Appendix N1 – Human Health Risk Assessment

N1.1 Introduction

Appendix N1 (contained herein) presents human health risk assessment details, including the following:

- Section N1.2: Procedures Used for the Selection of Site COPCs;
- Section N1.3: Chemical-Specific Factors for COPCs;
- Section N1.4: Lead Exposure Assessment;
- Section N1.5: Mid-Valley RAGS-D Tables; and
- Section N1.6: Risk Assessment Uncertainty Analysis.

Appendix N2 presents results of the Johnson and Ettinger Indoor Air evaluation for the off-gassing of VOCs from in-situ groundwater to indoor air.

This HHRA follows the approach discussed with and approved by USEPA Region 2 (Department of the Army, 2005).

Reference

Department of the Army, 2005, letter from Mr. Ted Gabel – Project Manager for Environmental Restoration, Picatinny to Mr. William Roach – USEPA Region 2 Project Manager, April 7.

Section N1.2 Procedures Used for the Selection of Site COPCs

N1.2.1 Introduction

The following procedures were used by Shaw Environmental & Infrastructure (formerly IT Corporation [IT]) to select human health chemicals of potential concern (COPC) within the Mid-Valley Groundwater Operable Unit (OU).

These procedures generally follow the USEPA Region 2-approved Risk Assessment Approach (IT, 2001). Recommended COPCs, with the COPC flag "Yes" in the next to last table column, are presented in the RAGS-D Table 2.1 for the Mid-Valley Groundwater OU (Appendix N1 Section N1.5).

The data base used in the HHRA included samples collected from monitoring wells located within footprints of the RDX and TCE Mid-Valley groundwater plumes (Figures 4-1 and 4-2, respectively, in the main text). Chemical analytical data used included VOCs, base explosives, and metals. No perched groundwater or hydro-punch data were used. In addition, only data collected subsequent to the initiation of the low-flow groundwater sampling protocol (i.e., 1996 – 2004) were used. The OU consists of both overburden and bedrock wells combined, given the possible hydraulic communication between these two zones.

N1.2.2 COPC Selection

The RAGS-D Table 2.1 includes the required data and the additional considerations requested by USEPA Region 2.

Some important points regarding the chemical analytical data set are presented in the following bullets.

- All rejected data (R-qualified) and blank-related data (B-qualified) have been removed from the data base used to generate the RAGS-D tables, as discussed in the USEPA-approved Approach document (IT, 2001).
- Some analytical results may co-eluted (such as 2- and 4-nitrotoluene) and as such do not have a Chemical Abstract Service (CAS) Number. In these instances a project-specific (fictitious) CAS Number is assigned by the data base management software, and this number appears on Table 2.1.
- Certain analytes may appear on the target analyte list with more than one analytical method for the same sample. For example, 2,4,6-trinitrotoluene (TNT) may appear twice under both semivolatile organic compounds (SVOC) and Explosives methods. In these cases, data from the method specified by the quality assurance project plan (QAPP) (IT, 1999) are used (in this case, results from the Explosives method are used).

The site-specific background values used for groundwater are from LMW-1 for the overburden aquifer and from 5MW-6 for the bedrock aquifer.

Screening toxicity values used are from USEPA Region 3's Risk-Based Concentration (RBC) Table dated April 2005. Screening values for constituents with cancer endpoints are based on a 1E-6 cancer risk threshold, whereas constituents with noncancer endpoints are based on a 0.1 hazard quotient (HQ) threshold (to account for potential additivity of multiple COPCs). Several constituents are flagged with an "!" in the RBC table (e.g., 2,4,6-TNT) because the cancer RBC is actually numerically greater than a

noncancer RBC adjusted to an HQ of 0.1. As the noncancer RBC is not provided for these constituents in the RBC Table, it was conservatively assumed that the noncancer RBC is 10-fold lower than the cancer RBC for these constituents. RBCs for constituents with their toxicity values flagged as "withdrawn" (W) on the RBC Table were retained for use in the RAGS-D Table 2.1. This is because a "W" on the RBC Table indicates the toxicity data are being reevaluated by USEPA and may be reinstated at a future date.

Applicable or Relevant and Appropriate Requirements (ARAR) and/or To Be Considered (TBC) values included the following:

- Maximum contaminant levels (MCLs), secondary MCLs (SMCLs), and copper and lead action levels for water were obtained from current drinking water standards (provided at the web site: www.epa.gov/safewater/mcl.html);

- For essential nutrients (including calcium, magnesium, phosphorus, potassium, and sodium), recommended daily allowances (RDAs) from the National Research Council, World Health Organization, or Journal of the American Medical Association were used to back calculate concentrations in water and soil/sediment. Standard default intake assumptions were used. Details for these back calculations are provided in Table N1-1.

Some constituents on the RAGS-D Table 2.1 may have two screening values (e.g., manganese, cadmium, uranium, mercury, 2,4-dinitrotoluene (DNT), 2,6-DNT, phosphorus, and vinyl chloride). The reasons for these "doubles" are briefly discussed as follows.

- Manganese (nonfood and food RBCs exist);
- Cadmium (water and food RBCs exist);
- Uranium (RBCs based on both IRIS and National Center for Environmental Assessment [NCEA] provisional toxicity data exist);
- Mercury (elemental mercury has no oral toxicity value whereas methyl mercury does, thus mercuric chloride has also been used as a surrogate for elemental mercury), except for water. As a drinking water MCL exists for elemental mercury, selection of mercuric chloride as a surrogate is not necessary for either surface water or groundwater;
- 2,4-DNT and 2,6-DNT are considered as noncarcinogens per the RBC Table; however, the "DNT mixture" entry in the RBC Table is based on carcinogenicity. Thus, the "DNT mixture" RBC has also been used as a surrogate for 2,4-DNT and 2,6-DNT results;
- Phosphorus (white phosphorus RBC and phosphorus nutrient RDA TBC values are available); and
- Vinyl chloride (adult and lifetime RBCs exist).

It should be noted that if some of these constituents were not detected within the Mid-Valley Groundwater OU, they do not appear in Table 2.1.

Whether or not a constituent with "double RBCs" was ultimately selected as a COPC, given it was not deselected for one of the valid deletion reasons, depended on the outcome of the screening process. If the COPC flag was "Yes" for both RBCs, then the constituent was carried forward for the quantitative risk assessment. If the COPC flag was "No" for both RBCs, then the constituent was not carried forward for the quantitative risk assessment. If one COPC flag was "Yes" and the other COPC flag was "No" the constituent was evaluated further. For purposes of this Picatinny Mid-Valley Groundwater OU HHRA, "doubles" with a "Yes/No" COPC Flag outcome were carried forward for the quantitative risk assessment, except for phosphorus. White phosphorus is not expected at Picatinny; therefore it is unrealistic to assume phosphorus measured in environmental media is anything other than naturally-occurring

phosphorus, which has a TBC RDA for this essential nutrient. For those COPCs with double RBCs that were carried forward for the quantitative risk assessment, appropriate toxicity information was selected (e.g., mercury is water would be expected to be methylated, whereas mercury in soil would not likely be methylated).

Some detected constituents, or constituents that co-eluted during chemical analysis, that did not have RBCs available were structurally similar to constituents that did have RBCs. For these constituents, logical and conservative surrogates were used. There is no criterion, per say, which was used to measure structural similarity, and logical surrogates were selected, as shown below. The surrogate selection was primarily based on similar compound components (e.g., Amino-DNT for 2-Amino-4,6-DNT) or based on general structural similarity for a class of compound (e.g., pyrene, as a representative PAH for acenaphthylene).

PARAMETER	CAS No.	SURROGATE
2- and 4-Nitrotoluene	NA	o-Nitrotoluene
2,4-Dinitrotoluene	121-14-2	DNT Mixture
2,6- Dinitrotoluene	606-20-2	DNT Mixture
2-Amino-4,6-Dinitrotoluene	35572-78-2	Amino-DNTs
3-Nitroaniline	99-09-2	2-Nitroaniline
4-Amino-2,6-Dinitrotoluene	19406-51-0	Amino-DNTs
4-Nitroaniline	100-01-6	2-Nitroaniline
Acenaphthylene	208-96-8	Pyrene
alpha-Chlordane	5103-71-9	Chlordane
AROCLOR 1016/1260	NA	AROCLOR 1260
AROCLOR 1232/1242	NA	AROCLOR 1242
Benzo(g,h,i)perylene	191-24-2	Pyrene
Benzylmercaptan	100-53-8	Benzenethiol
Chromium	7440-47-3	Chromium VI
cis-1,3-Dichloropropene	10061-01-5	1,3-Dichloropropene
Crotonitrile	4786-20-3	Methacrylonitrile
Cyclohexylamine	108-91-8	Aniline
delta-BHC	319-86-8	gamma-BHC (Lindane)
Endosulfan I	959-98-8	Endosulfan
Endosulfan II	33213-65-9	Endosulfan
Endosulfan Sulfate	1031-07-8	Endosulfan
Endrin aldehyde	7421-93-4	Endrin
Endrin ketone	53494-70-5	Endrin
gamma-chlordane	5103-74-2	Chlordane
Mercury	7439-97-6	Methylmercury
Nitrate/Nitrite	230-001	Nitrite
Phenanthrene	85-01-8	Pyrene
Thiophene	110-02-1	Furan
trans-1,3-Dichloropropene	10061-02-6	1,3-Dichloropropene

It should be noted that if some of these constituents were not detected within the Mid-Valley Groundwater OU data base, they do not appear in Table 2.1.

Rationale codes for selection or deletion are further discussed in the following bullets:

- Infrequent Detection but Associated Historically (HIST) code used to select detected constituents that would have otherwise been deleted due to frequency of detection (FOD) less than or equal to 5 percent. Historically associated constituents include the following:

Constituent(s)	Constituent(s) Historically Associated With the Mid-Valley Groundwater OU?
Explosives and lead	Yes
Some chlorinated solvents	Yes

  It should be noted that a low FOD (by itself) was only used to delete the following COPCs: 4-nitotoluene; thallium; 2,6-DNT; 1,1,2-trichloroethane; bromodichloromethane; carbon tetrachloride; and dibromochloromethane.

  2,6-DNT was deleted (with a FOD of 4.6%), even though it is an explosive, because 2,4-DNT (with a FOD of 5.6%) was selected as a COPC, and as these two compounds have two screening values (a noncarcinogenic screening value and a carcinogenic screening value; see previous discussion), it was conservative to assume that 2,4-DNT was carcinogenic. It should be noted that the USEPA IRIS database discussion of the carcinogenicity of a 2,4-DNT and 2,6-DNT mixture is based primarily on 2,4-DNT in the chemical mixture. The uncertainty associated with deleting 2,6-DNT is discussed in Section N1.6.

- Toxicity Information Available (TX) code used to select those detected constituents that had no RBC or ARAR/TBC value available, but do have usable toxicity data presented in USEPA's Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST) toxicity data bases.

- Above Screening Level (ASL) code used to select those detected constituents with maximum concentrations above either RBC or ARAR/TBC values.

- Group A Carcinogen (GAC) code used to select detected chemicals classified as Group A (known human) carcinogens, regardless of FOD or available screening values, as requested by USEPA Region 2.

- Break Down Product (BDP) code used to select some detected constituents that would otherwise be deleted. Chemicals were not eliminated as COPCs if they are known breakdown or degradation products of detected chemicals. Breakdown products were retained even if the concentrations of their precursors are not above the screening values. For example, in selecting COPCs for groundwater exposure, vinyl chloride is a known breakdown product of trichloroethylene (TCE) and tetrachloroethylene (PCE), thus in this example vinyl chloride (VC) would be retained as a COPC regardless of its detected concentration or FOD, because its concentration and FOD could be expected to increase in the future due to TCE's and PCE's environmental fate characteristics. Four important anaerobic chemical and biological transformation pathways for chlorinated solvents in groundwater are presented below (from McCarty, 1996), and are used to assign the BDP code:

  PCE → TCE →1,2-DCE → VC
  TCA → 1,1-DCA → Chloroethane
  TCA → 1,1-DCE → VC
  CCl_4 → Chloroform → Methylene chloride → Chloromethane

  Further breakdown products such as ethene, ethane, acetic acid, carbon dioxide, and water are not presented above as these products are not considered especially toxic.

- Elevated Detected Concentration (EDC) code used to select constituents that would otherwise be deleted due to low FOD (i.e., $\leq$ 5%). If the maximum detected concentration was greater than or

equal to 10-times the most restrictive screening value, then the constituent was selected as a COPC and was carried forward for the quantitative risk assessment. It should be noted that a low FOD code (by itself) only occurred for the following constituents: 4-nitotoluene; thallium; 2,6-DNT; 1,1,2-trichloroethane; bromodichloromethane; carbon tetrachloride; and dibromochloromethane, and none of these constituents had a maximum detected concentration that was more than10-times the most restrictive screening value.

- Infrequent Detection (IFD) code used to delete a constituent with an FOD less than or equal to 5 percent. As mentioned previously, this code was used (by itself) to delete the following constituents: 4-nitotoluene; thallium; 2,6-DNT; 1,1,2-trichloroethane; bromodichloro-methane; carbon tetrachloride; and dibromochloromethane.

- No toxicity information (NTX) code used to delete a constituent without toxicity screening value.

- Background Levels (BKG) code used to delete constituent with maximum detected concentration less than or equal to site-specific background threshold value, discussed previously.

- Below Screening and/or ARAR/TBC Level (BSL) code used to delete constituents with maximum concentration equal to or below most restrictive RBC, ARAR, or TBC value. Note: this code is superceded by GAC or BDP code.

N1.2.3 References

IT, 1999, Picatinny Arsenal Phase II Remedial Investigation and Feasibility Study (RI/FS) Sampling and Analysis Plans, Volume 1, Field Sampling Plan and Volume II, Quality Assurance Project Plan. U.S. Army Environmental Center.

IT, 2001, *Picatinny Arsenal Phase III-1A Human Health Risk Assessment Approach*, prepared for the U.S. Army Corps of Engineers, Baltimore District, TERC Number DACA31-95-D-0083, April 9.

McCarty, P.L., 1996, *Biotic and Abiotic Transformations of Chlorinated Solvents in Groundwater*, in "Symposium on Natural Attenuation of Chlorinated Organics in Groundwater," Dallas, Texas, September 11-13, USEPA Office of Research and Development, Washington, D.C., EPA/540/R-96/509.

USEPA, 2005, USEPA Region 3 Risk Based Concentration Table, April.

Section N1.3 Chemical-Specific Factors for COPCs

This section contains the following chemical-specific tables and/or equations:

- Table N1-2: Chemical-Specific Dermal Values
- Table N1-3: Chemical-Specific Physical Properties

Data and transport equations contained in these tables were used to estimate chemical intakes presented in Section N1.5.

Section N1.4 Lead Exposure Assessment

This section presents the lead exposure assessment for the Picatinny Mid-Valley Groundwater OU. As the OU had lead selected as a COPC in groundwater, lead exposure is assessed differently than other COPCs that have either cancer slope factors or noncancer reference doses. Lead was selected as a COPC because the maximum detected groundwater concentration was greater than the 0.015 mg/L (15 ug/L) lead action level for drinking water.

The average exposure point concentration for lead in groundwater is 3.81 ug/L. An average concentration is used, instead of 95 percent upperbound UCL EPC concentration, because the lead model uses a probabilistic blood lead level approach and calculates internal dose in a different manner than for other COPCs.

USEPA's *Integrated Exposure Uptake Biokinetic* (IEUBK) lead model for children (USEPA, 1994) was used. The child lead model is used for the future residential child receptor.

For the child lead model, recommended model defaults for dietary lead intake and maternal blood lead concentrations were used. After input data were specified for the child lead model, estimated lead intakes were calculated by the model for each time interval and intake pathway with estimated blood level levels also presented by the model for each time interval. It should be noted that lead concentrations in air, diet, soil, and dust were assumed to be zero. Model results are presented in both tabular and graphical format (see model output at the end of this section). The graphs present the probability density for the estimated blood lead levels, along with an estimate of the percentage of the exposed population expected to be above the U.S. Centers for Disease Controls (CDC) recommended blood lead threshold of concern (i.e., 10 micrograms per deciliter [ug/dL]). USEPA recommends that not more than 5 percent of the potentially exposed population have an estimated blood lead level equal to or greater than 10 ug/dL.

The child lead model estimated a future geometric mean blood lead concentration of 1.47 ug/dL and a probability that 0.002 percent of the potentially exposed future residential population would have an estimated blood lead level above the recommended threshold of concern of 10 ug/dL. This probability does not exceed USEPA's recommended percentage of 5 percent. Therefore, lead concentrations in groundwater are not a concern.

N1.4.1 References:

U.S. Environmental Protection Agency (USEPA), 1994, *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, Office of Solid Waste and Emergency Response, Washington, D.C., EPA/540/R-93/081, February.

Section N1.5 Mid-Valley Groundwater OU RAGS-D Tables

This section presents complete RAGS-D tables for the Mid-Valley Groundwater OU. The general format of the RAGS-D tables is as follows:

- Standard Table 1: Selection of Exposure Pathways
- Standard Table 2: Occurrence, Distribution and Selection of COPCs
- Standard Table 3: Medium-Specific Exposure Point Concentration Summary
- Standard Table 4: Values Used for Daily Intake Calculations
- Standard Table 5: Noncancer Toxicity Data
- Standard Table 6: Cancer Toxicity Data
- Standard Table 7: Calculation of Chemical Cancer Risks and Noncancer Hazards
- Standard Table 8: (not presented – only used for radiological risks)
- Standard Table 9: Summary of Receptor Risks and Hazards for COPCs
- Standard Table 10: Risk Summary

Section N1.6 Risk Assessment Uncertainty Analysis

This section presents a general uncertainty analysis for the Mid-Valley Groundwater OU HHRA, including a discussion on chromium speciation. Where appropriate, site-specific uncertainties are included and discussed.

There is a large degree of uncertainty associated with the estimates of human health risks in any risk assessment. Consequently, the estimates calculated for the sites should not be construed as absolute estimates of risk but rather as conditional estimates relative to the results of other risk assessments performed in a similar manner. The risk estimates were calculated based on a number of assumptions regarding exposure and toxicity. In general, the primary sources of uncertainty are associated with environmental sampling and analysis; selection of chemicals for evaluation; exposure assessment; and toxicological data.

A thorough understanding of the uncertainties associated with the risk estimates is critical to understanding the true nature of the estimated risks and to placing the estimated risks in proper perspective. Some of the more important sources of uncertainty associated with the estimations of risk at the sites are summarized below.

N1.6.1 Environmental Sampling and Analysis

Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical methods. Analytical precision or accuracy errors can be the source of a great deal of uncertainty. There is uncertainty associated with chemicals reported in samples at concentrations below the reported detection limit, but still included in data analysis, and with those chemicals qualified with the letter J, indicating that the concentrations are estimated. The effects of using data with these uncertainties may overestimate or underestimate risks. Based on the number of samples collected for the sites, environmental sampling and analysis uncertainty is generally expected to be acceptable.

N1.6.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Region 3 PRGs (adjusted for a target hazard quotient of 0.1; see Section N1.2) was conducted for each of the media samples at each site. It is unlikely that this risk-based screening would have excluded chemicals that would be of concern, based on the conservative exposure assumptions and the conservative basis of defining the COPCs. Although following this methodology does not provide a quantitative risk estimate for all chemicals (as it does not include non-detected constituents), it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals that were detected).

As mentioned in Section N1.2, the compound 2,6-DNT was dropped as a COPC due to low FOD (< 5%), even though this compound is an explosive. This may have slightly underestimated risks and hazards presented in this HHRA. To estimate the potential magnitude of this underestimation, risks and hazards estimated for 2,4-DNT (one of the selected COPCs) were scaled based on the potential difference in the exposure point concentrations. The EPC for 2,4-DNT was 2.04E-4 mg/L. The maximum detected concentration of 2,6-DNT was 7.1E-4 mg/L. Therefore, even if this MDC was used as the EPC for 2,6-

DNT (a highly conservative assumption), the estimate risks and hazards would be approximately 3.5 times greater than the risks and hazards estimated for 2,4-DNT, as shown as follows:

Receptor	Estimated Cancer Risk for 2,4-DNT from Section N1.5	Scaled Cancer Risk for 2,6-DNT using 3.5-Fold Scaling Factor
Industrial Research Worker	4.9E-7	1.7E-6
Adult Resident	1.3E-6	4.6E-6
Child Resident	7.7E-7	2.7E-6
	Estimated Noncancer Hazard for 2,4-DNT from Section N1.5	**Scaled Noncancer Hazard for 2,6-DNT using 3.5-Fold Scaling Factor**
Industrial Research Worker	0.001	0.0035
Adult Resident	0.0029	0.010
Child Resident	0.0066	0.023

Given the magnitude of the total cancer risks estimated for these receptors, the incremental addition from 2,6-DNT is insignificant (an increase of approximately 2 percent). Estimated hazards are below USEPA's target hazard index of 1.

N1.6.3 Exposure Assessment

There are several sources of uncertainty in the exposure assessment, including the determination of the exposure point concentrations, the selection of input parameters used to estimate chemical intakes, and other assumptions used in the exposure models. The uncertainties associated with these various sources are discussed below.

When calculating exposure point concentrations from sampling data, ½ of the reported sample quantitation limit was used for non-detected concentrations in the calculation of the EPC. Any approach dealing with non-detected chemical concentrations is associated with some uncertainty. This is because chemicals that were not detected at the specified sample quantitation limit may be absent from the medium or may be present at any concentration below the sample quantitation limit. The uncertainty in the exposure point concentration will increase as the number of non-detects in a data set increases.

The methodology for calculating the EPC included calculating the 95 percent UCL. If there were not enough data points to calculate the 95 percent UCL (five or fewer samples), the maximum COPC detected concentration would have been used as the EPC, however, no COPCs selected for quantitative evaluation in the HHRA had five or fewer samples. However, some estimated 95% UCLs exceeded the maximum detected concentration, and the exposure point concentration defaulted to the maximum detected concentration. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment. The use of the maximum detected concentration was used for the following COPCs (summarized in the following text table) to calculate risks and hazards, resulting in a potential overestimate of risk for pathways associated with exposures to these COPCs.

COPCs with EPCs Set at the Maximum Detected Concentration Because the Estimated 95% UCL Exceeded the Maximum Detected Concentration
Arsenic
1,1-Dichloroethane
Chloromethane
Vanadium

For data sets with an undefined data distribution, it was assumed that the data were lognormally distributed and the lognormal 95% UCL equation was used. This approach could significantly overestimate the EPC, as the "H" statistic used in the lognormal equation (USEPA, 1992) is exquisitely sensitive to deviations from lognormality. Current USEPA guidance on calculating the exposure point concentration (USEPA, 2002a) discusses how this approach is likely to be overly conservative.

With respect to determining EPCs, it was assumed that the concentrations of chemicals in the media evaluated would remain constant over time. Depending on the properties of the chemicals and the media in which they were detected, this assumption could overestimate risks to a low or high degree, since it is possible that chemicals could degrade or be transported to other media.

An underlying assumption of the risk assessments is that individuals at the sites would engage in certain activities that would result in exposures via each selected pathway. However, it should be noted that even if an individual engaged in an activity, it is not necessarily true that an exposure would be experienced. In addition, the parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for certain individuals within an exposed population may vary from those predicted depending upon their actual intake rates (e.g., water ingestion rates), nutritional status, or body weights. The exposure assumptions were selected to produce a high-end estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites. In addition, many USEPA (1991) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. Therefore, based on the conservative exposure assumptions used in the risk assessments, exposures and estimated potential risks are likely to be overestimated for the exposure pathways.

Evaluation of the dermal exposure pathway is affected by uncertainties in exposure parameters specific to dermal contact. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly overestimate or underestimate risks. In addition, exposures from both dermal and inhalation pathways may double count chemical intake.

N1.6.4 Toxicological Data

In most risk assessments, some of the largest sources of uncertainty are health criteria values. The health criteria used to evaluate long-term exposures, such as reference doses or cancer slope factors, are based on concepts and assumptions that bias an evaluation in the direction of over-estimation of health risk. As USEPA notes in its *Guidelines for Carcinogenic Risk Assessment* (USEPA, 1986): "There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There

are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns, and other cultural factors." These uncertainties are compensated for by using 95 percent UCLs or maximum likelihood estimates for cancer slope factors for carcinogens, and safety factors for reference doses for noncarcinogens. The assumptions provide a rough but plausible estimate of the high-end risk.

For dermal exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. To calculate risk estimates for the dermal pathway, therefore, absorbed dermal doses were combined with oral toxicity values. Oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal doses, which are expressed as internal (or absorbed) doses. In this assessment, oral absorption factors that reflect toxicity study conditions were used to modify the oral toxicity criteria. The risk estimates for the dermal pathways may be over- or underestimated where chemical-specific data were available, depending on how closely these values reflect the difference between the oral and dermal routes.

For chromium analytical data, it was assumed toxicity was most accurately represented by the use of chromium III toxicity data. The speciation of hexavalent chromium (Cr VI), the more toxic chromium fraction, is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with hexavalent chromium (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that hexavalent chromium may be present at a site (such as for control of scale in non-contact cooling water piping for a power plant), it is generally not included in an analytical program. For the Mid-Valley Groundwater OU, hexavalent chromium analyses were not performed on any of the groundwater samples.

If the toxicity values for hexavalent chromium were used for the total chromium analytical results, risks could be overestimated, triggering the potential calculation of preliminary remediation goals (PRGs). Use of these PRGs to identify hexavalent chromium hotspots for potential remedial action would be problematic, as hexavalent chromium was not measured at the sites. Thus it would be inappropriate to assume that total chromium chemical results are equivalent to hexavalent chromium concentrations, as this would suggest that concentrations of total chromium above a hexavalent chromium PRG would need to be remediated.

Hexavalent chromium is typically converted to trivalent chromium in the environment. As stated *in Water Related Environmental Fate of 129 Priority Pollutants* (USEPA, 1979), hexavalent chromium is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent chromium. Even if trace amounts of hexavalent chromium were present at a site, the environmental conditions at Picatinny, including typical precipitation events over the years, would tend to favor the conversion of this form of chromium to the more stable (less toxic) trivalent state.

Chromium speciation analysis was performed at Site 22/38 in September 1997 because of past metal plating operations at the site and exceedences of the chromium level of concern (LOC) in surface water and sediment samples collected at the site. Trivalent chromium was detected at Site 22/38 in both

surface water samples at concentrations in excess of the total chromium LOC (11 ug/L). No hexavalent chromium was detected in either surface water sample. Trivalent chromium was detected in all three sediment samples at concentrations in excess of the total chromium LOC (26 mg/kg). Hexavalent chromium was detected in each sediment sample at very low concentrations of 0.028, 0.068, and 0.043 mg/kg. These results were reported and discussed in the Final Phase III Additional RI Sites 22, 44, 61, 104, 122, 135, 141, and 145 (IT, September, 1999).

The guidance document *Air Pathway Screening Assessment for RCRA Subpart X Permitting* (U.S. Army Environmental Center, 1995) summarizes the results of many years of ordnance testing and characterization, including a listing of approximately 2,400 energetic items and major propellants. Chemical analytical characterization results are presented, and chromium (hexavalent or otherwise) is not a component of small arms, fuzes and primers, smokes and dyes, pyrotechnics, high-explosive projectiles, rockets and missiles, bombs, torpedoes, depth charges, bulk explosives, grenades, mines, Navy gun ammunition, and special function projectiles.

Based on the previous presented information, the fact that Picatinny processed these types of energetic material items and major propellants, and the Site 22/38 chromium speciation results, hexavalent chromium is not expected to be a significant constituent at any of the Mid-Valley Groundwater OU, and the assumption that total chromium detected in site media is hexavalent chromium is unwarranted.

To estimate the hypothetical impact of hexavalent chromium, in order to place an upper bound on possible risks and hazards, the following paragraphs present such an estimate for informational purposes only.

As hexavalent chromium is only carcinogenic via the inhalation route of exposure, and inorganics in groundwater cannot be inhaled, the hypothetical cancer risk associated with this form of chromium is zero. The hexavalent chromium noncarcinogenic RfD is 3.0E-3 mg/kg-day, compared with the total (trivalent) chromium RfD of 1.5E+0 mg/kg-day. This translates into a 500-fold difference, demonstrating that hexavalent chromium is potentially 500 times more toxic than trivalent chromium. This factor is used to scale up the estimated hazard quotients for the evaluated receptors as follows:

Receptor	**Estimated Trivalent Chromium Hazard Quotient from Section N1.5**	**Scaled Hexavalent Chromium Hazard Quotient Using Scaling Factor of 500**
Industrial Research Worker	0.000094	0.047
Adult Resident	0.00033	0.17
Child Resident	0.00069	0.35

Based on this uncertainty evaluation, even if total chromium in groundwater were 100% hexavalent chromium, the estimated hazards would be below USEPA's target hazard index of 1 for all evaluated receptors.

N1.6.5 Monitoring Wells Used for the HHRA

As mentioned in Section N1.2.1, the data base used in the HHRA included samples collected from monitoring wells located within footprints of the RDX and TCE Mid-Valley groundwater plumes (Figures 4-1 and 4-2, respectively, in the main text). It is acknowledged that it is hypothetically possible that a future private drinking water well may withdraw groundwater from the most impacted "center of the plume." However, this would be the maximally exposed individual (MEI), not the reasonable maximum exposure (RME) for future land use. USEPA risk assessment CERCLA guidance typically does not require risk calculations for the MEI. In addition, Exposure Point Concentrations in Groundwater (USEPA Region III, EPA/903/8-91/002, 1991) suggests that groundwater risk assessments use reasonable maximum concentrations of pollutants in the aquifer of concern. Therefore, calculating RME risks and hazards over a large area is consistent with USEPA guidance.

If EPCs were determined for the “center of the plume” (compared with using all the monitoring wells within the RDX and TCE plumes as defined previously) then risks and hazards would be expected to be greater than estimated in this HHRA. However, as the future residential adult and child risks and hazards are already estimated to exceed 1E-4 and 1, respectively (Section N1.5), HHRA conclusions would not change.

N1.6.6 Background Concentrations of Metals

Background concentrations of metals were presented in RAGS-D Table 2.1. However, none of the Mid-Valley Groundwater OU metals had maximum detected concentrations that were lower than these background values. Therefore, the risks and hazards estimated in this HHRA are not expected to be unduly influenced by the present of background metals in groundwater.

N1.6.7 References

IT Corporation, 2001, *Picatinny Arsenal Phase III-1A Human Health Risk Assessment Approach*, prepared for the U.S. Army Corps of Engineers, Baltimore District, TERC Number DACA31-95-D-0083, April 9.

IT Corporation, 1999, *Final Phase III Additional RI Sites 22, 44, 61, 104, 122, 135, 141, and 145*, prepared by IT Corporation, Mt. Arlington, New Jersey.

U.S. Army Environmental Center, 1995, *Air Pathway Screening Assessment for RCRA Subpart X Permitting*, prepared by Halliburton NUS Corporation, HAZWRAP, Oak Ridge, Tennessee, May.

U.S. Environmental Protection Agency (USEPA), 2002a, *Calculating Exposure Point Concentrations at Hazardous Waste Sites*, Office of Emergency and Remedial Response, Publication 9285.6-10, December.

U.S. Environmental Protection Agency (USEPA), 1992, *Supplemental Guidance to RAGS: Calculating the Concentration Term,* Office of Solid Waste and Emergency Response. Publication 9285.7-081, May.

U.S. Environmental Protection Agency (USEPA), 1991*, Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual Supplemental Guidance. Standard Default Exposure Factors*, Interim Final, Washington, D.C. OSWER Directive 9285.6-03. March.

U.S. Environmental Protection Agency (USEPA), 1989. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual*. Part A. Interim Final. USEPA/540/1-89/002. December 1989.

U.S. Environmental Protection Agency (USEPA), 1986*, Guidelines for Carcinogen Risk Assessment,* Fed. Reg. 51:33992-34003.

U.S. Environmental Protection Agency (USEPA), 1979, *Water Related Environmental Fate of 129 Priority Pollutants*, prepared by Versar Incorporated, Springfield, Virginia, NTIS No. PB80-204373, December.