** Air *****

Indoor Air Pb Concentration: 30.000 percent of outdoor.

Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m ³ /day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m ³)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

***** Diet *****

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

***** Drinking Water *****

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

***** Soil & Dust *****

Multiple Source Analysis Used

Average multiple source concentration: 1498.200 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000

Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
-----	-----	-----

4-5	2126.000	1498.200
5-6	2126.000	1498.200
6-7	2126.000	1498.200

***** Alternate Intake *****

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

***** Maternal Contribution: Infant Model *****

Maternal Blood Concentration: 2.500 ug Pb/dL

 CALCULATED BLOOD LEAD AND LEAD UPTAKES:

Year	Air (ug/dL)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.871	0.000	0.271
1-2	0.034	1.849	0.000	0.640
2-3	0.062	2.176	0.000	0.697
3-4	0.067	2.186	0.000	0.743
4-5	0.067	2.331	0.000	0.853
5-6	0.093	2.563	0.000	0.938
6-7	0.093	2.894	0.000	0.976

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	30.719	32.881	16.8
1-2	46.134	48.657	19.4
2-3	48.351	51.285	18.4
3-4	50.529	53.525	18.0
4-5	41.443	44.695	15.4
5-6	38.867	42.461	13.2
6-7	37.546	41.509	11.8

Adult Lead Model Results

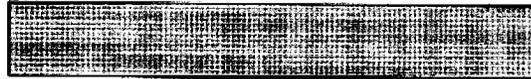
Indian Head Site 28

Utility Worker Exposure

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03



Exposure Variable	PbB		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	Equation ¹				Using Equation 1		Using Equation 2	
	1*	2**			GSD1 = Hom	GSD1 = Het	GSD2 = Hom	GSD2 = Het
PbS	X	X	Soil lead concentration	ug/g or ppm	2126	2126	2126	2126
R _(inh/abs)	X	X	Respiratory/inhalation rate	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD ₁	X	X	Geometric standard deviation PbB	--	2.1	2.3	2.1	2.3
PbB ₀	X	X	Baseline PbB	ug/dL	1.5	1.7	1.5	1.7
IR _s	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.480	0.480	--	--
IR _{gcp}		X	Total ingestion rate of inorganic soil and indoor dust	g/day	--	--	0.480	0.480
W _s		X	Weighting factor, fraction of IR _{gcp} ingested as outdoor soil	--	--	--	1.0	1.0
K _{sd}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
AF _{s,d}	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
EF _{s,d}	X	X	Exposure frequency (same for soil and dust)	days/yr	10	10	10	10
AT _{s,d}	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB _{adult}			PbB of adult worker, geometric mean	ug/dL	2.8	3.0	2.8	3.0
PbB _{total,95%}			95th percentile PbB among fetuses of adult workers	ug/dL	8.7	10.8	8.7	10.8
PbB _c			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0	10.0	10.0
P(PbB _{total} > PbB _c)			Probability that total PbB > PbB _c , assuming lognormal distribution	%	3.3%	6.0%	3.3%	6.0%

¹ Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_s, K_{sd}).
When IR_s = IR_{gcp} and W_s = 1.0, the equations yield the same PbB_{total,95%}.

*Equation 1, based on Eq. 1, 2 in USEPA (1996).

$$PbB_{adult} = (PbS * BKSF * IR_{gcp} * AF_{s,d} * EF_{s,d} * AT_{s,d}) / (GSD_1^{1.667} * R)$$

$$PbB_{total,95\%} = PbB_{adult} * (GSD_1^{1.667} * R)$$

**Equation 2, alternative approach based on Eq. 1, 2, and A.19 in USEPA (1996).

$$PbB_{adult} = PbS * BKSF * ((IR_{s,d}) * AF_{s,d} * EF_{s,d} * W_s) + (K_{sd} * (IR_{gcp}) * (1 - W_s) * AF_{s,d} * EF_{s,d}) / (GSD_2^{1.667} * R)$$

$$PbB_{total,95\%} = PbB_{adult} * (GSD_2^{1.667} * R)$$

Indian Head Site 28

Adult Trespasser Exposure

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03



Exposure Variable	PbB Equation ¹		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	1*	2**			Using Equation 1		Using Equation 2	
					GSD1 - Hom	GSD1 - Het	GSD1 - Hom	GSD1 - Het
PbS	X	X	Soil lead concentration	ug/g or ppm	2126	2126	2126	2126
R _{total}	X	X	Total inorganic Pb/B ratio	-	0.9	0.9	0.9	0.9
BKSF	X	X	Bioavailability (Soil Factor)	ng/dl per ug/day	0.4	0.4	0.4	0.4
GSD ₁	X	X	Geometric standard deviation PBR	-	2.1	2.3	2.1	2.3
PbP ₀	X	X	Baseline PbB	ug/dl	1.5	1.7	1.5	1.7
IR _{s,d}	X	X	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	-	-
IR _{ind}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	-	-	0.100	0.100
W _s		X	Weighting factor, fraction of IR _{s,d} ingested as outdoor soil	-	-	-	1.0	1.0
K _{d0}		X	Soil-to-air partition coefficient	-	-	-	0.7	0.7
AF _{s,d}	X	X	Absorption fraction (same for soil and dust)	-	0.12	0.12	0.12	0.12
EF _{s,d}	X	X	Exposure frequency (same for soil and dust)	days/yr	52	52	52	52
AT _{s,d}	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB _{adult}	PbB of adult worker, geometric mean			ug/dl	3.0	3.2	3.0	3.2
PbB _{total,0.95}	95th percentile PbB among females of adult workers			ug/dl	9.0	11.2	9.0	11.2
PbB ₀	Target PbB level of concern (e.g., 10 ug/dl)			ug/dl	10.0	10.0	10.0	10.0
P(PbB _{total,0.95} > PbB ₀)	Probability that total PbB > PbB ₀ , assuming lognormal distribution			%	3.7%	6.5%	3.7%	6.5%

¹ Equation 1 does not account for exposure between soil and dust ingestion (excludes W_s, K_{d0}).
When IR_s = IR_{s,d} and W_s = 1.0, the equations yield the same PbB_{total,0.95}.

*Equation 1, based on Eq. 1, 2 in USEPA (1996).

$PbB_{total} =$	$(PbS * BKSF * IR_{s,d} * AF_{s,d} * EF_{s,d} / AT_{s,d}) + PbB_0$
$PbB_{total,0.95} =$	$PbB_{0.95} * (GSD_1)^{1.645} * R$

**Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996)

$PbB_{total} =$	$PbS * BKSF * ((IR_{s,d}) * AF_{s,d} * EF_{s,d} * W_s + IR_{ind}) * (1 - W_s) * AF_{ind} * EF_{ind} / (365) * PbB_0$
$PbB_{total,0.95} =$	$PbB_{0.95} * (GSD_1)^{1.645} * R$

Indian Head Site 28

Construction Worker Exposure

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03



Exposure Variable	PbS		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	Equation ¹				Using Equation 1		Using Equation 2	
	1*	2**			GSD1 = Hom	GSD1 = Het	GSD2 = Hom	GSD2 = Het
PbS	X	X	Soil lead concentration	ug/c or ppm	2126	2126	2126	2126
R _{bioavail}	X	X	Total/material PbD ratio	--	0.9	0.9	0.9	0.9
BKCF	X	X	Bioavailability Factor	ug/dl per ug/day	0.4	0.4	0.4	0.4
GSD ₁	X	X	Geometric standard deviation PbS	--	2.1	2.1	2.1	2.1
PbD ₀	X	X	Baseline PbD	ug/dl	1.5	1.7	1.5	1.7
IR _s	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.480	0.480	--	--
IR _{s,D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.480	0.480
W _s		X	Weighting factor, fraction of IR _{s,D} ingested as outdoor soil	--	--	1.0	1.0	
K _{so}		X	Air to fraction of soil in dust	--	--	0.7	0.7	
AF _{s,D}	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
FF _{s,D}	X	X	Exposure frequency (same for soil and dust)	days/yr	250	250	250	250
AT _{s,D}	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB _{adult}	PbB of adult worker, geometric mean			ug/dl	35.1	35.3	35.1	35.3
PbB _{95th pct}	95th percentile PbB among fetuses of adult workers			ug/dl	106.9	121.9	106.9	121.9
PbB _c	Target PbB level of concern (e.g., 10 ug/dl)			ug/dl	10.0	10.0	10.0	10.0
P(PbB _{total} > PbB _c)	Probability that total PbB > PbB _c , assuming lognormal distribution			%	93.9%	91.7%	93.9%	91.7%

¹Equation 1 does not account for exposure between soil and dust ingestion (excludes W_s, K_{so}).
When IR_s = IR_{s,D} and W_s = 1.0, the equations yield the same PbB_{adult}.

*Equation 1, based on Eq. 1, 2 in USEPA (1996).

$$PbB_{adult} = (PbS * BKCF * IR_{s,D} * AF_{s,D} * K_{so} / AT_{s,D}) + PbD_0$$

$$PbB_{total, 95} = PbB_{adult} * (GSD_1^{1.65} * R)$$

**Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).

$$PbB_{adult} = PbS * BKCF * (IR_{s,D} * AF_{s,D} * FF_{s,D} * W_s / (K_{so} * (IR_{s,D} * (1 - W_s) * AF_{s,D} * FF_{s,D} * W_s) + PbD_0))$$

$$PbB_{total, 95} = PbB_{adult} * (GSD_1^{1.65} * R)$$

Indian Head Site 28 Lead Hot Spot Analysis

Industrial Worker Scenario

Calculations of Blood Lead Concentrations (PbB)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee



Version date 2/19/03

Exposure Variable	PbB Equation ¹		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario			
	1*	2**			Using Equation 1		Using Equation 2	
					GSD1 = Hom	GSD1 = Het	GSD1 = Hom	GSD1 = Het
PbS	X	X	Soil lead concentration	mg/kg or ppm	2126	2126	2126	2126
R _{total/outdoor}	X	X	Total/external PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Shape Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD ₁	X	X	Geometric standard deviation PbB	--	1.9	2.3	1.9	2.3
PbB ₀	X	X	Baseline PbB	ug/dL	1.4	1.8	1.4	1.8
IR _s	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	0.050	--	--
IR _{s+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.050	0.050
W _s		X	Weighting factor, fraction of IR _{s+D} ingested as outdoor soil	--	--	--	1.0	1.0
K ₁₀		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
AF _{s,D}	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
FF _{s,D}	X	X	Exposure frequency (same for soil and dust)	days/y	219	219	219	219
AT _{s,D}	X	X	Averaging time (same for soil and dust)	days/y	365	365	365	365
PbB _{adult}			PbB of adult worker, geometric mean	ug/dL	4.5	4.9	4.5	4.9
PbB _{total,95}			95th percentile PbB among phases of adult workers	ug/dL	11.5	17.2	11.5	17.2
PbB _t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0	10.0	10.0
P(PbB _{total,95} > PbB _t)			Probability that total PbB > PbB _t , assuming lognormal distribution	%	7.8%	16.0%	7.8%	16.0%

¹ Equation 1 does not apply to a exposure between soil and dust ingestion (excludes W_s, K₁₀).
When IR_s = IR_{s+D} and W_s = 1.0, the equations yield the same PbB_{total,95}.

*Equation 1, based on Eq. 1, 2 in USEPA (1996).

PbB _{adult}	=	(PbS * BKSF * (IR _s) * AF _{s,D} * EF _{s,D}) / AT _{s,D} + PbB ₀
PbB _{total,95}	=	PbB _{adult} * (GSD) ^{1.645} * R

**Equation 2, alternate approach based on Eq. 1, 2, and A-14 in USEPA (1996).

PbB _{adult}	=	PbS * BKSF * ((IR _s) * AF _{s,D} * W _s) / (K ₁₀ * (IR _{s+D}) * (1 - W _s) * AF _{s,D} * EF _{s,D}) / 365 * PbB ₀
PbB _{total,95}	=	PbB _{adult} * (GSD) ^{1.645} * R