RADFORD ARMY AMMUNITION PLANT, VIRGINIA

Area P
RCRA Facility Investigation Report

Prepared for:

USACE Baltimore District
10 S. Howard St.
Baltimore, MD 21201

Prepared by:

Shaw Environmental, Inc.
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Final Document

September 2010

received 11-9-10

10-125

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

November 4, 2010

Commander,
Radford Army Ammunition Plant
Attn: SJMRF-OP-EQ (Jim McKenna)
P.O. Box 2
Radford, VA 24141-0099

P.W. Holt
Environmental Manager
Alliant Techsystems, Inc.
Radford Army Ammunition Plant
P.O. Box 1
Radford, VA 24141-0100

Re: Radford Army Ammunition Plant, Va.
Review of Army's Final RCRA Facility Investigation Report for
Area of Concern (AOC) P

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) and Virginia Department of Environmental Quality (VDEQ) have reviewed the U.S. Army's (Army's) September 2010 Final RCRA Facility Investigation (RFI) Report for Area of Concern (AOC) P, located at the Radford Army Ammunition Plant (RFAAP) in Radford, Virginia. Based upon our review, the report is approved, and in accordance with Part II. (E) (5) of RFAAP's Corrective Action Permit, it can now be considered final.

If you have any questions, please call me at 215-814-3413. Thanks.

Sincerely,

William Geiger
RCRA Project Manager
Office of Remediation (3LC20)

cc: James Cutler, VDEQ

ATK

ATK Armament Systems
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October 18, 2010

Mr. William Geiger
RCRA General Operations Branch, Mail Code: 3WC23
Waste and Chemicals Management Division
U. S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Mr. James L. Cutler, Jr.
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 24143-0100

Subject: With Certification, Area P RCRA Facility Investigation Report, Final Document September 2010
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

Enclosed is the certification for the subject document that was sent to you on October 13, 2010. Also enclosed is the 13 October 2010 transmittal email.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder ATK staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 731-5782.

Sincerely,

P.W. Holt, Environmental Manager
Alliant Techsystems Inc.

c: Karen Sismour
Virginia Department of Environmental Quality
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10-815-149
JMcKenna

Rich Mendoza
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Tom Meyer
Corps of Engineers, Baltimore District
ATTN: CENAB-EN-HM
10 South Howard Street
Baltimore, MD 21201

Concerning the following:

Radford Army Ammunition Plant
Area P
RCRA Facility Investigation Report
Final Document
September 2010

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

SIGNATURE: Tom Rossi
PRINTED NAME: for Antonio Munera
TITLE: LTC, CM
Commanding

SIGNATURE:
PRINTED NAME: Kent Holiday
TITLE: Vice President and General Manager
ATK Energetics Systems

Greene, Anne

From:	McKenna, Jim
Sent:	Wednesday, October 13, 2010 3:14 PM
To:	Greene, Anne; Cutler,Jim; dennis.druck@us.army.mil; diane.wisbeck@arcadis-us.com; durwood willis2; Geiger.William@epamail.epa.gov; Redder, Jerome; jim spencer; Llewellyn, Tim; Lohman,Elizabeth; Mendoza, Rich; Meyer, Tom NAB02; Parks, Jeffrey N; Sismour,Karen; Timothy.Leahy@shawgrp.com; Tina_MacGillivray@URSCorp.com
Cc:	Davie, Robert; Holt, Paige
Subject:	Radford - Final Area P RFI Report (UNCLASSIFIED)
Attachments:	AOC P RFI_RTCs EPAVDEQ_rev060710 (2).pdf
Importance:	High

Classification: UNCLASSIFIED
Caveats: FOUO

All,

Below are the UPS Tracking Numbers for the Final Area P RCRA Facility Investigation Report. Also attached are the response to comments that RFAAP submitted on June 8, 2010 and EPA and DEQ approved August 26, 2010. Please let me know if you have any questions.

Thank you for your support of the Radford AAP Installation Restoration Program.
Jim McKenna

Will Geiger USEPA Region III - 1 hard copy - 1Z63V8842595573162 Jim Cutler VDEQ - 1 hard copy - 1Z63V8842597281170 Elizabeth Lohman -VDEQ - 1 electronic copy - 1Z63V8842598450753 James McKenna - Army stakeholder copies delivered on Oct 7, 2010 Richard Mendoza - Army stakeholder copies delivered on Oct 7, 2010 Tom Meyer - Army stakeholder copies delivered on Oct 7, 2010 Dennis Druck - Army stakeholder copies delivered on Oct 7, 2010 Susan Ryan - Army stakeholder copies delivered on Oct 7, 2010
Classification: UNCLASSIFIED
Caveats: FOUO

Response to Army Comments on the
Area P RCRA Facility Investigation Report
Radford, Virginia
November 2009 Draft

Comments from EPA/VDEQ

General Comments:

Comment 1.

Comment: Chloroform and tetrachloroethene (PCE) were detected in all four groundwater samples collected at Area P at concentrations that exceeded the tapwater Regional Screening Level (RSL), but below the federal maximum contaminant level (MCL). Total risks associated with exposures to contaminants of potential concern (COPCs) in groundwater were above the target risk range for the future industrial worker, future lifetime resident, and future child resident and were attributed primarily to these two constituents. The RFI Report has not presented sufficient evidence to conclude that chloroform and PCE are attributed to a source or sources other than Area P. An upgradient groundwater sample was not collected at this site, so it is unclear whether the PCE and chloroform impacts are site-related or can be attributed to another source. Additionally, limited historical information has been provided for this site, so the potential for these chemicals to be site-related cannot be ruled out. If additional data can show that an upgradient source is the likely cause of the groundwater volatile organic compound (VOC) contamination, please provide these data and identify the upgradient source. Please revise the RFI to address these concerns.

Response: Groundwater samples were collected to assess whether site soil was potentially impacting groundwater at the site. Chloroform has been demonstrated to be related to leaking drinking water pipes at several sites within the Main Manufacturing Area, and its presence here is also attributed to that source. PCE and chloroform were carried through the human health risk assessment and risks associated with these compounds were within EPA's risk range. The elevated cumulative HI for groundwater is related to the high metals concentrations in the total metals analysis, which were used in the risk assessment. The 2007 samples were also analyzed for dissolved metals (field–filtered) due to the high turbidity of the samples. Based on subsequent discussions with EPA/VDEQ, filtered metals results can be used in the risk assessment when the samples are turbid, as was the case here. It is proposed that the risk assessment be re-calculated using the filtered metals concentrations from the 2007 samples to demonstrate that groundwater exposures do not pose a risk or hazard.

Comment 2.

Comment: Soil boring logs and sample collection logs have not been provided with this RFI Report. The data collected during drilling and sample collection provides information about site geologic and hydrogeologic characteristics, and should be included as supporting documentation. Please revise the RFI Report to include soil borings logs and sample collection logs.

Response: The report will be revised to include any available soil boring or sample collection logs.

Comment 3. (HHRA)

Comment: While most of the exposure factors used in the human health risk assessment (HHRA) have been appropriately obtained from applicable guidance documents, several exposure factors were used without sufficient justification. Please revise the HHRA to address the following:

- The exposure frequency (EF) selected for a maintenance worker is 50 days a year, based on a best professional judgment that maintenance activities would occur one day a week, with two weeks of vacation a year. To support the use of this EF, please clarify what type(s) of maintenance activities are anticipated (mowing, etc.).

- The EF selected for an excavation worker is 125 days a year, which according to the Appendix D tables, is a value from EPA's 2002 *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24 (SSL Guidance). However, the default EF for a construction worker listed in the SSL Guidance is 250 days/year (Exhibit 5-1). Additionally, on Page 6-25 of the HHRA, third bullet, it is noted that an EF of 250 days/year was used in the Virginia Department of Environmental Quality's (VEDQ) Voluntary Remediation Program (VRP) trench model used to estimate VOCs in air at the site, but this EF value was not used for other construction worker scenarios evaluated in the HHRA. Please revise the HHRA to use the default EF of 250 days/year for all construction worker/excavation worker scenarios or provide additional justification for using an EF of 125 days/year to evaluate the other exposure pathways.

- The ingestion rate of produce was extracted from the 1997 *Exposure Factors Handbook*, Volume I (EPA/600/P-95/002Fa), with the same value (18.6 g/d) being used for both the adult and child receptor. Please note that EPA's *Child-Specific Exposure Factors Handbook*, Final Report, dated 2008, (EPA/600/R-06/096F) includes produce ingestion rates specific to the child receptor. Please revise the HHRA to use a child-specific produce ingestion rate.

Response: There are currently no routine activities occurring at Area P. To address occasional exposures due to grounds-keeping activities, such as mowing the grass or maintaining the storage areas, the maintenance worker scenario is based on a worker who visits the site once per week for 50 weeks during the year. These exposure parameters are consistent with the exposure parameters that have been applied at other sites at RFAAP over several years. Text will be added to Section 6.2.1 to further clarify the typical activities assumed for the maintenance worker.

There is no current construction at Area P. Given the size of Area P (approximately 50 ft by 200 ft) and its location on the river bank, extensive construction would not be expected at this site. Assuming five-day work weeks, the EF of 125 days/year represents a six-month construction period, which would seem reasonable for a site of this size and location. Text will be added to Section 6.2.1 to clarify this assumption. In addition, this EF is consistent with the EF values used for similar sites at RFAAP over several years.

The *Child-Specific Exposure Factors Handbook* will be reviewed to determine whether the child-specific ingestion rate for fruits and vegetables would be more conservative than the values used in the HHRA for Area P. In the event that the child-specific ingestion rate is more conservative, the HHRA will be revised accordingly. Conversely, if the ingestion rate for the adult is sufficiently protective of the child, the calculations will not be revised because there would be no change in the conclusions. The potential impacts on the HHRA due to differences between the ingestion rates would then be discussed in the uncertainty section.

Comment 4. (HHRA)

Comment: Several metals in groundwater (aluminum, chromium, cobalt, iron, manganese, and vanadium) contributed to hazard indices (HIs) greater than one for the future lifetime resident and future child resident. Lead concentrations in groundwater exceeded the federal action level, and the results of the IEUBK model indicated that lead concentrations in groundwater failed the lead exposure assessment for the resident. The uncertainty analysis briefly mentions that groundwater samples were collected using direct-push techniques, which produced highly turbid samples. The RFI further states, "It is likely that the analytical results for the groundwater samples reflect contribution from COPCs sorbed to particulates in the samples." However, the HHRA does not include a comparison of dissolved metals results to total metals results to lend further confidence to this assumption. Since no further action is recommended for Area P, further discussion of potential risks/hazard associated with metals in groundwater is warranted. A comparison of total and dissolved metals results should be provided, as well as a discussion of turbidity measurements collected during sampling.

Response: The risks and hazards associated with metals in groundwater will be re-calculated using the dissolved metals concentrations from the samples collected in 2007, rather than the total metals concentrations. In discussions with EPA and VDEQ subsequent to the completion of the HHRA in this RFI, EPA stated that dissolved metals concentrations can be used in the risk assessment if the samples are excessively turbid. The direct push samples collected at this site were turbid due to the fine-grained clay and silt in the first water bearing unit encountered, as well as the absence of a sandpack around the direct push sampler.

Comment 5.

Comment: This Screening Level Ecological Risk Assessment (SLERA) incorporates Steps 1, 2 and 3a from the Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997). Section 7.1 (SLERA Methods and Procedures) briefly explains the objective for each of the steps listed above. However, the distinction between Steps 2 and 3a becomes tangled as the reader proceeds through the SLERA. In the future, it would be helpful to organize the text in a way that presents the initial screening in its entirety before introducing the refinements in Step 3a. This separation will make the risk assessment process easier to follow and more transparent.

Response: The SLERA was performed following the procedures outlined in the RFAAP Final MWP (URS, 2003). A modified approach which incorporates Steps 1, 2 and 3a of the Ecological Risk Assessment Guidance for Superfund (ERAGS) was used for this process. Although this is a screening level assessment, the addition of Step 3a focuses the outcome of the SLERA, streamlines the review process, and allows one assessment to function as the initial forum for ecological risk management decision making at the site. Shaw feels the separation of Steps 2 and 3a is not necessary, and the wording of the text will be revised to clarify that Step 3a is a separate step per USEPA guidance.

Comment 6.

Comment: Two different approaches are used to evaluate direct-contact toxicity to soil- and sediment-dwelling invertebrates. The direct-contact soil assessment only uses the Maximum Detected Concentrations (MDCs), whereas the sediment evaluation uses the MDCs plus an Exposure Point Concentrations (EPCs) based on the 95% Upper Confidence Limit (UCL) (note: the sediment MDCs and EPCs were identical since only a single sediment sample was collected for evaluation). Table 7-13 (Direct Contact Toxicity Evaluation for Surface Soils at Area P) provides soil EPCs, but doesn't use these values in any comparisons. It is unclear why the procedure for evaluating soil and sediment invertebrates is different. Please explain in Section 7.1.8 (Approach for the Evaluation of Direct Contact Toxicity) why the soil and sediment evaluations differ and whether or not these divergent approaches follow the approved process.

Response: The direct contact soil assessment table will be modified to include comparison of the calculated soil EPCs to the soil benchmarks, making it consistent with the sediment direct contact assessment table.

Comment 7.

Comment: The Final Process for Ecological Risk Assessment – RFAAP document dated June 22, 2006 (revised September 17, 2007) states that "For upper trophic level receptors, NOAEL (No Observable Adverse Effect Level) values will be obtained from current scientific literature unless Eco-SSLs are available then the Eco SSLs will be used". A review of Table E-21 (NOAEL Toxicity Reference Values used to Derive Wildlife Toxicity Benchmarks for COPECs at Area P) showed that Toxicological Benchmarks for Wildlife (Sample et al, 1996) are the major source for inorganic mammalian and avian NOAELs. Mammalian Eco-SSLs are available for each of the inorganics listed. Avian Eco-SSLs are also available for each of the inorganics, except for silver. Please update this table and the food chain modeling to reflect the more appropriate NOAELs. These updates will not affect the outcome of the SLERA because the final conclusions focus on the LOAEL-based results.

Response: The sentence cited in the referenced document, prepared by URS on June 22, 2006 and revised on September 17, 2007, only refers to the direct contact assessment, not food chain modeling, according to Ms. Tina Devine of URS. In addition, it should be noted that Eco-SSL NOAEL TRVs are actually the geometric mean of numerous NOAEL values from selected literature studies, and are therefore not true NOAELs. Shaw has been using the wildlife TRV selection process contained in the subject report for SLERAs performed for sites at RFAAP since approximately 2002, and recommends that this process be retained for consistency. As noted in the comment, even if this revision were made, it would generally not affect the outcome of the SLERA because the final conclusions focus on the LOAEL-based results.

Specific Comments:

Comment 1.

Comment: **Executive Summary, Contamination Assessment, Page ES-1:** The first paragraph under the subheading "Soil" states, "The Area P data set from both soil investigations demonstrates that there were no industrial screening levels (i-SLs)...in soil samples collected for this site." For clarity, please revise the above sentence to state that there were no *exceedances* of the industrial screening levels in soil samples collected for this site.

Response: The text will be revised as requested.

Comment 2.

Comment: **Section 2.1, Site Description, Page 2-1:** This section states that Area P is a former spent battery storage area which is defined by a fenced-in gravel area. The current use of the site is not described. Additionally, Figure 2-1, Area P Site Map, shows a small building or other structure in the center of the site, but the RFI does not mention this structure. Please revise the RFI Report to describe the site's current use, and describe any features, including a possible structure, that are shown on Figure 2-1.

Response: The structure is a small shed with a conveyor belt leading into and out of it. Its original use is unknown, but was presumably where the spent batteries were stored. Currently the site is not used – the building is empty and the area is an empty, abandoned gravel area with grass growing up through the gravel. This information will be added to the text.

Comment 3.

Comment: **Section 2.2, Site History and Operations, Page 2-1:** This section includes only a single sentence on the site history and operations at Area P. The dates of operation of the scrap metal yard are not provided. Additionally, the RFI does not indicate how it is known that this area was used as a scrap metal yard. In *Work Plan Addendum 19: SWMU 48, SWMU 49, SWMU 50, SWMU 59, SWMU 41, Area O, FLFA, SWMU 43, Area P (Work Plan Addendum 19)*, dated July 2007, historical aerial photographs were used to document site activities at other RFAAP solid waste management units (SWMUs) and areas of concern (AOC), but it is unclear whether this type of assessment was performed for Area P. Additionally, in response to EPA Comment 38 on Work Plan Addendum 19 requesting similar information, RFAAP responded that if additional information on site history is discovered during the field investigation, then the Site

History section in the RFI Report will be updated to include the new information. Please revise the RFI Report to include any additional information on site history discovered during the field investigation. If a historical aerial photograph review was conducted for Area P, please provide the results of that evaluation. Additionally, please clarify how it is known that this area was formerly a scrap metal yard used for the storage of shredded scrap metal, decommissioned tanks, powder cans, and batteries prior to off-post shipment. An estimate of dates of operation should also be provided.

Response: Unfortunately, there is not much historical information about this site. Available documents and information have been reviewed and summarized in this section. Text will be added to clarify that the information about the scrap yard and materials stored at the location are taken from the Radford 1987 RCRA Facility Assessment. Additional information gathered during the field investigation was limited to the discovery of a depression (likely for loading and unloading trucks) and the associated drainage pipe where the sediment sample was collected.

Comment 4.

Comment: **Section 2.4.1, Area P Geology, Page 2-1:** The second paragraph states, "The site is located on a river terrace deposit and is expected to consist of a mixture of sand, silt, and clay with occasional gravel "riverjack" stringers where former channels existed." It is unclear why a soil description based on site-specific boring data has not been presented instead of an "expected" subsurface geology. Please revise the RFI Report to include a site-specific description of the Area P geology based on the data collected and observations made during the subsurface investigation at the site.

Response: Site borings were relatively shallow, so the geology section has been supplemented with additional data from similar sites along the New River. The geology within the river terrace deposits does not change significantly along the River within Radford AAP. Descriptions of the actual material encountered in the borings will be added to this section to support the conclusion that the encountered geology is similar to the "expected" geology.

Comment 5.

Comment: **Section 2.5, Site Hydrogeology, Page 2-4:** This section describes an engineered drainage system that exists at the north end of the site. This drainage system collects overland flow in an engineered depression and drains it through an underground pipe. The pipe then discharges to the bank of the New River. The RFI Report does not indicate whether the depression is concrete-lined, and/or if sediment has accumulated in the depression. Although a sediment sample was collected at the outfall of the discharge pipe, it is unclear whether a sample could also be collected within the depression itself. Please document the location of this drainage system on a site figure. Also, provide further description of the engineered depression's construction, and indicate whether a sediment sample could be collected from this location. If sediment has accumulated in this depression, further sampling of this area may be warranted to determine whether it has been impacted by overland flow.

Response: The description of the depression will be revised to state that it is an unlined depression that appears to have been used to line up the height of a truck bed with the conveyor belt onsite. The upstream end of the pipe (within the depression) appears to be an erosional environment, while there was obvious sediment accumulation at the discharge end of the pipe, which led to the decision to collect an additional sample at this location. Results of the surface soil samples collected onsite, as well as the results of the sediment sample collected at the discharge end of the pipe, do not indicate the need for an additional sample.

Comment 6.

Comment: **Section 3.1.4, Global Positioning System Activities, Page 3-2:** This section indicates that sample location coordinates and elevations were obtained for soil borings (APSB07, APSB08, APSB09, and APSB10). However, this section does not mention soil boring APSB06. Appendix B indicates that sample location coordinates and elevation were also obtained for boring APSB06. Please revise Section 3.1.4 to include this boring.

Response: The text will be revised as requested.

Comment 7.

Comment: **Section 3.1.6, Modifications to the Sampling Plan, Page 3-3:** A groundwater sample was not collected at boring location APGW01 since groundwater was not encountered at this location prior to refusal on weathered bedrock. The RFI Report does not address potential impacts of this modification to the sampling plan. Work Plan Addendum 19 indicates that APGW01 was proposed as an upgradient groundwater sampling location. Since chloroform and tetrachloroethene were detected in all of the other site groundwater samples, data from an upgradient sampling location are needed to determine whether these VOCs in groundwater are attributed to an upgradient source or to Area P. Please revise the RFI Report to discuss the impact of not sampling groundwater at boring location APGW01, as originally proposed in Work Plan Addendum 19. Please propose an alternate method for sampling upgradient groundwater or otherwise filling this data gap, as needed.

Response: Concentrations of both chloroform and PCE are well below their respective MCLs, and the risks (Section 6 - HHRA) due to these organics are within the risk range. Cumulative risks associated with groundwater are driven by metals. Total (rather than filtered) metals concentrations were used in the risk assessment because the HHRA in this RFI was completed prior to the agreement with EPA/VDEQ that filtered metals results could be used in the risk assessment. The HHRA will be revised to use the filtered groundwater results from the samples collected in 2007.

Comment 8.

Comment: **Section 4.1.2, Sediment Analytical Results, Page 4-7**: The sediment sample (APSD01) was analyzed for target analyte list (TAL) metals, target compound list (TCL) VOCs, semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), pesticides/PCBs, herbicides, explosives, and dioxins/furans. However, Section 4.1.2 only discusses the results for VOCs, PAHs, SVOCs, pesticides and PCBs. The results for metals, herbicides, explosives, and dioxins/furans have not been discussed, even though some of these constituents were detected in sediment, according to Table 4.3, Analytes Detected in Area P Sediment Samples. Please revise Section 4.1.2 to discuss the results for all of the analyte classes that were analyzed for in the sediment sample.

Response: This section appears to have been inadvertently truncated. The missing text will be added to the report

Comment 9.

Comment: **Sections 4.1.4.1 and 4.2.3:** The concluding paragraphs in both sections suggest that the r-SL level is an indicator for migration to groundwater. Although migration conclusions may in fact be reasonable they do not follow from discussion of a risked base concentration.

Response: Agreed. Text in this section will base conclusions on the more appropriate SSL – Transfer to Groundwater Screening Levels that are used in most of the section

Comment 10.

Comment: **Section 6.1.1.1, Surface Soil and Total Soil, Page 6-3:** Data from soil samples collected in 1992 were used for the Chemical of Potential Concern (COPC) screening process. Given the age of the data (18 years old), the HHRA should indicate whether these data were validated, and whether they are considered appropriate for use in a risk assessment. Please revise the HHRA to address these concerns.

Response: Soil samples were collected in 1992 and analyzed for metals. The analytical results were validated. Because metals concentrations in soil would be expected to be relatively stable in soil, these data were considered to be appropriate for the risk assessment. In addition, the range of concentrations for each constituent in the 1992 data set were generally within the same range as the overall data set for surface and total soil. The uncertainty associated with the use of older data will be discussed in the uncertainty section (Section 6.5.1) and the explanation presented in this RTC will be included.

Comment 11.

Comment: **Section 6.1.1.4, Groundwater, Page 6-4**: This section does not clarify whether the metals results in groundwater are representative of the total or dissolved fraction. Please revise the HHRA to indicate whether total or dissolved metals results are used in the HHRA and discuss any associated uncertainties in using these data within the uncertainty analysis.

Response: **[See RTC for General Comment 4].** The metals results represent concentrations of total metals as analyzed in unfiltered groundwater samples. Evaluation of unfiltered data is considered to be conservative and is consistent with Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (USEPA, 1989). Use of these data may be uncertain because several of these samples were turbid due to the length of time between sampling events and not representative of water that potential receptors are likely to drink. The HHRA will be revised to use the filtered groundwater data from the 2007 samples for metals concentration.

Comment 12.

Comment: **Section 6.1.2, Identification of COPCs, Page 6-4:** The first paragraph states that COPCs in sediment were identified by comparing the maximum detection concentration (MDC) of each constituent to the applicable residential soil RSLs, as presented in the September 2008 EPA RSL Tables. According to a note at the bottom of Table D.1-6, of Appendix D, it appears that the RSLs were also adjusted by a factor of 10 to account for sediment exposures. This adjustment is not discussed within the text of the document. Please revise the HHRA to indicate that the RSLs were adjusted by a factor of 10 for the sediment COPC evaluation.

Response: Text will be added to indicate that the RSLs were adjusted by a factor of 10 for the sediment COPC evaluation.

Comment 13.

Comment: **Section 6.1.2, Identification of COPCs, Page 6-4:** The third paragraph states, "Analytes for which no screening criteria exist were also selected as COPCs." This approach was followed for some chemicals but not others. It appears that screening criteria for surrogate chemicals may have been used for some chemicals for which screening criteria are not available (i.e., the screening value for pyrene was used for benzo(g,h,i)perylene in the sediment COPC screening). This approach is generally acceptable; however, the HHRA should discuss the use of surrogate chemicals in the COPC selection process, and clarify why the selected surrogates are considered appropriate. Please revise Section 6.1.2 to acknowledge the use of surrogates in the

COPC selection process and to discuss the structure activity relationship between chemicals lacking toxicity criteria and any identified surrogates.

Response: The surrogates used in this HHRA were consistent with those selected as surrogates in the Virginia Department of Environmental Quality's (VDEQ's) risk assessment guidance (VDEQ, 2009). A brief discussion regarding the use of surrogates for chemicals lacking toxicity values will be added to Section 6.1.2.

Comment 14.

Comment: **Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-6:** An adult recreational user of the New River was evaluated for exposure to surface water, but the child recreational user and/or the adolescent recreational user were not evaluated. The first paragraph of Section 6.6, HHRA Summary and Conclusions, states that "off-site adult and child residents were...evaluated for potential exposures to groundwater in the event that groundwater migrates off site in the future," but this does not appear to be the case. The same statement is also included on Page ES-2 of the Executive Summary under the Human Health Risk Assessment subheading. Sufficient justification for excluding off-site child and/or adolescent recreational users as potential receptors has not been provided. Please revise the HHRA to evaluate a child and/or adolescent recreational user's exposure to surface water (from groundwater discharge to the New River), or provide sufficient justification for not evaluating these exposures.

Response: Because the child receptors evaluated in this HHRA are assumed to be six years of age and under, it was considered highly unlikely that children in this age group would be wading or swimming in the New River due to the depth and current of the river. .The adolescent recreational user will be added to the HHRA. Exposure parameters will be obtained from The *Child-Specific Exposure Factors Handbook* (EPA, 2008) or the *Exposure Factors Handbook* (EPA, 1997), as appropriate. This additional scenario is not expected to change the overall conclusions of the HHRA. Because the site is adjacent to New River and the groundwater flow is in that direction, there is no place downgradient for a well. The onsite and offsite groundwater usage would then be identical and the offsite adult and child residential exposure scenarios would be identical to the onsite residential scenarios. A note will be added to the text of the onsite residential scenarios to explain why the downgradient receptor is not possible. The recreational users were substituted as the next most likely downgradient receptor.

Comment 15.

Comment: **Section 7.2.7, Uncertainty Analysis, Page 7-53:** The second paragraph on this page states, "Thirty-one of the non-detect surface soil and 46 of the non-detect sediment constituents had maximum detection limits that exceeded the screening criteria, respectively. These finding are no unexpected, given the conservative and numerically low screening values." The evaluation of the non-detects does not quantify the exceedance. Please consider adding a table showing the hazard quotients based on dividing the maximum non-detect detection limit with the corresponding screening value. This additional information would help the reader understand the magnitude of the exceedances and their potential to cause ecological harm.

Response: Calculation of HQs based on maximum detection limits for 100 percent non-detect constituents is not recommended, due to the fact that there is a high degree of uncertainty associated with what the potential exposure actually might be, as the concentration could range from essentially zero to the detection limit. In addition, as no further action is recommended based on the outcome of this uncertainty analysis (e.g., re-sampling with lower detection limits is not advised), additional evaluation, as suggested in the comment, would not provide usable information.

Comment 16.

Comment: **Table 7-16, Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Exposure Area P:** The "Screening Toxicity Value" and the "COPEC Flag" columns contain several "#REF!" entries which indicate that there is an error. Please review the table and update accordingly.

Response: Errors in the table will be corrected.

Comment 17.

Comment: **Section 8.1:** It is stated in the first paragraph that metals were not greater than SLs in any soil samples. The second paragraph states that antimony and copper were found above r-SLs in one surface soil sample. These statements should be reconciled.

Response: The text will be revised as requested for accuracy.

Comment 18.

Comment: **Section 8.4:** The filtered results appear to be the best evidence for the conclusion. These results and resulting risks should be clearly stated.

Response: Agreed. See Response to General Comment #4

From:	Geiger.William@epamail.epa.gov
Sent:	Thursday, April 29, 2010 1:45 PM
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Subject:	AOC P RFI Comments
Attachments:	AOC P RFI Comments.doc

Jim, attached are EPA/VDEQ comments for the AOC P RFI Report.

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Presented below are EPA/VDEQ review comments on the *Draft Area P RCRA Facility Investigation Report* for the Radford Army Ammunition Plant (RFAAP) located in Radford, Virginia, dated November 2009 (RFI Report).

GENERAL COMMENTS

1. Chloroform and tetrachloroethene (PCE) were detected in all four groundwater samples collected at Area P at concentrations that exceeded the tapwater Regional Screening Level (RSL), but below the federal maximum contaminant level (MCL). Total risks associated with exposures to contaminants of potential concern (COPCs) in groundwater were above the target risk range for the future industrial worker, future lifetime resident, and future child resident and were attributed primarily to these two constituents. The RFI Report has not presented sufficient evidence to conclude that chloroform and PCE are attributed to a source or sources other than Area P. An upgradient groundwater sample was not collected at this site, so it is unclear whether the PCE and chloroform impacts are site-related or can be attributed to another source. Additionally, limited historical information has been provided for this site, so the potential for these chemicals to be site-related cannot be ruled out. If additional data can show that an upgradient source is the likely cause of the groundwater volatile organic compound (VOC) contamination, please provide these data and identify the upgradient source. Please revise the RFI to address these concerns.

2. Soil boring logs and sample collection logs have not been provided with this RFI Report. The data collected during drilling and sample collection provides information about site geologic and hydrogeologic characteristics, and should be included as supporting documentation. Please revise the RFI Report to include soil borings logs and sample collection logs.

3. While most of the exposure factors used in the human health risk assessment (HHRA) have been appropriately obtained from applicable guidance documents, several exposure factors were used without sufficient justification. Please revise the HHRA to address the following:

    - The exposure frequency (EF) selected for a maintenance worker is 50 days a year, based on a best professional judgment that maintenance activities would occur one day a week, with two weeks of vacation a year. To support the use of this EF, please clarify what type(s) of maintenance activities are anticipated (mowing, etc.).

    - The EF selected for an excavation worker is 125 days a year, which according to the Appendix D tables, is a value from EPA's 2002 *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24 (SSL Guidance). However, the default EF for a construction worker listed in the SSL Guidance is 250 days/year (Exhibit 5-1). Additionally, on Page 6-25 of the HHRA, third bullet, it is noted that an EF of 250 days/year was used in the Virginia Department of Environmental Quality's (VEDQ) Voluntary Remediation

Program (VRP) trench model used to estimate VOCs in air at the site, but this EF value was not used for other construction worker scenarios evaluated in the HHRA. Please revise the HHRA to use the default EF of 250 days/year for all construction worker/excavation worker scenarios or provide additional justification for using an EF of 125 days/year to evaluate the other exposure pathways.

- The ingestion rate of produce was extracted from the 1997 *Exposure Factors Handbook*, Volume I (EPA/600/P-95/002Fa), with the same value (18.6 g/d) being used for both the adult and child receptor. Please note that EPA's *Child-Specific Exposure Factors Handbook*, Final Report, dated 2008, (EPA/600/R-06/096F) includes produce ingestion rates specific to the child receptor. Please revise the HHRA to use a child-specific produce ingestion rate.

4. Several metals in groundwater (aluminum, chromium, cobalt, iron, manganese, and vanadium) contributed to hazard indices (HIs) greater than one for the future lifetime resident and future child resident. Lead concentrations in groundwater exceeded the federal action level, and the results of the IEUBK model indicated that lead concentrations in groundwater failed the lead exposure assessment for the resident. The uncertainty analysis briefly mentions that groundwater samples were collected using direct-push techniques, which produced highly turbid samples. The RFI further states, "It is likely that the analytical results for the groundwater samples reflect contribution from COPCs sorbed to particulates in the samples." However, the HHRA does not include a comparison of dissolved metals results to total metals results to lend further confidence to this assumption. Since no further action is recommended for Area P, further discussion of potential risks/hazard associated with metals in groundwater is warranted. A comparison of total and dissolved metals results should be provided, as well as a discussion of turbidity measurements collected during sampling.

5. This Screening Level Ecological Risk Assessment (SLERA) incorporates Steps 1, 2 and 3a from the Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997). Section 7.1 (SLERA Methods and Procedures) briefly explains the objective for each of the steps listed above. However, the distinction between Steps 2 and 3a becomes tangled as the reader proceeds through the SLERA. In the future, it would be helpful to organize the text in a way that presents the initial screening in its entirety before introducing the refinements in Step 3a. This separation will make the risk assessment process easier to follow and more transparent.

6. Two different approaches are used to evaluate direct-contact toxicity to soil- and sediment-dwelling invertebrates. The direct-contact soil assessment only uses the Maximum Detected Concentrations (MDCs), whereas the sediment evaluation uses the MDCs plus an Exposure Point Concentrations (EPCs) based on the 95% Upper Confidence Limit (UCL) (note: the sediment MDCs and EPCs were identical since only a single sediment sample was collected for evaluation). Table 7-13 (Direct Contact Toxicity Evaluation for Surface Soils at Area P) provides soil EPCs, but doesn't use these values in any comparisons. It is unclear why the procedure for evaluating soil and sediment invertebrates is different. Please explain in Section

7.1.8 (Approach for the Evaluation of Direct Contact Toxicity) why the soil and sediment evaluations differ and whether or not these divergent approaches follow the approved process.

7. The Final Process for Ecological Risk Assessment – RFAAP document dated June 22, 2006 (revised September 17, 2007) states that "For upper trophic level receptors, NOAEL (No Observable Adverse Effect Level) values will be obtained from current scientific literature unless Eco-SSLs are available then the Eco SSLs will be used". A review of Table E-21 (NOAEL Toxicity Reference Values used to Derive Wildlife Toxicity Benchmarks for COPECs at Area P) showed that Toxicological Benchmarks for Wildlife (Sample et al, 1996) are the major source for inorganic mammalian and avian NOAELs. Mammalian Eco-SSLs are available for each of the inorganics listed. Avian Eco-SSLs are also available for each of the inorganics, except for silver. Please update this table and the food chain modeling to reflect the more appropriate NOAELs. These updates will not affect the outcome of the SLERA because the final conclusions focus on the LOAEL-based results.

SPECIFIC COMMENTS

1. **Executive Summary, Contamination Assessment, Page ES-1**: The first paragraph under the subheading "Soil" states, "The Area P data set from both soil investigations demonstrates that there were no industrial screening levels (i-SLs)…in soil samples collected for this site." For clarity, please revise the above sentence to state that there were no *exceedances* of the industrial screening levels in soil samples collected for this site.

2. **Section 2.1, Site Description, Page 2-1**: This section states that Area P is a former spent battery storage area which is defined by a fenced-in gravel area. The current use of the site is not described. Additionally, Figure 2-1, Area P Site Map, shows a small building or other structure in the center of the site, but the RFI does not mention this structure. Please revise the RFI Report to describe the site's current use, and describe any features, including a possible structure, that are shown on Figure 2-1.

3. **Section 2.2, Site History and Operations, Page 2-1:** This section includes only a single sentence on the site history and operations at Area P. The dates of operation of the scrap metal yard are not provided. Additionally, the RFI does not indicate how it is known that this area was used as a scrap metal yard. In *Work Plan Addendum 19: SWMU 48, SWMU 49, SWMU 50, SWMU 59, SWMU 41, Area O, FLFA, SWMU 43, Area P (Work Plan Addendum 19)*, dated July 2007, historical aerial photographs were used to document site activities at other RFAAP solid waste management units (SWMUs) and areas of concern (AOC), but it is unclear whether this type of assessment was performed for Area P. Additionally, in response to EPA Comment 38 on Work Plan Addendum 19 requesting similar information, RFAAP responded that if additional information on site history is discovered during the field investigation, then the Site History section in the RFI Report will be updated to include the new information. Please revise the RFI Report to include any additional information on site history discovered during the field investigation. If a historical aerial photograph review was conducted for Area P, please provide the results of that evaluation. Additionally, please clarify how it is known that this area was

formerly a scrap metal yard used for the storage of shredded scrap metal, decommissioned tanks, powder cans, and batteries prior to off-post shipment. An estimate of dates of operation should also be provided.

4. **Section 2.4.1, Area P Geology, Page 2-1:** The second paragraph states, “The site is located on a river terrace deposit and is expected to consist of a mixture of sand, silt, and clay with occasional gravel “riverjack” stringers where former channels existed.” It is unclear why a soil description based on site-specific boring data has not been presented instead of an “expected” subsurface geology. Please revise the RFI Report to include a site-specific description of the Area P geology based on the data collected and observations made during the subsurface investigation at the site.

8. **Section 2.5, Site Hydrogeology, Page 2-4**: This section describes an engineered drainage system that exists at the north end of the site. This drainage system collects overland flow in an engineered depression and drains it through an underground pipe. The pipe then discharges to the bank of the New River. The RFI Report does not indicate whether the depression is concrete-lined, and/or if sediment has accumulated in the depression. Although a sediment sample was collected at the outfall of the discharge pipe, it is unclear whether a sample could also be collected within the depression itself. Please document the location of this drainage system on a site figure. Also, provide further description of the engineered depression’s construction, and indicate whether a sediment sample could be collected from this location. If sediment has accumulated in this depression, further sampling of this area may be warranted to determine whether it has been impacted by overland flow.

9. **Section 3.1.4, Global Positioning System Activities, Page 3-2:** This section indicates that sample location coordinates and elevations were obtained for soil borings (APSB07, APSB08, APSB09, and APSB10). However, this section does not mention soil boring APSB06. Appendix B indicates that sample location coordinates and elevation were also obtained for boring APSB06. Please revise Section 3.1.4 to include this boring.

10. **Section 3.1.6, Modifications to the Sampling Plan, Page 3-3**: A groundwater sample was not collected at boring location APGW01 since groundwater was not encountered at this location prior to refusal on weathered bedrock. The RFI Report does not address potential impacts of this modification to the sampling plan. Work Plan Addendum 19 indicates that APGW01 was proposed as an upgradient groundwater sampling location. Since chloroform and tetrachloroethene were detected in all of the other site groundwater samples, data from an upgradient sampling location are needed to determine whether these VOCs in groundwater are attributed to an upgradient source or to Area P. Please revise the RFI Report to discuss the impact of not sampling groundwater at boring location APGW01, as originally proposed in Work Plan Addendum 19. Please propose an alternate method for sampling upgradient groundwater or otherwise filling this data gap, as needed.

11. **Section 4.1.2, Sediment Analytical Results, Page 4-7:** The sediment sample (APSD01) was analyzed for target analyte list (TAL) metals, target compound list (TCL) VOCs, semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), pesticides/PCBs, herbicides, explosives, and dioxins/furans. However, Section 4.1.2 only discusses the results for VOCs, PAHs, SVOCs, pesticides and PCBs. The results for metals, herbicides, explosives, and dioxins/furans have not been discussed, even though some of these constituents were detected in sediment, according to Table 4.3, Analytes Detected in Area P Sediment Samples. Please revise Section 4.1.2 to discuss the results for all of the analyte classes that were analyzed for in the sediment sample.

12. **Sections 4.1.4.1 and 4.2.3 –** The concluding paragraphs in both sections suggest that the r-SL level is an indicator for migration to groundwater. Although migration conclusions may in fact be reasonable they do not follow from discussion of a risked base concentration.

13. **Section 6.1.1.1, Surface Soil and Total Soil, Page 6-3:** Data from soil samples collected in 1992 were used for the Chemical of Potential Concern (COPC) screening process. Given the age of the data (18 years old), the HHRA should indicate whether these data were validated, and whether they are considered appropriate for use in a risk assessment. Please revise the HHRA to address these concerns.

14. **Section 6.1.1.4, Groundwater, Page 6-4:** This section does not clarify whether the metals results in groundwater are representative of the total or dissolved fraction. Please revise the HHRA to indicate whether total or dissolved metals results are used in the HHRA and discuss any associated uncertainties in using these data within the uncertainty analysis.

15. **Section 6.1.2, Identification of COPCs, Page 6-4**: The first paragraph states that COPCs in sediment were identified by comparing the maximum detection concentration (MDC) of each constituent to the applicable residential soil RSLs, as presented in the September 2008 EPA RSL Tables. According to a note at the bottom of Table D.1-6, of Appendix D, it appears that the RSLs were also adjusted by a factor of 10 to account for sediment exposures. This adjustment is not discussed within the text of the document. Please revise the HHRA to indicate that the RSLs were adjusted by a factor of 10 for the sediment COPC evaluation.

16. **Section 6.1.2, Identification of COPCs, Page 6-4**: The third paragraph states, "Analytes for which no screening criteria exist were also selected as COPCs." This approach was followed for some chemicals but not others. It appears that screening criteria for surrogate chemicals may have been used for some chemicals for which screening criteria are not available (i.e., the screening value for pyrene was used for benzo(g,h,i)perylene in the sediment COPC screening). This approach is generally acceptable; however, the HHRA should discuss the use of surrogate chemicals in the COPC selection process, and clarify why the selected surrogates are considered appropriate. Please revise Section 6.1.2 to acknowledge the use of surrogates in the

COPC selection process and to discuss the structure activity relationship between chemicals lacking toxicity criteria and any identified surrogates.

17. **Section 6.2.1, Conceptual Site Model/Receptor Characterization, Page 6-6:** An adult recreational user of the New River was evaluated for exposure to surface water, but the child recreational user and/or the adolescent recreational user were not evaluated. The first paragraph of Section 6.6, HHRA Summary and Conclusions, states that "off-site adult and child residents were…evaluated for potential exposures to groundwater in the event that groundwater migrates off site in the future," but this does not appear to be the case. The same statement is also included on Page ES-2 of the Executive Summary under the Human Health Risk Assessment subheading. Sufficient justification for excluding off-site child and/or adolescent recreational users as potential receptors has not been provided. Please revise the HHRA to evaluate a child and/or adolescent recreational user's exposure to surface water (from groundwater discharge to the New River), or provide sufficient justification for not evaluating these exposures.

18. **Section 7.2.7, Uncertainty Analysis, Page 7-53**: The second paragraph on this page states, "Thirty-one of the non-detect surface soil and 46 of the non-detect sediment constituents had maximum detection limits that exceeded the screening criteria, respectively. These finding are no unexpected, given the conservative and numerically low screening values." The evaluation of the non-detects does not quantify the exceedance. Please consider adding a table showing the hazard quotients based on dividing the maximum non-detect detection limit with the corresponding screening value. This additional information would help the reader understand the magnitude of the exceedances and their potential to cause ecological harm.

19. **Table 7-16, Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Exposure Area P:** The "Screening Toxicity Value" and the "COPEC Flag" columns contain several "#REF!" entries which indicate that there is an error. Please review the table and update accordingly.

20. **Section 8.1 –** It is stated in the first paragraph that metals were not greater than SLs in any soil samples. The second paragraph states that antimony and copper were found above r-SLs in one surface soil sample. These statements should be reconciled.

21. **Section 8.4 –** The filtered results appear to be the best evidence for the conclusion. These results and resulting risks should be clearly stated.

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
US ARMY PUBLIC HEALTH COMMAND (PROVISIONAL)
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND, MD 21010-5403

MCHB-TS-REH

14 DEC 2009

MEMORANDUM FOR Office of Environmental Quality, Radford Army Ammunition Plant (SJMRF-OP-EQ/Mr. Jim McKenna), P.O. Box 2, Radford, VA 24143-0002

SUBJECT: Draft RCRA Facility Investigation Report for Area P, Radford Army Ammunition Plant, Virginia, November 2009

1. The US Army Public Health Command (Provisional), formerly the US Army Center for Health Promotion and Preventive Medicine, reviewed the subject document on behalf of the Office of The Surgeon General pursuant to Army Regulation 200-1 (Environmental Protection and Enhancement). We appreciate the opportunity to review the report.

2. Our previous comments have been addressed. The recommendation for no further action at Area P should be protective of human health and the environment.

3. The document was reviewed by Mr. Dennis Druck, Environmental Health Risk Assessment Program. He can be reached at DSN 584-2953, commercial (410) 436-2953 or electronic mail, dennis.druck@us.army.mil.

FOR THE COMMANDER:

JEFFREY S. KIRKPATRICK
Director, Health Risk Management

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December 11, 2009

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Mr. James L. Cutler, Jr.
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 24143-0100

Subject: With Certification, Area P RCRA Facility Investigation Report, Draft Document November 2009
EPA ID# VA1 210020730

Dear Mr. Geiger and Mr. Cutler:

Enclosed is the certification for the subject document that was sent to you on December 10, 2009. Also enclosed is the 10 December 2009 transmittal email.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder ATK staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 731-5782.

Sincerely,

Phillip Lockard for

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c: Karen Sismour
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09-815-204
JMcKenna

Concerning the following:

Radford Army Ammunition Plant
Area P
RCRA Facility Investigation Report
Draft November 2009

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

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09-815-204
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Subject: Draft Area P RFI Report (UNCLASSIFIED)

Importance: High

Classification: UNCLASSIFIED
Caveats: FOUO

All:

Note the contractor will ship the subject document with a copy of this email to the POCs and tracking numbers below.

A certification letter will follow.

Thank you for your support of the Radford Army Ammunition Plant Installation Restoration Program.

Jim McKenna

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Mr. James Cutler	1Z63V8840191952590 (1 hard copy)
Ms. Elizabeth Lohman	1Z63V8840194818202 (1 electronic copy)
Mr. William Geiger	1Z63V8840193157982 (3 hard copies)

Classification: UNCLASSIFIED
Caveats: FOUO

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The Appendices are Included on a CD Located at the Back of This Report

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
ARCS	Assessment and Remediation of Contaminated Sediments
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances Disease Registry
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
cfs	cubic feet per second
cm	centimeters
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSEM	Conceptual Site Exposure Model
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
DA	dose absorbed per unit area per event
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EEQ	Environmental Effects Quotient
EPC	Exposure Point Concentration
EPD	Effective Prediction Domain
ERAGS	Ecological Risk Assessment Guidance for Superfund
FDEP	Florida Department of Environmental Protection
ft msl	feet above mean sea level
ft	feet
ft^2/min	square feet per minute
g/dL	grams per deciliter
GI	Gastrointestinal
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IAEA	International Atomic Energy Agency
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
i-SL	Industrial Screening Level
kg	kilograms
LOAEL	Lowest-Observed-Adverse-Effect Level
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
MMA	Main Manufacturing Area
MWP	Master Work Plan
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No-Observed-Adverse-Effect Level
ORNL	Oak Ridge National Laboratory
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PEF	Particulate Emission Factor
PEL	Probable Effects Level
PETN	Pentaerythritol tetranitrate
PPRTV	Provisional Peer Reviewed Toxicity Value
QA	Quality Assurance
QC	Quality Control

RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RFAAP	Radford Army Ammunition Plant
RfD	Risk Reference Dose
RFI	RCRA Facility Investigation
r-SL	Residential Screening Level
RTE	Rare, Threatened, or Endangered
Shaw	Shaw Environmental, Inc.
SL	Screening Level
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TEF	Toxicity Equivalence Factor
TOC	Total Organic Carbon
TRV	Toxicity Reference Value
tw-SL	Tap Water Screening Level
UCL	Upper Confidence Limit
UF	Uncertainty Factor
USEPA	U.S. Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VI	Verification Investigation
VOC	Volatile Organic Compound
VRP	Voluntary Remediation Program
WHO	World Health Organization

EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Area of Concern P (RAAP-037) – Spent Battery Storage Area during 2007. This investigation is required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) for Radford Army Ammunition Plant (RFAAP) and was performed in accordance with *Master Work Plan (MWP) Addendum 019* (Shaw, 2007). MWP Addendum 019 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by the U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality.

In addition to the MWP Addendum 019 field investigation, one other previous investigation was conducted at Area P. This investigation was a Verification Investigation (VI). The VI at Area P included surface and subsurface sampling to determine if the soils at Area P had been impacted from the possible spillage of spent battery acid.

During the development of MWP Addendum 019, a review of the data indicated that there had not been any groundwater samples taken yet at Area P and all analyte classes had not been tested for in soil samples, representing data gaps.

Once the data needs were identified, sampling strategies were developed to complete characterization of the site and refine the delineation of elevated constituents in site media. 2007 RFI activities at Area P included the collection and chemical analysis of five surface soil, five subsurface soil, one sediment, and four groundwater samples. Chemical results from these samples, as well as previous investigation samples, were evaluated to assess the nature and extent of contamination (*Section 4.0*), fate and transport analysis (*Section 5.0*), and potential impacts to human health (*Section 6.0*) and/or ecological receptors (*Section 7.0*).

Contamination Assessment

Soil. The soil at Area P was investigated during the 1992 sampling event and then again in 2007. The Area P data set from both soil investigations demonstrates that there were no chemicals detected above industrial screening levels (i-SLs) and indicates that one polychlorinated biphenyl (PCB) and two metals (antimony and copper) were found above their screening limits in soil samples collected for this site. PCB-1254 was detected above its residential screening level (r-SL) in two 2007 samples. Antimony and copper exceeded their respective r-SLs in a single 1992 sample.

None of the compounds that were found to be greater than soil r-SLs were identified by the human health risk assessment (HHRA) or screening level ecological risk assessment (SLERA) as posing a significant risk to human health or the environment. Of the two soil analytes (antimony and copper) that were above their r-SLs in the previous investigation, antimony was not detected in groundwater and copper was detected at concentrations below its maximum contaminant level (MCL) and the tap water screening level (tw-SL). The results from the investigations at Area P indicate that there are no major concerns in soil because of the relatively low concentrations and sparsely located constituents of concern.

Sediment. The sediment at Area P was investigated during the 2007 sampling event. The sample was collected from the discharge end of a drainage pipe that drains the site area under a berm towards the New River. The sample results indicate that one polynuclear aromatic hydrocarbon (PAH) and one PCB were found above their respective screening limits. Concentrations of both compounds [PAH - benzo(a)pyrene; PCB - PCB-1254] were below their i-SLs, but above their r-SLs in the sample.

None of the compounds that were found to be greater than SLs were also identified by the HHRA as posing a significant risk to human health. Sediment analytes that were found above their SLs were not also found in site groundwater.

Groundwater. Groundwater at Area P was investigated during the 2007 investigation. Four direct-push groundwater samples (APGW02, APGW03, APGW04, and APGW05) were collected at Area P to help demonstrate that site soil was not impacting groundwater.

Area P groundwater results from the 2007 sampling event indicated that two volatile organic compounds (VOCs) and 19 metals were detected above their screening limits. PAHs, semivolatile organic compounds, pesticides, PCBs, explosives, and herbicides were not detected in the groundwater samples. The two VOCs [chloroform and tetrachloroethene (PCE)] were found at concentrations above their tw-SLs, but below their MCLs, in all four samples. Samples were collected for both filtered (dissolved) metals and unfiltered (total) metals. These direct-push groundwater samples were collected without a sand-pack, increasing the amount of sediment in the sample. It is likely that the high concentration of metals in these samples is due to the sediment entrained in the sample. For the unfiltered analysis, five metals (aluminum, beryllium, chromium, iron, and manganese) were detected above both their tw-SLs and MCLs, five metals (barium, cobalt, mercury, nickel, and vanadium) were above their tw-SLs, and lead was detected above its MCL. Beryllium results were all flagged with a “B” validation qualifier, indicating that this compound was also detected in associated laboratory blanks. Chloroform is not a battery-related constituent and its presence is unlikely associated with the site. Chloroform is found uniformly in groundwater at RFAAP due to its drinking water treatment processes.

In filtered groundwater samples, only five metals (aluminum, chromium, cobalt, iron, and manganese) were greater than their SLs in site samples. Some of the compounds (chloroform, PCE, aluminum, chromium, cobalt, iron, manganese, and vanadium) that were found to be greater than SLs were also identified by the HHRA as potentially posing a risk to human health.

Fate and Transport Analysis

A fate and transport analysis (*Section 5.0*) was conducted to assess the potential for migration of the analytes that were detected above SLs, and were identified in the HHRA as a risk driver in Area P samples. Two VOCs (chloroform and PCE) and one PCB (PCB-1254) are included.

Human Health Risk Assessment

An HHRA was performed to evaluate the potential human health effects associated with previous activities at Area P. Receptors evaluated included current/future maintenance worker, future industrial worker, future excavation worker, future adult resident, future child resident, and lifetime resident. Off-site adult and adolescent recreational users were also evaluated for potential exposures to groundwater in the event that groundwater discharges to New River in the future.

The total cancer risk for current maintenance worker exposures to surface soil and groundwater were both below the target risk ranges and their hazard indices (HIs) were below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil, total soil, and groundwater were below their target risk ranges and their HIs were below 1.

For the future industrial worker, exposures to surface soil, total soil, and groundwater were within their target risk ranges (above the lower end of the range due to arsenic in soil and PCE in groundwater). The soils were within their ranges due to arsenic and groundwater due to PCE. The HIs were below 1.

For the future excavation worker, total cancer risk for exposures to total soil was below the target risk range. The total cancer risk associated with groundwater was equal to the lower limit of the target risk range. Both HIs were less than 1.

For the future lifetime resident, the total cancer risk for exposures to surface soil, total soil, and groundwater were within the target risk ranges (above the lower end of the range due to Aroclor 1254 and arsenic for surface soil, arsenic in total soil, and chloroform and PCE for groundwater). The HI for soil was less than 1. The HI for groundwater was equal to 1, with none of the HIs for individual COPCs exceeding 1.

For the child resident, the total cancer risk for exposures to surface soil, total soil, and groundwater were all within the target risk range, due to Aroclor 1254 and arsenic for surface soil, arsenic in total soil, and PCE for groundwater. The total HIs for surface and total soil were above 1; however, no individual chemical of potential concern (COPC) had an HI above 1. Aluminum, antimony, arsenic, cobalt, iron, manganese, and vanadium are within background concentrations for surface and total soil. If the hazard quotients (HQs) for background-related metals were excluded, the total HIs for surface and total soil would be less than 1. The total HI for groundwater was above 1, with none of the individual HIs for COPCs exceeding 1. Although some target organs HIs exceeded 1, these target organs HIs were less than 1 when the target organ HQs for background-related metals were excluded.

Off-site recreational users were evaluated to address potential future migration of COPCs in groundwater to surface water at the New River. For the future adult recreational user, the total cancer risk for exposures to off-site surface water (1E-06) was equal to the lower limit of the target risk range. The total HI was below 1. For the future adolescent recreational user, the total cancer risk for exposures to off-site surface water was less than the lower limit of the target risk range. The total HI was below 1.

Arsenic and Aroclor-1254 are the main risk-drivers in soil and PCE and chloroform are the main risk-drivers in groundwater at Area P.

Screening Level Ecological Risk Assessment

A SLERA (*Section 7.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at Area P. Common methods and procedures are presented in *Section 7.1*, and individual results for Area P are presented in *Section 7.2*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (copper, selenium, and zinc) in surface soil.

However, when alternative toxicity adjustment factors were used in the Tier 2 Lowest-Observed-Adverse-Effect Level (LOAEL)-based environmental effects quotient (EEQ) calculations, estimated EEQs would be expected to drop to 1 or less for all constituents. The direct contact assessment results suggest a potential reduction in wildlife food supply due to copper, lead, selenium, and zinc in surface soil and TCDD, lead, manganese, selenium, and zinc in sediment. However, due to the small size of the site (0.38 acres) and unsuitable habitat (gravel) this potential reduction in food is not considered biologically significant. In addition, although five chemicals of potential ecological concern (COPECs) in sediment had concentrations that exceeded more than 50 percent of the available screening benchmarks, the small size of the site (0.38 acres), the lack of aquatic habitat and the associated small size of the aquatic habitat (dry drainage ditch), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, no Tier 2 LOAEL EEQs exceeding 1 (when rounded to one significant figure) when using alternative toxicity reference value species extrapolation uncertainty factors, the fact that no wildlife rare, threatened, or endangered (RTE) species have been confirmed at the Area P study area, and the relatively small size of the solid waste management unit (0.38 acres), and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, sediment, or groundwater. The scientific/management decision point reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

Conclusions

Total risks associated with exposures to COPCs in soil were within the acceptable risk range for the future industrial worker, future lifetime resident, and future child resident. These risks were attributable to arsenic in surface and total soil and also Aroclor-1254 in surface soil for the future lifetime resident. However, the arsenic soil concentrations were within background levels at the site.

The total HIs for soil were below 1 for all receptors except the child resident. For the child resident, however, individual HQs for metals in soil were less than 1. Furthermore, when the background-related HQs were excluded, the total HI for soil was less than 1.

Total risks associated with exposures to COPCs in groundwater were above the acceptable risk range for the future industrial worker, future lifetime resident, and future child resident and were attributable primarily to PCE and chloroform. PCE and chloroform were only detected above their tw-SLs, and not above their MCLs in site groundwater samples. However, the maximum detected concentration (MDC) of lead in unfiltered groundwater samples was above the action level for drinking water. Lead concentrations in the filtered samples were below the drinking water action level and were used in the HHRA.

The total HIs for groundwater were equal to 1 for the future adult resident and above 1 for the future child resident; however, none of the HIs for individual COPCs were above 1.

There are no unacceptable risks or hazards for the current site workers. The SLERA concluded that there may be potential adverse impacts to terrestrial wildlife from site media. However, because no RTE wildlife species have been confirmed at the site, because of the relatively small size of the site, and because groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures to address ecological concerns are not warranted.

Based on the results of the Nature and Extent of Contamination Assessment, as well as the results of Human Health and Ecological Risk Assessments, both of which show limited risk to theoretical receptors, no further action is recommended for these sites.

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corp of Engineers, Baltimore District, to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Corrective Measures Study at Area P (RAAP-037) – Spent Battery Storage Area. The area is located in the northern portion of the Main Manufacturing Area (MMA) of Radford Army Ammunition Plant (RFAAP), adjacent to the New River, east of the main bridge over the New River (**Figure 1-1**). The work was performed in accordance with RFAAP's *Master Work Plan (MWP)* (URS, 2003) and *MWP Addendum 019* (Shaw, 2007) under Contract No. W912QR-04-D-0027.

One previous investigation has been conducted at Area P and is discussed in the following section of this report. A data review, including the development of a conceptual site model (CSM) and data gap analysis, was performed in *MWP Addendum 019* (Shaw, 2007). Review of the Area P data indicated that additional samples needed to be collected in order to characterize the current state of potentially impacted media, representing a data gap. Once the data needs were identified, sampling strategies were developed to complete the characterization of Area P.

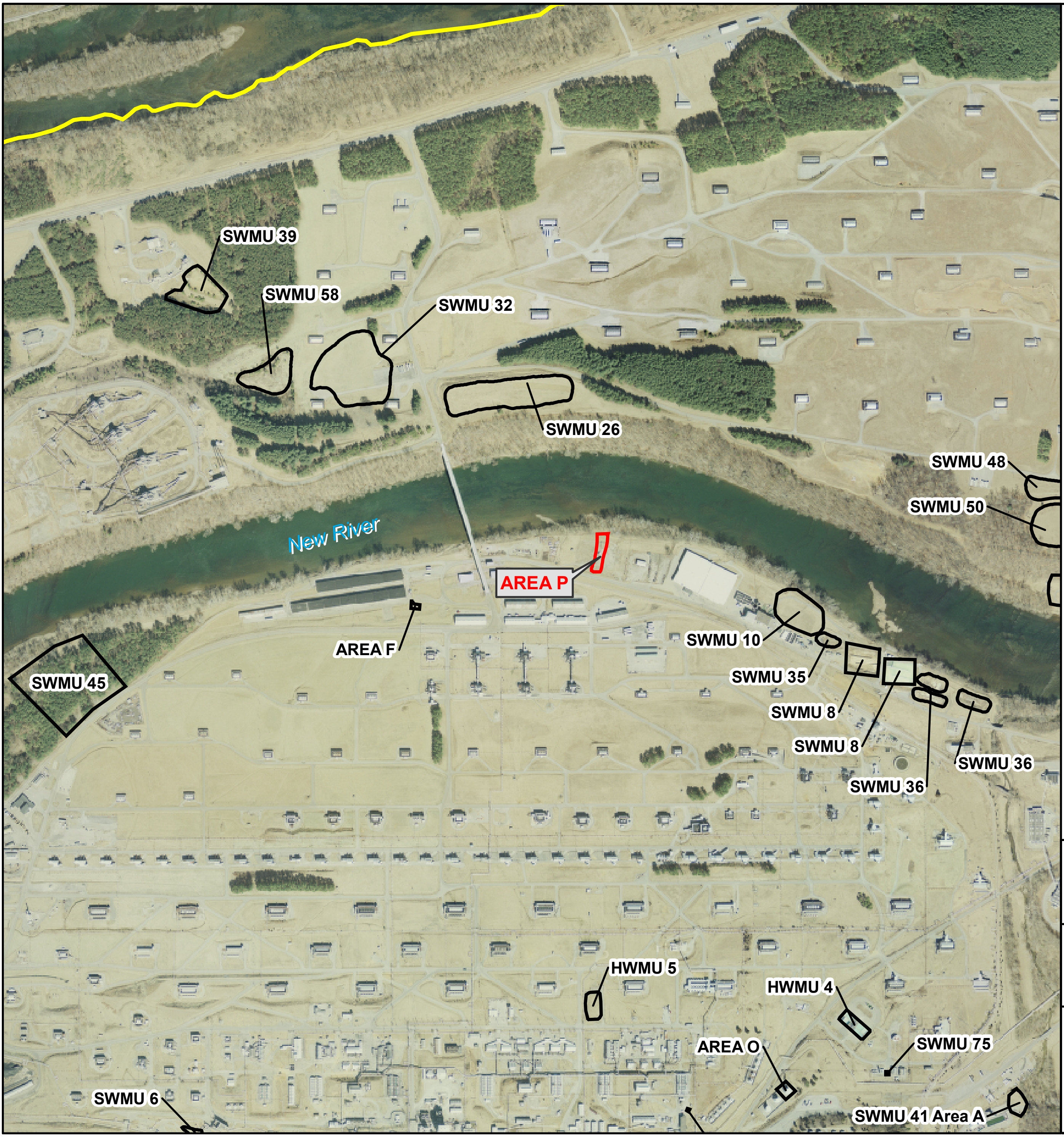
The objectives of the field investigation at Area P were designed to:

- Collect sufficient samples in order to conduct risk assessments.
- Address data gaps in both soil and groundwater.
- Obtain current data that can be compared to existing data.

Field activities were conducted in accordance with the *MWP, Master Quality Assurance Plan, Master Health and Safety Plan* (URS, 2003), *MWP Addendum 012* (IT, 2002), and *MWP Addendum 019* (Shaw, 2007), as approved by U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality (VDEQ). Modifications to *MWP Addendum 019* proposed sampling activities are presented in *Section 3.1.6*.

The data collected in 2007, in conjunction with existing data, was sufficient to complete a Nature and Extent of Contamination Assessment (*Section 4.0*), Fate and Transport Evaluation (*Section 5.0*), Human Health Risk Assessment (HHRA) (*Section 6.0*), and Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*).

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig1-1_AreaP_SiteLocMap_RFI.mxd (5/29/2009)



LEGEND

🟥 Area P Boundary

⬛ Other SWMU Boundary

🟨 Installation Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning & GIS Services.

N

Scale:
0 500 1,000 2,000
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 1-1
Area P
Site Location Map
Radford Army Ammunition Plant,
Radford, VA

2.0 SITE BACKGROUND

2.1 Site Description

Area P is presumably a former spent battery storage area which is defined by a fenced-in gravel area approximately 50 feet (ft) by 200 ft long (**Figure 2-1**). The land surface in the study area is typically level with a gentle slope towards the north to the New River, which is approximately 200 ft from the storage area. No site-specific hydrogeologic studies have been conducted at this site before 2007. Based on topography, groundwater is expected to flow north to the river.

As shown on **Figure 2-1**, a small building is found at the center of the site. This building is a small shed that has a conveyor belt leading into and out of it. Currently, the site is not used. The site area features an empty building with the remainder of the site being empty, except for gravel with grass growing up through it.

2.2 Site History and Operations

Area P is the center of a scrap metal yard that was formerly used for the storage of shredded scrap metal, decommissioned tanks, powder cans, and batteries prior to off-post shipment. This information was collected during the Radford 1987 RCRA Facility Assessment. During the 2007 RCRA field investigation, it was discovered that the site has an area of depression, which was likely for the loading and unloading of trucks, as well as an associated drainage pipe.

2.3 Site Soil

The surface of Area P is a gravel pad. Underlying the gravel, the U.S. Department of Agriculture has identified the soils as the Unison-Urban Land Complex (**Figure 2-2**) (SCS, 1985). These soils have been highly reworked through activities at RFAAP. A typical profile of Unison-Urban Land Complex has a surface layer of brown loam about 15 inches thick with yellowish-red sticky, plastic clay about 43 inches deep. The substratum is red, sandy clay loam below a depth of 58 inches. The Unison-Urban Land Complex typically has a slope modifier of 2 to 7 percent.

2.4 Site Geology

RFAAP is located in the New River Valley, which crosses the Valley and Ridge Provence approximately perpendicular to the regional strike of the bedrock, and cross cuts Cambrian and Ordovician limestone or dolostone. Deep clay-rich residuum is prevalent in areas underlain by carbonate rocks. The valley floor is covered by river floodplain and terrace deposits; karst topography is dominant throughout the area. Well and soil boring logs are presented in **Appendix B**.

2.4.1 Area P Geology

There has not been any subsurface soil samples collected beneath 6 ft below ground surface (bgs) at Area P. However, direct-push borings advanced for the collection of groundwater samples during the 2007 RFI encountered refusal on weathered limestone bedrock at depths ranging from 16 to 18 ft bgs.

The site is located on a river terrace deposit and is expected to consist of a mixture of sand, silt, and clay with occasional gravel “riverjack” stringers where former channels existed. The boring logs from the soil borings drilled in 2007 (found in **Appendix B**) support the last statement.

LEGEND

- Water Feature
- 2 ft Contour Line
- 10 ft Contour Line
- Dirt Road
- Paved Road
- Railroad
- Fence
- Area P Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 75 150 300
Feet

U.S. Army Corps of Engineers

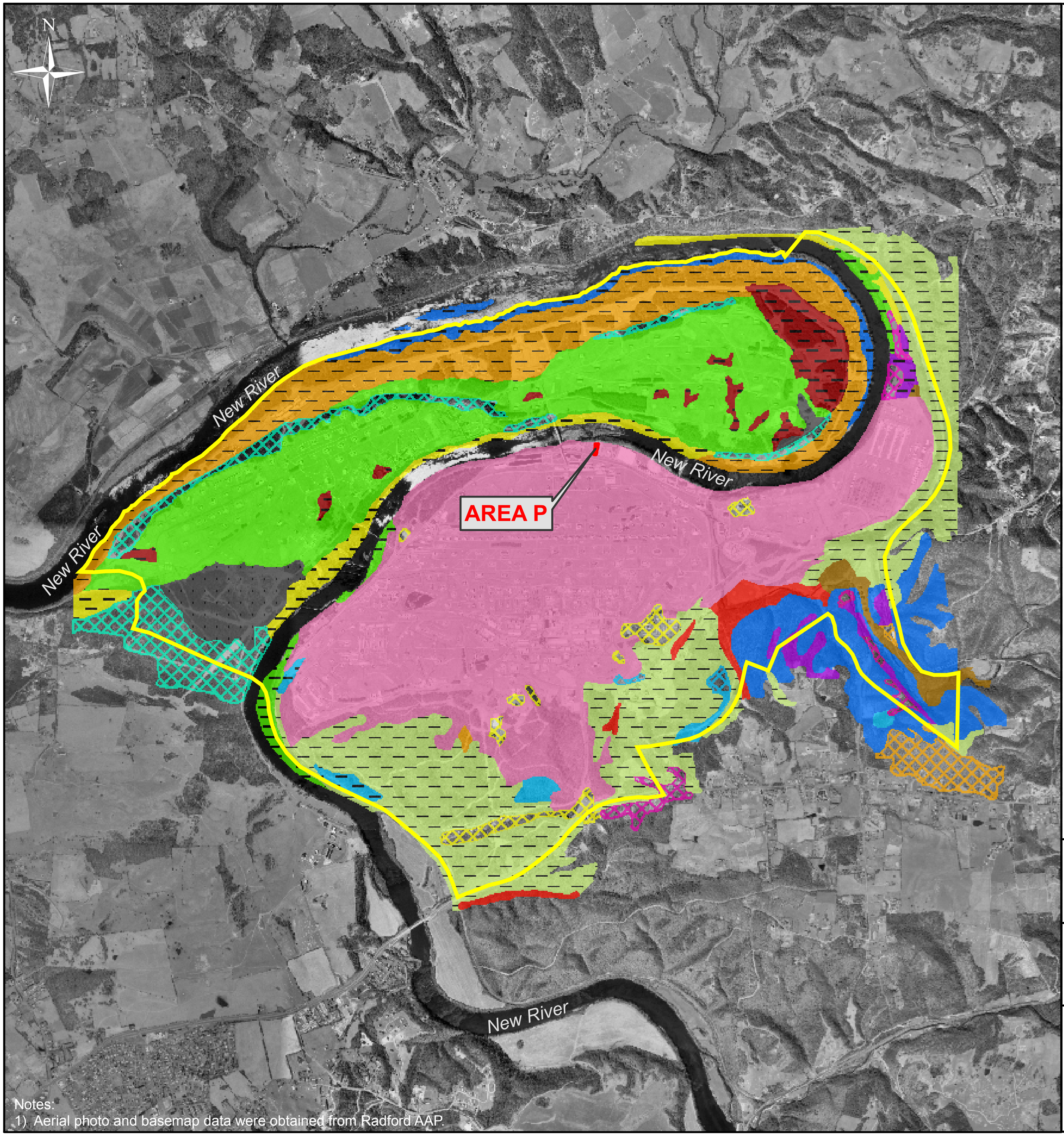
Shaw® Shaw Environmental, Inc.

FIGURE 2-1
Area P Site Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig2-1_AreaP_SiteMap_RFI.mxd (8/12/2010)

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig2-2_AreaP_SCS_Soils_RFI.mxd (5/29/2009)



Notes:
1) Aerial photo and basemap data were obtained from Radford AAP.

U.S. Army Corps of Engineers

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FIGURE 2-2
SCS Soil Types at the
Main Manufacturing Area
Radford Army Ammunition Plant,
Radford, VA

2.5 Site Hydrogeology

There are no monitoring wells at the site and no site-specific groundwater investigations were conducted prior to the direct-push borings advanced in 2007. A groundwater table was present below Area P in August 2007, ranging in depth from 14.15 to 17.25 ft bgs. Due to the site location on a river terrace deposit, groundwater is expected to flow north through the unconsolidated sediments and discharge in the New River.

Area P is a generally level area with a gentle slope northern slope north in the direction of the New River. The elevation at the site ranges from approximately 1,700 feet above mean sea level (ft msl) at the northwestern corner of the site to approximately 1,710 ft msl at the south edge of the site. Surface water is generally expected to follow the topography towards the New River. An engineered drainage system exists at the north end of the site. This drainage system collects overland flow in an engineered depression and drains it through an underground pipe. The pipe then discharges to the bank of the New River.

The engineered depression is an unlined depression that appears to have been used to line up the height of a truck bed with the conveyor belt on site. The depression is pointed-out on **Figure 2-1**. The upstream end of the pipe (within the depression) appears to be an erosional environment, while there was obvious sediment accumulation at the discharge end of the pipe, where a sediment sample was taken.

2.6 Previous Investigations

One previous investigation was conducted at Area P in 1992. The investigation and sample results are summarized below.

2.6.1 VI, Dames and Moore, 1992

In 1992, Dames and Moore performed a Verification Investigation (VI), which included surface and subsurface soil sampling to determine if the soil at Area P had been impacted from the possible spillage of spent battery acid. At each of five locations, one surface (0 to 0.5 ft bgs) and one subsurface soil sample (4 to 5 ft bgs) was collected and analyzed for target analyte list (TAL) metals and pH (**Table 2-1**). Soil sampling locations are depicted on **Figure 2-3**.

Table 2-1
Area P Previous Investigation Samples and Analyses – 1992 VI

Media	Sample ID	Depth (ft bgs)	Analyses
Surface Soil	PSB1 (RVFS*76)	0-0.5	TAL metals and pH
	PSB2 (RVFS*78)	0-0.5	TAL metals and pH
	PSB3 (RVFS*80)	0-0.5	TAL metals and pH
	PSB4 (RVFS*82)	0-0.5	TAL metals and pH
	PSB5 (RVFS*84)	0-0.5	TAL metals and pH
Subsurface Soil	PSB1 (RVFS*77)	4-5	TAL metals and pH
	PSB2 (RVFS*79)	4-5	TAL metals and pH
	PSB3 (RVFS*81)	4-5	TAL metals and pH
	PSB4 (RVFS*83)	4-5	TAL metals and pH
	PSB5 (RVFS*85)	4-5	TAL metals and pH

Arsenic, beryllium, and cobalt were detected at concentrations greater than soil screening criteria at the time of the investigation. A comparison to current screening levels (SLs) indicates that antimony and copper were detected above their residential screening levels (r-SLs) and background levels in surface soil sample PSB2 (RVFS*78) (**Table 2-2**). Concentrations of the remaining metals were found below their screening criteria. Metals found above their r-SL or industrial screening level (i-SL), but below their background level, are considered below their screening criteria and not a concern. pH results indicated that the soil samples varied from neutral to slightly basic.

Table 2-2
Analytes Detected in Area P Soil Samples - 1992 VI
Page 1 of 2

Analyte			Sample ID	**PSB1 (RVFS*76)**		**PSB1 (RVFS*77)**		**PSB2 (RVFS*78)**		**PSB2 (RVFS*79)**		**PSB3 (RVFS*80)**	
			Sample Date	**3/5/92**		**3/5/92**		**3/5/92**		**3/5/92**		**3/5/92**	
			Sample Depth	**0-0.5**		**4-5**		**0-0.5**		**4-5**		**0-0.5**	
	i-SL	**r-SL**	**Background**	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q
Metals (mg/kg)													
Aluminum	99000	7700	40041	12500		16600		3620		15800		11000	
Antimony	41	3.1	na	7.14	U	7.14	U	10.5		7.14	U	7.14	U
Arsenic	1.6	0.39	15.8	3.37		1.51		2		1.17		1.75	
Barium	19000	1500	209	138		113		73.1		126		132	
Beryllium	200	16	1.02	0.607		0.5	U	0.5	U	0.732		0.779	
Calcium	na	na	na	3350		1330		160000		2740		2080	
Chromium	1400	280	65.3	59.6		28.3		7.63		25.6		22.2	
Cobalt	30	2.3	72.3	12.6		13.5		2.65		11.6		10.5	
Copper	4100	310	53.5	**71.3**		15.1		**347**		**125**		15.7	
Iron	72000	5500	50962	24900		27500		6880		24400		19600	
Lead	800	400	26.8	**37.6**		10.5	U	**105**		21.9		**29.1**	
Magnesium	na	na	na	4110		4860		83000		4720		3210	
Manganese	2300	180	2543	608		493		130		447		625	
Nickel	2000	160	62.8	33.4		18.4		9.01		16.8		13	
Potassium	na	na	na	1400		1920		932		1880		1260	
Silver	510	39	na	0.589	U	0.68		1.79		0.753		0.589	U
Sodium	na	na	na	206		185		281		200		179	
Vanadium	720	55	108	40.2		49.8		12.1		46.4		31.3	
Zinc	31000	2300	202	155		73.6		115		89.1		128	
Misc.													
pH	na	na	na	7.66		6.9		8.68		7.6		7.82	

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-2
Analytes Detected in Area P Soil Samples - 1992 VI
Page 2 of 2

Analyte			Sample ID	**PSB3 (RVFS*81)**		**PSB4 (RVFS*82)**		**PSB4 (RVFS*83)**		**PSB5 (RVFS*84)**		**PSB5 (RVFS*85)**	
			Sample Date	**3/5/92**		**3/5/92**		**3/5/92**		**3/5/92**		**3/5/92**	
			Sample Depth	**4-5**		**0-0.5**		**4-5**		**0-0.5**		**4-5**	
	i-SL	**r-SL**	**Background**	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q	Result	Lab Q
Metals (mg/kg)													
Aluminum	99000	7700	40041	18200		10400		6350		13200		5580	
Antimony	41	3.1	na	7.14	U	7.14	U	7.14	U	7.14	U	7.14	U
Arsenic	1.6	0.39	15.8	1.34		0.923		0.71		2.44		0.618	
Barium	19000	1500	209	187		**257**		176		189		145	
Beryllium	200	16	1.02	0.923		0.5	U	0.5	U	0.691		0.5	U
Calcium	na	na	na	2300		1510		815		5000		1120	
Chromium	1400	280	65.3	33.5		22.7		12.7		27.7		12.6	
Cobalt	30	2.3	72.3	11.8		10.1		5.8		11.4		5.76	
Copper	4100	310	53.5	34.9		25.1		6.65		**76.2**		10.3	
Iron	72000	5500	50962	24700		17200		11600		23400		10400	
Lead	800	400	26.8	**49.2**		**43.7**		10.5	U	**150**		10.5	U
Magnesium	na	na	na	4770		3260		2000		5670		1940	
Manganese	2300	180	2543	430		582		253		497		308	
Nickel	2000	160	62.8	20.3		15.9		9.09		17.2		8.91	
Potassium	na	na	na	1890		1220		996		1740		626	
Silver	510	39	na	0.589	U	0.589	U	0.589	U	0.692		0.589	U
Sodium	na	na	na	198		261		218		222		188	
Vanadium	720	55	108	44		27.5		17.2		41.4		15.2	
Zinc	31000	2300	202	84.9		121		51.3		159		53.4	
Misc.													
pH	na	na	na	6.89		7.46		7.27		7.79		7.63	

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-2
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL = Screening Level (Source: ORNL Regional Screening Table, September 2008).
SL values in table are for the more conservative chromium VI.
SL values for chromium III are 150,000 (ind) and 12,000 (res), which were not exceeded.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 1999b).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
* = Laboratory duplicate not within control limits.
B = (organics) Blank contamination. Value detected in sample and associated blank.
A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = Validation Data Qualifiers
B = blank contamination. Value detected in sample and associated blank.
J = estimated concentration.
K = estimated concentration bias high.
L = estimated concentration bias low.
N = presumptive evidence for tentatively identified compounds using a library search.
U = analyte not detected.
UJ = estimated concentration non-detect.
UL = estimated concentration non-detect bias low.

LEGEND

● Previous Investigation Soil Sample Location

— Water Feature

▭ Area P Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 2-3
Area P Previous Investigation Sample Locations
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig2-3_AreaP_PreSampleLocations_RFI.mxd (5/29/2009)

3.0 FIELD INVESTIGATION PROGRAM

3.1 Shaw 2007 RFI

An additional field sampling event was conducted for Area P by Shaw in 2007 based on the EPA/VDEQ approved *MWP Addendum 019* (Shaw, 2007). The investigation was performed in order to obtain current analytical data for the site to complete its characterization. Additional soil samples were collected at Area P to refine the delineation of elevated constituents detected in previous investigations, as well as to define concentrations of untested analyte classes. Groundwater samples were also collected to determine whether the groundwater table was impacted by prior site activities. Samples and chemical analyses performed in support of the investigation are presented in **Table 3-1** below. Results from the investigation are discussed in *Section 4.0*.

Table 3-1
Area P Environmental Samples and Analyses – 2007 RFI

Media	Sampling ID	Depth (ft bgs)	Analytes
Surface Soil	APSB06A	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB07A	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB08A	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB09A	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB10A	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
Subsurface Soil	APSB06B	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB07B	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB08B	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB09B	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
	APSB10B	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and TAL metals
Sediment	APSD01	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, dioxins/furans, and TAL metals
Groundwater	APGW02	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals (total and dissolved), and perchlorate
	APGW03	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals (total and dissolved), and perchlorate
	APGW04	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals (total and dissolved), and perchlorate
	APGW05	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals (total and dissolved), and perchlorate

Refer to **Appendix A-1, Table A-1** for the preparation and analytical methodologies used.

3.1.1 Soil Results

As presented in **Table 3-1**, five surface soil samples (APSB06A, APSB07A, APSB08A, APSB09A, and APSB10A) and five subsurface soil samples (APSB06B, APSB07B, APSB08B, APSB09B, and APSB10B) were collected for chemical analysis. Sample locations are depicted on **Figure 3-1**. As shown in **Table 3-1**, the soil samples were analyzed for TAL metals, target compound list (TCL) volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), pesticides/polychlorinated biphenyls (PCBs), herbicides, and explosives. Analytes detected above SLs in site soil samples are illustrated on **Figure 3-2**.

3.1.2 Sediment Results

Sediment sample APSD01 was collected for chemical analysis from the outlet of the drainage pipe described in *Section 2.5*. The sample was collected from accumulated sediment at the outfall of the pipe. The sample location is depicted on **Figure 3-1**. As shown in **Table 3-1**, the sediment sample was analyzed for TAL metals, TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and dioxins/furans. Analytes detected above SLs in sediment are illustrated on **Figure 3-2**.

3.1.3 Groundwater Results

Four direct-push groundwater samples (APGW02, APGW03, APGW04, and APGW05) were collected for chemical analysis. As shown in **Table 3-1**, the direct-push groundwater samples were analyzed for TAL metals (total and dissolved), TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides and explosives, and perchlorate. The groundwater sample locations are illustrated on **Figure 3-1**, and the analytes detected above SLs are illustrated on **Figure 3-2**. The samples collected were very turbid and therefore were filtered in order to obtain more accurate metals concentrations. The filtered data was then used in the human health risk assessment since it was the better representation of actual concentrations.

3.1.4 Global Positioning System Activities

For Area P, sample location coordinates and elevations were obtained for soil borings (APSB06, APSB07, APSB08, APSB09, and APSB10), sediment sample (APSD01), and direct-push groundwater sample locations (APGW02, APGW03, APGW04, and APGW05) using a Trimble Geo XH Global Positioning System. The Geo XH system was used to obtain real-time position information with sub-meter accuracy and elevations at 1.5 to 2 times the horizontal accuracy. Horizontal position information was recorded in the U.S. State Plane [Virginia (South)] Plane Coordinate System (measured in U.S. survey feet) using the North American Datum of 1983. The vertical control was measured in feet using the National Geodetic vertical Datum of 1988. Position information will be entered into the Environmental Restoration Information System database. Sample location coordinates and elevations are presented in **Appendix C**.

3.1.5 Quality Assurance

The accuracy and integrity of 2007 RFI Area P data was ensured through the implementation of internal quality control (QC) measures in accordance with *MWP Addendum 019* (Shaw, 2007), as approved by USEPA Region III and the VDEQ. Quality assurance (QA) and QC activities, including field QC, laboratory QC, data management, and data validation were integrated into the investigation program to meet data quality objectives (DQOs) established for the RFI. The data were evaluated for each of the DQO indicators in **Appendix A-2, Table A-3** and found to meet the pre-established goals. Qualified data did not impact the data quality of the RFI.

Complete details of the RFI QA/QC analysis and activities are presented in **Appendix A-2**. Chemical data validation reports and analytical data are provided in **Appendix A-3**.

3.1.6 Modifications to the Sampling Plan

In some cases, modifications to the Work Plan are necessary to adjust for field conditions as they occur during field sampling. Adjustments to *MWP Addendum 019* (Shaw, 2007) were necessary during sampling activities at Area P.

Five direct-push groundwater samples were proposed to be collected for chemical analysis. However, groundwater was not encountered at direct-push location APGW01 prior to refusal on weathered bedrock. As described in *Section 3.1.2*, one sediment sample (APSD01) was collected from accumulated sediment at the discharge of the drainage pipe. This drainage pipe was discovered during sampling activities at Area P. This sediment sample was not proposed in *MWP Addendum 019* (Shaw, 2007) and was collected in order to help characterize potential contamination resulting from discharge of overland surface water flow at the site.

LEGEND

⊕	Groundwater Sample Location
▲	Sediment Sample Location
●	Soil Sample Location
—	Water Feature
☐	Area P Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

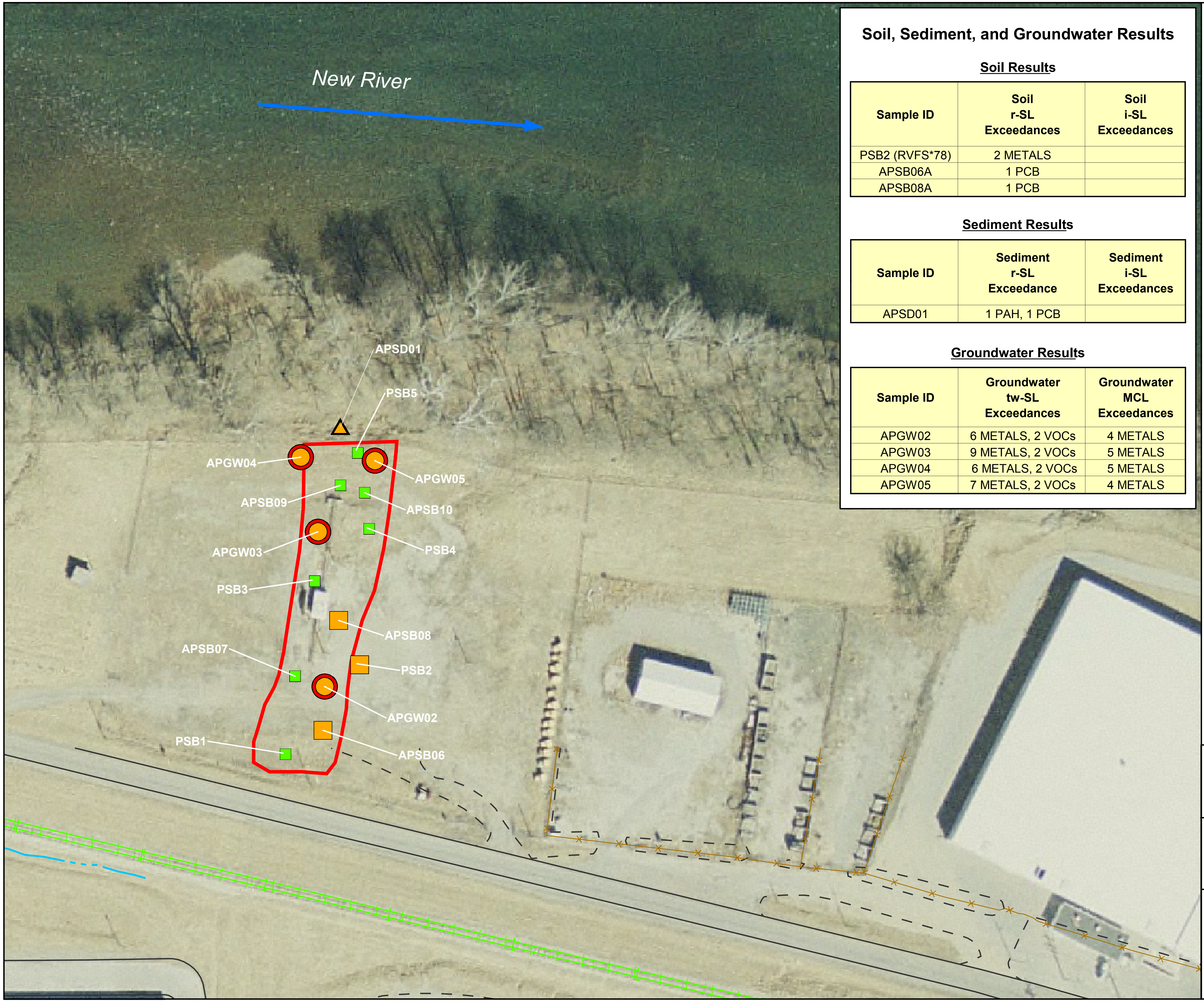
Scale:
0 75 150 300
Feet

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 3-1
Area P
2007 Investigation Sample Locations
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig3-1_AreaP_2007SampleLocations_RFI.mxd (5/29/2009)



Soil, Sediment, and Groundwater Results

Soil Results

Sample ID	Soil r-SL Exceedances	Soil i-SL Exceedances
PSB2 (RVFS*78)	2 METALS	
APSB06A	1 PCB	
APSB08A	1 PCB	

Sediment Results

Sample ID	Sediment r-SL Exceedance	Sediment i-SL Exceedances
APSD01	1 PAH, 1 PCB	

Groundwater Results

Sample ID	Groundwater tw-SL Exceedances	Groundwater MCL Exceedances
APGW02	6 METALS, 2 VOCs	4 METALS
APGW03	9 METALS, 2 VOCs	5 METALS
APGW04	6 METALS, 2 VOCs	5 METALS
APGW05	7 METALS, 2 VOCs	4 METALS

LEGEND

▲	Sediment Sample Location Result < r-SL and i-SL
▲	Sediment Sample Location Result >= r-SL
▲	Sediment Sample Location Result >= i-SL
●	Groundwater Sample Location Result < MCL and tw-SL
●	Groundwater Sample Location Result >= tw-SL
●	Groundwater Sample Location Result >= MCL
🟩	Soil Sample Location Result < r-SL and i-SL
🟧	Soil Sample Location Result >= r-SL
🟥	Soil Sample Location Result >= i-SL
–×–	Fence
– – –	Dirt Road
——	Paved Road
–+–	Railroad
——	Water Feature
▭	Area P Boundary

N

Scale:

0 37.5 75 150 Feet

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

U.S. Army Corps of Engineers

Shaw® Shaw Environmental, Inc.

FIGURE 3-2
Soil, Sediment, and Groundwater Results at Area P
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\Radford_MMA\GIS_Documents\Project_Maps\Area_P\RFAAP_Fig3-2_AreaP_Sample_Results_RFI.mxd (5/29/2009 3:32:13 PM)

4.0 NATURE AND EXTENT OF CONTAMINATION

The following sections provide a discussion of the site conditions and the nature and extent of chemicals found in soil, sediment, and groundwater at Area P. The distribution and concentrations of chemicals and parameter groups (i.e., VOCs, SVOCs, etc.) are evaluated for source locations, migration pathways, hotspots, and potential disposition areas.

Soil/Sediment Screening. Chemical results from soil and sediment samples are compared to adjusted USEPA Region III i-SLs and r-SLs (USEPA, 2008a), as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. I-SLs and r-SLs were adjusted downward to a hazard index (HI) of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening.

Current (September 2008) screening values and background 95% upper tolerance limits are presented for comparison in the soil and sediment result tables. Analytical results for inorganics in soil are indicated on the tables and figures as constituents of concern when they were above both the background value and a screening value. Eliminating analytes as constituents of concern when they are above an SL but below their background value allows site-specific constituents to be more clearly indicated on the tables and figures. Soil and sediment results from the 2007 RFI are presented in *Section 4.1*.

Groundwater Screening. Surface water and groundwater sampling results are compared to the 2006 Edition of the Drinking Water Standards and Health Advisories [i.e., maximum contaminant levels (MCLs) and secondary MCLs] (USEPA, 2006a) and adjusted tap water screening levels (tw-SLs) (USEPA, 2008a). Consistent with soil screening, tw-SLs were adjusted downward to an HI of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening. Groundwater results from the 2007 RFI are presented in *Section 4.1*.

4.1 RFI, Shaw, 2007

4.1.1 Soil Analytical Results

Five surface soil samples (APSB06A, APSB07A, APSB08A, APSB09A, and APSB10A) and five subsurface samples (APSB06B, APSB07B, APSB08B, APSB09B, and APSB10B) were collected at Area P and analyzed for TAL metals, TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, and explosives. Detected results are presented in **Table 4-1**, summarized in **Table 4-2**, and illustrated on **Figure 3-2**.

VOCs. Two VOCs [tetrachloroethene (PCE) and trichloroethene (TCE)] were detected in Area P soil samples. PCE was detected in sample APSB08A and TCE was detected in APSB07A. However, all the concentrations were well below the adjusted industrial and residential SLs.

PAHs. PAHs were not detected in any site soil samples.

SVOCs. Non-PAH SVOCs were not detected in any site soil samples.

Pesticides. Pesticides were not detected in any of the site soil samples.

PCBs. One PCB (PCB-1254) was detected in two surface soil samples (APSB06A and APSB08A). At both locations, PCB-1254 was detected above its r-SL, but below its i-SL.

Table 4-1
Analytes Detected in Area P Soil Samples - 2007 RFI
Page 1 of 3

Analyte			Sample ID Sample Date Sample Depth	**APSB06A 7/26/07 0-0.5**					**APSB06B 7/26/07 4-6**					**APSB07A 7/26/07 0-0.5**					**APSB07B 7/26/07 4-6**				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																							
Tetrachloroethene	2700	570	na	4.7	U		0.95	4.7	4.7	U		0.94	4.7	4.9	U		0.99	4.9	5.5	U		1.1	5.5
Trichloroethene	14000	2800	na	4.7	U		0.95	4.7	4.7	U		0.94	4.7	5.4			0.99	4.9	5.5	U		1.1	5.5
PAHs (ug/kg)		None detected																					
SVOCs (ug/kg)		None detected																					
Pesticides (ug/kg)		None detected																					
PCBs (mg/kg)																							
PCB-1254	0.74	0.022	na	0.403			0.047	0.094	0.019	U		0.0095	0.019	0.018	U		0.009	0.018	0.019	U		0.0095	0.019
Explosives (mg/kg)		None detected																					
Herbicides (ug/kg)		None detected																					
Metals (mg/kg)																							
Aluminum	99000	7700	40041	10200		J	2.7	11	12300		J	2.7	11	10300		J	2.7	11	13400		J	2.7	11
Antimony	41	3.1	na	0.94	J	B	0.21	3.3	1.1	J	B	0.22	3.4	0.72	J	B	0.21	3.4	1	J	B	0.21	3.3
Arsenic	1.6	0.39	15.8	1.8		L	0.22	0.45	1.8		L	0.22	0.46	2.1		K	0.22	0.45	1.8		K	0.22	0.44
Barium	19000	1500	209	170		J	0.28	11	106		J	0.29	11	190		J	0.28	11	108		J	0.28	11
Beryllium	200	16	1.02	0.97		L	0.056	0.28	0.91		L	0.057	0.29	0.74		L	0.056	0.28	0.81		L	0.055	0.28
Cadmium	81	7	0.69	0.056	U	UL	0.056	0.22	0.57	U	UL	0.57	1.2	0.18	J	L	0.056	0.22	0.055	U	UL	0.055	0.22
Calcium	na	na	na	3190		J	5.6	280	1120		J	5.7	290	12900		J	5.6	280	1350		J	5.5	280
Chromium	1400	280	65.3	16.6		J	0.078	0.56	18.9		J	0.08	0.57	13.9		J	0.079	0.56	19.5		J	0.077	0.55
Cobalt	30	2.3	72.3	8.1		J	0.061	2.8	9.4		J	0.063	2.9	7.3		J	0.062	2.8	9.4		J	0.061	2.8
Copper	4100	310	53.5	10.9		J	0.11	1.4	9.2		J	0.11	1.4	9.4		J	0.11	1.4	10		J	0.11	1.4
Iron	72000	5500	50962	14400		J	0.78	5.6	18800		J	0.8	5.7	15700		J	0.79	5.6	17700		J	0.77	5.5
Lead	800	400	26.8	17.8		J	0.13	5.6	7.5		J	0.14	5.7	**53.3**		**J**	0.13	5.6	6.3		J	0.13	5.5
Magnesium	na	na	na	2910		J	5.6	280	3070		J	5.7	290	9060		J	5.6	280	3200		J	5.5	280
Manganese	2300	180	2543	838		J	0.28	4.2	580		J	0.29	4.3	1150		J	0.56	8.4	471		J	0.28	4.1
Mercury	2.8	0.67	0.13	0.082	J	J	0.011	0.088	0.027	J	J	0.01	0.084	0.037	J	J	0.011	0.09	0.029	J	J	0.011	0.087
Nickel	2000	160	62.8	11.7		J	0.14	2.2	11.4		J	0.14	2.3	9.7		J	0.14	2.2	12.4		J	0.14	2.2
Potassium	na	na	na	1220		J	5.6	560	1270		J	5.7	570	1350		J	5.6	560	1350		J	5.5	550
Selenium	510	39	na	4.2	J	J	0.25	5.6	6.1		J	0.26	5.7	2.8	J	J	0.25	5.6	5.6		J	0.25	5.5
Sodium	na	na	na	28	U		28	560	29	U		29	570	52	J	B	28	560	28	U	UL	28	550
Vanadium	720	55	108	21.9		J	0.056	2.8	30.4		J	0.057	2.9	21.1		J	0.056	2.8	32.7		J	0.055	2.8
Zinc	31000	2300	202	103		J	0.28	1.1	47.3		J	0.29	1.1	160		J	0.28	1.1	47.4		J	0.28	1.1

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-1
Analytes Detected in Area P Soil Samples - 2007 RFI
Page 2 of 3

Analyte			Sample ID	APSB08A					APSB08B					APSB09A					APSB09B				
			Sample Date	7/26/07					7/26/07					7/26/07					7/26/07				
			Sample Depth	0-0.5					4-6					0-0.5					4-6				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																							
Tetrachloroethene	2700	570	na	6.4			1.1	5.3	6.4	U		1.3	6.4	5.2	U		1	5.2	6.7	U		1.3	6.7
Trichloroethene	14000	2800	na	5.3	U		1.1	5.3	6.4	U		1.3	6.4	5.2	U		1	5.2	6.7	U		1.3	6.7
PAHs (ug/kg)		None detected																					
SVOCs (ug/kg)		None detected																					
Pesticides (ug/kg)		None detected																					
PCBs (mg/kg)																							
PCB-1254	0.74	0.022	na	0.0402			0.0097	0.019	0.019	U		0.0094	0.019	0.018	U		0.009	0.018	0.018	U		0.0088	0.018
Explosives (mg/kg)		None detected																					
Herbicides (ug/kg)		None detected																					
Metals (mg/kg)																							
Aluminum	99000	7700	40041	11400		J	2.8	12	9040		J	2.7	11	5370		J	2.5	10	4920		J	2.7	11
Antimony	41	3.1	na	1.2	J	B	0.23	3.6	0.83	J	B	0.22	3.4	0.59	J	B	0.2	3.1	0.5	J	B	0.21	3.3
Arsenic	1.6	0.39	15.8	4.3		K	0.23	0.47	1.6		L	0.22	0.46	0.93		L	0.2	0.42	0.7		L	0.22	0.44
Barium	19000	1500	209	159		J	0.3	12	86.5		J	0.28	11	54.2		J	0.26	10	49.1		J	0.28	11
Beryllium	200	16	1.02	0.83		L	0.059	0.3	0.66			0.057	0.28	0.44			0.052	0.26	0.41			0.055	0.28
Cadmium	81	7	0.69	0.39		L	0.059	0.24	0.057	U	UL	0.057	0.23	0.052	U	UL	0.052	0.21	0.055	U	UL	0.055	0.22
Calcium	na	na	na	3380		J	5.9	300	9520		J	5.7	280	1180		J	5.2	260	927		J	5.5	280
Chromium	1400	280	65.3	17.2		J	0.083	0.59	12.8		J	0.08	0.57	10.9		J	0.073	0.52	12.2		J	0.077	0.55
Cobalt	30	2.3	72.3	7.9		J	0.065	3	6.6		J	0.063	2.8	4.8		J	0.057	2.6	4.3		J	0.061	2.8
Copper	4100	310	53.5	**108**		**J**	0.11	1.5	8.8		J	0.11	1.4	5		J	0.099	1.3	3.4		J	0.11	1.4
Iron	72000	5500	50962	19300		J	0.83	5.9	12200		J	0.8	5.7	7860		J	0.73	5.2	7450		J	0.77	5.5
Lead	800	400	26.8	**141**		**J**	0.14	5.9	8.2		J	0.14	5.7	4.9	J	J	0.12	5.2	2.7	J	J	0.13	5.5
Magnesium	na	na	na	2940		J	5.9	300	5980		J	5.7	280	1620		J	5.2	260	1390		J	5.5	280
Manganese	2300	180	2543	1240		J	0.59	8.9	401		J	1.1	17	171		J	0.052	0.78	150		J	0.055	0.83
Mercury	2.8	0.67	0.13	0.091			0.011	0.09	0.02	J	J	0.011	0.087	0.01	J	J	0.01	0.084	0.012	J	J	0.011	0.091
Nickel	2000	160	62.8	11.6		J	0.15	2.4	9.2		J	0.14	2.3	6.8		J	0.13	2.1	6.2		J	0.14	2.2
Potassium	na	na	na	1270		J	5.9	590	1040		J	5.7	570	796		B	5.2	520	697		B	5.5	550
Selenium	510	39	na	5.6	J	J	0.27	5.9	2.6	J	J	0.26	5.7	2.5	J	J	0.23	5.2	2.4	J	J	0.25	5.5
Sodium	na	na	na	232	J	B	30	590	28	U		28	570	26	U		26	520	28	U		28	550
Vanadium	720	55	108	21.3		J	0.059	3	18.2		J	0.057	2.8	12.4		J	0.052	2.6	11.5		J	0.055	2.8
Zinc	31000	2300	202	**1060**		**J**	3	12	50.9		J	0.28	1.1	36.5		J	0.26	1	26.2		J	0.28	1.1

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-1
Analytes Detected in Area P Soil Samples - 2007 RFI
Page 3 of 3

Analyte			Sample ID	APSB10A					APSB10B				
			Sample Date	7/26/07					7/26/07				
			Sample Depth	0-0.5					4-6				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)													
Tetrachloroethene	2700	570	na	5.2	U		*1*	*5.2*	6.2	U		*1.2*	*6.2*
Trichloroethene	14000	2800	na	5.2	U		*1*	*5.2*	6.2	U		*1.2*	*6.2*
PAHs (ug/kg)		None detected											
SVOCs (ug/kg)		None detected											
Pesticides (ug/kg)		None detected											
PCBs (mg/kg)													
PCB-1254	0.74	0.022	na	0.018	U		*0.009*	*0.018*	0.018	U		*0.0092*	*0.018*
Explosives (mg/kg)		None detected											
Herbicides (ug/kg)		None detected											
Metals (mg/kg)													
Aluminum	99000	7700	40041	5440		J	*2.6*	*11*	4720		J	*2.6*	*11*
Antimony	41	3.1	na	0.51	J	B	*0.2*	*3.2*	0.46	J	B	*0.21*	*3.3*
Arsenic	1.6	0.39	15.8	1.1		L	*0.21*	*0.43*	0.77		L	*0.21*	*0.44*
Barium	19000	1500	209	52.7		J	*0.27*	*11*	44.6		J	*0.27*	*11*
Beryllium	200	16	1.02	0.43			*0.053*	*0.27*	0.37			*0.055*	*0.27*
Cadmium	81	7	0.69	0.053	U	UL	*0.053*	*0.21*	0.055	U	UL	*0.055*	*0.22*
Calcium	na	na	na	2800		J	*5.3*	*270*	1380		J	*5.5*	*270*
Chromium	1400	280	65.3	9.4		J	*0.075*	*0.53*	8.9		J	*0.076*	*0.55*
Cobalt	30	2.3	72.3	4.5		J	*0.059*	*2.7*	4.2		J	*0.06*	*2.7*
Copper	4100	310	53.5	6.1		J	*0.1*	*1.3*	3.1		J	*0.1*	*1.4*
Iron	72000	5500	50962	7920		J	*0.75*	*5.3*	6900		J	*0.76*	*5.5*
Lead	800	400	26.8	8.2		J	*0.13*	*5.3*	3.7	J	J	*0.13*	*5.5*
Magnesium	na	na	na	2190		J	*5.3*	*270*	1560		J	*5.5*	*270*
Manganese	2300	180	2543	176		J	*0.053*	*0.8*	132		J	*0.055*	*0.82*
Mercury	2.8	0.67	0.13	0.01	J	J	*0.009*	*0.079*	0.011	U		*0.011*	*0.086*
Nickel	2000	160	62.8	6.6		J	*0.13*	*2.1*	5.7		J	*0.14*	*2.2*
Potassium	na	na	na	853		B	*5.3*	*530*	725		B	*5.5*	*550*
Selenium	510	39	na	2.4	J	J	*0.24*	*5.3*	2	J	J	*0.25*	*5.5*
Sodium	na	na	na	27	U		*27*	*530*	27	U		*27*	*550*
Vanadium	720	55	108	11.5		J	*0.053*	*2.7*	10.8		J	*0.055*	*2.7*
Zinc	31000	2300	202	52.8		J	*0.27*	*1.1*	25.9		J	*0.27*	*1.1*

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-1
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL = Screening Level (Source: ORNL Regional Screening Table, September 2008).
SL values in table are for the more conservative chromium VI.
    SL values for chromium III are 150,000 (ind) and 12,000 (res), which were not exceeded.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 1999b).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
* = Laboratory duplicate not within control limits.
B = (organics) Blank contamination. Value detected in sample and associated blank.
A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = Validation Data Qualifiers
B = blank contamination. Value detected in sample and associated blank.
J = estimated concentration.
K = estimated concentration bias high.
L = estimated concentration bias low.
N = presumptive evidence for tentatively identified compounds using a library search.
U = analyte not detected.
UJ = estimated concentration non-detect.
UL = estimated concentration non-detect bias low.

Table 4-2
Summary of Analytes Detected in Area P Soil Samples - 2007 RFI

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
Tetrachloroethene	2700	570	na	0	0	na	1	10	6.4	6.4	APSB08A
Trichloroethene	14000	2800	na	0	0	na	1	10	5.4	5.4	APSB07A
PAHs (ug/kg)		None detected									
SVOCs (ug/kg)		None detected									
Pesticides (ug/kg)		None detected									
PCBs (mg/kg)											
PCB-1254	0.74	0.022	na	0	2	na	2	10	0.0402	0.403	APSB06A
Explosives (mg/kg)		None detected									
Herbicides (ug/kg)		None detected									
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	0	0	10	10	4720	13400	APSB07B
Antimony	41	3.1	na	0	0	na	10	10	0.46	1.2	APSB08A
Arsenic	1.6	0.39	15.8	0	0	0	10	10	0.7	4.3	APSB08A
Barium	19000	1500	209	0	0	0	10	10	44.6	190	APSB07A
Beryllium	200	16	1.02	0	0	0	10	10	0.37	0.97	APSB06A
Cadmium	81	7	0.69	0	0	0	2	10	0.18	0.39	APSB08A
Calcium	na	na	na	na	na	na	10	10	927	12900	APSB07A
Chromium	1400	280	65.3	0	0	0	10	10	8.9	19.5	APSB07B
Cobalt	30	2.3	72.3	0	0	0	10	10	4.2	9.4	APSB06B
Copper	4100	310	53.5	0	0	1	10	10	3.1	108	APSB08A
Iron	72000	5500	50962	0	0	0	10	10	6900	19300	APSB08A
Lead	800	400	26.8	0	0	2	10	10	2.7	141	APSB08A
Magnesium	na	na	na	na	na	na	10	10	1390	9060	APSB07A
Manganese	2300	180	2543	0	0	0	10	10	132	1240	APSB08A
Mercury	2.8	0.67	0.13	0	0	0	9	10	0.01	0.091	APSB08A
Nickel	2000	160	62.8	0	0	0	10	10	5.7	12.4	APSB07B
Potassium	na	na	na	na	na	na	10	10	697	1350	APSB07A
Selenium	510	39	na	0	0	na	10	10	2	6.1	APSB06B
Sodium	na	na	na	na	na	na	2	10	52	232	APSB08A
Vanadium	720	55	108	0	0	0	10	10	10.8	32.7	APSB07B
Zinc	31000	2300	202	0	0	1	10	10	25.9	1060	APSB08A

Explosives. Explosives were not detected in any site soil samples.

Herbicides. Herbicides were not detected in any site soil samples.

TAL Inorganics. Twenty-one TAL metals were detected in site soil samples. However, none of the detected metals were above both their background levels as well as their residential or industrial SLs. Three metals (copper, lead, and zinc) were detected above their background levels only.

4.1.2 Sediment Analytical Results

One sediment sample (APSD01) was collected from the outfall area of a drainage pipe in Area P directed towards the New River, and analyzed for TAL metals, TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, and dioxins/furans. Detected results are presented in **Table 4-3**.

VOCs. VOCs were not detected in the Area P sediment sample.

PAHs. Seven PAHs [benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene] were detected in the sediment sample. However, benzo(a)pyrene was the only PAH detected above its r-SL in the sediment sample. None of the detected PAHs were above i-SLs.

SVOCs. Non-PAH SVOCs were not detected in the Area P sediment sample.

Pesticides. Pesticides were not detected in the Area P sediment sample.

PCBs. Two PCBs (PCB-1254 and PCB-1260) were detected in the Area P sediment sample. However, only PCB-1254 was detected at a concentration above its r-SL, but well below i-SLs.

Explosives. Explosives were not detected in the Area P sediment sample.

Herbicides. One herbicide (dicamba) was detected in the Area P sediment sample, but at a value well below its SLs.

Metals. Twenty-one metals were detected in the Area P sediment sample. However, only lead and zinc were found above their background levels.

Dioxins/Furans. Twenty-five dioxin/furan congeners and totals were detected in the sediment sample. However, none were detected above any of their SLs.

4.1.3 Groundwater Analytical Results

Four groundwater samples (APGW02, APGW03, APGW04, and APGW05) were collected at Area P through direct-push sampling for chemical analysis (see **Table 3-1**). Detected groundwater results are presented in **Table 4-4** and summarized in **Table 4-5**.

VOCs. Two VOCs (chloroform and PCE) were detected in Area P groundwater samples. These VOCs were detected above their tw-SLs, but below MCLs at all four sample locations.

PAHs. PAHs were not detected in the Area P groundwater samples.

SVOCs. Non-PAH SVOCs were not detected in the Area P groundwater samples.

Pesticides. Pesticides were not detected in the Area P groundwater samples.

PCBs. PCBs were not detected in the Area P groundwater samples.

Table 4-3
Analytes Detected in Area P Sediment Samples - 2007 RFI
Page 1 of 2

Analyte			Sample ID	**APSD01**				
			Sample Date	**7/19/07**				
			Sample Depth	**0-0.5**				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)		None detected						
PAHs (ug/kg)								
Benz(a)anthracene	2100	150	na	16.2	J	J	*15*	*60*
Benzo(a)pyrene	210	15	na	18	J	J	*15*	*60*
Benzo(b)fluoranthene	2100	150	na	24.7	J	J	*15*	*60*
Benzo(g,h,i)perylene	1700000	170000	na	15.1	J	J	*15*	*60*
Benzo(k)fluoranthene	21000	1500	na	15.2	J	J	*15*	*60*
Chrysene	210000	15000	na	21.1	J	J	*15*	*60*
Indeno(1,2,3-cd)pyrene	2100	150	na	15.1	J	J	*15*	*60*
SVOCs (ug/kg)		None detected						
Pesticides (ug/kg)		None detected						
PCBs (mg/kg)								
PCB-1254	0.74	0.022	na	0.042	J	J	*9.4*	*19*
PCB-1260	0.74	0.22	na	0.0418	J	J	*9.4*	*19*
Explosives (mg/kg)		None detected						
Herbicides (ug/kg)								
Dicamba	1800000	180000	na	14.5		K	*5.8*	*7.7*
Metals (mg/kg)								
Aluminum	99000	7700	40041	8300			*1.2*	*11*
Antimony	41	3.1	na	0.88	J	B	*0.29*	*3.3*
Arsenic	1.6	0.39	15.8	1.5			*0.22*	*0.44*
Barium	19000	1500	209	132			*0.28*	*11*
Beryllium	200	16	1.02	0.84			*0.055*	*0.28*
Cadmium	81	7	0.69	0.064	J	J	*0.055*	*0.22*
Calcium	na	na	na	1260			*3.2*	*280*
Chromium	1400	280	65.3	13.4			*0.05*	*0.55*
Cobalt	30	2.3	72.3	10.1			*0.055*	*2.8*
Copper	4100	310	53.5	9.8			*0.05*	*1.4*
Iron	72000	5500	50962	19500			*0.66*	*5.5*
Lead	800	400	26.8	**125**			*0.11*	*5.5*
Magnesium	na	na	na	1810			*0.41*	*280*
Manganese	2300	180	2543	1470			*0.33*	*8.3*
Mercury	2.8	0.67	0.13	0.038	J	B	*0.007*	*0.093*
Nickel	2000	160	62.8	9			*0.055*	*2.2*
Potassium	na	na	na	1060			*5.5*	*550*
Selenium	510	39	na	6.4		K	*0.11*	*5.5*
Sodium	na	na	na	111	J	B	*46*	*550*
Vanadium	720	55	108	19.1			*0.033*	*2.8*
Zinc	31000	2300	202	**504**			*0.72*	*11*

Table 4-3
Analytes Detected in Area P Sediment Samples - 2007 RFI
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Analyte			Sample ID	**APSD01**				
			Sample Date	**7/19/07**				
			Sample Depth	**0-0.5**				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL
Dioxins/Furans (ng/kg)								
2,3,7,8-TCDF	130	37	na	0.509	A	B		
2,3,7,8-TCDD	18	4.5	na	0.191	A, EMPC	J	*0.168*	*0.168*
1,2,3,7,8-PECDD	na	na	na	0.875	A	J		
1,2,3,4,7,8-HXCDD	460	100	na	1.53	A	J		
1,2,3,6,7,8-HXCDD	460	100	na	4.08	A	J		
1,2,3,7,8,9-HXCDD	460	100	na	4.19	A	J		
1,2,3,4,6,7,8-HPCDD	na	na	na	178				
OCDD	61000	15000	na	2180				
1,2,3,7,8-PECDF	440	120	na	0.238	A	J		
2,3,4,7,8-PECDF	44	12	na	0.0965	A, EMPC	J	*0.561*	*0.561*
1,2,3,4,7,8-HXCDF	na	na	na	0.938	A	B		
1,2,3,6,7,8-HXCDF	na	na	na	0.763	A	J		
2,3,4,6,7,8-HXCDF	na	na	na	0.965	A	J		
1,2,3,7,8,9-HXCDF	na	na	na	0.561	U		*0.561*	*0.561*
1,2,3,4,6,7,8-HPCDF	na	na	na	37.6				
1,2,3,4,7,8,9-HPCDF	na	na	na	1.14	A	J		
OCDF	44000	12000	na	115				
TOTAL TCDD	na	na	na	1.3	U		*0.168*	*0.168*
TOTAL PECDD	18	4.5	na	3.27	A, EMPC	J		
TOTAL HXCDD	180	45	na	27.3				
TOTAL HPCDD	1800	450	na	304				
TOTAL TCDF	na	na	na	3.48	A, EMPC	J		
TOTAL PECDF	na	na	na	5.8	A, EMPC	J		
TOTAL HXCDF	130	37	na	23.4	A, EMPC	J		
TOTAL HPCDF	1300	370	na	95.9	A, EMPC	J		

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-3
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.

The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene.

Inorganic results below background UTLs are not indicated as exceedances on the table.

SL = Screening Level (Source: ORNL Regional Screening Table, September 2008).

SL values in table are for the more conservative chromium VI.

SL values for chromium III are 150,000 (ind) and 12,000 (res), which were not exceeded.

Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 1999b).

mg/kg = milligrams per kilogram (parts per million).

ng/kg = nanograms per kilogram (parts per trillion).

µg/kg = micrograms per kilogram (parts per billion).

NA = not applicable.

NT = analyte not tested.

Lab Q = Lab Data Qualifiers

* = Laboratory duplicate not within control limits.

B = (organics) Blank contamination. Value detected in sample and associated blank.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = Validation Data Qualifiers

B = blank contamination. Value detected in sample and associated blank.

J = estimated concentration.

K = estimated concentration bias high.

L = estimated concentration bias low.

N = presumptive evidence for tentatively identified compounds using a library search.

U = analyte not detected.

UJ = estimated concentration non-detect.

UL = estimated concentration non-detect bias low.

Table 4-4
Analytes Detected in Area P Groundwater Samples - 2007 RFI
Page 1 of 2

Analyte	Sample ID		APGW02					APGW03					APGW04					APGW05				
	Sample Date		7/31/07					7/31/07					7/31/07					7/31/07				
	MCL	**tw-SL**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																						
Chloroform	80	0.19	0.71	J	J	*0.21*	*1*	1.5			*0.21*	*1*	1.9			*0.21*	*1*	1.2			*0.21*	*1*
Tetrachloroethene	5	0.11	2			*0.25*	*1*	1.4			*0.25*	*1*	1.3			*0.25*	*1*	2.1		J	*0.25*	*1*
PAHs (ug/L)			None detected																			
SVOCs (ug/L)			None detected																			
Pesticides (ug/L)			None detected																			
PCBs (ug/L)			None detected																			
Explosives (ug/L)			None detected																			
Herbicides (ug/L)			None detected																			
Metals, Total (ug/L)																						
Aluminum	50	3700	39800			*79*	*200*	93100			*79*	*200*	28100			*79*	*200*	45300		J	*79*	*200*
Barium	2000	730	404			*5*	*200*	1150			*5*	*200*	449			*5*	*200*	654		J	*5*	*200*
Beryllium	4	7.3	4.7	J	B	*2*	*8*	12.4		B	*2*	*8*	5.2	J	B	*2*	*8*	6.5	J	B	*2*	*8*
Calcium	na	na	59300			*100*	*1000*	56300			*100*	*1000*	45900			*100*	*1000*	54700			*100*	*1000*
Chromium	100	11	72.4		K	*0.92*	*10*	234		K	*0.92*	*10*	115		K	*0.92*	*10*	91.9		K	*0.92*	*10*
Cobalt	na	1.1	29	J	J	*1*	*50*	62.7			*1*	*50*	20.5	J	J	*1*	*50*	30.8	J	J	*1*	*50*
Copper	1300	150	33.8			*1.2*	*25*	124			*1.2*	*25*	28.2			*1.2*	*25*	28.4		J	*1.2*	*25*
Iron	300	2600	54300			*15*	*300*	129000			*15*	*300*	37200			*15*	*300*	47500		J	*15*	*300*
Lead	15	na	24.8			*2.1*	*5*	558			*2.1*	*5*	21.3			*2.1*	*5*	48.7		J	*2.1*	*5*
Magnesium	na	na	33200			*100*	*5000*	38600			*100*	*5000*	21300			*100*	*5000*	25600		J	*100*	*5000*
Manganese	50	88	1320			*1*	*15*	2600			*1*	*15*	545			*1*	*15*	1170			*1*	*15*
Mercury	2	0.063	0.11	U		*0.11*	*1*	0.21	J	J	*0.11*	*1*	0.11	U		*0.11*	*1*	0.18	J	J	*0.11*	*1*
Nickel	na	73	49.3			*1*	*40*	143			*1*	*40*	40.4			*1*	*40*	60.2		J	*1*	*40*
Potassium	na	na	7320	J	J	*100*	*10000*	11900			*100*	*10000*	4520	J	J	*100*	*10000*	5760	J	J	*100*	*10000*
Selenium	50	18	4.6	J	J	*4*	*10*	7.1	J	J	*4*	*10*	4.2	J	J	*4*	*10*	4	U		*4*	*10*
Silver	100	18	0.96	J	J	*0.77*	*10*	0.93	J	J	*0.77*	*10*	0.88	J	J	*0.77*	*10*	1.3	J	J	*0.77*	*10*
Sodium	na	na	7480	J	K	*500*	*10000*	8770	J	K	*500*	*10000*	6930	J	K	*500*	*10000*	7200	J	K	*500*	*10000*
Vanadium	na	26	98.6			*1.1*	*50*	163			*1.1*	*50*	48.4	J	J	*1.1*	*50*	71.6		J	*1.1*	*50*
Zinc	5000	1100	166			*5*	*20*	873			*5*	*20*	176			*5*	*20*	254		J	*5*	*20*

Table 4-4
Analytes Detected in Area P Groundwater Samples - 2007 RFI
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Analyte	Sample ID	Sample Date	APGW02					APGW03					APGW04					APGW05				
			7/31/07					7/31/07					7/31/07					7/31/07				
	MCL	tw-SL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Metals, Dissolved (ug/L)																						
Aluminum	50	3700	6160			79	200	79	U	UL	79	200	2870			79	200	2180			79	200
Antimony	6	1.5	3.3	U	UJ	3.3	6	3.3	U	UJ	3.3	6	3.3	U	UJ	3.3	6	3.3	U	UJ	3.3	6
Arsenic	10	0.045	3.7	U		3.7	10	3.7	U		3.7	10	3.7	U		3.7	10	3.7	U		3.7	10
Barium	2000	730	97.1	J	J	5	200	55.2	J	J	5	200	90.7	J	J	5	200	81.9	J	J	5	200
Beryllium	4	7.3	1	U		1	4	1	U		1	4	1	U		1	4	1	U		1	4
Cadmium	5	1.8	1	U		1	5	1	U		1	5	1	U		1	5	1	U		1	5
Calcium	na	na	37500		J	100	1000	40100		J	100	1000	41100		J	100	1000	44100		J	100	1000
Chromium	100	11	10.9			0.92	10	2.6	J	J	0.92	10	11			0.92	10	6.8	J	J	0.92	10
Cobalt	na	1.1	4.6	J	J	1	50	1	U		1	50	1.8	J	J	1	50	1.1	J	J	1	50
Copper	1300	150	3.8	J	J	1.2	25	1.2	U		1.2	25	1.2	U		1.2	25	1.2	U		1.2	25
Iron	300	2600	8270			15	300	15	U		15	300	2830			15	300	1450			15	300
Lead	15	na	4.4	J	J	2.1	5	2.1	U		2.1	5	2.1	U		2.1	5	2.1	U		2.1	5
Magnesium	na	na	15800			100	5000	15000			100	5000	16100			100	5000	15200			100	5000
Manganese	50	88	197			1	15	107			1	15	51.9			1	15	27			1	15
Mercury	2	0.063	0.11	U		0.11	1	0.11	U		0.11	1	0.11	U		0.11	1	0.11	U		0.11	1
Nickel	na	73	6.7	J	J	1	40	1	U		1	40	4.1	J	J	1	40	2.7	J	J	1	40
Potassium	na	na	3260	J	J	100	10000	2440	J	J	100	10000	2720	J	J	100	10000	2550	J	J	100	10000
Selenium	50	18	4	U		4	10	4	U		4	10	4	U		4	10	4	U		4	10
Silver	100	18	0.77	U		0.77	10	0.77	U		0.77	10	0.77	U		0.77	10	0.77	U		0.77	10
Sodium	na	na	6770	J	J	500	10000	6760	J	J	500	10000	7140	J	J	500	10000	6700	J	J	500	10000
Thallium	2	0.24	6.5	U		6.5	10	6.5	U		6.5	10	6.5	U		6.5	10	6.5	U		6.5	10
Vanadium	na	26	14.7	J	J	1.1	50	1.1	U		1.1	50	5	J	J	1.1	50	3.5	J	J	1.1	50
Zinc	5000	1100	21			5	20	5	U		5	20	12.2	J	J	5	20	6.7	J	J	5	20
Misc. (ug/L)																						
Perchlorate	na	2.6	0.327			0.112	0.2	0.346			0.112	0.2	0.362			0.112	0.2	0.408			0.112	0.2

**Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-4
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.

The pyrene tw-SLs were used for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene.

The 2-methylnaphthalene tw-SL was used for 1-methylnaphthalene.

Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.

MCL Action Levels were used for copper and lead.

MCL = Maximum Contaminant Level (Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA, August 2006).

tw-SL = Tap Water Screening Level (Source: ORNL Regional Screening Table, September 2008).

tw-SL value in table is for the more conservative chromium VI.

tw-SL value for chromium III is 5,500, which was not exceeded.

ng/L = nanograms per liter (parts per trillion).

µg/L = micrograms per liter (parts per billion).

NA = not applicable.

NT = analyte not tested.

Lab Q = Lab Data Qualifiers

B = (organics) Blank contamination. Value detected in sample and associated blank.

A (Dioxins) = B = (metals) Value <MRL and >MDL and is considered estimated.

E (metals) = Reported value is estimated because of the presence of interferences.

EMPC (Dioxins) = The ion-abundance ratio between the two characteristic PCDD/PCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).

J = (organics) Value <MRL and >MDL and is considered estimated.

U = Analyte not-detected at the method reporting limit.

X = (dioxins) Ion abundance ratio outside acceptable range. Value reported is EMPC.

Val Q = Validation Data Qualifiers

B = blank contamination. Value detected in sample and associated blank.

J = estimated concentration.

K = estimated concentration bias high.

L = estimated concentration bias low.

N = presumptive evidence for tentatively identified compounds using a library search.

U = analyte not detected.

UJ = estimated concentration non-detect.

UL = estimated concentration non-detect bias low.

Table 4-5
Summary of Analytes Detected in Area P Groundwater Samples - 2007 RFI
Page 1 of 2

Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/L)									
Chloroform	80	0.19	0	4	4	4	0.71	1.9	APGW04
Tetrachloroethene	5	0.11	0	4	4	4	1.3	2.1	APGW05
PAHs (ug/L)		None detected							
SVOCs (ug/L)		None detected							
Pesticides (ug/L)		None detected							
PCBs (ug/L)		None detected							
Explosives (ug/L)		None detected							
Herbicides (ug/L)		None detected							
Metals, Total (ug/L)									
Aluminum	50	3700	4	4	4	4	28100	93100	APGW03
Barium	2000	730	0	1	4	4	404	1150	APGW03
Beryllium	4	7.3	4	1	4	4	4.7	12.4	APGW03
Calcium	na	na	na	na	4	4	45900	59300	APGW02
Chromium	100	11	2	4	4	4	72.4	234	APGW03
Cobalt	na	1.1	na	4	4	4	20.5	62.7	APGW03
Copper	1300	150	0	0	4	4	28.2	124	APGW03
Iron	300	2600	4	4	4	4	37200	129000	APGW03
Lead	15	na	4	na	4	4	21.3	558	APGW03
Magnesium	na	na	na	na	4	4	21300	38600	APGW03
Manganese	50	88	4	4	4	4	545	2600	APGW03
Mercury	2	0.063	0	2	2	4	0.18	0.21	APGW03
Nickel	na	73	na	1	4	4	40.4	143	APGW03
Potassium	na	na	na	na	4	4	4520	11900	APGW03
Selenium	50	18	0	0	3	4	4.2	7.1	APGW03
Silver	100	18	0	0	4	4	0.88	1.3	APGW05
Sodium	na	na	na	na	4	4	6930	8770	APGW03
Vanadium	na	26	na	4	4	4	48.4	163	APGW03
Zinc	5000	1100	0	0	4	4	166	873	APGW03

Table 4-5
Summary of Analytes Detected in Area P Groundwater Samples - 2007 RFI
Page 2 of 2

Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Metals, Dissolved (ug/L)									
Aluminum	50	3700	3	1	3	4	2180	6160	APGW02
Barium	2000	730	0	0	4	4	55.2	97.1	APGW02
Calcium	na	na	na	na	4	4	37500	44100	APGW05
Chromium	100	11	0	1	4	4	2.6	11	APGW04
Cobalt	na	1.1	na	3	3	4	1.1	4.6	APGW02
Copper	1300	150	0	0	1	4	3.8	3.8	APGW02
Iron	300	2600	3	2	3	4	1450	8270	APGW02
Lead	15	na	0	na	1	4	4.4	4.4	APGW02
Magnesium	na	na	na	na	4	4	15000	16100	APGW04
Manganese	50	88	3	2	4	4	27	197	APGW02
Nickel	na	73	na	0	3	4	2.7	6.7	APGW02
Potassium	na	na	na	na	4	4	2440	3260	APGW02
Sodium	na	na	na	na	4	4	6700	7140	APGW04
Vanadium	na	26	na	0	3	4	3.5	14.7	APGW02
Zinc	5000	1100	0	0	3	4	6.7	21	APGW02
Misc. (ug/L)									
Perchlorate	na	2.6	na	0	4	4	0.327	0.408	APGW05

Explosives. Explosives were not detected in the Area P groundwater samples.

Herbicides. Herbicides were not detected in the Area P groundwater samples.

Metals. Nineteen metals were detected in the Area P groundwater samples. Results from total metals analyses indicated that ten of these metals (aluminum, barium, beryllium, chromium, cobalt, iron, manganese, mercury, nickel, and vanadium) were detected at concentrations greater than their tw-SLs. Six metals (aluminum, beryllium, chromium, iron, lead, and manganese) exceeded their MCL. From the dissolved samples, only five metals (aluminum, chromium, cobalt, iron, and manganese) were detected above their tw-SLs and three metals (aluminum, iron, and manganese) were detected above their MCLs.

Misc. Perchlorate was detected in all four groundwater samples, but not at concentrations above its SLs.

4.1.4 Soil Screening Level Comparison

4.1.4.1 Area P Soil Screening Results

As shown in **Table 4-6**, detected soil results from all Area P soil samples were compared to the current (September 2008) Oak Ridge National Laboratory (ORNL) Regional soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2008a). As indicated in the table, one VOC (PCE) and one PCB (PCB-1254) were found above their soil screening levels (SSLs).

While concentrations above SSLs indicate a theoretical potential for impact to groundwater, empirical evidence in the form of actual groundwater chemical data, soil boring characterization and chemical analyses, soil characteristics/chemistry, and fate and transport analysis offer more concrete evidence of site conditions and potential impact to groundwater.

As discussed in *Section 4.1.3*, groundwater samples were collected from four direct-push samples during the 2007 Investigation and analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, explosives, herbicides, TAL metals, and perchlorate. Groundwater results indicated that two VOCs (chloroform and PCE) and eleven metals (aluminum, barium, beryllium, chromium, cobalt, iron, lead, manganese, mercury, nickel, and vanadium) were present above groundwater SLs.

Based on SSL and groundwater screening results, the only analyte found above both SSLs and groundwater screening criteria at Area P was PCE. PCE was only detected above its SSL in one surface soil sample out of ten soil samples at the site, indicating that PCE is not migrating downward through the soil to groundwater. Although PCB-1254 was found above its SSLs in soil, it was not detected in any Area P groundwater samples.

4.2 Nature and Extent Summary and Conclusions

4.2.1 Area P Soil

The soil at Area P was investigated during the 1992 VI and then again in 2007 in support of an RFI. A summary of all analytes detected in soil during all investigations of Area P can be found in **Table 4-7**.

The Area P data set from all soil investigations indicates that one PCB and two metals were found above their screening limits in soil samples collected for this site. PCB-1254 was detected

Table 4-6
Overall SSL Transfer Exceedance Summary for Area P

Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)									
Tetrachloroethene	na	1.04	na	1	1	10	6.4	6.4	APSB08A
Trichloroethene	na	12.2	na	0	1	10	5.4	5.4	APSB07A
PAHs (ug/kg)		None detected							
SVOCs (ug/kg)		None detected							
Pesticides (ug/kg)		None detected							
PCBs (mg/kg)									
PCB-1254	na	0.102	na	1	2	10	0.0402	0.403	APSB06A
Explosives (mg/kg)		None detected							
Herbicides (ug/kg)		None detected							
Metals (mg/kg)									
Aluminum	40041	1100000	0	0	20	20	3620	18200	PSB3 (RVFS*81)
Antimony	na	13.2	na	0	11	20	0.46	10.5	PSB2 (RVFS*78)
Arsenic	15.8	0.026	0	0	20	20	0.618	4.3	PSB1 (RVFS*76)
Barium	209	6000	1	0	20	20	44.6	257	PSB4 (RVFS*82)
Beryllium	1.02	1160	0	0	15	20	0.37	0.97	APSB06A
Cadmium	0.69	28	0	0	2	20	0.18	0.39	APSB08A
Calcium	na	na	na	na	20	20	815	160000	PSB2 (RVFS*78)
Chromium	65.3	42	0	0	20	20	7.63	59.6	PSB1 (RVFS*76)
Cobalt	72.3	9.8	0	0	20	20	2.65	13.5	PSB1 (RVFS*77)
Copper	53.5	1020	5	0	20	20	3.1	347	PSB2 (RVFS*78)
Iron	50962	12800	0	0	20	20	6880	27500	PSB1 (RVFS*77)
Lead	26.8	na	8	na	17	20	2.7	150	PSB5 (RVFS*84)
Magnesium	na	na	na	na	20	20	1390	83000	PSB2 (RVFS*78)
Manganese	2543	1140	0	0	20	20	130	1240	PSB3 (RVFS*80)
Mercury	0.13	0.66	0	0	9	10	0.01	0.091	APSB08A
Nickel	62.8	960	0	0	20	20	5.7	33.4	PSB1 (RVFS*76)
Potassium	na	na	na	na	20	20	626	1920	PSB1 (RVFS*77)
Selenium	na	19	na	0	10	20	2	6.1	APSB06B
Silver	na	32	na	0	4	20	0.68	1.79	PSB2 (RVFS*78)
Sodium	na	na	na	na	12	20	52	281	PSB2 (RVFS*78)
Vanadium	108	5200	0	0	20	20	10.8	49.8	PSB1 (RVFS*77)
Zinc	202	13600	1	0	20	20	25.9	1060	APSB08A
Misc.									
pH	na	na	na	na	10	10	6.89	8.68	PSB2 (RVFS*78)

SSL = Soil Screening Level (USEPA, September 2008).

mg/kg = milligrams per kilogram (parts per million).

ng/kg = nanograms per kilogram (parts per trillion).

ug/kg = micrograms per kilogram (parts per billion).

NA = not applicable.

Table 4-7
Overall Soil Summary for Area P

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
Tetrachloroethene	2700	570	na	0	0	na	1	10	6.4	6.4	APSB08A
Trichloroethene	14000	2800	na	0	0	na	1	10	5.4	5.4	APSB07A
PAHs (ug/kg)		None detected									
SVOCs (ug/kg)		None detected									
Pesticides (ug/kg)		None detected									
PCBs (mg/kg)											
PCB-1254	0.74	0.022	na	0	2	na	2	10	0.0402	0.403	APSB06A
Explosives (mg/kg)		None detected									
Herbicides (ug/kg)		None detected									
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	0	0	20	20	3620	18200	PSB3 (RVFS*81)
Antimony	41	3.1	na	0	1	na	11	20	0.46	10.5	PSB2 (RVFS*78)
Arsenic	1.6	0.39	15.8	0	0	0	20	20	0.618	4.3	APSB08A
Barium	19000	1500	209	0	0	1	20	20	44.6	257	PSB4 (RVFS*82)
Beryllium	200	16	1.02	0	0	0	15	20	0.37	0.97	APSB06A
Cadmium	81	7	0.69	0	0	0	2	20	0.18	0.39	APSB08A
Calcium	na	na	na	na	na	na	20	20	815	160000	PSB2 (RVFS*78)
Chromium	1400	280	65.3	0	0	0	20	20	7.63	59.6	PSB1 (RVFS*76)
Cobalt	30	2.3	72.3	0	0	0	20	20	2.65	13.5	PSB1 (RVFS*77)
Copper	4100	310	53.5	0	1	5	20	20	3.1	347	PSB2 (RVFS*78)
Iron	72000	5500	50962	0	0	0	20	20	6880	27500	PSB1 (RVFS*77)
Lead	800	400	26.8	0	0	8	17	20	2.7	150	PSB5 (RVFS*84)
Magnesium	na	na	na	na	na	na	20	20	1390	83000	PSB2 (RVFS*78)
Manganese	2300	180	2543	0	0	0	20	20	130	1240	PSB3 (RVFS*80)
Mercury	2.8	0.67	0.13	0	0	0	9	10	0.01	0.091	APSB08A
Nickel	2000	160	62.8	0	0	0	20	20	5.7	33.4	PSB1 (RVFS*76)
Potassium	na	na	na	na	na	na	20	20	626	1920	PSB1 (RVFS*77)
Selenium	510	39	na	0	0	na	10	20	2	6.1	APSB06B
Silver	510	39	na	0	0	na	4	20	0.68	1.79	PSB2 (RVFS*78)
Sodium	na	na	na	na	na	na	12	20	52	281	PSB2 (RVFS*78)
Vanadium	720	55	108	0	0	0	20	20	10.8	49.8	PSB1 (RVFS*77)
Zinc	31000	2300	202	0	0	1	20	20	25.9	1060	APSB08A
Misc.											
pH	na	na	na	na	na	na	10	10	6.89	8.68	PSB2 (RVFS*78)

above its r-SL twice, in surface soil samples APSB06A and APSB08A. The two metals found above their r-SLs were antimony and copper, both in surface soil sample PSB2 (RVFS*78).

The only compound that was found to be greater than its soil r-SL and was also identified by the HHRA or SLERA as posing a significant risk to human health or the environment was PCB-1254 in surface soil. The only soil analyte that was above its SLs in soil and was also detected in 2007 groundwater samples was copper, which did not exceed groundwater SLs.

Based on the results from the soil investigations at Area P, there are no concerns in soil.

4.2.2 Area P Sediment

The sediment at Area P was only investigated, by means of one sample collected from accumulated sediment at the end of the drainage outfall, during the 2007 sampling event in support of the 2007 RFI. All analytes detected in sediment during that investigation of Area P can be found in **Table 4-3**.

Data from the sample indicates that one PAH and one PCB were found above their applicable screening limits. The PAH benzo(a)pyrene was detected above its r-SL in the sample. One PCB (PCB-1254) was detected above its r-SL in the sample as well.

Only PCB-1254 was also identified by the HHRA as posing a significant risk to human health in surface soil only. These analytes were not detected in any groundwater samples. Therefore, based on these results, accumulated sediment transported through surface water drainage across Area P is not a concern.

4.2.3 Area P Groundwater

Groundwater at Area P was investigated only during the 2007 investigation. Four direct-push groundwater samples (APGW02, APGW03, APGW04, and APGW05) were collected to determine whether site soil was impacting groundwater. A summary of all analytes detected in the 2007 investigation of Area P's groundwater can be found in **Table 4-5**, and all the individual results can be found in **Table 4-4**.

Area P groundwater results from the 2007 sampling event indicated that two VOCs and 11 total metals were detected above their screening limits. The two VOCs (chloroform and PCE) were found at concentrations above their tw-SLs, but below MCLs in all four samples. Only five total metals (aluminum, beryllium, chromium, iron, and manganese) were detected above both their tw-SLs and MCLs, five metals (barium, cobalt, mercury, nickel, and vanadium) were only detected above their tw-SLs, and lead was only detected above its MCL. However, beryllium was detected in all four samples, but with a "B" validation qualifier in all of them – indicating that this compound was also detected in associated laboratory blanks. Also, some metals detected above their tw-SLs (cobalt, mercury, nickel, and vanadium) do not have MCLs to compare to them. In addition, lead does not have a tw-SL to compare to the detected concentration.

It should be noted that the samples collected from Area P were collected from direct-push sample locations. These groundwater samples are collected without a sand-pack, which increases the amount of sediment in the sample. It is likely that the high concentration of metals in these samples is due to the sediment entrained in the sample.

In filtered groundwater samples, only five metals (aluminum, chromium, cobalt, iron, and manganese) were greater than their SLs in site samples. PAHs, SVOCs, pesticides, PCBs, explosives, and herbicides were not detected in 2007 site groundwater samples.

Although chloroform, PCE, aluminum, chromium, cobalt, iron, and manganese were found to be greater than SLs in groundwater, none of the compounds were detected above both their r-SLs and background levels in any of the 20 soil samples collected from the site. Therefore, it is evident that previous site activities did not negatively affect site soil or groundwater.

5.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of the fate and transport mechanisms for chemicals of potential concern (COPCs) at Area P. Physical and chemical properties of the impacted media and of the contaminant(s) affect the fate and persistence of contamination in the environment (Rosenblatt et al., 1975). A general discussion of the physical properties and mechanisms which may govern the fate of contaminants in the environment, and a discussion of contaminant transport is presented in **Appendix D**. A discussion of the physical and chemical properties affecting soil conditions at Area P is presented as *Section 5.1*.

Of the soil samples collected at Area P, only PCB-1254, antimony, and copper were detected above their r-SLs in site soil.

A generalized fate and transport discussion for those constituents identified as risk drivers in the HHRA are presented in *Section 5.2*.

5.1 Soil Properties Affecting Fate and Transport

Chemical and physical properties of soil influence the fate and transport of constituents through the environment. Grain size distribution, pH, and total organic carbon (TOC) are commonly used to assess these chemical and physical characteristics of the soil. A summary of each follows.

Grain Size Distribution. The grain size distribution measures the amount of clay, silt, sand, and gravel in a sample based on the diameter of the material. Soil particles less than 0.002 millimeters are classified as clay and have a very large specific surface area, allowing them a significant capacity to adsorb water and other substances. Clay composition greatly influences soil fertility and the physical conditions of the soil. Clay directly affects the permeability and the plasticity of soil by generally lowering the soil’s permeability and increasing the plasticity. Because pores between clay particles are very small and convoluted, movement of both water and air is very slow. Fate and transport of chemical compounds are hindered when passing through a soil with a high composition of clay due to clay’s ability to adsorb cations and to retain soil moisture. Not much is known about the details of the soil composition at Area P due to the lack of soil and well boring logs. What is known is that the surface of Area P is a gravel pad. Underlying the gravel, the U.S. Department of Agriculture has identified the soils as the Unison-Urban Land Complex. These soils have been highly reworked through activities at RFAAP. A typical profile of Unison-Urban Land Complex has a surface layer of brown loam about 15 inches thick with yellowish-red sticky, plastic clay about 43 inches deep. The substratum is red, sandy clay loam below a depth of 58 inches. The Unison-Urban Land Complex typically has a slope modifier of 2 to 7 percent. Therefore, the site soil beneath Area P has a high percentage of clay and is a low permeability zone where it is more difficult for constituents to pass through the soil.

There have been no subsurface soil samples collected beneath 6 ft bgs at Area P. It is located on a river terrace deposit and is expected to consist of a mixture of sand, silt and clay with occasional gravel “riverjack” stringers where former channels existed.

The grain size distribution is also used to assess the permeability of soil. Well-sorted sands and gravels have a smaller distribution of grain size and a higher permeability. Poorly sorted, clayey sands and gravels have a large range in grain size and lower permeability because the smaller clay and silt particles fill in the void spaces between the sand and gravel. The soils at Area P appear to be fairly poorly-sorted and therefore aid in a slightly lower permeability rate.

Soil pH. Soil pH is a measure of acidity or alkalinity and is an important chemical property because it is an indication of soil reaction potential. Soil reaction influences the fate of many pollutants, affecting their breakdown and potential movement. For example, hydrolysis is the reaction of a compound with water. It usually involves the introduction of a hydroxyl (-OH) group into an organic compound, usually at a point of unbalanced charge distribution. The hydrolysis reaction can displace halogens and may be catalyzed by the presence of acids, bases, or metal ions. Therefore, the rate of hydrolysis is pH and metal-ion concentration dependent. The transport of some contaminants is also affected by pH. This is less significant for neutral and slightly polarized organic compounds, which are somewhat affected by pH, but is significant for chemicals that tend to ionize (Lyman et al., 1990). When the pH of the groundwater is approximately 1.0 to 1.5 units above the negative log of the acid dissociation constant (pK_a), adsorption becomes significant, retarding transport rates. pH also affects the rate of biodegradation that may occur at a site. Most bacteria find the optimum pH range to be 6.5 to 7.5 and are not able to survive at pH values greater than 9.5 or below 4.0 (Knox et al., 1993).

Soil at RFAAP generally ranges in pH from slightly less than 4.0 to slightly more than 9.61. A review of pH results during the *Facility-Wide Background Study Report* (IT, 2001) across soil types at the MMA did not yield outstanding trends. Higher soil pH results were generally associated with limestone and shale parent material (IT, 2001).

pH soil measurements were taken from Area P March 1992 soil samples. Those measurements had an average pH of 7.57. This pH indicates that the site soil has the optimum pH for bacteria to thrive and degradation to occur.

TOC. Organic matter content is expressed as a percentage, by weight, of the soil material that is a composition of plant and animal residues in the soil at various stages of decomposition. Available water capacity and infiltration rate are affected by organic matter content. Sorption and desorption are two major mechanisms affecting the fate of contaminants in the subsurface. Sorption is the process by which a compound is retained onto a solid particle rather than remaining dissolved in solution. The sorption of contaminants to the soil matrix is an important factor affecting their transport in terrestrial environments. Hydrophobic contaminants will accumulate at an interface or partition into a nonpolar phase (e.g., associate with the organic content of the subsurface medium) rather than partition into the water phase. For nonionic organic chemicals and aquifer materials, sorption is largely controlled by the clay and organic carbon content of the soil. In addition, this means that the amount of TOC present in the soil matrix has a large affect on the fate of both organic and inorganic compounds. The degree to which TOC affects the fate of a chemical varies dependent on the properties of the chemical itself. Soil TOC concentrations at RFAAP range from 0.075 to 30.4 percent, with a median value of 0.5 percent.

5.2 Fate and Transport of Analytes Detected Above Screening Levels

As discussed in *Section 4.0*, the analytes that were detected above SLs in Area P soil samples between 1992 and 2007 were two metals (antimony and copper) in 1992 and one PCB (PCB-1254) in 2007. The analyte detected above SLs that was also identified as a soil risk driver in the HHRA for Area P was PCB-1254.

The analytes detected above SLs in Area P groundwater from the 2007 sampling event indicated that two VOCs and 19 metals were detected above their screening limits. The two VOCs (chloroform and PCE) were found at concentrations above their tw-SLs in all four samples. Five of the 19 metals (aluminum, beryllium, chromium, iron, and manganese) were detected above both their tw-SLs and MCLs, five metals (barium, cobalt, mercury, nickel, and vanadium) were only above their tw-SLs, and lead was only detected above its MCL. However, beryllium was detected and B-flagged, meaning it was also found in blind samples and is then not regarded as a true detection. The analytes detected above SLs that were also identified as groundwater risk drivers in the HHRA for Area P (*Section 6.0*) were PCE and chloroform.

Specific characteristics of these risk drivers are discussed in more detail in the following sections.

5.2.1 Volatile Organic Compounds

5.2.1.1 Chloroform

In the Area P groundwater samples, chloroform was detected above its tw-SL in all four samples collected. However, chloroform is not a battery-related constituent and its presence is unlikely associated with the site. Chloroform is found uniformly in groundwater at RFAAP due to its drinking water treatment processes.

Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste. It will burn only when it reaches very high temperatures. In the past, chloroform was used as an inhaled anesthetic during surgery, but it is not used that way today. Today, chloroform is used to make other chemicals and can also be formed in small amounts when chlorine is added to water. Other names for chloroform are trichloromethane and methyl trichloride.

Chloroform evaporates easily into the air. Most of the chloroform in air breaks down eventually, but it is a slow process. The breakdown products in air include phosgene and hydrogen chloride, which are both toxic. It does not stick to soil very well and can travel through soil to groundwater. Chloroform dissolves easily in water and some of it may break down to other chemicals. Chloroform lasts a long time in groundwater (ATSDR, 1997a).

5.2.1.2 PCE

PCE was detected above its tw-SL in all four Area P groundwater samples. PCE is a manufactured chemical used for dry cleaning and metal degreasing. Other names for PCE include perchloroethylene, tetrachloroethene, and tetrachloroethylene. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell PCE when it is present in the air at a level of 1 part PCE per million parts of air (1 ppm) or more, although some can smell it at even lower levels (ATSDR, 1997b).

5.2.2 PCBs

PCB-1254 was detected above its r-SL in two surface soil samples. It was also detected above its r-SL in one sediment sample. However, PCBs were not detected in site groundwater samples.

PCBs, which are also known by the trade name “Aroclor,” were produced by the partial chlorination of biphenyl in the presence of a catalyst. The production of PCBs in large quantities began in 1929. Prior to 1974, PCBs were used both for nominally closed applications (e.g., capacitor and transformers, and heat transfer and hydraulic fluids) and in open-end applications (e.g., flame retardants, inks, adhesives, microencapsulation of dyes for carbonless duplicating paper, paints, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings) (Durfee, 1976; IARC, 1978; Orris et al., 1986; Safe, 1984; Welsh, 1995). The manufacture of PCBs in the United States ceased in 1977 because of evidence that PCBs were toxic and accumulated in the environment.

PCBs are distinguished by a four-digit code in which the first two digits (e.g., 12) indicate the production process and the second two digits indicate the weight percent of chlorine (e.g., 48). Thus, Aroclor-1254 is a PCB with an average chlorine content of 54%. The water solubility for Aroclor-1254 is 4.1 x 10^{-2} mg/L. Therefore, this Aroclor is not soluble in water. The vapor pressure of Aroclor-1254 is 4.40 x 10^{-5} mm Hg. As a result of the low vapor pressure, this PCB will not volatilize to the atmosphere. This point is further supported by the Henry's Law Constant, which for this compound is 2.0 x 10^{-4} atm-m^3/mole. The log K_{oc} and log K_{ow} values for Aroclor-1254 is 6.33 and 6.94, respectively. The log K_{oc} values indicate that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff. The log K_{ow} values support this argument indicating that PCBs have a stronger affinity for nonpolar soil particles than a polar water phase.

PCBs are highly immobile. PCBs are very persistent in the environment and are extremely resistant to oxidation and hydrolysis. The properties that made PCBs applicable for industrial use are the same properties that cause it to be persistent in the environment: chemical stability; thermal stability; resistance to hydrolysis by water, alkalis, and acids; and low flammability. Based on the K_{oc} and K_{ow} values, Aroclor-1248 and Aroclor-1254 will tend to remain in soil once released into the environment.

6.0 HUMAN HEALTH RISK ASSESSMENT

This HHRA evaluates the probability and magnitude of potential adverse effects on human health associated with exposure to site-related chemicals in soil, surface water, sediment and groundwater. The HHRA was conducted for each of the sites consistent with guidance included in USEPA's *Interim Final Risk Assessment Guidance for Superfund (RAGS)* and other current USEPA/USEPA Region III resources and guidance documents as noted throughout this section and on the RAGS Part D tables provided in **Appendix E-1**. Additional information regarding the site background can be found in *Section 2.0*. This HHRA consists of the following six sections:

- **Section 6.1: Data Summary and Selection of COPCs:** Relevant site data are gathered, examined, and discussed. Basic constituent statistics and SLs are summarized. COPCs are identified by comparison to screening criteria as discussed in *Section 6.1.2*.
- **Section 6.2: Exposure Assessment:** Potentially exposed populations (e.g., receptors) and exposure routes are identified, and exposure point concentrations (EPCs) are calculated for COPCs. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each exposure route and intakes are calculated.
- **Section 6.3: Toxicity Assessment:** Toxicity criteria for COPCs are compiled and presented.
- **Section 6.4: Risk Characterization:** Quantitative risks and hazards are estimated and summarized by combining toxicity criteria with intakes for each exposure route.
- **Section 6.5: Uncertainties Analysis:** Uncertainties, "including uncertainties in the physical setting definition for the site, in the models used, in the exposure parameters, and in the toxicity assessment" (USEPA, 1989a) are discussed.
- **Section 6.6: Summary and Conclusions:** The results of the HHRAs are summarized.

The tabulated risk assessment results are presented in accordance with USEPA guidance described in *RAGS: Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)* (USEPA, 2001a). RAGS D requires the risk assessment results to be presented in a series of standardized tables, which are presented in **Appendix E-1**.

6.1 Data Summary and Selection of COPCs

6.1.1 Data Summary

Table 6-1 identifies the soil, sediment and groundwater samples used in the HHRA for Area P. The complete data tables for detected analytes for each media are provided in **Tables 4-1 through 4-5**. Additional information regarding the data used in the HHRAs is summarized below:

- Though several dioxins are known to be toxic, toxicity criteria are limited to 2,3,7,8-TCDD. Therefore, the HHRA uses the method outlined in Interim Procedures

Table 6-1
Area P
Sample Groupings

AREA P		
SURFACE SOIL[a]		
APSB06A	APSB10A	PSB4 (RVFS*82)
APSB07A	PSB1 (RVFS*76)	PSB5 (RVFS*84)
APSB08A	PSB2 (RVFS*78)	
APSB09A	PSB3 (RVFS*80)	
TOTAL SOIL[b]		
APSB06A	APSB09B	PSB3 (RVFS*80)
APSB06B	APSB10A	PSB3 (RVFS*81)
APSB07A	APSB10B	PSB4 (RVFS*82)
APSB07B	PSB1 (RVFS*76)	PSB4 (RVFS*83)
APSB08A	PSB1 (RVFS*77)	PSB5 (RVFS*84)
APSB08B	PSB2 (RVFS*105)	PSB5 (RVFS*85)
APSB09A	PSB2 (RVFS*78)	
SEDIMENT[a]		
APSD01		
GROUNDWATER		
APGW02	APGW04	APGW05
APGW03		

(a) Surface soil and sediment samples consist of samples collected at depths of 0 to 0.5 feet.
(b) Total soil sample group includes all surface soil and subsurface soil samples from 0 to 6 feet.

for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) (USEPA, 1989b, 1994b; Van den Berg et al., 2006) to assess risks due to exposure to dioxins and/or furans. Each congener is assigned a toxicity equivalence factor (TEF), which corresponds to its toxicity relative to 2,3,7,8-TCDD. Each congener detection is multiplied by its corresponding TEF; the adjusted concentrations are then summed to derive one total 2,3,7,8-TCDD equivalent concentration for each sample. This concentration is then compared with toxicity criteria for 2,3,7,8-TCDD to calculate risks. TEFs are presented and total 2,3,7,8-TCDD equivalents are calculated for sediment in **Appendix E-2**.

- If a constituent was measured by two methods, results from the more sensitive analytical method were used. For example, PAHs were analyzed as part of the SVOC method, as well as by a PAH-specific method. Results from the specific method were used.
- J-flagged data (estimated concentration) are considered detections and are used without modification.
- The qualification and validation of the analytical data included a comparison of the site data to corresponding blank (laboratory, equipment rinse, field, and trip) concentration data. If the detected concentration in a site sample was less than ten times (for common laboratory contaminants) or five times (for other compounds) the concentration in the corresponding blank sample, the sample was qualified with a “B.” According to USEPA Region III guidance (USEPA, 1995a, 2000b), it cannot be unequivocally stated that the result is not “non-detected” at that concentration. Therefore, B-qualified data are typically eliminated from the data set.
- Rejected results (R-flagged) are not used.
- Data from duplicate sample pairs are averaged and treated as one result. If an analyte is detected in one of the sample pair, one half the detection limit of the non-detect is averaged with the detected result and the result is considered detected.

Additional information regarding specific soil, sediment, surface water, and groundwater samples used in the HHRA is provided in *Sections 6.1.1.1 through 6.1.1.4*.

6.1.1.1 Surface Soil and Total Soil

The soil samples used for COPC screening of Area P were collected during sampling events in 1992 and 2007. As presented in **Table 6-1**, the soil samples for Area P have been divided into surface soil (0 to 0.5 ft bgs) and subsurface soil (4 to 6 ft bgs). The total soil data grouping was assembled by combining the surface and subsurface soil data sets to address mixing of potential soil contamination during construction or land development activities. A total of 10 surface soil samples and 10 subsurface soil samples were used in the HHRA for Area P.

6.1.1.2 Sediment

One sediment sample was collected during sampling events completed in 2007 and used for the COPC screening for Area P. This sample was collected at the end of a pipe that drains the site through the shoreline bank to the New River. This sample location is listed in **Table 6-1**.

6.1.1.3 Surface Water

No surface water samples were collected from Area P.

6.1.1.4 Groundwater

Groundwater samples collected during sampling events completed in 2007 were used for the COPC screening for Area P. A total of four samples were collected. These sample identifications are listed in **Table 6-1**. The direct push samples collected at this site were turbid due to the fine-grained clay and silt in the first water-bearing unit encountered, as well as the absence of a sandpack around the direct push sampler. Both unfiltered and filtered samples were collected and analyzed. In discussions with EPA and VDEQ (Shaw, 2010), EPA indicated that dissolved metals concentrations could be used in the HHRA if the samples were excessively turbid. Therefore, the filtered groundwater data were used to quantitatively evaluate metals in the risk/hazard calculations.

6.1.2 Identification of COPCs

COPCs were identified for the sites by comparing the maximum detected concentration (MDC) with the following risk-based SLs for each media: USEPA r-SLs (surface soil, total soil and sediment) and USEPA tw-SLs (surface water and groundwater) as presented in the September 2008 USEPA Regional Screening Tables (USEPA, 2008a). In accordance with USEPA regional guidance, SLs for non-carcinogenic chemicals were adjusted downward to a hazard quotient (HQ) of 0.1 to ensure that chemicals with additive effects were not prematurely eliminated during screening. Although current and future land uses at Area P are most likely to be industrial in nature, r-SLs (rather than industrial) were used for comparisons with soil concentrations. Because the residential scenario was evaluated for this HHRA, r-SLs were used to screen chemicals in soil as a conservative measure. In addition, lead action levels of 400 milligrams per kilogram (mg/kg) for residential receptors were used in the COPC identification since toxicity criteria were not available for lead (USEPA, 1994a).

Because there are no r-SLs for sediment, r-SLs for soil were used to select sediment COPCs. The r-SLs were adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects. To be consistent with the *RFAAP Final MWP*, Section 6.2.2, Selection of COPCs for the HHRA (URS, 2003), all r-SLs were then increased by one order of magnitude (e.g., multiplied by 10) to represent the types of exposures that are more likely to occur for sediment. Similarly, because tw-SLs are not available for surface water, tw-SLs were used to select surface water COPCs. The tw-SLs were adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects. All r-SLs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for surface water.

The maximum concentrations of the four essential human nutrients that do not have SLs (i.e., calcium, magnesium, potassium, and sodium) were compared with dietary Allowable Daily Intakes. The essential nutrients calcium, magnesium, potassium and sodium were eliminated as COPCs. Although iron is also an essential nutrient, there is an SL available for iron. If iron concentrations in soil or water resulted in an HQ of 1.0 or greater, a “margin of exposure” evaluation was also performed. Risks from exposure to iron were characterized by comparing estimated iron intake to the Recommended Daily Allowance (RDA) and concentrations known to cause effects in children (USEPA, 1996a).

For some COPCs without toxicity criteria, chemicals with similar structures and properties served as surrogates. The surrogates for this HHRA are based on proxy compounds as identified in VDEQ's Risk Assessment Guidance, Risk-Based Screening Levels Proxy Values (VDEQ, 2008). The rationale for these proxy compounds is, as follows:

- Pyrene was the surrogate for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. Although these compounds are more structurally similar to acenaphthene, the screening values for pyrene are more conservative.
- 1,4 dichlorobenzene was the surrogate for 1,3 dichlorobenzene because it is a similar compound.
- Endosulfan was the surrogate for endosulfan I, endosulfan II, and endosulfan sulfate because it is a similar compound.
- Chlordane was the surrogate for gamma-chlordane because it is a mixed isomer.

Analytes detected at a maximum concentration greater than the corresponding adjusted SL or screening values identified above for nutrients and lead were selected as COPCs. Analytes for which no screening criteria exist were also selected as COPCs. COPC screening tables for Area P are presented in **Appendix E-1**, **Tables E.1-2** (COPC Determination Detects-Surface Soil), **E.1-4** (COPC Determination Detects-Total Soil), **E.1-6** (COPC Determination Detects-Sediment), and **E.1-8a** (COPC Determination Detects-Unfiltered Groundwater) and **E.1-8b** (COPC Determination Detects-Filtered Groundwater). The COPCs selected for each medium are summarized in **Table 6-2**.

Similarly, the reporting limits for those constituents that were not detected were compared with SLs for each medium. Chemicals that were not detected in at least one medium have not been included in the HHRA. The reporting limits for the non-detected constituents were screened against the SLs to ensure that the range of reporting limits was generally low enough to detect constituents that would be greater than SLs. The maximum reporting limits for these constituents were compared with SLs. The results of these comparisons for Area P are shown in **Appendix E-1**, **Tables E.1-3** (Non-Detect Screening- Surface Soil), **E.1-5** (Non-Detect Screening-Total Soil), **E.1-7** (Non-Detect Screening-Sediment), and **E.1-9** (Non-Detect Screening-Groundwater). Detected constituents identified as COPCs were carried through the

Table 6-2
Summary of Chemicals of Potential Concern at Area P

Chemical (a)	Surface Soil	Total Soil	Sediment (b)	Groundwater
Organics				
Aroclor 1254	X	X		
Chloroform				X
Tetrachloroethene				X
Inorganics				
Aluminum	X	X		X
Antimony	X	X		
Arsenic	X	X		
Barium				X
Chromium				X
Cobalt	X	X		X
Copper	X	X		
Iron	X	X		X
Lead				X
Manganese	X	X		X
Nickel				X
Vanadium	X	X		X

(a) Chemicals detected in all media at Area P.

(b) A sediment sample was taken at Area P; however, none of the detected compounds were determined to be COPCs.

X = Selected as a COPC in this media.

quantitative risk assessment. The reporting limits for constituents that were not detected in surface soil, total soil, sediment, surface water, or groundwater are evaluated with respect to their screening criteria and discussed in the uncertainty section (*Section 6.5.2*).

6.2 Exposure Assessment

The objective of the exposure assessment is to estimate "the type and magnitude of exposures to chemicals of potential concern" (USEPA, 1989a). When combined with chemical-specific toxicity information (summarized in the toxicity assessment), these exposures produce estimations of potential risks.

6.2.1 Conceptual Site Model/Receptor Characterization

Refined CSMs for Area P are presented on **Figures 6-1 and 6-2** for current and future exposure scenarios, respectively.

Area P, the Spent Battery Storage Area, is a 50 ft by 200 ft long fenced gravel area located adjacent to the New River. This area is located in the center of a scrap metal yard that was formerly used for storage of shredded scrap metal, decommissioned tanks, powder cans, and batteries to off-shipment post.

The surface of the site is a gravel pad. The site is generally level, sloping toward the north to the river, which is 200 ft from the storage area. Although no hydrogeologic studies have been conducted, groundwater at Area P is expected to flow north and discharge to the New River. Surface water runoff is expected to flow with the topography toward the New River. There is an engineered drainage system at the north end of the site.

There are currently no routine activities occurring at Area P. To address occasional exposures due to grounds-keeping activities, such as mowing the grass or maintaining the storage area, it was conservatively assumed that maintenance workers are the most likely receptors at the site. The maintenance worker scenario was based on a worker who visits the site once per week for 50 weeks during the year. Due to Installation security, it is unlikely that trespassers could gain access to Area P; however, risks associated with the maintenance worker are considered protective of the limited exposure experienced by the trespasser.

If future development occurs, maintenance workers, industrial/commercial workers, and excavation workers could be exposed to surface soil, subsurface soil, and sediment as a result of disturbing soil during construction/excavation activities. For the construction worker, a construction period of 125 days/year or six months was assumed on the basis of five-day work weeks. Given the size of Area P (approximately 50 ft by 200 ft) and its location on the river bank, extensive construction would not be expected at the site. Therefore, maintenance worker, industrial worker, and excavation worker exposures at Area P were evaluated for surface soil, total soil, and sediment in the HHRA.

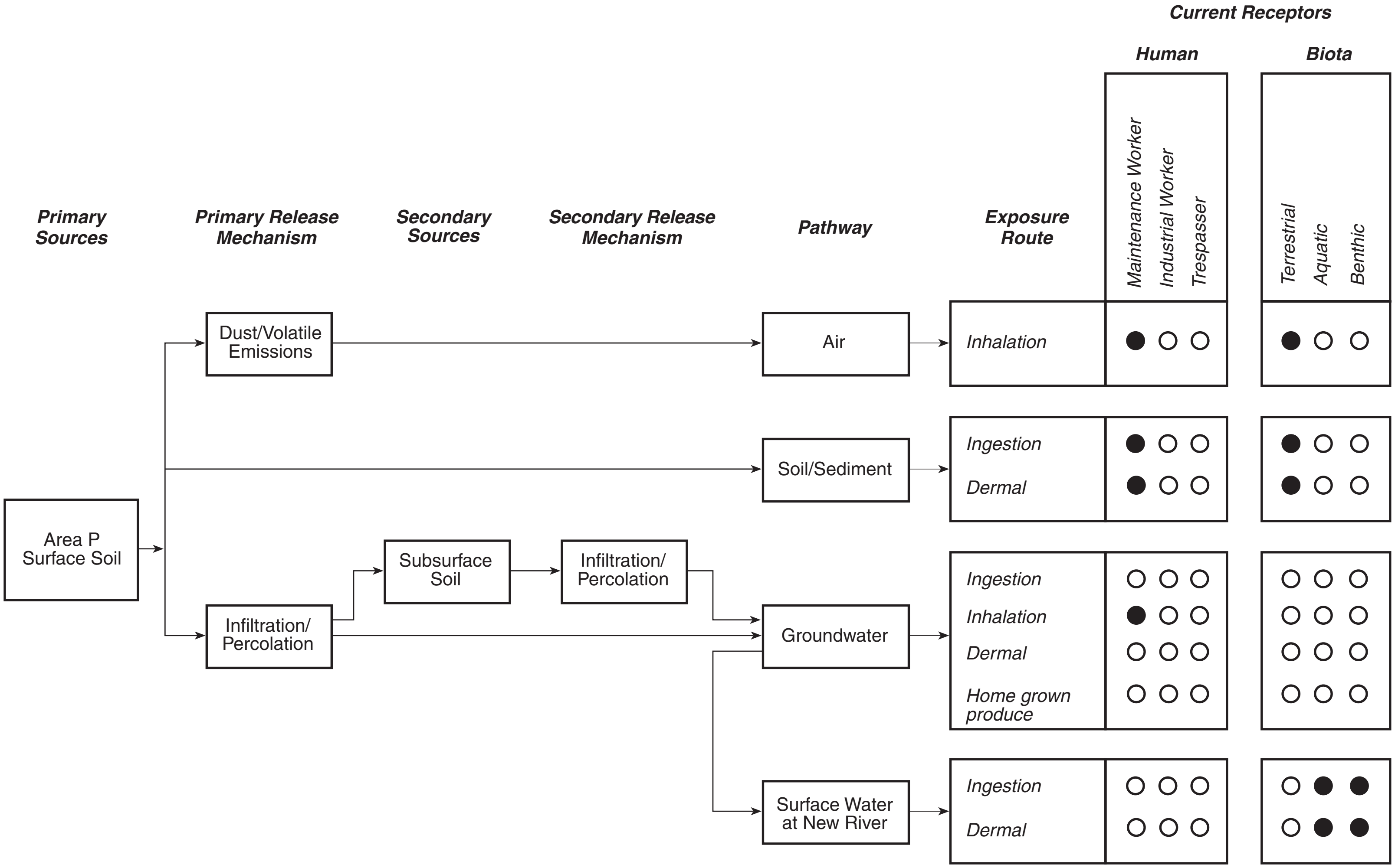
Although groundwater from Area P is not expected to be used for potable purposes, industrial workers were evaluated for hypothetical exposures to groundwater.

RFAAP is likely to remain a military installation; therefore, a residential scenario is considered unlikely. However, the residential scenario was evaluated for exposures to surface soil, total soil, sediment, and groundwater at Area P to assess clean closeout requirements under RCRA.

Because the site is adjacent to the New River and the groundwater flows in that direction, there is no place downgradient for a well. On-site and off-site groundwater usage would be identical, as well as the adult and child residential exposure scenarios. Therefore, downgradient residents were not evaluated separately. Because the groundwater at Area P flows toward the river and discharges to surface water, the recreational users of the New River represent the next most likely downgradient receptors. Therefore, adult and adolescent recreational users were evaluated for exposures to surface water at the river. Because the child receptors in this HHRA were assumed to be six years of age and younger, it was considered highly unlikely that children in this age group would be wading or swimming in the New River due to its depth and current.

6.2.2 Identification of Exposure Pathways

The potential receptors identified for the site include maintenance workers, industrial workers, excavation workers, child residents, adult residents, lifetime residents, and recreational users. **Appendix E-1, Table E.1-1** summarizes the selection of exposure pathways for each receptor listing the rationale for the inclusion or exclusion of each pathway at Area P.



Pathway	Exposure Route	Human			Biota		
		Maintenance Worker	Industrial Worker	Trespasser	Terrestrial	Aquatic	Benthic
Air	Inhalation	●	○	○	●	○	○
Soil/Sediment	Ingestion	●	○	○	●	○	○
	Dermal	●	○	○	●	○	○
Groundwater	Ingestion	○	○	○	○	○	○
	Inhalation	●	○	○	○	○	○
	Dermal	○	○	○	○	○	○
	Home grown produce	○	○	○	○	○	○
Surface Water at New River	Ingestion	○	○	○	○	●	●
	Dermal	○	○	○	○	●	●

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

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Figure 6-1. Current Land Use Conceptual Site Model for Area P Radford Army Ammunition Plant, Virginia

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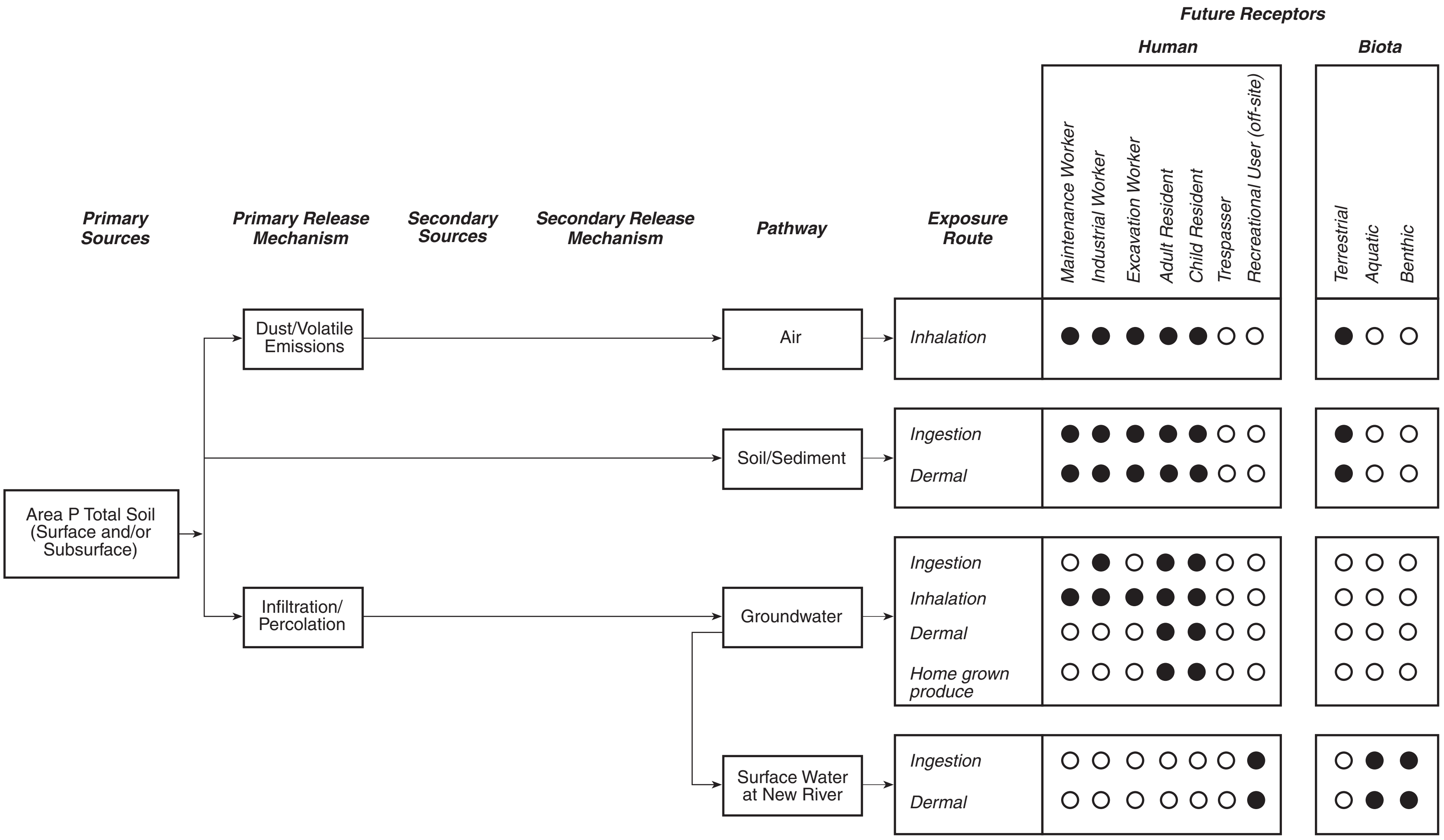

Pathway	Exposure Route	Maintenance Worker	Industrial Worker	Excavation Worker	Adult Resident	Child Resident	Trespasser	Recreational User (off-site)	Terrestrial	Aquatic	Benthic
Air	Inhalation	●	●	●	●	●	○	○	●	○	○
Soil/Sediment	Ingestion	●	●	●	●	●	○	○	●	○	○
	Dermal	●	●	●	●	●	○	○	●	○	○
Groundwater	Ingestion	○	●	○	●	●	○	○	○	○	○
	Inhalation	●	●	●	●	●	○	○	○	○	○
	Dermal	○	○	○	●	●	○	○	○	○	○
	Home grown produce	○	○	○	●	●	○	○	○	○	○
Surface Water at New River	Ingestion	○	○	○	○	○	○	●	○	●	●
	Dermal	○	○	○	○	○	○	●	○	●	●

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

Figure 6-2. Future Land Use Conceptual Site Model for Area P Radford Army Ammunition Plant, Virginia

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6.2.3 Calculation of EPCs

To calculate intakes, a 95% upper confidence limit of the mean concentration (95% UCL) for each COPC is used as a conservative estimate of the average concentration in a given environmental medium to which a receptor would be exposed. The 95% UCL estimate is referred to as the EPC. The 95% UCL is used rather than the mean concentration, to account for uncertainty when estimating EPCs from sample data (USEPA, 1989a). Methods used to calculate 95% UCLs are based on guidance provided in the documents *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA, 2002a) *and ProUCL Version 4.0 Technical Guide* (USEPA, 2007a).

In general, the method used to calculate a 95% UCL depends on: 1) the prevalence of non-detects, 2) the data distribution (e.g., normal, gamma, or lognormal), and 3) number of samples. Non-detects introduce uncertainty in the data set because the true concentration may be between zero to just below the detection limit. Therefore, distributional assumptions are difficult to ascertain for COPCs with a high rate of non-detects. EPA's (2007a) ProUCL 4.00.02 statistical program was used to evaluate estimate 95% UCL values for nearly all the soil COPC data sets. For data sets with non-detects, ProUCL uses the Kaplan-Meier estimation method to derive a recommended 95% UCL (USEPA, 2007a). Where ProUCL recommends the results of more than one statistical approach, the most conservative (highest) 95% UCL value was used in the HHRA. Where fewer than 5 percent of samples had detected values, ProUCL does not recommend a 95% UCL value. In these cases, 95% UCL values were derived using a bootstrap-t statistical program, described by Efron (1982) and discussed in USEPA (1997a). Non-detect values are represented in this bootstrap-t program as random numbers between zero and the detection limit that are generated by the iterative process written into the program. EPCs for soil (surface and total) COPCs are presented in **Appendix E-1, Tables E.1-10 and E.1-11**. As shown in **Table E.1-12,** there were no COPCs identified in the sediment at Area P. The output from ProUCL 4.0 is provided in **Appendix E-3**. EPCs were not calculated for groundwater or seep water; therefore, the MDC for COPCs identified for groundwater and seep water were used in the risk assessment. The EPC values for unfiltered and filtered groundwater are shown in **Appendix E-1, Tables E.1-13a** and **E.1-13b**, respectively. The EPCs for metals in unfiltered groundwater are presented for the purpose of comparison only. The EPCs for metals for filtered groundwater were carried through the quantitative HHRA.

Models were used to estimate concentrations of COPCs in air from soil, concentrations of COPCs in air from groundwater, and concentrations of COPCs in homegrown produce from groundwater, as appropriate. These models are discussed in *Section 6.2.4*.

6.2.4 Quantification of Exposure: Calculation of Daily Intakes

For each receptor and pathway, chronic daily intake (CDI, expressed as milligrams of COPC per kilogram body weight per day) for each COPC is estimated by combining the EPC with exposure parameters such as ingestion rate, frequency of contact, duration, and frequency of exposure. In addition, intake parameters are selected so the combination of intake variables results in an estimate of the reasonable maximum exposure for that pathway (USEPA, 1989a). Intake formulas, exposure parameters, and chemical-specific parameters for each of the receptors for Area P are provided in **Appendix E-1**, **Tables E.1-14 through E.1-25**.

The particulate emission factors (PEFs) used to calculate inhalation daily intakes associated with soil were calculated in accordance with the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002b), as provided in **Appendix E-1, Tables E.1-26 through E.1-28**.

For exposures to groundwater and surface water via dermal contact, the amount of chemical in water absorbed through the skin must be estimated in order to calculate the dose used in the intake formula. The dose absorbed per unit area per event (DA) is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Following USEPA (2004a) guidance, receptor-specific DA values were calculated for groundwater and surface water using USEPA's worksheet (2001b) and chemical-specific parameters described in **Appendix E-1, Tables E.1-29 through E.1-32**.

To evaluate potential inhalation of chloroform and PCE from groundwater at Area P, an EPC was calculated for each constituent in air using the models depicted in the following sections and provided in **Appendix E-1, Tables E.1-33 through E.1-37**. For this scenario, the volatilization model outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. In this case, chemical intake is a result of inhalation of outdoor vapors that originate from dissolved hydrocarbons in groundwater located somewhere below ground surface. The equations used to calculate the volatilization factor to ambient air for VOCs (chloroform and PCE) in Area P groundwater are presented in **Appendix E-1**, **Table E.1-33**.

The Johnson and Ettinger model (USEPA, 2004b) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the groundwater and into a structure. The worksheet for this model was used to estimate air concentrations of chloroform and PCE in office buildings and residences for this HHRA (USEPA, 2004c). The worksheets for chloroform and PCE at Area P are found in **Appendix E-4**. The results are given in **Appendix E-1, Table E.1-34**.

In the event that excavation work is performed at Area P, the worker may be exposed to volatile emissions from groundwater below the bottom of the trench. While USEPA does not have a standardized model for estimating concentrations of airborne VOCs in a trench or a pit, the VDEQ provides such a model on their Voluntary Remediation Program (VRP) web site (VDEQ, 2008). Two versions of the model have been developed on the basis of depth to groundwater at the site: depths less than or equal to 15 ft and depths greater than 15 ft. The equation and parameters are given in **Appendix E-1, Table E.1-35**.

The EPCs for VOCs in air due to volatilization from Area P groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987, 2003) shower room model. The model is described in **Appendix E-1, Table E.1-36**.

Groundwater-to-air EPCs for VOCs at Area P are summarized in **Appendix E-1, Table E.1-37**.

It is noted that the transfer of COPCs in groundwater to vegetables by watering a garden was initially considered as a potential exposure pathway (Appendix E-1, Table E.1-1); however, USEPA has determined that sufficient data for modeling this pathway only exist for arsenic, cadmium, mercury, nickel, selenium, and zinc (USEPA, 1996b). None of these metals were identified as COPCs in the groundwater associated with Area P. Therefore, this pathway was not quantitatively evaluated in this HHRA.

6.3 Toxicity Assessment

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (2008b). The health effects analysis considers chronic (long-term) exposures. Using the following hierarchy (USEPA, 2003a), the chronic toxicity criteria were obtained from:

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2008b).
- Tier 2 – Provisional Peer Reviewed Toxicity Values (PPRTVs) - as developed on a chemical-specific basis by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (USEPA, 2003a). Because access to PPRTV is limited, these values were obtained directly from the USEPA Regional Screening Level Table (USEPA, 2008a).
- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information, such as the Agency for Toxic Substances Disease Registry (ATSDR) Minimum Risk Levels, California Environmental Protection Agency, and the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

Toxicity criteria used to quantify non-carcinogenic hazards (risk reference doses - RfDs) and carcinogenic risks (slope factors - CSFs) are presented in **Appendix E-1**, **Tables E.1-38 through E.1-41**.

6.4 Risk Characterization

Quantitative risks and hazards due to exposure to COPCs are estimated and summarized by combining toxicity criteria (presented in the Toxicity Assessment) with CDIs (calculated in the Exposure Assessment). Methods used to calculate risks and hazards are taken from USEPA (1989a).

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated CDI by the CSF. In order to assess the individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals are summed within each exposure pathway. For the residential scenario, carcinogenic risk was evaluated for the lifetime resident.

Non-carcinogenic adverse health effects are calculated by dividing the CDI of each COPC by its RfD, forming an HQ. HQs with a value greater than one (1.0) indicate the potential for adverse health effects. To estimate non-carcinogenic adverse health effects due to simultaneous exposure to several COPCs, HQs for individual COPCs are summed within each exposure pathway to form an HI. As with HQs, HIs that are greater than 1.0 indicate potential adverse health effects. In such cases, COPCs are divided into categories based on the target organ affected (e.g., liver, kidney) and target organ-specific HIs are recalculated. Non-carcinogenic hazards were evaluated for both child and adult residents independently.

Excess lifetime cancer risks derived in this report are compared with USEPA's target risk range for Superfund sites of 1E-06 to 1E-04 (USEPA, 1989a). In addition, USEPA's Office of Solid Waste and Emergency Response has issued a directive (USEPA, 1991a) clarifying the role of HHRA in the Superfund process. The directive states that, if the cumulative carcinogenic risk to a receptor (based on reasonable maximum exposure for both current and future land use) is less than 1E-04 and the non-carcinogenic HI is equal to or less than 1, action generally is not warranted unless adverse environmental effects are likely.

Calculation of risks and hazards due to exposure to COPCs are provided in **Appendix E-1**, **Tables E.1-42 through E.1-57**. The risks and HIs for each receptor are presented in **Appendix E-l**, **Tables E.1-58 through E.1-65**. These risks and hazards are summarized in **Table 6-3**. A refinement of the HIs based on target organs is conducted by calculating HIs on a target organ-specific basis. In addition, **Appendix E-1, Tables E.1-66 through E.1-72**, summarize risks and hazards for risk/HI drivers (i.e., those COPCs contributing to a total risk greater than 1.E-04 or a total target organ hazard greater than 1.0).

6.4.1 Iron Margin of Exposure Evaluation

Because iron concentrations in soil resulted in an HQ of 0.5 or higher for the child resident at Area P, a “margin of exposure evaluation” was conducted. This evaluation consists of a comparison of estimated intake of iron to the RDA and concentrations known to cause adverse health effects in children. The calculated intake of iron via the route of ingestion is compared with amounts that are associated with an RDA of 10 mg/day (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996a).

The calculated intake of iron via ingestion of groundwater was 0.53 mg/kg-day and ingestion of surface soil was 0.254 mg/kg-day. Therefore, the total estimated intake of iron by ingestion was 0.78 mg/kg-day. The intake calculated for groundwater at Area P was within the allowable range (0.36 to 1.11 mg/kg-day).

Table 6-3
Summary of Risks and Hazards
Area P

Timeframe/Receptor	**Risk**	**Risk Drivers**	**HI**	**Target Organ Segregation HI>1**[a]
Current maintenance worker	5E-07	N/A	5E-02	N/A
Future maintenance worker	5E-07	N/A	5E-02	N/A
Future industrial worker	**6E-06**	**Surface Soil** Arsenic **Groundwater** Tetrachloroethene	6E-01	N/A
Future excavation worker	**1E-06**	N/A	8E-01	N/A
Future adult resident	N/A	N/A	**1E+00**	No individual COPC or target organ was equal to 1.
Future child resident	**1E-05**	**Total Soil** Arsenic **Groundwater** Tetrachloroethene	**3E+00**	**CNS** (1.7) - Total Soil [Aluminum - Ing (0.15); Manganese - Ing (0.34), Derm (0.24)] Groundwater [Aluminum - Ing (0.39); Manganese - Ing (0.52)] **Blood** (1.2) - Total Soil [Iron - Ing (0.34)] Groundwater [Iron - Ing (0.76)] **Liver** (1.1) - Total Soil [Iron - Ing (0.34)] Groundwater [Iron - Ing (0.76)] **GI Tract** (1.1) - Total Soil [Iron - Ing (0.34)] Groundwater [Iron - Ing (0.76)]
Future lifetime resident	**6E-05**	**Total Soil** Arsenic **Groundwater** Tetrachloroethene Chloroform	N/A	N/A
Future off-site adult recreational user	**1E-06**	N/A	9E-03	N/A
Future off-site adolescent recreational user	3E-07	N/A	1E-02	N/A

NA = Not Applicable

HI = Hazard Index

HQ = Hazard Quotient

Bold = Exceeds or equals USEPA Risk or Hazard Range.

Ing = Ingestion; Inh = Inhalation; Derm = Dermal

CNS = Central Nervous System

GI = Gastrointestinal

NOTE: Aluminum, antimony, arsenic, cobalt, iron, manganese, and vanadium are within background concentrations for surface and total soil. Note that results for antimony in surface soil are uncertain because antimony was detected in one site sample and none of the background samples.

(a) Cumulative HIs and individual HQs are rounded to the nearest tenth. HIs > 1 and HQs > 0.1 are listed.

6.4.2 Background

Statistical evaluations were conducted to compare metals concentrations in soil at Area P with background concentrations presented in the *RFAAP Facility-Wide Background Study Report* (IT, 2001). These evaluations followed the procedures outlined in the USEPA *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (USEPA, 2002c) and were conducted using USEPA's ProUCL 4.0 statistical program. Statistical analyses included distribution testing of site data sets and background data sets, evaluation of data using descriptive summary statistics, and comparisons of site data to background. Distribution testing showed that either the site data sets or the background data sets in each case were not normal, and therefore, consistent with *Section 4.1* of the above-referenced USEPA guidance, comparisons of site to background were conducted using non-parametric testing rather than attempting to transform the data sets logarithmically. Unless otherwise noted, Gehans test was conducted for each metal with background data sets to evaluate whether site concentrations were consistently higher or lower than the background data set. Gehans test was used because it was found to handle data sets with multiple detection limits better than the Wilcoxon Mann Whitney test. There is no background data set for groundwater.

Notes on the methodology and the results of the background evaluation are summarized in **Tables 6-4 and 6-5**. The ProUCL 4.0 output is provided in **Appendix E-5**. One inorganic COPC risk driver (arsenic) was identified for surface and total soil Area P. Based on the background evaluation, concentrations of arsenic were within background for both surface and total soil. The total HIs for surface and total soil exceeded 1 for the child resident. Although no individual COPCs had HIs above 1, aluminum, antimony, cobalt, iron, manganese, and vanadium contributed to the surface and total soil HIs. These constituents are within background, however, for both surface and total soil.

6.5 Uncertainties

Risk assessments involve the use of assumptions, judgments, and incomplete data to varying degrees that contribute to the uncertainty of the final estimates of risk. Uncertainties result both from the use of assumptions or models in lieu of actual data and from the error inherent in the estimation of risk related parameters and may cause risk to be overestimated or underestimated. Based on the uncertainties described below, this risk assessment should not be construed as presenting an absolute estimate of risk to persons potentially exposed to COPCs.

Consideration of the uncertainty attached to various aspects of the risk assessment allows better interpretation of the risk assessment results and understanding of the potential adverse effects on human health. In general, the primary sources of uncertainty are associated with environmental sampling and analysis, selection of chemicals for evaluation, toxicological data, and exposure assessment. The effects of these uncertainties on the risk estimates are discussed below.

6.5.1 Environmental Sampling and Analysis

If the samples do not adequately represent media at Area P, hazard/risk estimates could be overestimated or underestimated. The sampling and analysis plan was designed to investigate anticipated areas of contamination and delineate area(s) of concern. Therefore, there is less chance that the hazard/risk estimates are biased low. Also, if the analytical methods used do not apply to some chemicals that are present at each area, risk could be underestimated.

Table 6-4
Background Comparison for Surface Soil at Area P

Soil COPC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Aluminum [c]	No	Yes
Antimony [d]	No	Yes
Arsenic [c]	No	Yes
Cobalt	No	Yes
Iron [c]	No	Yes
Manganese [c]	No	Yes
Vanadium [c]	No	Yes

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.

[b] If both Site and Background data sets had normal distribution with 100% detects, the t-test was used (note: this only occurred for iron in Area P total soil vs. background comparisons).

[c] If both data sets were 100 % detect, then Wilcoxon Mann Whitney test used.

[d] Results for antimony are uncertain as antimony was only detected in one sample in the site data and not detected in any samples in the background data. See Appendix.

Table 6-5
Background Comparison for Total Soil at Area P

Soil COPC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Aluminum [c]	No	Yes
Antimony	No	Yes
Arsenic	No	Yes
Cobalt	No	Yes
Iron [c]	No	Yes
Manganese [c]	No	Yes
Vanadium [c]	No	Yes

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.
[b] If both Site and Background data sets had normal distribution with 100% detects, the t-test was used (note: this only occurred for iron in Area P total soil vs. background comparisons).
[c] If both data sets were 100 % detect, then Wilcoxon Mann Whitney test used.

Because the analytical methods at the site were selected to address all chemicals that are known or suspected to be present on the basis of the history of each area, the potential for not identifying a COPC is reduced.

Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical procedures. Analytical accuracy errors or sampling errors can result in rejection of data, which decreases the available data for use in the HHRA, or in the qualification of data, which increases the uncertainty in the detected chemical concentrations. There is uncertainty associated with chemicals reported in samples at concentrations below the method reporting limit but still included in data analysis and with those chemicals qualified “J” indicating that the concentrations are estimated. Another issue involves the amount of blank related (i.e., B-qualified) data in the data set. Although B-qualified were eliminated, however, the amount of B-qualified data in the data set was low.

It is acknowledged that some of the soil samples used in this HHRA were collected and analyzed for metals in 1992. Because metals concentrations would be expected to be relatively stable in soil, these data were considered to be appropriate for the risk assessment. In addition, the range of concentrations for each constituent in the 1992 data set were generally within the same range as the overall data set for surface and total soil. It is unlikely that the use of these data would have resulted in an overall underestimation of risk or hazard.

As described in *Section 6.1.1.4*, sampling techniques contributed to the uncertainty associated with the risk and hazards calculated for groundwater at Area P. Groundwater samples at Area P were collected using the GeoProbe™ system, which is a direct-push technique. The groundwater samples collected using this technique exhibited high turbidity due to the fine-grained clay and silt in the first water-bearing unit encountered, as well as the absence of a sandpack around the direct push sampler. It is likely that the analytical results for the unfiltered groundwater samples reflected the contribution from COPCs adsorbed to particulates in the samples. In discussions with EPA and VDEQ (Shaw, 2010), EPA indicated that dissolved metals concentrations could be used in the HHRA if the samples were excessively turbid. Therefore, the filtered groundwater data were used to quantitatively evaluate metals in the risk/hazard calculations. Therefore, it is less likely that the risks and hazards for groundwater at Area P are over-estimated.

6.5.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA Regional SLs was conducted for surface soil, total soil, sediment, and groundwater. Chemicals with maximum concentrations below their respective SLs were not carried through the assessment. It is unlikely that this risk-based screening excluded chemicals that should be included, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the SLs. Although following this methodology does not provide a quantitative risk estimate for every chemical, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations exceed their respective SLs) and the cumulative risk estimates would not be expected to be significantly greater. As presented on the non-detect method detection limit (MDL) screening tables, the maximum MDL exceeded the adjusted SLs for several chemicals in soil, sediment, and groundwater; therefore, the site-related risks and hazards could be underestimated for the risk assessments due to inadequate detection limits. The results for the evaluations of non-detects at Area P are discussed in the following sections.

The reporting limits for chemicals that were not detected in surface soil, total soil, sediment, and groundwater at Area P were compared with SLs in **Appendix E-1, Tables E.1-3, E.1-5, E.1-7, and E.1-9**, respectively. As shown in **Appendix E-1, Table E.1-3**, reporting limits in surface soil exceeded SLs for 5 of 150 constituents (3 percent). These constituents include benzo(a)pyrene, bis(2-chloroethyl)ether, dibenz(a,h)anthracene, nitroglycerin, n-nitroso-di-n-propylamine, and thallium. The PAHs, benzo(a)pyrene and dibenz(a,h)anthracene, could be associated with past disposal activities. Nitroglycerin has been detected elsewhere on the Installation. If these constituents are actually present, risk and hazard could be underestimated. However, the reporting limits exceed SLs that are based on a cancer risk of 1E-06 or HQ of 0.1. If the reporting limits were compared with SLs based on 1E-05 and HQ of 1, most of them would not exceed. For 14 of 139 constituents (10 percent) in surface soil, there were no SLs for comparison. These constituents include: 2-hexanone, 2-nitroaniline, 2-nitrophenol, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, 4-nitrophenol, carbazole, dibenzofuran, dichloroprop, dimethylphthalate, di-octylphthalate, p-chloro-m-cresol, and pentaerythritol tetranitrate (PETN). These chemicals are not known to be associated with past disposal at Area P.

As shown in **Appendix E-1, Table E.1-5**, reporting limits in total soil exceeded SLs for 5 of 144 constituents (3 percent). These constituents include: benzo(a)pyrene, bis(2-chloroethyl)ether, dibenz(a,h)anthracene, nitroglycerin, n-nitroso-di-n-propylamine, and thallium. As discussed for surface soil, it is possible that PAHs could have been associated with past disposal activities at Area P. If these constituents are actually present, risk and hazard could be underestimated. Nitroglycerin has been detected elsewhere on the Installation. However, the reporting limits exceed SLs that are based on a cancer risk of 1E-06 or HQ of 0.1. If the reporting limits were compared with SLs based on 1E-05 and HQ of 1, most of these constituents would not exceed. For 13 of 144 constituents (9 percent) in total soil, there were no SLs for comparison. These constituents were similar to those identified for surface soil. These chemicals are not known to be associated with past disposal at Area P.

As shown in **Appendix E-1, Table E.1-7**, the reporting limits for only one constituent (thallium) out of 150 constituents in sediment exceeded SLs. The reporting limit slightly exceeded the SL. If the reporting limit was compared with an SL based on an HQ of 1, this constituent would not exceed. For 14 of 150 constituents (9 percent) in sediment, there were no SLs for comparison. These constituents include: PETN, thallium, dichloroprop, dimethylphthalate, 2-nitroaniline, 2-nitrophenol, 4-nitrophenol, carbazole, dibenzofuran, di-octylphthalate, p-chloro-m-cresol, 2-hexanone, 4-bromophenyl phenylether, and 4-chlorophenyl phenylether. These chemicals are not known to be associated with past disposal at Area P.

As shown in **Appendix E-1, Table E.1-9**, reporting limits in groundwater exceeded SLs for 59 of 156 constituents (38 percent). For 13 of 156 constituents (8 percent) in groundwater, there were no SLs for comparison. Some of these constituents could potentially be site-related. In particular, vinyl chloride is a degradation product of PCE, which was identified as a COPC in groundwater. It is assumed, however, groundwater exposures at Area P involve limited exposure frequency and exposure duration for maintenance and industrial workers. In addition, while a residential scenario has been included for completeness, it is unlikely that Area P groundwater will be used for residential purposes in the future.

In general, these chemicals, if present in surface soil, total soil, surface water, sediment, and groundwater, could contribute additional risk and hazard at Area P. Reporting limits for these analyses were reviewed at the start of the project. Although some of the reporting limits were known to exceed SLs, the differences were small. Therefore, while risks and hazards associated with the site may be underestimated, this uncertainty is not anticipated to change the conclusions of this HHRA.

For some COPCs without screening levels, the values used for screening were based on surrogate chemicals with similar structures and properties served as surrogates. The surrogates for this HHRA were based on proxy compounds as identified in VDEQ's Risk Assessment Guidance, Risk-Based Screening Levels Proxy Values (VDEQ, 2008). With the exception of the benzo(g,h,i)perylene in sediment, these compounds were not detected and were only screened with respect to the detection limits. Use of the screening levels of these compounds had no effect on the risks/hazards calculated in this HHRA.

Background concentrations of metals in soil at RFAAP have been characterized and are used in statistical comparisons of site soil to evaluate whether concentrations of metals detected at Area P are consistently higher or lower than background. However, the background data obtained may not fully characterize naturally-occurring metals levels at the site. Uncertainties associated with the use of these data may lead to a low-to-moderate overestimation or underestimation of surface and total soil risks due to metals. In addition, antimony was detected in one of ten surface soil samples and none of the background samples. Although the background comparison indicates that the site data set for antimony is below background, the result is uncertain. Because the HI for antimony did not exceed 1, however, this uncertainty would have a minimal impact on the cumulative HI and the target organ evaluation.

Background concentrations of metals in groundwater at RFAAP have not been characterized. Consequently, it is not possible to statistically compare metals concentrations in groundwater at Area P with background metals concentrations. It is possible that the HQs calculated for metals in groundwater are within the background range.

Screening criteria are derived from RDAs for essential human dietary minerals, trace elements, and electrolytes that are potentially toxic at very high doses (i.e., calcium, magnesium, potassium, and sodium). None of these elements were selected as COPCs in soil. Omitting these essential human nutrients from further evaluation is expected to have a low effect on risk and hazard estimates.

6.5.3 Exposure Assessment

The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the exposure parameters used to estimate chemical doses. An underlying assumption in the HHRA is that individuals at the site would engage in activities that result in exposures via each selected pathway. For example, it was assumed that maintenance workers engage in regular activities (once a week) under current and future land use conditions resulting in exposure to COPCs. This assumption is conservative, in that it is more likely that the activity patterns occur occasionally.

For Area P, the PEFs for the maintenance workers and industrial workers were based on 0.5 acres rather than the actual size of the site (0.229 acres). An area of 0.5 acres was assumed in the calculation because the factors for the Q/C calculations were derived for sites between 0.5 to 500 acres (USEPA, 2002b). In addition, the PEF for the residents was based on a 0.5-acre residential lot per USEPA guidance (USEPA, 1996b). Because the sampling plan was based on less than 0.5 acre, the PEF values for these receptors are likely to overestimate the inhalation risk and hazard for the residents. These potential uncertainties would not affect the conclusions for Area P.

The non-cancer hazard estimates for the inhalation of dust emissions by the construction worker receptor are based on the construction worker PEF calculation. Because future plans for construction or excavation at Area P are not known, assumptions regarding the duration of construction activities and type and number of construction vehicles were based on the acreage of each site. Although the inhalation cancer risk/non-cancer hazard estimates could be overestimated, the calculated risks and hazards were below the target risk range and HI. In addition, there is generally a higher level of uncertainty associated with the use of modeled concentrations (i.e., PEF) than in the use of measured concentrations if valid measurement data are available for the exposure medium and exposure location.

In establishing EPCs, the concentrations of chemicals in the media evaluated are assumed to remain constant over time. Depending on the properties of the chemical and the media in which it was detected, this assumption could overestimate or underestimate risks, based on the degree of chemical transport to other media or the rate and extent a chemical degrades over time. For example, the biodegradation of PCE could result in the formation of vinyl chloride over time. Vinyl chloride is classified as a known human carcinogen. Therefore, the cancer risks associated with future exposures to groundwater may be underestimated.

When calculating EPCs from sample data using ProUCL, non-detect samples are coded as “zeros.” As indicated in the ProUCL output for Area P (**Appendices E-3 and E-5**), summary statistics, such as the arithmetic mean, are based on the detected values only. For the calculation of the 95% UCL of the mean, the program substitutes surrogate values for the detection limits. Approaches which substitute values for non-detected chemical concentrations are associated with uncertainty, because chemicals that were not detected at the specified sample MDL may be absent from the medium or may be present at a concentration below the sample MDL. Furthermore, only the detected concentrations in each data set are used to determine the distribution of the data. For data sets with non-detects, the uncertainty associated with the distribution of the data could result in an over-estimation of the EPC.

The 95% UCL is used as the EPC for each medium if at least eight to ten samples are available. If the 95% UCL exceeds the maximum detected value or if fewer than five samples are available, the maximum is conservatively used as a default EPC. Using a value that is based on one sampling location (i.e., the maximum) has associated uncertainty and it adds a great deal of conservatism to the assessment. The 95% UCL was used as the EPC for each chemical in soil. Therefore, the cancer risk/non-cancer hazard estimates are not likely to be biased high. The EPCs for groundwater, however, were based on maximum values, which could result in an overestimation of risk or hazard.

The exposure parameters used to describe the extent, frequency, and duration of exposure is associated with uncertainty. Actual risks for individuals within an exposed population may differ from those predicted, depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weight. Exposure assumptions were selected to produce an upper bound estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites (e.g., exposures were assumed to occur for 25 years for workers). In addition, many USEPA (1991b) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. For example, although current USEPA guidance recommends default soil ingestion rates of 100 mg/day for individuals over 6 years of age, other studies, such as Calabrese et al. (1990), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate adult exposures and risks. In addition, chemicals in soil are assumed 100% bioavailable; this assumes that ingested chemicals present in a soil matrix are absorbed through the gastrointestinal (GI) tract, which is unlikely due to the affinity of contaminants for soil particles. Therefore, based on the conservative exposure assumptions used in the HHRA, exposures and estimated potential risks are likely to be overestimated for the ingestion of soil pathways.

Evaluation of the dermal absorption exposure pathway is affected by uncertainties in dermal exposure parameters. 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. Uncertainties that are more significant are associated with the selection and use of dermal absorption factors. For this HHRA, the dermal absorption factors and calculations were based on USEPA Region III guidance, USEPA's *RAGS: Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004a). Very limited information is available on dermal absorption of chemicals from contacted soil under environmental conditions. In fact, there are not actual human epidemiological data to support the hypothesis that absorption of soil bound compounds under exposure conditions is a complete route of exposure. For example, the Public Health Statements from the ATSDR (1992, 2000, 2004, 2006, 2007) indicate that metals such as aluminum, arsenic, cobalt, manganese, and vanadium are not known to result in human health effects by dermal absorption because very little can enter the body through the skin under normal circumstances (i.e., without exposure to very high concentrations for long periods or exposure to skin that is damaged). Therefore, using the dermal absorption factors to evaluate dermal absorption exposures to soil may result in an overestimation of risks.

For exposures to COPCs in groundwater via dermal absorption, the USEPA's dermal guidance (USEPA, 2004a) cautions that the procedures for estimating dermal dose from water contact are very new. The dermal permeability estimates are probably the most uncertain of the parameters in the dermal dose equation. The equation used to calculate the term, DA_{event}, is based on a regression model that predicts the water permeability coefficient for organics. Statistical analysis of the regression equation provides the range of octanol/water partition coefficients (K_{ow}) and molecular weights where this regression model could be used to predict permeability coefficients (Effective Prediction Domain or EPD). The permeability coefficients for the halogenated compounds (chloroform and PCE) are likely to be underestimated. Because halogenated chemicals have a lower ratio of molar volume relative to their molecular weight than hydrocarbons (due to the relatively weighty halogen atom), the K_p correlation based on molecular weight of hydrocarbons will tend to underestimate permeability coefficients for halogenated organic chemicals (USEPA, 2004a). In determining whether the dermal absorption pathway warrants assessment, USEPA's dermal guidance considers the risks and hazards of dermal exposure relative to those of drinking water exposures. In cases where dermal exposure was less than 10 percent of drinking water exposure, the COPC was not included in the dermal risk assessment. As shown in **Appendix E-1, Tables E.1-29 through E.1-32** for groundwater at Area P, chloroform and several metals were not included in the assessment. For surface water, however, all COPCs were included in the dermal assessment because exposures via ingestion were very low. Given the uncertainty associated with the dermal absorption of metals, the risks and hazards calculated for the surface water are likely to be overestimated.

Several models were used to evaluate exposure scenarios that involve the volatilization of COPCs from groundwater to air. These models include: the ASTM Model for volatilization from groundwater to ambient air, the Johnson & Ettinger Model for migration of VOCs from groundwater into indoor air, the VDEQ Trench Model for volatilization of VOCs from groundwater into a construction/utility trench, and the Foster-Chrostowski Shower Model for volatilization of VOCs from groundwater into shower air. The uncertainties associated with these models are discussed in the following sections.

The volatilization model outlined in ASTM RBCA Guidance (ASTM, 1995) was used to estimate the concentrations of VOCs in ambient or outdoor air at Area P that originate from dissolved hydrocarbons in groundwater located some distance below ground surface (**Appendix E-1, Table E.1-33**). This model calculates a representative concentration in air based on the following assumptions:

- A constant dissolved concentration in groundwater.
- Linear equilibrium partitioning between the dissolved chemicals and groundwater and chemical vapors in the groundwater table.
- Steady-state vapor- and liquid-phase diffusion through the capillary fringe and vadose zones to ground surface.
- No loss of chemical as it diffuses toward the ground surface (i.e., no biodegradation).
- Steady well-mixed atmospheric dispersion for the emanating vapors within the breathing zone as modeled by a “box model” for air dispersion.

A number of uncertainties associated with this model would likely result in an overestimation of risk and hazard in this HHRA. First, the maximum concentrations of chloroform and PCE in groundwater were assumed to be the constant dissolved concentration. Use of the maximum value may over-estimate risk and hazard. Second, it is assumed that there is no loss of chemical due to biodegradation over time. This assumption is especially conservative with respect to exposure for the industrial worker scenario, which is based on an exposure duration of 25 years. Third, it is assumed that vapor concentrations remain constant over the duration of exposures and that all inhaled chemicals are absorbed.

The ASTM model also considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. Uncertainty based on mechanisms such as partitioning, diffusion, and dispersion would be dependent on chemical-specific and site-specific conditions and could result in either over- or underestimation of chemical concentrations at Area P.

The Johnson and Ettinger model (1991; USEPA, 2004b) was used to estimate indoor air concentrations of volatiles migrating from groundwater through the soil and into potential future on-site and off-site residences and buildings (**Appendix E-1, Table E.1-34**). As acknowledged in the *User’s Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2004b), the Johnson and Ettinger model “…was developed for use as a screening level model and consequently is based on a number of simplifying assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction." Limitations and assumptions associated with the Johnson and Ettinger model are described in the *User's Guide* (USEPA, 2004b). These include:

Contaminant Distribution and Occurrence

- No contaminant free-liquid/precipitate phase present.
- Contaminant is homogeneously distributed within the zone of contamination.
- No contaminant sources or sinks in the building.
- Equilibrium partitioning at contaminant source.
- Chemical or biological transformations are not significant (i.e., the model will predict more intrusion).

For the Area P HHRA, the maximum concentrations of chloroform and/or PCE in groundwater were conservatively used as the inputs for the groundwater concentrations in the model. Although homogeneous distribution is assumed, the maximum concentration is not likely to be representative of the chemical concentrations across the site. Also, neither sorption nor biodegradation is accounted for in the transport of vapor from the source to the base of the building. Vinyl chloride is a possible byproduct of biodegradation over time. Potential future cancer risks associated with vinyl chloride could result in an underestimation of risk. On balance, however, the risk and hazard associated with inhalation of COPCs in indoor air are likely to be overestimated.

Subsurface Characteristics

- Soil is homogeneous within any horizontal plane.
- All soil properties in any horizontal plane are homogeneous.
- The top of the capillary fringe must be below the bottom of the building floor in contact with the soil.
- The EPA version of the Johnson and Ettinger Model assumes the capillary fringe is uncontaminated.

At Area P, the soil type above the water table consists of fine-grained silts, fine grained sands, and clay. Because the soil type is not homogeneous, the soil parameters were based on silty clay. Therefore, at Area P, the soil and the soil properties in any horizontal plane are not homogeneous. The *User's Guide* (USEPA, 2004b) acknowledges that "…In theory the limitations are readily conceptualized, but in practice the presence of these limiting conditions may be difficult to verify even when extensive characterization data are available." Although there are a number of limitations associated with the Johnson and Ettinger Model, it is likely that similar limitations are encountered at other RCRA and Superfund sites. The results of the risk assessments at RFAAP as well as others would be more uncertain if a less accepted or less documented model was used.

Transport Mechanisms

- Transport is one-dimensional.
- There are two separate flow zones: diffusive and convective.

- Vapor-phase diffusion is the dominant mechanism for transporting contaminant vapors from contaminant sources located away from the foundation to the soil region near the foundation.
- There is a straight-line gradient in the diffusive flow zone.
- Diffusion through soil moisture is insignificant.
- Convective transport is likely to be most significant in the region very close to the basement or the foundation, and vapor velocities decrease rapidly with increasing distance from a structure.
- Vapor flow is described by Darcy's Law (i.e., porous media flow assumption).
- Steady state convection is assumed (i.e., the flow is not affected by barometric pressure or infiltration). Convective flow near the foundation is uniform (i.e., flow rate does not vary by location).
- Convective velocity through cracks or porous medium is uniform.
- Significant convective transport only occurs in the vapor phase.
- All contaminant vapors originating from directly below the basement will enter the basement, unless the floor and walls are perfect barriers. Contaminant vapors enter structures primarily through cracks and openings in the walls and foundation.

Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs were estimated or inferred from available data and other non-site-specific sources of information. In addition, because there are currently no structures at or near Area P, the default values for a typical residential building were used to represent the building characteristics in the model. Depth to groundwater was assumed to be the shallowest depth (approximately 14 ft). Finally, it is assumed that vapor velocities decrease rapidly with increasing distance from a structure. These assumptions contribute to a conservative estimate of the VOC concentrations in building air at Area P.

As stated in *Section 6.2.4,* EPA has not developed a standardized model for estimating concentrations of airborne VOCs released from groundwater during construction or excavation activities. Therefore, VDEQ's VRP trench model was used in this HHRA (**Appendix E-1, Table E.1-35**). Due to several conservative assumptions used in VDEQ's trench model, risks and hazards due to potential exposures to groundwater during the hypothetical excavation of a construction/utility trench are likely to be overestimated. The uncertainties associated with this model include:

- The maximum concentrations of chloroform and/or PCE in Area P groundwater were used to estimate exposures to VOCs in ambient air in a construction/utility trench. The use of the maximum value is likely to overestimate risk and hazard. In addition, the model does not account for the dilution, dissipation, or degradation of VOCs over time.
- The depth of the trench was set at VDEQ's default value at 8 ft.
- To be consistent with the other excavation/construction exposures in this HHRA, an exposure frequency of 250 days/year and exposure duration of 1 year were assumed for a worker in the trench. The default value for exposure time in the trench model was 4 hours per each day of excavation/construction work. As a practical matter, it is

unlikely that the same individual(s) would work in a trench at either site for 4 hours each day for 1 year.

The Foster-Chrostowski (1987, 2003) shower room model was used to estimate the EPCs of VOCs in air due to volatilization from groundwater during showering and applied to an adult resident (**Appendix E-1, Table E.1-36**). Although VOCs may volatilize into indoor air from most typical household uses of groundwater, showering likely represents the upper–bound for exposure. The warm water temperature of a shower facilitates volatilization and the receptor is confined in a relatively small space with the released VOCs. The showering scenario and the characteristics of a typical shower room have been studied sufficiently to permit the estimation of shower room air concentrations of VOCs.

There are several factors that contribute to the potential uncertainty of the results of the shower model (Foster and Chrostowski, 2003). These factors include chemical-specific input parameters (e.g., Henry's Law constants), calculation of mass-transfer coefficients, and indoor air compartment flow rates. The calculation of mass transfer coefficients is an important component of modeling volatilization and requires information on chemical-specific properties as well as the interfacial area across which volatilization can occur. Mass transfer can be affected by different water characteristics, such as water flow rate, shower nozzle type, droplet size, distribution, and water temperature. There are also uncertainties associated with the choice of the flow. For example, a plug flow model represents the mass transfer from a flowing water supply, such as a shower. Other model uncertainties include the exclusion of some sources of VOC volatilization into indoor air other than the water droplet in the shower. The Foster-Chrostowski model does not address volatilization from water after it has impacted nearby surfaces or as it drains from the floor of the shower. As a result, risk or hazard could be underestimated.

Finally, although the shower model focuses on indoor air concentrations associated with showering, it does not address other indoor air from uses of water such as bathing, air humidifiers, dish washing machines, clothes washing machines, toilets, and sinks. Therefore, with respect to chloroform and PCE in indoor air from all potential household uses, risk and hazard are likely to be underestimated.

To address potential discharge of groundwater from Area P to surface water in the New River, it was conservatively assumed that adult receptors could be exposed to COPCs from discharged groundwater during recreational activities at the river. The concentrations of COPCs in Area P groundwater were used in the risk and hazard calculations without adjustment for dilution. For the future adult recreational user at Area P, the total cancer risk for exposures to off-site surface water (1E-06) was equal to the lower limit of the target risk range. The total HI was below 1. Based on the calculations performed for the SLERA (*Section 7.1.10*), a conservative dilution factor of 100 is assumed. Therefore, the risk associated with discharge from Area P is likely overestimated and below the target risk range of 1E-06 to 1E-04.

6.5.4 Toxicological Data

The HHRA relies on USEPA derived dose response criteria. These health effects criteria are conservative and are designed to be protective of sensitive subpopulations. The health criteria used to evaluate long-term exposures, such as RfDs or CSFs, are based on concepts and assumptions that bias an evaluation in the direction of overestimation 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 upper bound 95% UCLs for CSFs (carcinogens), and safety factors for RfDs (non-carcinogens). The assumptions used here provide a rough but plausible estimate of the upper limit of risk; in other words, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero. More refined modeling in the area of dose response calculation (e.g., using maximum likelihood dose response values rather than the 95% UCL) would be expected to substantially lower the final risk.

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitates the use of oral toxicity data. To calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses are combined with oral toxicity values (also discussed above in *Section 6.3*). Oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal absorption doses, which are expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors that reflect the toxicity study conditions were used to modify the oral toxicity criteria. For those chemicals lacking sufficient information, a default oral absorption factor of 1.0 was used. The risk estimates for the dermal absorption pathways may be overestimated or underestimated, depending on how the values used in the HHRA reflect the difference between the oral and dermal routes.

Inhalation toxicity criteria are unavailable for many of the COPCs. This HHRA does not use oral-based toxicity criteria to estimate risks from inhalation exposure because of the following uncertainties associated with such a substitution:

- Many contaminants show portal-of-entry toxicity - that is, adverse health effects occur primarily at the tissue site at which the chemical is introduced into the body (e.g., GI tract, lung, or skin).
- Physiological and anatomical differences between the GI tract and respiratory systems invalidate a cross-route quantitative risk extrapolation. The small intestine of humans contains a very large surface area that readily absorbs most compounds by passive diffusion (Klaasen et al., 1986). The oral absorption of a few compounds, such as iron, is an energy-dependent (active-transport) process, wherein the absorption rate is proportional to the body’s current need for iron.
- The rate and extent of pulmonary absorption are much more complex and depend on such factors as particle size distribution of the airborne toxicant and blood-gas solubility of the toxicant (Klaasen et al., 1986). Particles with median aerodynamic diameters of approximately 1 micrometer or less are absorbed by the alveolar region of the human lung. Larger particles deposit in the tracheobronchial or nasopharyngeal regions where they are cleared by mucociliary mechanisms and subsequently swallowed or physically removed and exhaled. Therefore, pulmonary absorption is more highly dependent on the physiochemical properties of the material than oral absorption.

- Because highly soluble gases (e.g., chloroform) are more rapidly absorbed into the blood than poorly soluble gases (e.g., ethylene), they take much longer to reach equilibrium. Thus, the inhalation absorption rate of a gas is more dependent on blood solubility than the oral absorption rate of the same substance administered as a liquid.
- Human inhalation risk estimates based on oral toxicity data in subhuman species are distorted by both route-to-route extrapolation and interspecies extrapolation. For example, the rodent GI tract, which includes a structurally unique forestomach, is anatomically and functionally distinct from the human lung, which contains a very large alveolar surface area for extensive absorption. The rate and extent of absorption across these distinct physiological systems are not alike.

In addition, for inhalation exposure to substances present as dusts, vapors, gases, or airborne particulate matter, dose extrapolation is far more complex, and therefore associated with uncertainty. The major confounding factors that prohibit a direct dose extrapolation of an inhaled toxicant are the following:

- Over 40 functionally different cell types in the lung - the distribution, consequent metabolic reactions, and air exchange rates vary widely across species.
- Differential concentration and activity of the detoxifying protein glutathione.
- Interspecies and intraspecies differences in the ability to repair pulmonary cell damage, and to clear toxic contaminants and immune complexes from the respiratory tract. For example, species vary in the ability to activate macrophages - nonspecific immune cells that can both protect the inner lining of the respiratory system and, at high concentrations, damage healthy tissues.
- Anatomical variations in the respiratory pathway, which affect both absorption rates and time to reach steady-state blood levels.
- Sensitivity to solubility and concentration variables; because of metabolic saturation (i.e., the exhaustion of normal metabolic activity caused by exposure to high concentrations), highly soluble contaminants deviate from first-order kinetics - which makes it difficult to predict the rates and extent of biotransformation and detoxification reactions. Furthermore, intermittent inhalation exposure to highly blood-soluble chemicals results in bioaccumulation in fat tissue because of the insufficient time between exposure sessions for complete clearance of the contaminant. Such slow release from the fat compartment to other body tissues can result in toxicological and metabolic effects that are difficult to assess and vary across species.

The lack of toxicity values for the inhalation pathway could result in an underestimation of risk or hazard. With the exception of the excavation worker, however, risks and hazards associated with dusts and particulates are typically small relative to the ingestion and dermal pathways.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria were used where available (**Appendix E-1, Tables E.1-38 through E.1-41**). Provisional toxicity criteria (i.e., PPRTVs) present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. PPRTVs or other oral toxicity provisional values were used for Aroclor 1254, chloroform, aluminum, cobalt, iron, and vanadium for Area P. Provisional inhalation toxicity values were used for Aroclor 1254, chloroform, PCE, aluminum, and cobalt for Area P. The source for the oral RfD for copper is the HEAST (USEPA, 1997b). The HEAST has not been updated since 1997. For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because these toxicity criteria have not been formally accepted by USEPA, there is uncertainty with these values and, therefore, with the risks and hazards calculated using these toxicity criteria. For example, the HQs calculated for aluminum, cobalt, and iron in groundwater are uncertain due to the use of provisional oral RfDs for the ingestion pathway. Because the process for deriving provisional values is conservative, it is likely that the HQs for these metals are over-estimated.

For some COPCs without toxicity criteria, chemicals with similar structures and properties served as surrogates. Constituents for which toxicity data from surrogates were applied include:

- acenaphthylene, benzo(g,h,i)perylene, phenanthrene (surrogate: pyrene)
- 1,3 dichlorobenzene (surrogate: 1,4 dichlorobenzene)
- endosulfan I, endosulfan II, endosulfan sulfate (surrogate: endosulfan)
- endrin aldehyde, endrin ketone (surrogate: endrin)
- gamma-chlordane (surrogate: chlordane)

The values for these surrogates are consistent with those shown in VDEQ's Risk Assessment Guidance, Tables 4.1 and 4.2. (VDEQ, 2008).

For some chemicals, toxicity criteria were unavailable (**Appendix E-1, Tables E.1-38 through E.1-41**). Although lack of published toxicity data could result in an underestimation of risk and hazard in this HHRA, this uncertainty is likely to be balanced by the conservative nature of the verified toxicity values that were available for use.

It is noted that the Supplemental SSL Guidance (USEPA, 2002b) recommends that toxicity values for subchronic exposures be used to calculate the HQs for exposures by the construction worker. Although subchronic values for some chemicals are included in USEPA's database of Provisional Peer-Reviewed Toxicity Values, this web site cannot be accessed without authorization. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of the HIs. Typically, subchronic toxicity values are 10-fold greater than chronic toxicity values. Because chronic toxicity values were used for all COPCs, the calculated hazards are likely to be overestimated. For Area P, however, hazards associated with individual COPCs for this pathway were below the target HI.

6.5.5 Risk Characterization

Minor uncertainty is associated with rounding of the risk and hazard estimates. Thus, the actual risk or hazard may be slightly greater or less than the presented values. A related issue is that rounding results in differences between summed risk and hazard values, depending on how the summing is performed. For example, the RAGS Table 7 and 8 spreadsheets in **Appendix E-1, Tables E.1-42 through E.1-57** present risks and hazards that are summed for exposure route, exposure point, exposure medium, and medium total. The individual chemical-specific risks and hazards are summed only for the initial exposure route in deriving the total. For the subsequent summations (exposure point, exposure medium, and medium total), each is the summation of the preceding sums. For this reason, there can also be or rounding-related differences between the “same” values presented in RAGS Table 9 and 10 spreadsheets in **Appendix E-1, Tables E.1-58 through E.1-72**.

6.6 HHRA Summary and Conclusions

This HHRA was performed to evaluate the potential human health effects associated with previous activities at Area P. Receptors evaluated for both areas included current/future maintenance worker, future industrial worker, future excavation worker, future adult resident, future child resident, and lifetime resident. Off-site adult and child residents were also evaluated for potential exposures to groundwater in the event that groundwater migrates off site in the future.

As presented in *Section 6.4*, the total cancer risk for current maintenance worker exposures to surface soil (5E-07) was below the target risk range of 1E-06 to 1E-04. The total HI for surface soil was less than 1. The total cancer risk associated with groundwater (4E-12) was below the target risk range. The total HI for groundwater was below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil (5E-07) was below the target risk range of 1E-06 to 1E-04. The total HI for surface soil was less than 1. The total cancer risk for exposures to total soil (3E-07) was below the target risk range. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (4E-12) was below the target risk range. The total HI for groundwater was below 1.

For future industrial worker exposures to surface soil, the total cancer risk for exposures to surface soil (2E-06) was within the target risk range of 1E-06 to 1E-04 due to arsenic. The total HI for surface soil was less than 1. The total cancer risk for exposures to total soil (1E-06) was equal to the lower limit of the target risk range due to arsenic. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (4E-06) was within the target risk range due to PCE. The total HI for groundwater was less than 1. The MDC of lead in groundwater exceeded the MCL for lead.

For the future excavation worker, the total cancer risk for exposures to total soil (1E-07) was below the target risk range of 1E-06 to 1E-04. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (1E-06) was equal to the lower limit of the target risk range. The total HI for groundwater was less than 1.

For the future lifetime resident, the total cancer risk for exposures to surface soil (9E-06) was within the target risk range of 1E-06 to 1E-04 due to Aroclor 1254 and arsenic. The total HI for surface soil was less than 1. For the future lifetime resident, the total cancer risk for exposures to total soil (6E-06) was within the target risk range of 1E-06 to 1E-04 due to arsenic. The total HI for total soil was less than 1. The total cancer risk associated with groundwater (5E-05) was within the target risk range, primarily due to chloroform and PCE. The total HI for groundwater (1E+00) was equal to 1. None of the HIs for individual COPCs were equal to 1. For the child resident, the total cancer risk for exposures to surface soil (6E-06) was within the target risk range of 1E-06 to 1E-04 due to Aroclor 1254 and arsenic. The total HI for surface soil (3E+00) was above 1, although no individual HQ exceeded 1. Aluminum, antimony, arsenic, cobalt, iron, manganese, and vanadium were found to be within background concentrations. If the HQs for background-related metals were excluded, the total HI for surface soil would be less than 1. For the child resident, the total cancer risk for exposures to total soil (4E-06) was within the target risk range of 1E-06 to 1E-04 due to arsenic. The total HI for total soil (2E+00) was above 1. No individual HQ exceeded 1. Aluminum, antimony, arsenic, cobalt, iron, manganese, and vanadium were found to be within background concentrations. If the HQs for background-related metals were excluded, the total HI for total soil would be less than 1. The total cancer risk associated with groundwater (1E-05) was within the target risk range, primarily due to PCE. The total HI for groundwater (3E+00) was above 1. None of the HIs for individual COPCs were above 1. When recalculated by target organ, the following organs exceeded 1: CNS (1.7), blood (1.2), liver (1.1), and GI tract (1.1). The target organ HIs were less than 1 when the target-organ HQs for background-related metals were excluded. The margin-of-exposure evaluation for iron also indicated that the iron intake was within the allowable range.

Off-site recreational users were evaluated to address potential future migration of COPCs in groundwater to surface water at the New River. For the future adult recreational user, the total cancer risk for exposures to off-site surface water (1E-06) was equal to the lower limit of the target risk range. The total HI was below 1.

For the future adolescent recreational user, the total cancer risk for exposures to off-site surface water was less than the lower limit of the target risk range. The total HI was below 1.

7.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

A SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at Area P. Common methods and procedures are presented in *Section 7.1*, and individual results are presented in *Section 7.2*.

7.1 SLERA Methods and Procedures

This section provides the rationale for the methods and procedures used during the evaluation of the data collected at Area P and performance of the SLERA.

A SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at Area P. The results of the SLERA contribute to the overall characterization of the site and the scientific/management decision point (SMDP) reached for the SLERA includes one of the following:

- There is adequate information to conclude that ecological risks are negligible and therefore there is no need for further action at the site on the basis of ecological risk.
- The information is not adequate to make a decision at this point and further refinement of data is needed to augment the ecological risk screening.
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERA was performed following the *RFAAP Final MWP* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001c), the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996), and Steps 1, 2 and 3a of the *Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997c). Steps 1, 2 and 3a were completed as part of the SLERA. The addition of Step 3a, which is a separate step in USEPA (1997c) and bridges the gap between a SLERA and BERA, focuses the outcome of the SLERA, streamlines the review process, and allows one assessment to function as the initial forum for ecological risk management decision making at the site.

The primary objective of the SLERA is to assess whether there is enough information to state that there is the potential for unacceptable risks to ecological receptors as a result of potential hazardous substance releases. Characterizing the ecological communities in the vicinity of Area P, assessing the particular hazardous substances being released, identifying pathways for receptor exposure, and estimating the magnitude and likelihood of potential risk to identified receptors meets this objective. The SLERA addresses the potential for adverse effects to vegetation, the soil invertebrate community, wildlife, endangered and threatened species, and wetlands or other sensitive habitats that may be associated with Area P.

Concentrations of chemicals were measured in surface soil, sediment, surface water, and groundwater which were the relevant environmental media at Area P.

Using available concentration data, the SLERA was performed by following Steps 1 and 2 of USEPA (1997c). Step 1 includes a screening-level problem formulation and ecological effects evaluation, and Step 2 includes an SL preliminary exposure estimate and risk calculation. The SLERA is organized as follows: General Site Characterization (*Section 7.1.1*); Methodologies for the Identification of Chemicals of Potential Ecological Concern (COPECs) and

Concentration Statistics (*Section 7.1.2*); Identification of Exposure Pathways and Potential Receptors for Analysis (*Section 7.1.3*); Identification of Assessment and Measurement Endpoints (*Section 7.1.4*); Exposure Estimation (*Section 7.1.5*); Ecological Effects Assessment (*Section 7.1.6*); Risk Characterization (*Section 7.1.7*); Direct Contact Toxicity (*Section 7.1.8*); Background Metals Evaluation (*Section 7.1.9*); Groundwater/Seep Discharge to New River (*Section 7.1.10*); and General Uncertainty Analysis (*Section 7.1.11*).

7.1.1 General Site Characterization

This section includes a general discussion of the Installation, vegetative communities, a species inventory, and a discussion on threatened and endangered species. Area P is located in the northeast section of the MMA at RFAAP (**Figure 1-1**), immediately adjacent to the New River. **Figure 2-1** shows the layout of the site. Area P is approximately 0.378 acres and served as a storage area for scrap metal, decommissioned tanks, powder cans, and batteries prior to off-post shipment.

7.1.1.1 General Installation Background

The Virginia Department of Game and Inland Fisheries (1999) conducted the most recent Installation-wide biological survey at RFAAP. Major objectives of this survey were to sample flora and fauna, identify and delineate the major habitat community types, and provide management recommendations for both community types and threatened, endangered or species of concern. Eight community types were identified at RFAAP:

- Bottomland forest.
- Calcareous forest.
- Cliffs.
- Grasslands.
- Oak forest.
- Pine plantation.
- Successional forest.
- Water.

Endangered plants or animals were not observed at Area P during the Installation-wide biological survey of 1999. Five state-listed rare plants were observed at RFAAP during this survey: *Clematis coattails, Cystoptris tennesseensis, Hasteola suaveolens, Sagittaria rigida,* and *Eleocharis intermedia*. State threatened animals located at RFAAP include the invertebrate *Speyeria idalia* and the birds *Ammodramus henslowii* (Henslow’s sparrow) and *Lanius ludovicianus* (loggerhead shrike).

An earlier comprehensive inventory of the mammals, birds, reptiles, aquatic invertebrates, trees, and plants found on the Installation, and of fish inhabiting the New River where it flows through the Installation, was conducted in 1976 during the RFAAP Installation Assessment (USATHAMA, 1976). Information from that assessment was summarized in previous documents (Dames and Moore, 1992). The summarized information was updated for the RFI through personal communication with RFAAP biologists and is presented in the following paragraphs (from URS, 2003).

Many of the reptiles, mammals, and birds listed in the assessment (USATHAMA, 1976) are believed to breed on the Installation. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. Public fishing occurs in the New River where it flows through RFAAP.

The Virginia Department of Game and Inland Fisheries identified the following terrestrial flora and fauna as endangered or threatened for Pulaski and Montgomery Counties:

- Plant species - six endangered, three threatened.
- Insect species - one endangered, four threatened.
- Bird species - three endangered.
- The locally endangered mountain lion.

In addition, a fish, salamander, four additional bird species, and the river otter are identified as species of concern in the two counties in which RFAAP is located.

Tree species at RFAAP include the shortleaf pine, loblolly pine, eastern white pine, yellow poplar, and black walnut. There are 2,537 acres of managed woodland on site (personal communication with T. Thompson, RFAAP Conservation Specialist 1995, as cited in URS, 2003).

RFAAP is located at the boundary of the central Appalachian Ridges and Valleys Ecoregion and the central Appalachian Ecoregion (Omernik, 1986). These two Ecoregions are characterized in **Table 7-1**.

Table 7-1
Ecoregions of RFAAP

Ecoregion	Land Surface Form	Potential Natural Vegetation	Land Use
Central Appalachian Ridges and Valleys	Open low hills to open low mountains	Appalachian oak in undisturbed areas	Mosaic of cropland and pasture with some woodland and forest
Central Appalachian	Open low to high hills, open mountains	Mixed mesophytic forest[1], Appalachian oak, northern hardwoods[2]	Forest and woodland mostly ungrazed

[1] maple, buckeye, beech, tuliptree, oak, linden
[2] maple, birch, beech, hemlock

Based on previous site visits and investigations, the available photographic record was compiled (**Appendix F-1, Photos F-1 through F-3**). A Shaw ecologist performed site reconnaissance activities in 2008. Prior to the reconnaissance, relevant information was obtained, including topographic maps, township, county, or other appropriate maps. This information was used to identify the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near many of the RFAAP solid waste management units (SWMUs). Additionally, the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, which identifies the locations of threatened and endangered species at RFAAP, was reviewed. The location of known or potential contaminant sources affecting the sites and the probable gradient of the pathway by which contaminants may be released to the surrounding environment were identified. The reconnaissance was used to evaluate more subtle clues of potential effects from contaminant releases.

7.1.1.2 Surface Water

Area P is located approximately 200 ft south of the New River and is a generally flat area that slopes gently towards the north in the direction of the New River. The elevation at the site ranges from approximately 1,710 ft msl at the south edge of the site to approximately 1,700 ft msl at the northwest corner of the site. Surface water runoff is expected to follow topography towards the New River. According to RFAAP utility maps, there are no storm drains or other engineered drainage systems at the site; however, a sediment sample was collected from accumulated sediment at the discharge end of a pipe that is part of an engineered drainage system at the northern boundary of Area P.

7.1.1.3 Groundwater

One sediment sample was collected at the northern boundary of Area P in 2007. Sediment from this source is the likely exposure point for ecological receptors; however, due to the proximity of the sites to the New River and the potential for groundwater discharge to river, groundwater was evaluated further in *Section 7.2.6*.

Site groundwater is also being evaluated separately under the Horseshoe Area Groundwater Study.

7.1.1.4 Wetlands

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of site photographs, there are no wetlands at Area P. There are also no wetlands close enough to the site that could potentially be impacted or receive surface water drainage from the site.

7.1.1.5 Vegetative Communities

Vegetative communities at the site, as presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, were verified using the photographs in **Appendix E-1**. As shown in **Appendix F-1, Photos F-1 through F-3**, the area surrounding Area P is primarily an unmaintained gravel pad with grassy patches and a conveyer structure, with some trees and the New River located along the northern edge.

The two primary habitat types (grass and riparian edge) can be expected to support different wildlife species assemblages; however, given the close proximity of the habitats to each other, many species would be expected to spend some amount of time within each community type for foraging and resting activities, depending on the season.

Based on information from the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of available site information, the following community description is presented for typical grassland communities at RFAAP.

The grassland communities at RFAAP are an aggregation of several community types that are so intermingled that delineation is impractical. Grassland may conveniently be subdivided into old field, meadow, and cultivated field. The term old field is used here to denote areas that were formerly open and subsequently abandoned, but are still open. In most cases, these areas were formerly pasture or hayfield. Small trees or shrubs may be present individually or in small groups, but a canopy is lacking. There is a small riparian habitat just beyond the northern edge of the sites. Old fields, in most cases, are dominated by native, warm-season species with a wide variety of other grasses, sedges, and herbs mixed in. The two dominants are little bluestem (*Schizachyrium scoparium*) and broomsedge (*Andropogon virginicus*) with others such as *Tridens flavus, Panicum oligosanthes, Panicum anceps, Eragrostis spectabilis, Setaria glauca, Sorghastrum nutans*, and *Paspalum* being frequent. Much of the old-field community is mowed (on an infrequent basis) to help keep woody plants maintained.

Meadows are areas that are mowed regularly and, in most cases, have been planted in forage grasses for haying. These are typically non-native, cool-season species such as *Festuca elatior, Poa pratensis, Phleum pratense, Agrostis gigantea, Bromus inermis, Dactylis glomerata*, and *Arrhenatherum elatius*. These species may also be mixed with native species characteristic of old fields.

Cultivated fields are areas that have been plowed and seeded with various cover crops. These areas have a major ruderal component that persists after abandonment. Principal weed species are *Cirsium arvense, Carduus acanthoides, Carduus nutans, Erechtites hieracifolia, Hypochaeris radicata, Verbascum thapsus, Hieracium pilosella,* and *Datura stramonium*.

Grassland communities at RFAAP comprise 4,379 acres, or about 63 percent of the 6,901-acre total [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey].

7.1.1.6 Species Inventory

As presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, six different taxa and several species were recorded during the survey. **Table 7-2** presents the numbers of species recorded at RFAAP that may be within or near the grassland community type.

Table 7-2
Species Inventory within RFAAP's Grassland Community Type

Taxa	Number of Species	Typical Examples
Plants	24	little bluestem, broomsedge, panic grass, orchard grass, foxtail, timothy, thistle, fireweed, hawkweed
Invertebrates	~250 in 17 taxonomic orders	millipedes, beetles, flies, springtails, seed bugs, bees, ants, moths, butterflies, dragonflies, mantis, caddisflies, isopods, pill bugs, amphipods
Reptiles and amphibians	24	salamanders, toads, frogs, turtles, snakes
Fish	12	sunfish, minnows, trout (not expected at the site)
Birds	83	robin, swift, dove, sparrow, warbler, wren, hawk
Mammals	13	red fox, white-tailed deer, shrew, meadow vole

7.1.1.7 Threatened, Rare and Endangered Species Information

Threatened, rare, or endangered species found within the grassland community type at RFAAP include those presented in **Table 7-3** [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey]. Given the grassland community type at the site, it is possible these species could also occur at the site; however, as mentioned in *Section 7.1.1.1*, no threatened, rare, or endangered species have been documented at Area P.

Table 7-3
Threatened, Rare, and Endangered Species in RFAAP's Grassland Community

Common Name	Scientific Name	Federal Status	State Status
Midland sedge	*Carex mescochorea*	not available	Watchlist
Shaggy false gromwell	*Onosmodium hispidissimum*	not available	Watchlist
Regal fritillary butterfly	*Speyeria idalia*	not available	State threatened
Henslow’s sparrow	*Ammodramus henslowii*	not available	State threatened
Loggerhead shrike	*Lanius ludovicianus*	not available	State threatened

Although a unique community type (calcareous fen) exists within the RFAAP grassland community type, it is not found at or near Area P.

7.1.2 Methodologies for the Identification of COPECs and Concentration Statistics

Using the chemical results from environmental media samples collected at Area P, a subset of the chemicals detected having data of good quality and that were not a result of non-site sources are identified. The COPEC selection process is described in more detail in the following subsections; however, screening results are presented in *Section 7.2.2*. A discussion of non-detected constituent concentrations compared with ecotoxicity screening values is presented in the Uncertainty Analysis section.

Lists of samples are presented in *Section 7.2.1*. A general discussion of comparing non-detected constituent concentrations with ecotoxicity screening values is presented in the general Uncertainty Analysis section (*Section 7.1.11*).

7.1.2.1 Data Organization

The data for each chemical have been sorted by medium. To assess potential ecological impacts, soil data from 0 to 2 ft bgs, as well as sediment and surface water data, have been considered. The 0 to 2 ft soil depth interval was selected for three primary reasons: 1) to maintain consistency with other RFAAP ecological risk assessment documents that used 0 to 2 ft, or a similar depth interval (e.g., *Ecological Risk Assessment Approach*, IT, 1998; *Screening Ecological Risk Assessment*, IT, 1999); 2) to address the most important ecological soil depth exposure interval, as soil depths below 2 ft would be infrequently contacted; and 3) to focus on the soil depth interval expected to have the highest COPEC concentrations, as discharges at Area P were primarily surficial. Although some burrowing wildlife (e.g., the red fox) may actually burrow to depths greater than 2 ft, their prey items would be primarily associated with surface soil, and incidental contact by the fox with deeper soil is expected to be insignificant compared to exposures associated with soil in the 0 to 2 ft depth range.

Chemicals that were not detected at least once in a medium are not included in the risk assessment, although non-detected constituents are discussed in the Uncertainty Analysis section (*Section 7 2.7*).

The analytical data may have qualifiers from the analytical laboratory QC or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings from USEPA (1989a) are discussed, along with other data issues in

Appendix A-2, **QA/QC Evaluation**. Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the HHRA.

7.1.2.2 Descriptive Statistical Calculations

Because of the uncertainty associated with characterizing contamination in environmental media, the 95% UCL of the mean has been estimated for chemicals selected as COPECs. The calculation of EPCs follows the same procedure used for the HHRA (*Section 6.2.3*).

7.1.2.3 Frequency of Detection

Chemicals that are detected infrequently (<5%) have been included in the risk evaluation as a conservative approach. Therefore, a low frequency of detection was not used to exclude COPECs.

7.1.2.4 Natural Site Constituents (Essential Nutrients)

As a conservative step, the essential nutrients calcium, magnesium, potassium, and sodium were assessed in the SLERA.

7.1.2.5 Selection of COPECs

Comparison of the MDCs of chemicals with available toxicity benchmarks was not performed based on USEPA Region 3 Biological Technical Assistance Group (BTAG) comments prohibiting a “prescreening” during the SLERA process (USEPA, 2005). Therefore, all detected chemicals in an environmental medium were assessed for the direct contact exposure pathway, and important bioaccumulative constituents (USEPA, 2000c) and explosives were selected for assessment using food chain modeling (as per USEPA Region 3 BTAG requirements). COPEC selection for Area P is detailed in *Section 7.2.2*.

Dioxin-like compounds (PCDDs and PCDFs) were detected in soil at Area P. For the Area P SLERA, dioxin-like compounds were treated according to procedures provided by USEPA and the World Health Organization (WHO) (Van den Berg et al., 2006; USEPA, 1989b, 1994b; WHO, 1998). Dioxin-like compounds are present in the environmental media as complex mixtures. PCDDs and PCDFs consist of a family of approximately 75 and 135 congeners, respectively. To simplify the task of screening PCDDs/PCDFs for evaluation in this risk assessment, these compounds were evaluated with respect to a single member of this class of compounds. The concentration of each congener was evaluated on the basis of its concentration relative to that of 2,3,7,8-TCDD, which has been shown to be the most potent congener of the class of PCDDs/PCDFs. For the SLERA, the higher of the TEFs for mammals and birds was used, as a conservative approach (Van den Berg et al., 2006; WHO, 1998). The toxicity equivalent procedure itself is described in the HHRA (*Section 6.1.1*).

It should be noted that USEPA recommends that aluminum should only be identified as a COPEC for those sites with soil with a pH less than 5.5 (USEPA, 2000c). The technical basis for this rationale is that soluble and toxic forms of aluminum are present in soil with soil pH values of less than 5.5. An analysis of five surface soil samples collected at Area P resulted in a soil pH range of 7.46 to 7.82. Since the pH values from these soil samples are estimated to be greater than 5.5, aluminum was not evaluated for direct contact exposure at Area P.

7.1.3 Identification of Exposure Pathways and Potential Receptors for Analysis

RFAAP terrestrial and aquatic wildlife may be exposed to COPECs by several pathways, including: (1) the ingestion of impacted soil, sediment, surface water, or food while foraging; (2) dermal absorption of chemicals from soil, sediment, or surface water; and (3) inhalation of chemicals that have been wind-eroded from soil or have volatilized from soil or water. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food and surface water. The incidental ingestion of impacted soil or sediment (while foraging) is typically a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are viable exposure pathways and were considered in the SLERA.

Receptor-specific exposures via inhalation or dermal absorption were not selected for further evaluation because of a lack of appropriate exposure data and the expectation that these pathways would be insignificant in comparison to the other exposure pathways quantified. Inhalation exposure would be expected to be minimal due to dilution of airborne COPECs in ambient air. Dermal exposure would also be expected to be minimal due to the expectation that wildlife fur or feathers would act to impede the transport the COPECs to the dermal layer.

The appropriate assessment receptors have been selected for evaluation in the SLERA. In order to narrow the exposure characterization portion of the SLERA on species or components that are the most likely to be affected, the SLERA has focused the selection process on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (waterfowl and fish), aquatic invertebrates, and semi-aquatic mammals and birds. Species presence was assessed during a literature review and during the site reconnaissance prior to identification of target receptor species.

Primary criteria for selecting appropriate assessment receptors included, but were not limited to, the following:

- The assessment receptor will have a relatively high likelihood of contacting chemicals via direct or indirect exposure.
- The assessment receptor will exhibit marked sensitivity to the COPECs given their mode of toxicity, propensity to bioaccumulate, etc.
- The assessment receptor will be a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance).

7.1.3.1 Terrestrial Receptors

Five representative receptor species that are expected or possible in Area P were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits, including herbivory, omnivory, and carnivory. Note: potential impacts to terrestrial plants were considered by documenting the presence or absence of vegetative stress at the site as well as by comparing soil concentrations with conservative screening values. The five animal species selected include the meadow vole (*Microtus pennsylvanicus*) (small, herbivorous mammal), short-tailed shrew (*Blarina brevicauda*) (small, insectivorous mammal), American robin (*Turdus* *migratorius*) (small omnivorous bird), red-tailed hawk (*Buteo jamaicensis*) (large, carnivorous bird), and red fox (*Vulpes vulpes*) (medium, carnivorous mammal). Data used to model exposure for these species are summarized in **Appendix F-2, Table F-1**.

The meadow vole, shrew, and robin represent the prey base for the larger predators of the area (represented by the red-tailed hawk and the red fox). A terrestrial food web is presented on **Figure 7-1**. Many of these species have limited home ranges, particularly the meadow vole, shrew, and American robin, which make them particularly vulnerable to exposure from site constituents. Receptor profiles for these five selected species are presented in the following five sections.

Meadow Vole. The meadow vole inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. The vole resides in every area of the United States and Canada where there is good grass cover, ranges in size from about 9 to 13 centimeters (cm) in length, and weighs between 17 and 52 grams (USEPA, 1993). The meadow vole has a limited foraging range, increasing its potential to be exposed (directly or indirectly) to COPECs in on-site surface soil. The vole has an average home range of 0.09 acres, with summer ranges larger than winter ranges. The vole does not hibernate and is active year-round. Population densities can range up to several hundred per hectare (USEPA, 1993).

Short-Tailed Shrew. The short-tailed shrew is an insectivore that feeds largely on soil invertebrates. It would be potentially exposed to COPECs through prey items and have a relatively high rate of incidental ingestion of soil while foraging on earthworms. This short-tailed shrew weighs between 15 and 29 grams (Whitaker, 1995). Total length of this shrew is 76 to 102 millimeters (Burt and Grossenheider, 1980). The range of this shrew extends from southeastern Canada and the northeastern U.S. to Nebraska, Missouri, Kentucky, and in the mountains to Alabama (Whitaker, 1995). Preferable habitat for the shrew includes forests, grasslands, marshes, and brushy areas. It will make a nest of dry leaves, grass, and hair beneath logs, stumps, rocks, or debris (Burt and Grossenheider, 1980). This mammal has a voracious appetite, and will consume earthworms, other terrestrial invertebrates, and sometimes young mice (Whitaker, 1995). Mean population densities range from 5.7, in the winter, to 28 per acre in the summer (USEPA, 1993). Their home range varies from 0.5 to 1 acre (Burt and Grossenheider, 1980) and an average value of 0.96 acres has been used in the SLERAs (**Appendix F-2, Table F-1**).

American Robin. The American robin is an omnivore that feeds on both plants (primarily fruit) and terrestrial invertebrates including earthworms. The robin occurs throughout most of the continental United States and Canada during the breeding season and winters in the southern half of the United States and Mexico and Central America. They live in a variety of habitats, including woodlands, wetlands, suburbs and parks. Robins are likely to forage throughout RFAAP and are present year-round. Most robins build nests of mud and vegetation on the ground or in the crotches of trees or shrubs. Robins forage primarily on the ground and in low vegetation by probing and gleaning. They are approximately 25 cm in size, have a body weight range of 63 to 103 grams, and an average home range of 1.2 acres (USEPA, 1993).

Red-Tailed Hawk. The red-tailed hawk is a common predator in the mixed landscapes typifying RFAAP. The wooded habitats and riverside trees within RFAAP are considered ideal foraging and nesting habitats for these raptors. This hawk is one of the most common and widespread members of the genus *Buteo* in the continental United States and Canada (Brown and

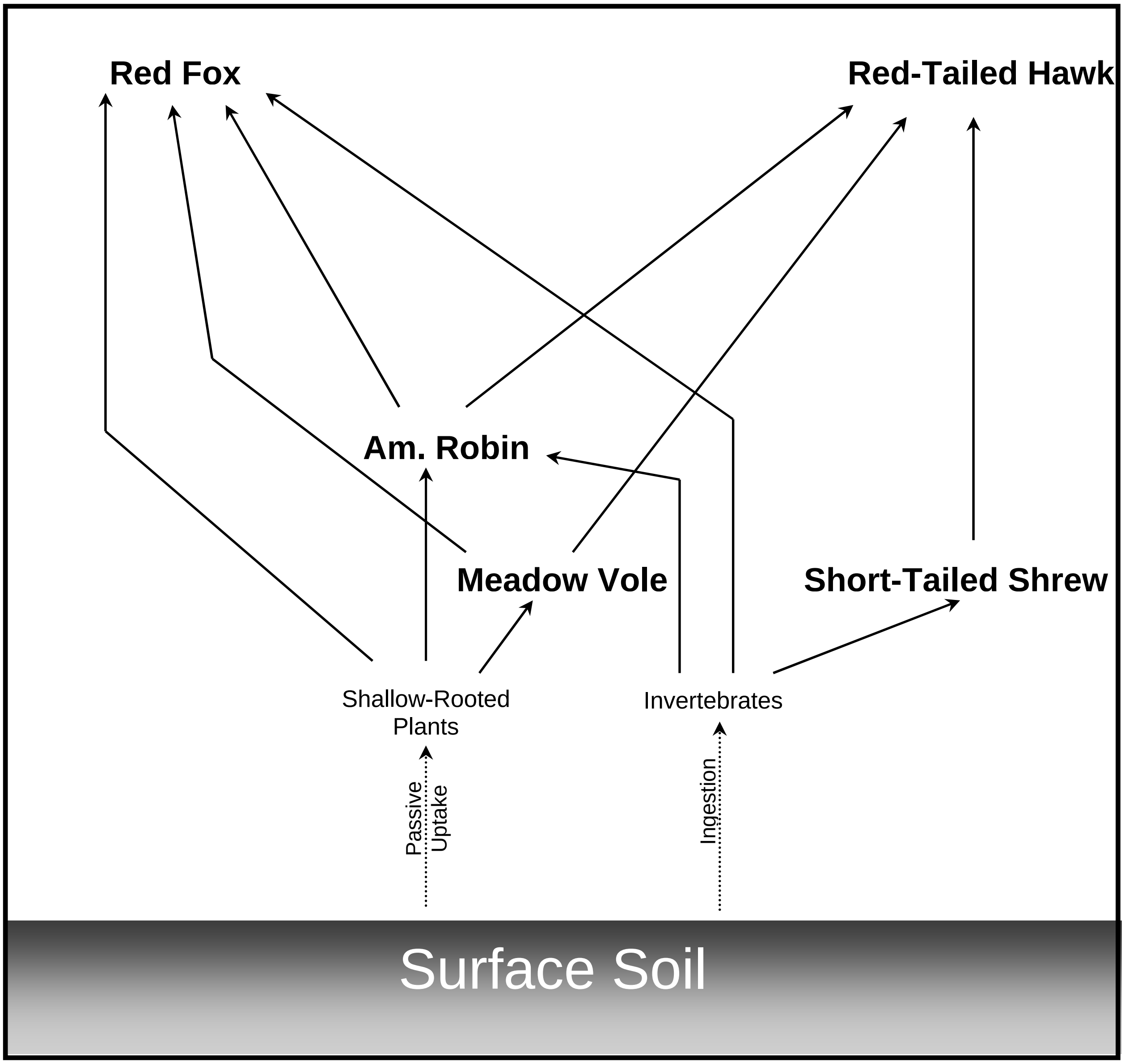


Figure 7-1. Simplified Terrestrial Food Web Conceptual Site Exposure Model (CSEM)

Amadon, 1968). Red-tailed hawks live in a variety of habitats, such as farmlands, woodlands, mountains, and deserts, as long as there is open country interspersed with woods, bluffs, or streamside trees. They are primarily carnivorous, feeding on small rodents, as well as fish. Other prey items include amphibians, reptiles, crayfish, and other birds (Adamcik et al., 1979; Ehrlich et al., 1988). Home range has been reported as small as 66.8 acres, with a population density of 0.16 pairs per acre (Janes, 1984), although USEPA (1993) reports an average territory size of 2,081 acres. Breeding population density is one nest per 0.009 acre or one individual per 0.004 acre. Body weight for male red-tails is 1,028.6 to 1,142.9 grams, and for females 1,371.4 to 1,600 grams (Brown and Amadon, 1968), although USEPA (1993) reports an average body weight of 1,134 grams. More northerly populations are migratory, while the more southerly are year-round residents.

Red Fox. The red fox is a carnivorous predator that occurs in a wide range of habitats typical of RFAAP. Red fox use many types of habitat, including cropland, rolling farmland, brush, pastures, hardwood stands, and coniferous forests. They are present throughout the United States and Canada, and are the most widely distributed carnivore in the world. These foxes have a length of 56 to 63 cm, with a 35 to 41 cm tail and an average weight of 4,530 grams. They do not undergo hibernation, and most often occupy abandoned burrows or dens of other species.

One fox family per 100 to 1,000 hectares is typical, and the average home range is 892 hectares (2,204 acres) (USEPA, 1993). Fecundity is higher in areas of high mortality and low population density.

A pictorial representation of potential exposure has been prepared and is presented as **Figure 7-1**. This food web pictorial clarifies the conceptual site exposure model (CSEM). The CSEM traces the contaminant pathways through both abiotic components and biotic food web components of the environment. The CSEM presents potentially complete exposure pathways.

7.1.3.2 Aquatic Receptors

Two representative aquatic receptor species that are expected or possible in Area P were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits, including herbivory, omnivory, and carnivory. Note: potential impacts to aquatic plants and other aquatic biota were assessed by comparing measured surface water and sediment COPEC concentrations with available direct contact criteria. The two animal species selected include the great blue heron (*Ardea herodias*) (medium, piscivorous bird) and the mink, (small, omnivorous mammal). Data used to model exposure for these species are summarized in **Appendix F-2, Table F-1**.

An aquatic food web is presented on **Figure 7-2**. The selected aquatic receptor species have a potential for high abundance at the sites that have adequate aquatic habitat; also, sufficient toxicological information (with the exception of some COPECs for the bird species) is available in the literature for comparative and interpretive purposes. Both of the species are considered important to the stability of the local ecological food chain and biotic community. Finally, the selected species have readily-available exposure data, as summarized in the *Wildlife Exposure Factors Handbook* (USEPA, 1993).

Receptor profiles for these two selected species are presented in the following paragraphs.

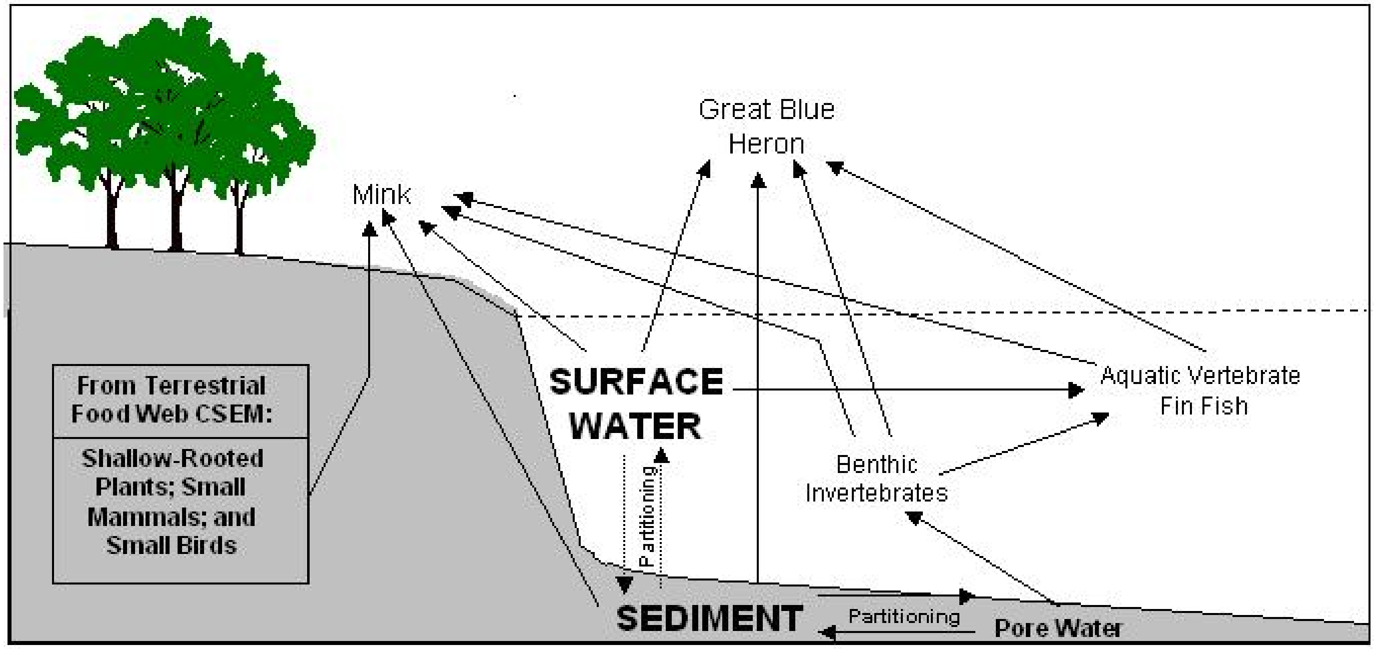


Figure 7-2. Simplified Aquatic Food Web Conceptual Site Exposure Model (CSEM)

Great Blue Heron. The great blue heron is the largest member of its group in North America (99 to 132 cm) (Bull and Farrand, 1995), with body weights ranging from 2.2 to 2.58 kilograms (kg) (USEPA, 1993). It ranges from coastal Alaska, and Nova Scotia south to Mexico (Bull and Farrand, 1995). Habitat of this heron includes both fresh and marine waters, including freshwater lakes and rivers, brackish marshes, lagoons, mangroves, and coastal wetlands, particularly where small fish are plentiful (USEPA, 1993). Great blues tend to nest in dense colonies, or heronries. The location of the heronry is generally close to foraging grounds, and tall trees are preferred over shorter trees or bushes for nest sites. Fish are the preferred prey, but the heron will also eat crustaceans, amphibians, reptiles, insects, birds, and mammals. Foraging home range may be as great as 24 kilometers; however, an average home range of 21 acres is used in the current assessment. Population densities along streams and rivers range from 2.3 to 3.6 birds per kilometer (USEPA, 1993). Once a year, the female will lay 2 to 7 eggs (Bull and Farrand, 1995), and the first year mortality rate is approximately 64 percent (USEPA, 1993).

Mink. The mink is the most abundant and widespread carnivorous mammal in North America. Mink are distributed throughout North America, except in the extreme north of Canada, Mexico, and arid areas of the southwestern United States. Mink do not undergo hibernation and are active year-round. Mink are particularly sensitive to PCBs and similar chemicals. Mink body size varies greatly throughout its range, with males weighing markedly more than females. Males measure from 33 to 43 cm with an 18 to 23 cm tail, and females measure from 30 to 36 cm, with a 13 to 20 cm tail. An average body weight of 1.02 kg has been used for purposes of the current assessment, and body weights range from 0.55 to 1.73 kg (USEPA, 1993).

Mink are found associated with aquatic habitats of every kind, including waterways such as rivers, streams, lakes, and ditches, as well as swamps, marshes, and backwater areas. Mink prefer irregular shorelines to more open exposed banks. They also tend to use brushy or woody cover adjacent to the water, where cover for prey is abundant and where downfall and debris provide den sites. Mink are predominantly nocturnal hunters. Shorelines and emergent vegetation are the mink’s principal hunting areas. Mink are opportunistic feeders, taking whatever is abundant. Mammals can be the mink’s most important prey year-round, but mink also hunt aquatic prey such as fish, amphibians, and crustaceans and other terrestrial prey such as birds, reptiles, and insects, depending on the season. In winter, mink often supplement their diet with fish.

The home range of mink encompasses both their foraging areas around waterways and their dens. Home range depends mostly on food abundance, but also on the age and sex of the mink, season, and social stability. In winter, mink spend more time near dens and use a smaller portion of their range than in summer. Adult male home ranges are generally larger than female home ranges, particularly during the mating season when males may range over 1,000 hectares. For the purposes of this assessment an average home range of 35 acres was used (USEPA, 1993).

7.1.4 Identification of Assessment and Measurement Endpoints

The protection of ecological resources such as habitats and species of plants and animals is a principal motivation for conducting the SLERA. To assess whether the protection of these resources are met at the site, assessment and measurement endpoints have been formulated to define the specific ecological values to be protected and to define the degree to which each may be protected.

Unlike the HHRA process, which focuses on individual receptors, a SLERA focuses on populations or groups of interbreeding nonhuman, non-domesticated receptors. In the SLERA process, the risks to individuals are generally assessed if they are protected under the Endangered Species Act.

Selected assessment endpoints reflect environmental values that are protected by law, are critical resources, and/or have relevance to ecological functions that may be impaired. Both the entity and attribute are identified for each assessment endpoint (Suter, 1993).

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint.

Measurement endpoints for the SLERAs are based on toxicity values from the available literature. When possible, receptors and endpoints have been concurrently selected by identifying those that are known to be adversely affected by chemicals at the site based on published literature.

7.1.4.1 Assessment Endpoints

ERAGS (USEPA, 1997c) states: “For the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the habitats' ability to support plant and animal populations and communities.”

The selected assessment endpoints for Area P are stated as the protection of long-term survival and reproductive capabilities for populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. The corresponding null hypothesis (H_o) for each of the assessment endpoints is stated as: the presence of site contaminants within soil, surface water, sediment, vegetation, and prey will have no adverse effect on the survival or reproductive capabilities of populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. In addition, assessment endpoints for the base of the food chain are stated as the protection of long-term survival and reproduction of terrestrial plants and soil/sediment dwelling invertebrates.

The food web CSEMs were developed to illustrate how the selected terrestrial and aquatic species are ecologically linked. For terrestrial and aquatic invertebrates, small prey items, fish, and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues (*Section 7.1.5*). These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary route of exposure.

7.1.4.2 Measurement Endpoints

Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results or community diversity indices) that can be compared statistically to detect adverse responses to a site contaminant (USEPA, 1997c).

As two of the selected receptor species (the American robin and the short-tailed shrew) feed on terrestrial invertebrates, a reduction in the abundance of these invertebrates could result in an adverse impact due to food shortages. Therefore, the direct contact toxicity of COPECs to soil invertebrates was selected as a measurement endpoint for protection of long-term survival and reproductive capabilities for populations of insectivorous mammals and omnivorous birds.

7.1.5 Exposure Estimation

This section includes a discussion of how COPEC exposures were quantified, including intake (*Section 7.1.5.1*) and bioaccumulation (*Section 7.1.5.2*).

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the sites was developed, considering both current and reasonably plausible future use scenarios.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (bioaccumulation). Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment; animals ingesting surface water; plants absorbing contaminants by uptake from contaminated soil or sediment; and the dermal contact of aquatic organisms with contaminated surface water or sediment. In addition, as discussed in *Section 7.1.3*, dermal contact and inhalation exposures are considered insignificant compared to other quantified routes of exposure.

Bioavailability of a chemical is an important contaminant characteristic that influences the degree of chemical-receptor interaction. The surface soil pH at samples collected from Area P range from about 7.5 to 8.7. For purposes of the SLERA, bioavailability is conservatively assumed to be 100 percent.

For terrestrial and aquatic faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface soil, surface water, or sediment, and on transfer factors used for food chain exposure. Exposure rates for terrestrial and aquatic wildlife receptors in this SLERA are based solely upon ingestion of contaminants from these media and from consumption of other organisms.

7.1.5.1 Intake

The first step in estimating exposure rates for terrestrial and aquatic wildlife involves the calculation of food ingestion and drinking water intake rates for site receptors. USEPA (1993) includes a variety of exposure information for a number of avian and mammalian species. Information regarding feeding rates, watering rates and dietary composition are available for many species, or may be estimated using allometric equations (Nagy, 1987). Data have also been gathered on incidental ingestion of soil and/or sediment, and are incorporated for the receptor species. This information is summarized in **Appendix F-2**, **Table F-1**. For the SLERA, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure [i.e., area use factor (AUF) set equal to unity], and the use of COPEC MDCs as EPCs. Less conservative Tier 2 exposures are based on average dietary and incidental soil intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95% UCLs. These Tier 2 exposures may be considered as a portion of Step 3a of the ERAGS 8-step process.

Algorithms have been evaluated for calculating exposure for terrestrial vertebrates that account for exposure via ingestion of contaminated water, incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and prey items. Results for these algorithms are presented in **Appendix F-2, Tables F-2 through F-15**.

The basic equation for estimating dose through the dietary pathway is:

$$D_p = \sum_{k=1}^{m} (C_k \times F_k \times I_k) / W$$

where:

D_p = the potential average daily dose (mg/kg-day),
C_k = the average COPEC concentration in the kth food type (mg/kg dry weight)
F_k = the fraction of the kth food type that is contaminated
I_k = the ingestion rate of the kth food type (kg dry weight/day)
W = the body weight of the receptor (kg wet weight).

Literature values for animal-specific sediment ingestion have been used if available. However, such values generally are not available in the literature. Where sediment ingestion rates could not be found, the animal-specific incidental soil ingestion rate is used for sediment ingestion as well, if the receptors life history profile suggests a significant aquatic component, and if sediment is a medium of concern at the site.

The estimated chemical intakes for the exposed receptors for the relevant pathway and scenario are presented in the risk characterization spreadsheets referenced in *Section 7.2.3*.

7.1.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERA, bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for soil-to-plants, soil-to-earthworms, soil-to-small mammals and birds, sediment-to-aquatic invertebrates, and surface water-to-fish are presented in **Appendix F-2**, **Tables F-16, F-17, F-18, F-19, and F-20**, respectively. BAFs and/or BCFs were not available for every COPEC, but were estimated as described in the footnotes to these tables. For each BAF/BCF pathway, both a Tier 1 and Tier 2 value is presented, as recommended in the *Site Screening Process* (USEPA, 2001c) and the *RFAAP Final MWP* (URS, 2003). The Tier 1 BAF/BCF is generally the upper bound value found in the literature, to represent a worst-case exposure scenario, while the Tier 2 BAF/BCF represents a conservative, yet more realistic exposure value.

Soil-to-plant BAF/BCF values (**Appendix F-2**, **Table F-16**) are based on information from Bechtel Jacobs (1998a), USEPA (2008c), Efroymson (2001), Baes et al. (1984), International Atomic Energy Agency (IAEA) (1994), and Travis and Arms (1988). Values are based on regression equations, if available, that produce a BAF/BCF value that scales in a non-linear fashion with soil COPEC concentration. If a regression equation is not available or not recommended for a particular COPEC, a median value is used for the Tier 2 assessment. It should be noted that as the regression equation predicts COPEC concentrations in plants, the actual BAF/BCF value is estimated by dividing the estimated plant COPEC concentration by the soil COPEC concentration. For organic COPEC without available BAF/BCF values, the K_{ow} regression equation from Travis and Arms (1988) is used, as shown as follows:

$$Log\ BAF / BCF = -0.578 \times Log\, K_{ow} + 1.588$$

where:

Log Kow = log octanol-water partition coefficient (see **Appendix F-2, Table F-16**)

In order to estimate Tier 1 and Tier 2 BAF/BCF plant uptake values using the Travis and Arms (1988) regression equation, the log K_{ow} value from the USEPA EPI Suite program (USEPA, 2007b) was used. BAF/BCF values estimated for organics using the Travis and Arms (1988) equation ranged from 0.0036 (for Aroclor 1254) to 0.0039 (for TCDD) for the Tier 1 and Tier 2 approaches (**Appendix F-2**, **Table F-16**).

Soil-to-earthworm BAF/BCF values (**Appendix F-2**, **Table F-17**) are based on information from USEPA (2008c), Sample et al. (1998a), and Sample et al. (1999). Earthworms are used as a surrogate species to represent terrestrial invertebrates including insects. Values are based on Ecological Soil Screening Level (EcoSSL) uptake values or regression equations, if available. If a regression equation or recommended uptake value is not available for a particular COPEC, an upper-bound value is used. It should be noted that as the regression equation predicts COPEC concentrations in earthworms, the actual BAF/BCF value is estimated by dividing the earthworm COPEC concentration by the soil COPEC concentration.

Soil-to-small mammal and small bird BAF/BCF values (**Appendix F-2**, **Table F-18**) are based on information from USEPA (2008c) and Sample et al. (1998b). Values are based on regression equations (USEPA, 2008c) or upperbound BAF/BCF values if no regression equation is available. If no organic surrogate soil uptake value was available, a conservative default BAF/BCF of 1 was used for the Tier 1 assessment, while a default BAF/BCF of 0.5 was used for the Tier 2 assessment.

Sediment-to-aquatic invertebrate BAF/BCF values (**Appendix F-2**, **Table F-19**) are based on information from Bechtel Jacobs (1998b). If no uptake value was available for inorganic COPECs, geometric means of the available inorganic uptake values from Bechtel Jacobs (1998b) were used: the geometric mean of the 90th percentile values (2.1) was used for the Tier 1 BAF/BCF value and the geometric mean of the median values (0.42) was used for the Tier 2 BAF/BCF value. If no uptake value was available for organic COPECs, a soil-to-terrestrial invertebrate BAF/BCF value was used (from **Appendix F-2**, **Table F-17**).

Water-to-fish BAF/BCF values (**Appendix F-2, Table F-20**) are based on information from IAEA (1994), Bintein and Devillers (1993), USEPA (1999a), and USEPA (1989c). The Tier 1 value was the maximum BAF/BCF value available from the literature, while the Tier 2 value used represents a conservative, yet more realistic uptake value.

For surface water organic COPECs that did not have available literature uptake values from IAEA (1994), the following equation from Bintein and Devillers (1993) with the log K_{ow} value from the USEPA EPI Suite program (USEPA, 2007b), was used to estimate the BAF/BCF, along with the COPEC-specific K_{ow}:

$$Log\,BAF/BCF = 0.910 \times Log K_{ow} - 1.975 \times Log(6.8 \times 10^{-7} \times K_{ow} + 1) - 0.786$$

where:

Log Kow = log octanol-water partition coefficient (see **Appendix F-2, Table F-20**)

However, since the only aquatic food chain COPEC was arsenic, no Fish BAF/BCF values were estimated using the Bintein and Devillers (1993) equation (**Appendix F-2**, **Table F-20**).

7.1.6 Ecological Effects Characterization

This ecological effects characterization section presents the selection of literature benchmark values and the development of reference toxicity values.

7.1.6.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values have been consulted, such as Toxicological Benchmarks for Wildlife (Sample et al., 1996); EcoSSLs (USEPA, 2008c); Ecorisk Database, Release 2.2 (LANL, 2005); Toxicological Profile for Silver, U.S. Public Health Service (ATSDR, 1990); Toxicological Profile for 1,1,2,2-Tetrachloroethane, U.S. Public Health Service (ATSDR, 1996); PAH Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review (Eisler, 1987); TERRETOX, http://www.epa.gov/ecotox; Terrestrial Toxicity Database (USACHPPM, 2002); SLERA Protocol for Hazardous Waste Combustion Facilities (USEPA, 1999a); Office of Pesticide Programs Environmental Effects Database (USEPA, 2000d); and IRIS (USEPA, 2008b). Some values were extrapolated to chronic NOAEL or Lowest-Observed-Adverse-Effect Level (LOAEL) values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors (UFs).

7.1.6.2 Development of Toxicity Reference Values

Toxicity reference values (TRVs) were selected from available data for use in the Area P SLERA. These TRVs focus on the growth, survival, and reproduction of species and/or populations. Empirical data are available for the specific receptor-endpoint combinations in some instances. However, for some COPECs, data on surrogate species and/or on endpoints other than the NOAEL and LOAEL had to be used. The NOAEL is a dose of each COPEC that will produce no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint for the Tier 1 approach since it would provide the greatest degree of protection to the receptor species; however, both NOAELs and LOAELs are used for informational purposes in the Tier. Both the NOAEL and the LOAEL were also used in the Tier 2 approach; however, the LOAEL is recommended as a point of comparison for decision-making for risk management purposes. In general, LOAELs for growth, reproduction and/or developmental endpoints are thought to be protective at the population level of biological organization. In addition, in instances where data are unavailable for a site-associated COPEC, toxicological information for surrogate chemicals had to be used. Safety factors are used to adjust for these differences and extrapolate risks to the site's receptors at the NOAEL and/or

LOAEL endpoint. This process is described below and the values are presented in **Appendix F-2, Tables F-21 and F-22** for NOAEL and LOAEL TRVs, respectively.

Toxicity information pertinent to identified receptors has been gathered for those analytes identified as COPECs. Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference was given to chronic studies noting concentrations at which no adverse effects were observed and ones for which the lowest concentrations associated with adverse effects were observed.

Using the relevant toxicity information, TRVs have been calculated for each of the COPECs. TRVs represent NOAELs and LOAELs with safety factors incorporated for toxicity information derived from studies other than no-effects or lowest-effects studies.

TRVs have been calculated from LD_{50} values, when required, using safety factors specified in Ford et al. (1992) and reported in Wentsel et al. (1996) and summarized in the footnotes to **Appendix F-2, Tables F-21 and F-22**. As recommended by Hull et al. (2007), allometric dose scaling using body mass was not performed for chronic TRVs because this approach is not scientifically defensible and interclass toxicity extrapolations were not performed as physiological differences between classes are too great to be addressed with the use of simplistic safety factors. Separate UFs were used to account for extrapolation to the no effects or lowest-effects endpoints, for study duration, and for extrapolation across taxonomic groups (e.g., species, genus, family, order), as shown in **Appendix F-2, Table F-23** for the receptors used in the SLERAs. Although additional safety factors may be employed for endangered species, no endangered species were selected as representative receptors and these additional safety factors were not required.

These factors were used together to derive a final adjusted TRV, as shown in the risk characterization spreadsheets referenced in *Section 7.1.7*. TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant. To complete this comparison, receptor exposures to site contaminants are calculated.

7.1.7 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semi quantitative approaches have been taken to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs.

For this assessment, TRVs and exposure rates have been calculated and are used to generate HQs (Wentsel et al., 1996), by dividing the receptor exposure rate for each contaminant by the calculated TRV. Environmental effects quotients (EEQs) or HQs are a means of estimating the potential for adverse effects to organisms at a contaminated site, and for assessing the potential that toxicological effects will occur among site receptors.

7.1.7.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance or via reviewing site photographs. The overall health of the plant community at the sites was comparable to the plant communities in the surrounding areas. Plants were not quantitatively evaluated in the SLERAs as the *RFAAP Final MWP* (URS, 2003) states: “Owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects." In addition, because of an inadequate plant toxicity database, and because of the disturbed nature of the sites (i.e., mowing on an infrequent basis to eliminate woody plants), potential risks to plants are not deemed a reason to recommend further action. However, terrestrial plant impacts are discussed further in *Section 7.2.4*.

7.1.7.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with Area P are estimated in the SLERA. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure doses with TRVs. The EEQs (or HQs) are compared to HQ guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. Whether or not HQ summation was appropriate and scientifically defensible is based on whether the chemicals have a similar mode of toxicological action (see *Section 7.2.3.2*). While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial and aquatic receptors at Area P are presented in risk characterization tables for the seven selected receptor species.

7.1.8 Approach for the Evaluation of Direct Contact Toxicity

For direct contact exposure to COPECs in surface soil, sediment, and surface water; measured COPEC concentrations were simply compared with direct contact benchmarks appropriate for these media. COPEC media concentrations are compared with BTAG-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in soil, sediment, and surface water. The results are summarized in *Section 7.2.4*.

7.1.8.1 Soil

A two-step process was used to assess direct contact soil toxicity. First, the maximum detected soil concentration was compared with the lowest available EcoSSL (USEPA, 2008c), or if an EcoSSL was not available, with the lowest BTAG (USEPA, 1995b) soil screening value. A chemical was only retained as a COPEC if the MDC exceeded the EcoSSL, or in the absence of an EcoSSL, if the MDC exceeded the BTAG soil screening value. If no EcoSSL or BTAG value was available, the value was also carried forward for comparison to other available screening values (listed below). The results are summarized in *Section 7.2.4.1*.

In the second step, the MDCs of the chemicals carried-forward were compared with up to five individual soil screening values [although not the BTAG screening value, as the BTAG (USEPA, 1995b) soil screening values are no longer available on the BTAG website and are in the process of being revised]. In addition, an exposure concentration more representative of potential community-level effects is also used in the evaluation, expressed as the 95% UCL.

- Dutch intervention values (Netherlands Ministry of Housing, Spatial Planning and Environment, 2000), Circular on Target Values and Intervention Values for Soil Remediation.
- Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.
- Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2008c).
- ORNL (1997a, ES/ER/TM-85/R3), screening benchmarks for plants.
- ORNL (1997b, ES/ER/TM-126/R2), screening benchmarks for earthworms.

7.1.8.2 Sediment

As there are no promulgated sediment screening criteria for aquatic organisms potentially exposed to COPECs in sediment collected from Area P, a weight-of-evidence approach was used, where the more sediment benchmarks exceeded by the COPEC concentration, the greater the potential for adverse effects. The results are summarized in *Section 7.2.4.2*. As most sediment-dwelling aquatic biota are relatively non-mobile, maximum detected sediment concentrations are used. In addition, an exposure concentration more representative of potential community-level effects is also used in the evaluation, expressed as the 95% UCL. Sediment benchmarks used to assess direct contact exposure include the following:

- BTAG Screening Values (USEPA, 2006b).
- Threshold Effect Concentrations from Assessment and Remediation of Contaminated Sediments (ARCS) program (ORNL, 1997c).
- Probable Effect Concentrations from ARCS program (ORNL, 1997c).
- No Effect Concentrations from ARCS program (ORNL, 1997c).
- Sediment Quality Benchmarks (ORNL, 1997c).
- Canadian Interim Sediment Quality Guidelines (CCME, 2003).
- Canadian Probable Effects Levels (PELs) (CCME, 2003).
- National Oceanic and Atmospheric Administration (NOAA) Effect Range – Low values (ORNL, 1997c).
- NOAA Effect Range – Median (ORNL, 1997c).
- Florida Department of Environmental Protection (FDEP) Threshold Effect Concentrations (MacDonald et al., 2003).
- FDEP Probable Effect Concentrations (MacDonald et al., 2003).
- Washington State Adverse Effect Thresholds (ORNL, 1997c).

7.1.9 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to determine if any inorganic COPECs were potentially related to naturally-occurring soil concentrations. Inorganics with MDCs that are not statistically different based on appropriate population statistical tests are considered background related (*Section 6.4.3*). Individual results are discussed in *Section 7.2.6*.

7.1.10 Groundwater/Seep Discharge to New River

Determination of a Dilution Factor

In order to evaluate concentrations of groundwater COPECs in the New River resulting from groundwater discharge at Area P, a dilution factor was estimated using the following equation:

$$DF = \frac{Q_{NewRiver}}{Q_{gw}}$$

where:

DF = dilution factor (unitless)
$Q_{\text{New River}}$ = volumetric low flow in the New River (cfs)
Q_{gw} = average volumetric discharge rate for groundwater (cfs)

Volumetric Flow in the New River. Compared with the flow in the New River, groundwater discharge from Area P to the New River is relatively low; therefore, considerable dilution of the groundwater COPECs is expected. As shown on **Figure 7-3**, average monthly flows in the New River adjacent to the site range from a low of approximately 2,400 cubic feet per second (cfs) in August-September to a high of approximately 6,000 cfs in March. Considering the low-flow value minus one standard deviation and the high-flow value plus one standard deviation (for the 64-year period of record) the average August-September and March monthly flows could range from approximately 800 to 8,400 cfs (**Figure 7-3**). The flow in the New River near the site is controlled by discharges from the Claytor Reservoir located approximately eight miles upstream (Appalachian Power Company, 2006). Due to hydroelectric power needs for the Claytor Hydroelectric Project and agreements with downstream users, the Claytor Hydroelectric Project is operated to provide a minimum average daily flow of 750 cfs (Appalachian Power Company, 2006). The Little River provides additional flow to the New River between the Claytor Reservoir spillway and the site. As shown on **Figure 7-4**, average monthly flows in the Little River range from a low of approximately 251 cfs in August to a high of approximately 538 cfs in March. Considering the low-flow value minus one standard deviation and the high-flow value plus one standard deviation (for the 76-year period of record), the average August and March Little River monthly flows could range from approximately 51 to 760 cfs (**Figure 7-4**). Based on this information, the 7-day average low flow expected with a recurrence interval of 10 years (7Q10) is estimated to be approximately 50 cfs for the Little River. The 7Q10 value is a conservative low flow value typically used to assess possible adverse impacts to aquatic life during the critical low flow period. According to Nelms et al. (1997), a 75th percentile 7Q10 flow can be estimated using a drainage area base-flow factor of 0.16 cfs per square mile for streams and rivers in the south Valley and Ridge Region of Virginia. As the Little River has a drainage area of 300 square miles, use of a drainage area base-flow factor of 0.16 cfs translates into an estimated 7Q10 of 48 cfs that is very close to the estimate of 50 cfs.

Adding the Little River estimated 7Q10 flow of 50 cfs to the minimum Claytor Reservoir discharge flow of 750 cfs results in an estimated total low flow of 800 cfs for the New River near the site.

Figure 7-3. New River Mean Monthly Flow at Radford Virgina (1939-2003)

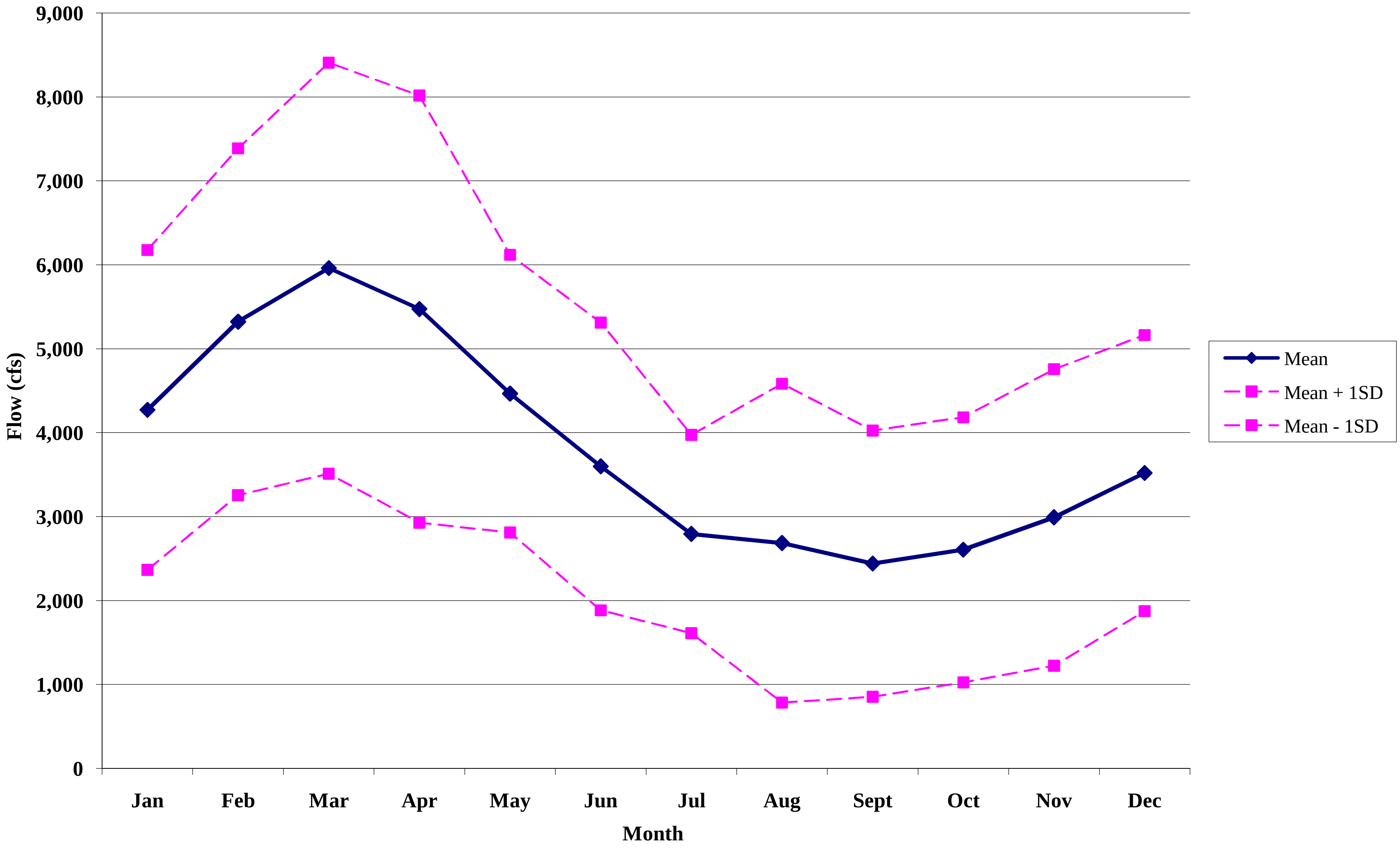
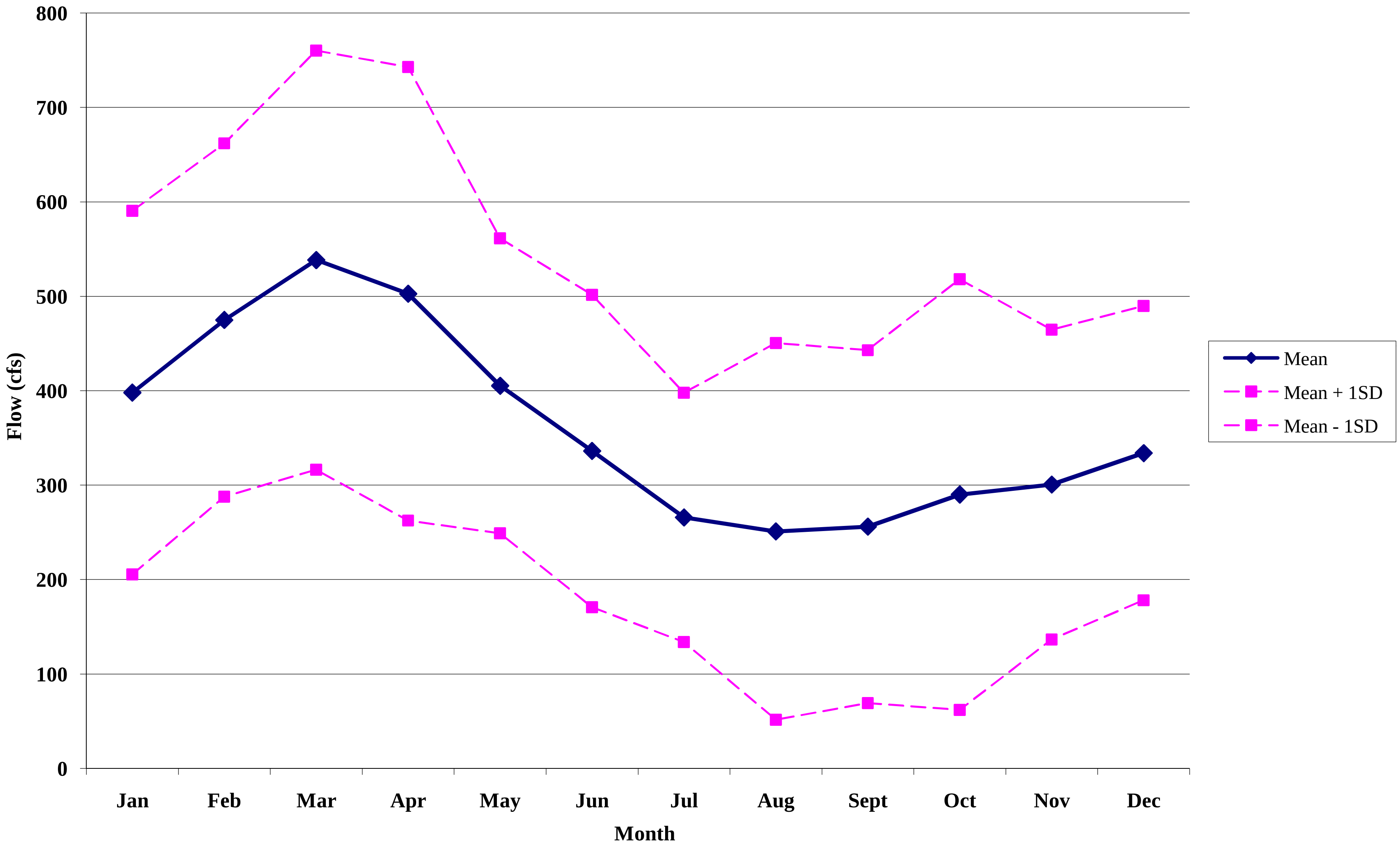


Figure 7-4. Little River Mean Monthly Flow near Radford Virginia (1929-2005)



Average Volumetric Flow of Contaminated Groundwater. The average volumetric discharge rate for the contaminated groundwater is defined by the following equation:

$$Q_{gw} = T \bullet I \bullet w$$

where:

Q_{gw} = volumetric discharge rate [ft^3/s]
T = transmissivity [ft^2/s]
I = hydraulic gradient [dimensionless]
w = width of groundwater plume[ft]

The estimated groundwater transmissivity used in this evaluation is based on the maximum transmissivity for flood plain monitoring wells (31MW1 and 54MW4) in the Horseshoe Area of RFAAP. Based on short-term pumping test results presented in the Current Conditions Report (Shaw, 2005), groundwater transmissivities from two wells, 31MW1 and 54MW4, were estimated at 1.2E-3 square feet per minute (ft^2/min) and 6.8E-3 ft^2/min, respectively. The maximum groundwater transmissivity (6.8E-03 ft^2/min, or 1.13E-4 ft^2/s) was used in this analysis. Groundwater gradient data were not available for Area P; therefore, gradient data from SWMU 43 were used for Area P. Groundwater gradients were estimated at SWMU 43 to range from 0.005 ft/ft to 0.0105 ft/ft. The maximum groundwater gradient (0.0105 ft/ft) was used in this analysis.

The width of the potentially contaminated groundwater plume at Area P (based on the width of the battery storage) used to estimate the groundwater discharge rate was 75 ft. The resulting dilution factor for Area P is 8.95E+06 (e.g., 800/8.94E-5 = 8.95E+6). Since this dilution factor is large and mixing of the groundwater with the flow in the New River is not instantaneous, a conservative dilution factor of 100 is assumed for Area P.

7.1.11 General Uncertainty Analysis

The results of the SLERA are influenced to some degree by variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the media or species sampled. Alternatively, uncertainty within the risk analysis can be reduced by using species-specific and site-specific data (i.e., to better quantify contamination of media, vegetation, and prey through: direct field measurements, toxicity testing of site-specific media, and field studies using site-specific receptor species). Detailed media, prey, and receptor field studies are costly; thus, the preliminary analyses of risk have been conducted to limit the potential use of these resource-intensive techniques to those COPECs that continue to show a relatively high potential for ecological risk. Since assessment criteria were developed based on conservative assumptions, the result of the assessment errs on the side of conservatism. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true null hypothesis) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false null hypothesis).

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error; laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Calculating an estimated value based on a large number of assumptions is often the alternative to the accurate (but costly) method of direct field or laboratory observation, measurement, or testing.

There were numerous chemical constituents not detected in surface soil, sediment, and/or surface water samples. The uncertainty associated with these constituents' detection limits for Area P was evaluated by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value (see *Section 7.2.7*).

Some of the non-detect constituents had maximum detection limits that exceeded the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

The general uncertainty analysis is presented in **Table 7-4** and lists some of the major assumptions made for the SLERA; the direction of bias caused by each assumption (i.e., if the uncertainty results in an overestimate or underestimate of risk); the likely magnitude of impact [quantitative (percent difference), or qualitative (high, medium, low, or unknown)]; if possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases; and the ease of implementing the recommendation (USEPA, 1997a).

The uncertainty analysis identifies and, if possible, quantifies the uncertainty in the individual preliminary scoping assessment, problem formulation, exposure and effects assessment, and risk characterization phases of the SLERA. Based on this uncertainty analysis, the most important biases that may result in an overestimation of risk include the following:

- Assuming that COPECs are 100 percent bioavailable.
- Using some laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and/or prey species.
- Use of the HQ method to estimate risks to populations or communities.

Table 7-4
General Uncertainty Analysis

Component	Bias	Magnitude	Ways to Minimize Uncertainty	Additional Comments
Use of 95% UCL as source-term concentration	Overestimates Risk	Medium	Use central tendency	Easy to implement, but may not be acceptable to Agency.
Use of representative receptor species for site ecological community	Underestimates Risk	Low	Select additional receptor species	Easy to implement, but unlikely to change conclusions.
Use of conservative foraging factors (i.e., 100%) for some species	Overestimates Risk	Medium	Use more site-specific foraging factors, i.e., less than 100%	May be difficult to obtain site-specific foraging factors.
Assumption that COPECs are 100% bioavailable	Overestimates Risk	Medium to High	Obtain medium- and COPEC-specific bioavailability factors	Would be very difficult and costly to obtain these bioavailability factors.
Discounting of dermal and inhalation exposure routes	Underestimates Risk	Low	Include dermal and inhalation routes of exposure	Would be difficult to quantify these routes of exposure.
Use of partitioning and transfer factors to estimate COPEC concentrations in plants, invertebrates, and prey items.	Overestimates Risk	Medium to High	Measure COPEC concentrations in site plants, invertebrates, and/or other prey species	Would be costly to implement, but could significantly reduce EEQs.
Use of safety factors to convert LOAEL and LD_{50} toxicity data to NOAELs	Overestimates Risk	Medium	Obtain COPEC-specific NOAEL data	Would be costly to implement, unless data available in the literature.
Use of uncertainty factor of 8 to extrapolate TRVs between most species within the same class	Overestimates Risk	Medium	1) Assume TRVs similar for species in the same genus, family, or order; or 2) obtain species-specific NOAEL data	1) May not be accepted by Agency. 2) Would be very difficult to obtain species-specific NOAEL data.
Use of surrogate constituents to estimate toxicity for those COPECs without available toxicity data	Overestimates Risk	Low to Medium	Obtain COPEC-specific toxicity data	Would be very costly to obtain COPEC-specific toxicity data, unless available in the literature.
Use of hazard quotient method to estimate risks to populations or communities may be biased	Overestimates Risk	High	Perform population or community studies	Would be very costly to perform.

7.2 Screening Level Ecological Risk Assessment

This section presents the SLERA for Area P (Battery Storage Area). The detailed methodology used for performance of the SLERA is presented in *Section 7.1*. This section includes a Site Characterization (*Section 7.2.1*); Summary of COPEC Selection (*Section 7.2.2*); Risk Characterization (*Section 7.2.3*); Direct Contact Toxicity (*Section 7.2.4*); Background Metals Considerations (*Section 7.2.5*); Groundwater Evaluation (*Section 7.2.6*); Uncertainty Analysis (*Section 7.2.7*); and Results and Conclusions (*Section 7.2.8*).

7.2.1 Site Characterization

The Spent Battery Storage Area, Area P (**Figure 2-1**), is a 50 ft by 200 ft long (approximately 0.378 acres) fenced gravel area located adjacent to the New River. The site is generally level, sloping gently towards the north to the river, which is 200 ft from the storage area. Area P is in the center of a scrap metal yard that was formerly used for storage of scrap metal, decommissioned tanks, powder cans, and batteries prior to off-post shipment.

Surface soil, sediment, and groundwater samples collected from the site and utilized in the SLERA are listed in **Table 7-5**; note that subsurface soil samples were not used in the SLERA (see *Section 7.1.2.1* for discussion).

Table 7-5
Area P Sample Groupings

Surface Soil	Sediment	Groundwater
APSB06A	APSD01	APGW02
APSB07A		APGW03
APSB08A		APGW04
APSB09A		APGW05
APSB10A		TMGW05 (duplicate)
PSB1 (RVFS*76)		
PSB2 (RVFS*78)		
PSB3 (RVFS*80)		
PSB4 (RVFS*82)		
PSB5 (RVFS*84)		

7.2.2 Summary of COPEC Selection

Tables 7-6 and 7-7 (surface soil) and **Tables 7-8 and 7-9** (sediment) have been prepared for detected constituents with the following information:

- CAS number.
- Chemical name.
- Range of detected concentrations, and associated qualifiers.
- Concentration units.
- Location of MDC.
- Frequency of detection.
- Range of detection limits.

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at Area P

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	11097-69-1	Aroclor 1254	4.02E-02	4.03E-01	mg/kg	APSB06A	2/5	1.80E-02 - 1.80E-02	Yes	DET
	127-18-4	Tetrachloroethene	6.40E-03	6.40E-03	mg/kg	APSB08A	1/5	4.70E-03 - 5.20E-03	Yes	DET
	79-01-6	Trichloroethene	5.40E-03	5.40E-03	mg/kg	APSB07A	1/5	4.70E-03 - 5.30E-03	Yes	DET
	7429-90-5	Aluminum	3.62E+03	1.32E+04	mg/kg	PSB5 (RVFS*84)	10/10	N/A	Yes	DET
	7440-36-0	Antimony	1.05E+01	1.05E+01	mg/kg	PSB2 (RVFS*78)	1/10	2.00E-01 - 7.14E+00	Yes	DET
	7440-38-2	Arsenic	9.23E-01	4.30E+00 K	mg/kg	APSB08A	10/10	N/A	Yes	DET
	7440-39-3	Barium	5.27E+01 J	2.57E+02	mg/kg	PSB4 (RVFS*82)	10/10	N/A	Yes	DET
	7440-41-7	Beryllium	4.30E-01	9.70E-01 L	mg/kg	APSB06A	8/10	5.00E-01 - 5.00E-01	Yes	DET
	7440-43-9	Cadmium	1.80E-01 L	3.90E-01 L	mg/kg	APSB08A	2/10	5.20E-02 - 7.00E-01	Yes	DET
	7440-70-2	Calcium	1.18E+03 J	1.60E+05	mg/kg	PSB2 (RVFS*78)	10/10	N/A	Yes	DET
	7440-47-3	Chromium	7.63E+00	5.96E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	DET
	7440-48-4	Cobalt	2.65E+00	1.26E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	DET
	7440-50-8	Copper	5.00E+00 J	3.47E+02	mg/kg	PSB2 (RVFS*78)	10/10	N/A	Yes	DET
	7439-89-6	Iron	6.88E+03	2.49E+04	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	DET
	7439-92-1	Lead	4.90E+00 J	1.50E+02	mg/kg	PSB5 (RVFS*84)	10/10	N/A	Yes	DET
	7439-95-4	Magnesium	1.62E+03 J	8.30E+04	mg/kg	PSB2 (RVFS*78)	10/10	N/A	Yes	DET
	7439-96-5	Manganese	1.30E+02	1.24E+03 J	mg/kg	APSB08A	10/10	N/A	Yes	DET
	7439-97-6	Mercury	1.00E-02 J	9.10E-02	mg/kg	APSB08A	5/10	5.00E-02 - 5.00E-02	Yes	DET
	7440-02-0	Nickel	6.60E+00 J	3.34E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	DET
	7440-09-7	Potassium	9.32E+02	1.74E+03	mg/kg	PSB5 (RVFS*84)	8/8	N/A	Yes	DET
	7782-49-2	Selenium	2.40E+00 J	5.60E+00 J	mg/kg	APSB08A	5/10	2.50E-01 - 2.50E-01	Yes	DET
	7440-22-4	Silver	6.92E-01	1.79E+00	mg/kg	PSB2 (RVFS*78)	2/10	7.30E-02 - 5.89E-01	Yes	DET
	7440-23-5	Sodium	1.79E+02	2.81E+02	mg/kg	PSB2 (RVFS*78)	5/8	2.60E+01 - 2.80E+01	Yes	DET
	7440-62-2	Vanadium	1.15E+01 J	4.14E+01	mg/kg	PSB5 (RVFS*84)	10/10	N/A	Yes	DET
	7440-66-6	Zinc	3.65E+01 J	1.06E+03 J	mg/kg	APSB08A	10/10	N/A	Yes	DET

COPEC Selection Rationale Codes

Selection Reason: Detected constituent (DET)
Deletion Reason: Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions:

N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern
for Surface Soil Food Chain Exposure at Area P

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	11097-69-1	Aroclor 1254	4.02E-02	4.03E-01	mg/kg	APSB06A	2/5	1.80E-02 - 1.80E-02	Yes	IBC
	127-18-4	Tetrachloroethene	6.40E-03	6.40E-03	mg/kg	APSB08A	1/5	4.70E-03 - 5.20E-03	No	NIBC
	79-01-6	Trichloroethene	5.40E-03	5.40E-03	mg/kg	APSB07A	1/5	4.70E-03 - 5.30E-03	No	NIBC
	7429-90-5	Aluminum	3.62E+03	1.32E+04	mg/kg	PSB5 (RVFS*84)	10/10	N/A	No	NIBC
	7440-36-0	Antimony	1.05E+01	1.05E+01	mg/kg	PSB2 (RVFS*78)	1/10	2.00E-01 - 7.14E+00	No	NIBC
	7440-38-2	Arsenic	9.23E-01	4.30E+00 K	mg/kg	APSB08A	10/10	N/A	Yes	IBC
	7440-39-3	Barium	5.27E+01 J	2.57E+02	mg/kg	PSB4 (RVFS*82)	10/10	N/A	No	NIBC
	7440-41-7	Beryllium	4.30E-01	9.70E-01 L	mg/kg	APSB06A	8/10	5.00E-01 - 5.00E-01	No	NIBC
	7440-43-9	Cadmium	1.80E-01 L	3.90E-01 L	mg/kg	APSB08A	2/10	5.20E-02 - 7.00E-01	Yes	IBC
	7440-70-2	Calcium	1.18E+03 J	1.60E+05	mg/kg	PSB2 (RVFS*78)	10/10	N/A	No	NIBC
	7440-47-3	Chromium	7.63E+00	5.96E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	IBC
	7440-48-4	Cobalt	2.65E+00	1.26E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	No	NIBC
	7440-50-8	Copper	5.00E+00 J	3.47E+02	mg/kg	PSB2 (RVFS*78)	10/10	N/A	Yes	IBC
	7439-89-6	Iron	6.88E+03	2.49E+04	mg/kg	PSB1 (RVFS*76)	10/10	N/A	No	NIBC
	7439-92-1	Lead	4.90E+00 J	1.50E+02	mg/kg	PSB5 (RVFS*84)	10/10	N/A	Yes	IBC
	7439-95-4	Magnesium	1.62E+03 J	8.30E+04	mg/kg	PSB2 (RVFS*78)	10/10	N/A	No	NIBC
	7439-96-5	Manganese	1.30E+02	1.24E+03 J	mg/kg	APSB08A	10/10	N/A	No	NIBC
	7439-97-6	Mercury	1.00E-02 J	9.10E-02	mg/kg	APSB08A	5/10	5.00E-02 - 5.00E-02	Yes	IBC
	7440-02-0	Nickel	6.60E+00 J	3.34E+01	mg/kg	PSB1 (RVFS*76)	10/10	N/A	Yes	IBC
	7440-09-7	Potassium	9.32E+02	1.74E+03	mg/kg	PSB5 (RVFS*84)	8/8	N/A	No	NIBC
	7782-49-2	Selenium	2.40E+00 J	5.60E+00 J	mg/kg	APSB08A	5/10	2.50E-01 - 2.50E-01	Yes	IBC
	7440-22-4	Silver	6.92E-01	1.79E+00	mg/kg	PSB2 (RVFS*78)	2/10	7.30E-02 - 5.89E-01	Yes	IBC
	7440-23-5	Sodium	1.79E+02	2.81E+02	mg/kg	PSB2 (RVFS*78)	5/8	2.60E+01 - 2.80E+01	No	NIBC
	7440-62-2	Vanadium	1.15E+01 J	4.14E+01	mg/kg	PSB5 (RVFS*84)	10/10	N/A	No	NIBC
	7440-66-6	Zinc	3.65E+01 J	1.06E+03 J	mg/kg	APSB08A	10/10	N/A	Yes	IBC

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]
Explosives (EXP)
Deletion Reason: Not Important Bioaccumulative Compound (NIBC)
Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions
N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

Table 7-8
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Sediment Direct Contact Exposure at Area P
Page 1 of 2

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
Sediment	NA	2,3,7,8-TCDD-TE	5.20E-06	5.20E-06	mg/kg	APSD01	1/1	N/A	Yes	DET
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	3.76E-05	3.76E-05	mg/kg	APSD01	1/1	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.78E-04	1.78E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.14E-06 J	1.14E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	9.38E-07 B	9.38E-07 B	mg/kg	APSD01	1/1	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.53E-06 J	1.53E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	7.63E-07 J	7.63E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	4.08E-06 J	4.08E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	4.19E-06 J	4.19E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	2.38E-07 J	2.38E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	8.75E-07 J	8.75E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	9.65E-07 J	9.65E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	9.65E-08 J	9.65E-08 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	5.09E-07 B	5.09E-07 B	mg/kg	APSD01	1/1	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.91E-07 J	1.91E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Heptachlorodibenzofuran	9.59E-05 J	9.59E-05 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Heptachlorodibenzo-p-dioxin	3.04E-04	3.04E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Hexachlorodibenzofuran	2.34E-05 J	2.34E-05 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Hexachlorodibenzo-p-dioxin	2.73E-05	2.73E-05	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Pentachlorodibenzofuran	5.80E-06 J	5.80E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Pentachlorodibenzo-p-dioxin	3.27E-06 J	3.27E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Tetrachlorodibenzofuran	3.48E-06 J	3.48E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	2.18E-03	2.18E-03	mg/kg	APSD01	1/1	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	1.15E-04	1.15E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	11097-69-1	Aroclor 1254	4.20E-02 J	4.20E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	11096-82-5	Aroclor 1260	4.18E-02 J	4.18E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	56-55-3	Benzo(a)anthracene	1.62E-02 J	1.62E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	50-32-8	Benzo(a)pyrene	1.80E-02 J	1.80E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	205-99-2	Benzo(b)fluoranthene	2.47E-02 J	2.47E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	191-24-2	Benzo(g,h,i)perylene	1.51E-02 J	1.51E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	207-08-9	Benzo(k)fluoranthene	1.52E-02 J	1.52E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	218-01-9	Chrysene	2.11E-02 J	2.11E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	1918-00-9	Dicamba	1.45E-02 K	1.45E-02 K	mg/kg	APSD01	1/1	N/A	Yes	DET

Table 7-8
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Sediment Direct Contact Exposure at Area P
Page 2 of 2

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	193-39-5	Indeno(1,2,3-cd)pyrene	1.51E-02 J	1.51E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	7429-90-5	Aluminum	8.30E+03	8.30E+03	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-38-2	Arsenic	1.50E+00	1.50E+00	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-39-3	Barium	1.32E+02	1.32E+02	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-41-7	Beryllium	8.40E-01	8.40E-01	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-43-9	Cadmium	6.40E-02 J	6.40E-02 J	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-70-2	Calcium	1.26E+03	1.26E+03	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-47-3	Chromium	1.34E+01	1.34E+01	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-48-4	Cobalt	1.01E+01	1.01E+01	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-50-8	Copper	9.80E+00	9.80E+00	mg/kg	APSD01	1/1	N/A	Yes	DET
	7439-89-6	Iron	1.95E+04	1.95E+04	mg/kg	APSD01	1/1	N/A	Yes	DET
	7439-92-1	Lead	1.25E+02	1.25E+02	mg/kg	APSD01	1/1	N/A	Yes	DET
	7439-95-4	Magnesium	1.81E+03	1.81E+03	mg/kg	APSD01	1/1	N/A	Yes	DET
	7439-96-5	Manganese	1.47E+03	1.47E+03	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-02-0	Nickel	9.00E+00	9.00E+00	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-09-7	Potassium	1.06E+03	1.06E+03	mg/kg	APSD01	1/1	N/A	Yes	DET
	7782-49-2	Selenium	6.40E+00 K	6.40E+00 K	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-62-2	Vanadium	1.91E+01	1.91E+01	mg/kg	APSD01	1/1	N/A	Yes	DET
	7440-66-6	Zinc	5.04E+02	5.04E+02	mg/kg	APSD01	1/1	N/A	Yes	DET

COPEC Selection Rationale Codes

Selection Reason:	Detected constituent (DET)
Deletion Reason:	Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions:

N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

Table 7-9
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Sediment Food Chain Exposure at Area P
Page 1 of 2

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Sediment	NA	2,3,7,8-TCDD-TE	5.20E-06	5.20E-06	mg/kg	APSD01	1/1	N/A	Yes	IBC
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	3.76E-05	3.76E-05	mg/kg	APSD01	1/1	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1.78E-04	1.78E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.14E-06 J	1.14E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	9.38E-07 B	9.38E-07 B	mg/kg	APSD01	1/1	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1.53E-06 J	1.53E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	7.63E-07 J	7.63E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	4.08E-06 J	4.08E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	4.19E-06 J	4.19E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	2.38E-07 J	2.38E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	8.75E-07 J	8.75E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	9.65E-07 J	9.65E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	9.65E-08 J	9.65E-08 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	5.09E-07 B	5.09E-07 B	mg/kg	APSD01	1/1	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.91E-07 J	1.91E-07 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Heptachlorodibenzofuran	9.59E-05 J	9.59E-05 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Heptachlorodibenzo-p-dioxin	3.04E-04	3.04E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Hexachlorodibenzofuran	2.34E-05 J	2.34E-05 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Hexachlorodibenzo-p-dioxin	2.73E-05	2.73E-05	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Pentachlorodibenzofuran	5.80E-06 J	5.80E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Pentachlorodibenzo-p-dioxin	3.27E-06 J	3.27E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	NA	Total Tetrachlorodibenzofuran	3.48E-06 J	3.48E-06 J	mg/kg	APSD01	1/1	N/A	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	2.18E-03	2.18E-03	mg/kg	APSD01	1/1	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	1.15E-04	1.15E-04	mg/kg	APSD01	1/1	N/A	No	TEQ
	11097-69-1	Aroclor 1254	4.20E-02 J	4.20E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	11096-82-5	Aroclor 1260	4.18E-02 J	4.18E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	56-55-3	Benzo(a)anthracene	1.62E-02 J	1.62E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	50-32-8	Benzo(a)pyrene	1.80E-02 J	1.80E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	205-99-2	Benzo(b)fluoranthene	2.47E-02 J	2.47E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	191-24-2	Benzo(g,h,i)perylene	1.51E-02 J	1.51E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	207-08-9	Benzo(k)fluoranthene	1.52E-02 J	1.52E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	218-01-9	Chrysene	2.11E-02 J	2.11E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	1918-00-9	Dicamba	1.45E-02 K	1.45E-02 K	mg/kg	APSD01	1/1	N/A	No	NIBC

Table 7-9
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Sediment Food Chain Exposure at Area P
Page 2 of 2

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	193-39-5	Indeno(1,2,3-cd)pyrene	1.51E-02 J	1.51E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7429-90-5	Aluminum	8.30E+03	8.30E+03	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-38-2	Arsenic	1.50E+00	1.50E+00	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7440-39-3	Barium	1.32E+02	1.32E+02	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-41-7	Beryllium	8.40E-01	8.40E-01	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-43-9	Cadmium	6.40E-02 J	6.40E-02 J	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7440-70-2	Calcium	1.26E+03	1.26E+03	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-47-3	Chromium	1.34E+01	1.34E+01	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7440-48-4	Cobalt	1.01E+01	1.01E+01	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-50-8	Copper	9.80E+00	9.80E+00	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7439-89-6	Iron	1.95E+04	1.95E+04	mg/kg	APSD01	1/1	N/A	No	NIBC
	7439-92-1	Lead	1.25E+02	1.25E+02	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7439-95-4	Magnesium	1.81E+03	1.81E+03	mg/kg	APSD01	1/1	N/A	No	NIBC
	7439-96-5	Manganese	1.47E+03	1.47E+03	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-02-0	Nickel	9.00E+00	9.00E+00	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7440-09-7	Potassium	1.06E+03	1.06E+03	mg/kg	APSD01	1/1	N/A	No	NIBC
	7782-49-2	Selenium	6.40E+00 K	6.40E+00 K	mg/kg	APSD01	1/1	N/A	Yes	IBC
	7440-62-2	Vanadium	1.91E+01	1.91E+01	mg/kg	APSD01	1/1	N/A	No	NIBC
	7440-66-6	Zinc	5.04E+02	5.04E+02	mg/kg	APSD01	1/1	N/A	Yes	IBC

COPEC Selection Rationale Codes

Selection Reason:	Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]
	Explosives (EXP)
Deletion Reason:	Not Important Bioaccumulative Compound (NIBC)
	Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions

N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

- COPEC selection conclusion: YES or NO.
- Rationale for selection or rejection of the COPEC.

COPECs were selected as shown in **Tables 7-6 through 7-9**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Tables 7-6 and 7-8**). For food chain exposure pathways, detected COPECs were selected if they were important bioaccumulative constituents (USEPA, 2000c) or explosive compounds (**Tables 7-7 and 7-9**).

Twenty-five COPECs (three organic and 22 inorganic COPECs) have been selected for surface soil direct contact exposure (**Table 7-6**).

Eleven COPECs (one organic and 10 inorganic COPECs) have been selected for surface soil food chain exposure (**Table 7-7**).

Twenty-nine COPECs (11 organic and 18 inorganic COPECs) have been selected for sediment direct contact exposure (**Table 7-8**).

Eighteen COPECs (10 organic and 8 inorganic COPECs) have been selected for sediment food chain exposure (**Table 7-9**).

EPCs based on the statistical procedures discussed in *HHRA Section 6.2.3* are presented in **Tables 7-10** (surface soil) and **7-11** (sediment). Arithmetic mean concentrations are presented for informational purposes.

Groundwater COPECs are discussed in *Section 7.2.6*.

7.2.3 Risk Characterization

This section presents the SLERA risk characterization results, following the detailed methods and procedures presented in *Section 7.1.7*.

7.2.3.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance and review of site photographs was performed, and no obvious signs of vegetative stress were noted. Area P ground cover consists of gravel intermixed with some grass cover (**Appendix F-1, Photos F-1 through F-3**). The overall health of the grassland/field communities at the site was comparable to those of the surrounding area. As allowed in the *RFAAP Final MWP* (URS, 2003), that states "owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects," plants were not quantitatively evaluated in this SLERA. As there were no unique or site-specific terrestrial plant issues discovered at Area P, a qualitative evaluation was deemed adequate. However, a terrestrial plant impact screening assessment is discussed in *Section 7.2.4*. It should also be noted that plants (and invertebrates) are included in the SLERAs as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

7.2.3.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with Area P are estimated in this section. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The EEQs (or HQs) are compared to HQ

Table 7-10
Medium-Specific Exposure Point Concentration Summary for Area P Surface Soil

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Soil	Aroclor 1254	mg/kg	2.22E-01	N/A	N/A	4.03E-01	4.03E-01	mg/kg	Max	Test (7)
	Tetrachloroethene	mg/kg	6.40E-03	N/A	N/A	6.40E-03	6.40E-03	mg/kg	Max	Test (7)
	Trichloroethene	mg/kg	5.40E-03	N/A	N/A	5.40E-03	5.40E-03	mg/kg	Max	Test (7)
	Aluminum	mg/kg	9.34E+03	No	1.13E+04 (N)	1.32E+04	1.13E+04	mg/kg	95% Student's-t	Test (4)
	Antimony [5]	mg/kg	1.05E+01	N/A	3.83E+00 (NP)	1.05E+01	3.83E+00	mg/kg	95% UCL-Bst	Test (8)
	Arsenic	mg/kg	2.07E+00	No	2.70E+00 (N)	4.30E+00	2.70E+00	mg/kg	95% Student's-t	Test (4)
	Barium	mg/kg	1.42E+02	No	1.80E+02 (N)	2.57E+02	1.80E+02	mg/kg	95% Student's-t	Test (4)
	Beryllium	mg/kg	6.86E-01	No	7.51E-01 (N)	9.70E-01	7.51E-01	mg/kg	95% KM-t	Test (4)
	Cadmium [5]	mg/kg	2.85E-01	N/A	3.56E-01 (NP)	3.90E-01	3.56E-01	mg/kg	95% UCL-Bst	Test (8)
	Calcium	mg/kg	1.95E+04	No	1.75E+05 (NP)	1.60E+05	1.75E+05	mg/kg	Max	Test (2)
	Chromium	mg/kg	2.08E+01	No	3.08E+01 (G)	5.96E+01	3.08E+01	mg/kg	95% Approx. Gamma	Test (6)
	Cobalt	mg/kg	7.99E+00	No	9.87E+00 (N)	1.26E+01	9.87E+00	mg/kg	95% Student's-t	Test (4)
	Copper	mg/kg	6.75E+01	No	1.64E+02 (G)	3.47E+02	1.64E+02	mg/kg	95% Approx. Gamma	Test (6)
	Iron	mg/kg	1.57E+04	No	1.95E+04 (N)	2.49E+04	1.95E+04	mg/kg	95% Student's-t	Test (4)
	Lead	mg/kg	5.91E+01	No	9.02E+01 (N)	1.50E+02	9.02E+01	mg/kg	95% Student's-t	Test (4)
	Magnesium	mg/kg	1.18E+04	No	9.08E+04 (NP)	8.30E+04	8.30E+04	mg/kg	Max	Test (2)
	Manganese	mg/kg	6.02E+02	No	8.28E+02 (N)	1.24E+03	8.28E+02	mg/kg	95% Student's-t	Test (4)
	Mercury	mg/kg	4.60E-02	No	5.59E-02 (N)	9.10E-02	5.59E-02	mg/kg	95% KM-% Btstrp	Test (4)
	Nickel	mg/kg	1.35E+01	No	1.85E+01 (G)	3.34E+01	1.85E+01	mg/kg	95% Approx. Gamma	Test (6)
	Potassium	mg/kg	1.30E+03	No	1.45E+03 (N)	1.74E+03	1.45E+03	mg/kg	95% Student's-t	Test (4)
	Selenium	mg/kg	3.50E+00	No	3.69E+00 (N)	5.60E+00	3.69E+00	mg/kg	95% KM-% Btstrp	Test (4)
	Silver [5]	mg/kg	1.24E+00	N/A	5.60E-01 (NP)	1.79E+00	5.60E-01	mg/kg	95% UCL-Bst	Test (8)
	Sodium	mg/kg	2.30E+02	Yes	2.44E+02 (N)	2.81E+02	2.44E+02	mg/kg	95% KM-% Btstrp	Test (1)
	Vanadium	mg/kg	2.41E+01	No	3.04E+01 (N)	4.14E+01	3.04E+01	mg/kg	95% Student's-t	Test (4)
	Zinc	mg/kg	2.09E+02	No	6.25E+02 (NP)	1.06E+03	6.25E+02	mg/kg	95% Cheby, Mean, SD	Test (3)

Notes: N/A = Not applicable

[1] ProUCL software (version 4.0, USEPA, 2007) recommends use of Kaplan-Meier method if there are multiple detection limits.

[2] Statistical Distribution and 95% UCL as determined by ProUCL (unless otherwise noted): (G) the data were determined to follow gamma distribution; (L) the data were determined to follow lognormal distribution; (NP) the data were determined to be non-parametric; (N) the data were determined to be normally distributed.

[3] Statistic: Maximum Detected Value (Max); 95% KM Chebyshev (95% KM-Cheby); 97.5% KM Chebyshev (97.5% KM-Cheby); 99% KM Chebyshev (99% KM-Cheby); 95% KM Percentile Bootstrap (95% KM-% Btstrp); 95% KM (t) (95% KM-t); 95% KM-BCA (95% KM-BCA); 95% H-UCL (95% H-UCL); 95% Chebyshev -Mean, SD- UCL (95% Cheby, Mean, SD); 97.5% Chebyshev -Mean, SD- UCL (97.5% Cheby, Mean, SD); 99% Chebyshev -Mean, SD- UCL (99% Cheby, Mean, SD); 95% UCL of Log-transformed Data (95% UCL-T) 95% Student's-t (95% Student's-t); 95% Modified-t (95% Modified-t); 95% UCL based on bootstrap statistic (95% UCL-Bst); 95% Approximate Gamma UCL (95% Approx. Gamma); 95% KM Chebyshev-MVUE (95% KM-Cheby-MVUE).

[4] Unless otherwise noted (see footnote 5), ProUCL EPC selection rationale based on, detection limit values, distribution, standard deviation, and sample size (see ProUCL output in appendix for further details):

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): The 95% UCL exceeds the maximum detected concentration, therefore, maximum concentration used for EPC.
Test (3): Shapiro-Wilk W test, Kolmogorov-Smirnov (K-S), and Anderson-Darling (A-D) tests, indicate data follow nonparametric distribution.
Test (4): Shapiro-Wilk W test indicates data are normally distributed.
Test (5): Shapiro-Wilk W test indicates data are log-normally distributed.
Test (6): Kolmogorov-Smirnov (K-S) and/or Anderson-Darling (A-D) tests indicate data follow gamma distribution.
Test (7): Sample size is less than or equal to 5, therefore, maximum concentration used for EPC.
Test (8): 95% UCL estimated by a non-Pro-UCL bootstrap method.

[5] Infrequent detection resulted in ProUCL modeling error for this constituent, therefore the distribution was assumed to be non-parametric and the UCL was determined using a non-ProUCL bootstrap method with random numbers for NDs (see text for details).

Table 7-11
Medium-Specific Exposure Point Concentration Summary for Area P Sediment

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No)[1]	95% UCL (Distribution)[2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic[3]	Rationale[4]
Sediment	2,3,7,8-TCDD-TE	mg/kg	5.20E-06	N/A	N/A	5.20E-06	5.20E-06	mg/kg	Max	Test (7)
	Aroclor 1254	mg/kg	4.20E-02	N/A	N/A	4.20E-02	4.20E-02	mg/kg	Max	Test (7)
	Aroclor 1260	mg/kg	4.18E-02	N/A	N/A	4.18E-02	4.18E-02	mg/kg	Max	Test (7)
	Benzo(a)anthracene	mg/kg	1.62E-02	N/A	N/A	1.62E-02	1.62E-02	mg/kg	Max	Test (7)
	Benzo(a)pyrene	mg/kg	1.80E-02	N/A	N/A	1.80E-02	1.80E-02	mg/kg	Max	Test (7)
	Benzo(b)fluoranthene	mg/kg	2.47E-02	N/A	N/A	2.47E-02	2.47E-02	mg/kg	Max	Test (7)
	Benzo(g,h,i)perylene	mg/kg	1.51E-02	N/A	N/A	1.51E-02	1.51E-02	mg/kg	Max	Test (7)
	Benzo(k)fluoranthene	mg/kg	1.52E-02	N/A	N/A	1.52E-02	1.52E-02	mg/kg	Max	Test (7)
	Chrysene	mg/kg	2.11E-02	N/A	N/A	2.11E-02	2.11E-02	mg/kg	Max	Test (7)
	Dicamba	mg/kg	1.45E-02	N/A	N/A	1.45E-02	1.45E-02	mg/kg	Max	Test (7)
	Indeno(1,2,3-cd)pyrene	mg/kg	1.51E-02	N/A	N/A	1.51E-02	1.51E-02	mg/kg	Max	Test (7)
	Aluminum	mg/kg	8.30E+03	N/A	N/A	8.30E+03	8.30E+03	mg/kg	Max	Test (7)
	Arsenic	mg/kg	1.50E+00	N/A	N/A	1.50E+00	1.50E+00	mg/kg	Max	Test (7)
	Barium	mg/kg	1.32E+02	N/A	N/A	1.32E+02	1.32E+02	mg/kg	Max	Test (7)
	Beryllium	mg/kg	8.40E-01	N/A	N/A	8.40E-01	8.40E-01	mg/kg	Max	Test (7)
	Cadmium	mg/kg	6.40E-02	N/A	N/A	6.40E-02	6.40E-02	mg/kg	Max	Test (7)
	Calcium	mg/kg	1.26E+03	N/A	N/A	1.26E+03	1.26E+03	mg/kg	Max	Test (7)
	Chromium	mg/kg	1.34E+01	N/A	N/A	1.34E+01	1.34E+01	mg/kg	Max	Test (7)
	Cobalt	mg/kg	1.01E+01	N/A	N/A	1.01E+01	1.01E+01	mg/kg	Max	Test (7)
	Copper	mg/kg	9.80E+00	N/A	N/A	9.80E+00	9.80E+00	mg/kg	Max	Test (7)
	Iron	mg/kg	1.95E+04	N/A	N/A	1.95E+04	1.95E+04	mg/kg	Max	Test (7)
	Lead	mg/kg	1.25E+02	N/A	N/A	1.25E+02	1.25E+02	mg/kg	Max	Test (7)
	Magnesium	mg/kg	1.81E+03	N/A	N/A	1.81E+03	1.81E+03	mg/kg	Max	Test (7)
	Manganese	mg/kg	1.47E+03	N/A	N/A	1.47E+03	1.47E+03	mg/kg	Max	Test (7)
	Nickel	mg/kg	9.00E+00	N/A	N/A	9.00E+00	9.00E+00	mg/kg	Max	Test (7)
	Potassium	mg/kg	1.06E+03	N/A	N/A	1.06E+03	1.06E+03	mg/kg	Max	Test (7)
	Selenium	mg/kg	6.40E+00	N/A	N/A	6.40E+00	6.40E+00	mg/kg	Max	Test (7)
	Vanadium	mg/kg	1.91E+01	N/A	N/A	1.91E+01	1.91E+01	mg/kg	Max	Test (7)
	Zinc	mg/kg	5.04E+02	N/A	N/A	5.04E+02	5.04E+02	mg/kg	Max	Test (7)

Notes: N/A = Not applicable

[1] ProUCL software (version 4.0, USEPA, 2007) recommends use of Kaplan-Meier method if there are multiple detection limits.

[2] Statistical Distribution and 95% UCL as determined by ProUCL (unless otherwise noted): (G) the data were determined to follow gamma distribution; (L) the data were determined to follow lognormal distribution; (NP) the data were determined to be non-parametric; (N) the data were determined to be normally distributed.

[3] Statistic: Maximum Detected Value (Max); 95% KM Chebyshev (95% KM-Cheby); 97.5% KM Chebyshev (97.5% KM-Cheby); 99% KM Chebyshev (99% KM-Cheby); 95% KM Percentile Bootstrap (95% KM-% Btstrp); 95% KM-t (95% KM-t); 95% KM-BCA (95% KM-BCA); 95% H-UCL (95% H-UCL); 95% Chebyshev -Mean, SD- UCL (95% Cheby, Mean, SD); 97.5% Chebyshev -Mean, SD- UCL (97.5% Cheby, Mean, SD); 99% Chebyshev -Mean, SD- UCL (99% Cheby, Mean, SD); 95% UCL of Log-transformed Data (95% UCL-T) 95% Student's-t (95% Student's-t); 95% Modified-t (95% Modified-t); 95% UCL based on bootstrap statistic (95% UCL-Bst); 95% Approximate Gamma UCL (95% Approx. Gamma); 95% KM Chebyshev-MVUE (95% KM-Cheby-MVUE).

[4] Unless otherwise noted (see footnote 5), ProUCL EPC selection rationale based on, detection limit values, distribution, standard deviation, and sample size (see ProUCL output in appendix for further details):

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): The 95% UCL exceeds the maximum detected concentration, therefore, maximum concentration used for EPC.
Test (3): Shapiro-Wilk W test, Kolmogorov-Smirnov (K-S), and Anderson-Darling (A-D) tests, indicate data follow nonparametric distribution.
Test (4): Shapiro-Wilk W test indicates data are normally distributed.
Test (5): Shapiro-Wilk W test indicates data are log-normally distributed.
Test (6): Kolmogorov-Smirnov (K-S) and/or Anderson-Darling (A-D) tests indicate data follow gamma distribution.
Test (7): Sample size is less than or equal to 5, therefore, maximum concentration used for EPC.
Test (8): 95% UCL estimated by a non-Pro-UCL bootstrap method.

guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. Whether or not HQ summation was appropriate and scientifically defensible is based on whether the chemicals have a similar mode of toxicological action. While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect.

The summation of HQs into an HI was performed in this SLERA as a conservative approach. To assess whether or not individual COPEC HQs should be segregated based on dissimilar modes of toxicological action, individual COPEC effects were evaluated. However, as risk drivers resulted in HQs ranging from less than 1 to 503 (see following paragraphs), segregation of COPECs by mode of toxicological action was not necessary.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at Area P are presented in risk characterization tables (**Appendix F-2, Tables F-2 through F-15**) for the seven selected receptor species. These summed EEQs are presented in **Table 7-12** (generally rounded to two significant figures), along with the hazard driver [COPEC(s) contributing the majority of the total estimated EEQ] and the exposure pathway of concern (the pathway contributing the most to the total estimated EEQ).

As shown in **Table 7-12**, Tier 1 total EEQs ranged from approximately 1 to 503 for the seven receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew was predicted to be the most impacted, followed by the American robin, the mink, the meadow vole, the red fox, the red-tailed hawk, and the great blue heron. The inorganic constituents chromium, selenium, and zinc; and the organic constituents TCDD and Aroclor 1254 were the COPECs contributing the most to the total EEQs for each of the receptors. Exposure pathways of most concern, based on the results of the Tier 1 food chain modeling, were fish, plant, terrestrial invertebrate, and small mammal ingestion.

More realistic Tier 2 total EEQs were also elevated, especially values based on NOAEL TRVs, which ranged from 0.001 to 26. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs, and both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk, red fox, mink, and great blue heron were below one. Tier 2 total EEQs based on LOAEL values were 10 for the short-tailed shrew, 8.7 for the meadow vole, and 5.2 for the American robin (**Table 7-12**).

The specific results of the Tier 2 risk estimation for the meadow vole, short-tailed shrew, and American robin are discussed below. The specific results for the red-tailed hawk, red fox, mink, and great blue heron are not discussed because the summed EEQs are below one.

Meadow Vole. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (16 and 8.7, respectively). Three COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): selenium (9.7), copper (2.7), and arsenic (1.1). Only selenium (6) and copper (2) had LOAEL-based EEQs that exceeded 1 when rounded to one significant figure. The primary exposure pathway was the ingestion of plants. The results of the Tier 2 risk evaluation for meadow voles are presented in **Appendix F-2, Table F-3**.

Table 7-12
Wildlife EEQ Hazard Summary for Food Chain Exposure at Area P

Receptor	Tier 1[a]		Tier 2[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	66	37	16	8.7
Hazard Driver(s)[c]:	Se - plant ingestion		Se - plant and soil ingestion	
Short-tailed shrew	503	141	26	10
Hazard Driver(s)[c]:	Aroclor 1254 - terrestrial invertebrate ingestion		Cu and Se - terrestrial invertebrate ingestion	
American robin	291	56	24	5.2
Hazard Driver(s)[c]:	Aroclor 1254, Cr, and Zn - terrestrial invertebrate ingestion		Cr, Se, and Zn - terrestrial invertebrate ingestion	
Red-tailed hawk	9.9	2.7	0.001	0.0003
Hazard Driver(s)[c]:	Cr and Se - small mammal ingestion		--	
Red fox	26	10	0.001	0.001
Hazard Driver(s)[c]:	Aroclor 1254 and Se - small mammal ingestion		--	
Mink	72	19	0.06	0.02
Hazard Driver(s)[c]:	TCDD and Se - fish ingestion		--	
Great blue heron	6.0	1.0	0.03	0.01
Hazard Driver(s)[c]:	Zn - fish ingestion		--	

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF (unless regression equation is used), max Intake Rates, min BW, and FHR =1.
[b] Tier 2 = EEQ using 95% EPC, non-max BAF/BCF BCF (unless regression equation is used), avg Intake Rates, avg BW and calculated FHR less than or equal to 1.
[c] Hazard drivers are those chemicals contributing the most to the total estimated EEQ, and the primary route of exposure associated with this driver.

Notes:

EEQ = Ecological Effects Quotient.

LOAEL = Lowest-Observed-Adverse-Effect Level

NOAEL = No-Observed-Adverse-Effect Level

Short-tailed Shrew. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (26 and 10, respectively). Seven COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): selenium (6.5), Aroclor 1254 (6.3), copper (4.0), arsenic (2.8), lead (2.3), zinc (2.2), and cadmium (1.7). Two COPECs had LOAEL-based EEQs that exceeded 1 when round to one significant figure: selenium (4) and copper (3). The primary exposure pathway was the ingestion of terrestrial invertebrates. The results of the short-tailed shrew Tier 2 risk evaluation are presented in **Appendix F-2, Table F-5**.

American Robin. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (24 and 5.2, respectively). Five COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): zinc (14.4), selenium (2.5), lead (2.3), Aroclor 1254 (2.1), and chromium (1.1). Only zinc had a LOAEL-based EEQ that exceeded 1 when rounded to one significant figure: zinc (2). The primary exposure pathway was the ingestion of terrestrial invertebrates. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-7**.

7.2.4 Approach for the Evaluation of Direct Contact Toxicity

To evaluate direct contact exposure, for those organisms that live within an environmental medium, COPEC media concentrations are compared with BTAG-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Surface soil, sediment, and surface water were the exposure media at Area P. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in the specific medium. Detailed procedures are presented in *Section 7.1.8* and the results are summarized in **Tables 7-13** (surface soil) and **7-14** (sediment).

7.2.4.1 Surface Soil

Based on the results of the first step, 12 COPECs were selected based on an EcoSSL or BTAG exceedance while three additional chemicals were evaluated further because of the lack of available EcoSSL or BTAG screening values (**Table 7-13**). In the second step, the MDC and EPC of these 15 chemicals were compared with up to five individual soil screening values. The results of the second screening step are as follows:

- There were no available benchmarks available for calcium, magnesium, potassium, or sodium.
- The antimony MDC only exceeded one of the four available antimony benchmarks for direct contact for antimony, and none of the benchmarks were exceeded if the EPC was used. Therefore, the potential for direct contact toxicity is not likely significant enough to recommend further action at Area P.
- The chromium MDC and EPC only exceeded two of the four available benchmarks for direct contact for chromium. Therefore, the potential for direct contact toxicity is not likely significant enough to recommend further action at Area P.
- The copper MDC and EPC exceeded all four available benchmarks for direct contact for copper. Therefore, there is potential for direct contact toxicity for copper at Area P. This may or may not result in the reduction of terrestrial invertebrates as a food source at Area P.

Table 7-13
Direct Contact Toxicity Evaluation for Surface Soil at Area P

Chemical (1)	Detection Frequency	Maximum Concentration	Exposure Point Concentration	Minimum Concentration	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	Dutch Intervention Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded Using MDC (8)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded Using EPC (8)	Comment
Aroclor 1254	2/5	4.03E-01	4.03E-01	4.02E-02	**1.00E-01**	Yes	Plant tox (no ref)	1.0	0.5	NVA	40	NVA	0/3	0/3	No exceedences
Tetrachloroethene	1/5	6.40E-03	6.40E-03	6.40E-03	3.00E-01	No									
Trichloroethene	1/5	5.40E-03	5.40E-03	5.40E-03	3.00E-01	No									
Aluminum	10/10	1.32E+04	1.13E+04	3.62E+03	---	No	pH > 5.5	NVA	NVA	NVA	---	NVA	---	---	pH = 7.87
Antimony	1/10	1.05E+01	3.83E+00	1.05E+01	**2.70E-01**	Yes	Mammal tox	15	20	78	**5**	NVA	1/4	0/4	
Arsenic	10/10	4.30E+00	2.70E+00	9.23E-01	1.80E+01	No									
Barium	10/10	2.57E+02	1.80E+02	5.27E+01 J	3.30E+02	No									
Beryllium	8/10	9.70E-01	7.51E-01	4.30E-01	2.10E+01	No									
Cadmium	2/10	3.90E-01	3.56E-01	1.80E-01 L	**3.60E-01**	Yes		12	1.4	32	4	20	0/5	0/5	No exceedences
Calcium	10/10	1.60E+05	1.75E+05	1.18E+03 J	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	NVA	
Chromium (Cr III tox)	10/10	5.96E+01	3.08E+01	7.63E+00	**2.60E+01**	Yes		380	64	NVA	**1**	**0.4**	2/4	2/4	
Chromium (Cr VI tox)	10/10	5.96E+01	3.08E+01	7.63E+00	1.30E+02	No									
Cobalt	10/10	1.26E+01	9.87E+00	2.65E+00	1.30E+01	No									
Copper	10/10	3.47E+02	1.64E+02	5.00E+00 J	**2.80E+01**	Yes	Bird tox	NVA	**63**	**70**	**100**	**50**	4/4	4/4	
Iron	10/10	2.49E+04	1.95E+04	6.88E+03	5 ≤ pH ≤ 8	No									
Lead	10/10	1.50E+02	9.02E+01	4.90E+00 J	**1.10E+01**	Yes	Bird tox	530	**70**	**120**	**50**	500	3/5	2/5	
Magnesium	10/10	8.30E+04	8.30E+04	1.62E+03 J	**4.40E+03**	Yes	No reference	NVA	NVA	NVA	NVA	NVA	NVA	NVA	
Manganese	10/10	1.24E+03	8.28E+02	1.30E+02	**2.20E+02**	Yes	Plant tox	NVA	NVA	**220**	**500**	NVA	2/2	2/2	Plant tox
Mercury	5/10	9.10E-02	5.59E-02	1.00E-02 J	**5.80E-02**	Yes	No reference	10	6.6	NVA	0.3	0.1	0/4	0/4	No exceedences
Nickel	10/10	3.34E+01	1.85E+01	6.60E+00 J	3.80E+01	No									
Potassium	8/8	1.74E+03	1.45E+03	9.32E+02	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	NVA	
Selenium	5/10	5.60E+00	3.69E+00	2.40E+00 J	**5.20E-01**	Yes	Plant tox	NVA	**1**	**0.52**	**1**	70	3/4	3/4	Plant tox
Silver	2/10	1.79E+00	5.60E-01	6.92E-01	4.20E+00	No									
Sodium	5/8	2.81E+02	2.44E+02	1.79E+02	NVA	Yes		NVA	NVA	NVA	NVA	NVA	NVA	NVA	
Vanadium	10/10	4.14E+01	3.04E+01	1.15E+01 J	**7.80E+00**	Yes	Bird tox	NVA	130	NVA	**2**	NVA	1/2	1/2	EcoSSL says data insufficient to derive direct contact SSL
Zinc	10/10	1.06E+03	6.25E+02	3.65E+01 J	**4.60E+01**	Yes	Plant tox (OHMTADS)	**720**	**200**	**120**	**50**	**200**	5/5	4/5	Plant tox

All values presented in mg/kg.

BOLD Text = MDC exceeds screening concentration.

NVA = No Value Available

LMW = Low Molecular Weight PAH

HMW = High Molecular Weight PAH

Surface soil pH of 7.87 is geometric mean of five samples collected at Area P.

(1) COPECs from Table 7-6.

(2) Screening toxicity values from BTAG (1995) or EcoSSL (USEPA, 2007). EcoSSLs given highest priority as they are more definitive.

(3) Dutch Intervention Values are from the Netherlands Ministry of Housing, Spacial Planning and Environment (February 2000).

(4) Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.

(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2007).

(6) Screening benchmarks for plants from ORNL (1997, ES/ER/TM-85/R3).

(7) Screening benchmarks for earthworms from ORNL (1997, ES/ER/TM-126/R2).

(8) Final weight of evidence evaluation does not utilize BTAG (1995) values, as these values are no longer available on the BTAG website and are in the process of being revised.

Table 7-14
Direct Contact Toxicity Evaluation for Sediment at Area P

COPEC	MDC (mg/kg)	EPC (mg/kg)	USEPA Region 3 BTAG (mg/kg)^{A}	ARCS^{B}			SQB (mg/kg)^{B,C}	Canadian ISQG (mg/kg)^{D}	Canadian PEL (mg/kg)^{D}	NOAA^{B}		FDEP^{F}		Weight of Evidence Exceedence	
				TEC (mg/kg)	PEC (mg/kg)	NEC (mg/kg)				ER-L (mg/kg)	ER-M (mg/kg)	TEL (mg/kg)	PEL (mg/kg)	Using MDC	Using EPC
2,3,7,8-TCDD-TE	5.20E-06	5.20E-06	**8.50E-07**	---	---	---	---	**8.50E-07**	2.15E-05	---	---	---	---	2 / 3	2 / 3
Aroclor 1254	4.20E-02	4.20E-02	5.98E-02	---	---	---	8.10E-01	---	---	**2.27E-02**	1.80E-01	1.61E+00	6.76E-01	1 / 6	1 / 6
Aroclor 1260	4.18E-02	4.18E-02	5.98E-02	---	---	---	4.50E+03	---	---	**2.27E-02**	1.80E-01	1.61E+00	6.76E-01	1 / 6	1 / 6
Benzo(a)anthracene	1.62E-02	1.62E-02	1.08E-01	2.60E-01	4.20E+00	3.50E+00	1.10E-01	3.17E-02	3.85E-01	2.61E-01	1.60E+00	1.08E-01	1.05E+00	0 / 11	0 / 11
Benzo(a)pyrene	1.80E-02	1.80E-02	1.50E-01	3.50E-01	3.94E-01	4.40E-01	1.40E-01	3.19E-02	7.82E-01	4.30E-01	1.60E+00	1.50E-01	1.45E+00	0 / 11	0 / 11
Benzo(b)fluoranthene	2.47E-02	2.47E-02	2.72E-02	2.72E-02	---	4.00E+00	---	---	---	---	---	---	---	0 / 3	0 / 3
Benzo(g,h,i)perylene	1.51E-02	1.51E-02	1.70E-01	2.90E-01	6.30E+00	3.80E+00	---	---	---	---	---	---	---	0 / 4	0 / 4
Benzo(k)fluoranthene	1.52E-02	1.52E-02	2.40E-01	---	---	---	---	---	---	---	---	---	---	0 / 1	0 / 1
Chrysene	2.11E-02	2.11E-02	1.66E-01	5.00E-01	5.20E+00	4.00E+00	---	5.71E-02	8.62E-01	3.84E-01	2.80E+00	1.66E-01	1.29E+00	0 / 10	0 / 10
Dicamba	1.45E-02	1.45E-02	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Indeno(1,2,3-cd)pyrene	1.51E-02	1.51E-02	1.90E-01	7.80E-02	8.37E-01	3.80E+00	---	---	---	---	---	---	---	0 / 4	0 / 4
Aluminum	8.30E+03	8.30E+03	---	---	5.80E+04	7.32E+04	---	---	---	---	---	---	---	0 / 2	0 / 2
Arsenic	1.50E+00	1.50E+00	9.80E+00	1.21E+01	5.70E+01	9.29E+01	---	5.90E+00	1.70E+01	8.20E+00	7.00E+01	9.79E+00	3.30E+01	0 / 10	0 / 10
Barium	1.32E+02	1.32E+02	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Beryllium	8.40E-01	8.40E-01	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Cadmium	6.40E-02	6.40E-02	9.90E-01	5.92E-01	1.17E+01	4.11E+01	---	6.00E-01	3.50E+00	1.20E+00	9.60E+00	9.90E-01	4.98E+00	0 / 10	0 / 10
Calcium	1.26E+03	1.26E+03	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Chromium	1.34E+01	1.34E+01	4.34E+01	5.60E+01	1.59E+02	3.12E+02	---	3.73E+01	9.00E+01	8.10E+01	3.70E+02	4.34E+01	1.11E+02	0 / 10	0 / 10
Cobalt	1.01E+01	1.01E+01	5.00E+01	---	---	---	---	---	---	---	---	---	---	0 / 1	0 / 1
Copper	9.80E+00	9.80E+00	3.16E+01	2.80E+01	7.77E+01	5.48E+01	---	3.57E+01	1.97E+02	3.40E+01	2.70E+02	3.16E+01	1.49E+02	0 / 10	0 / 10
Iron	1.95E+04	1.95E+04	2.00E+04	---	---	---	---	---	---	---	---	---	---	0 / 1	0 / 1
Lead	1.25E+02	1.25E+02	**3.58E+01**	**3.42E+01**	3.96E+02	**6.87E+01**	---	**3.50E+01**	**9.13E+01**	**4.67E+01**	2.18E+02	**3.58E+01**	1.28E+02	7 / 10	7 / 10
Magnesium	1.81E+03	1.81E+03	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Manganese	1.47E+03	1.47E+03	**4.60E+02**	1.67E+03	**1.08E+03**	**8.19E+02**	---	---	---	---	---	---	---	3 / 4	3 / 4
Nickel	9.00E+00	9.00E+00	2.27E+01	3.96E+01	3.85E+01	3.79E+01	---	---	---	2.09E+01	5.16E+01	2.27E+01	4.86E+01	0 / 8	0 / 8
Potassium	1.06E+03	1.06E+03	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Selenium	6.40E+00	6.40E+00	**2.00E+00**	---	---	---	---	---	---	---	---	---	---	1 / 1	1 / 1
Vanadium	1.91E+01	1.91E+01	---	---	---	---	---	---	---	---	---	---	---	0 / 0	0 / 0
Zinc	5.04E+02	5.04E+02	**1.21E+02**	**1.59E+02**	1.53E+03	5.41E+02	---	**1.23E+02**	**3.15E+02**	**1.50E+02**	**4.10E+02**	**1.21E+02**	**4.59E+02**	8 / 10	8 / 10

--- No Value Available

BOLD Text = MDC exceeds screening concentration.

ARCS = Assessment and Remediation of Contaminated Sediment

COPEC = Chemical of Potential Ecological Concern.

EPC = Exposure Point Concentration. The 95% upper confidence limit concentration was selected as the EPC unless it exceeded the maximum detected concentration, in which case the MDC was chosen as the EPC.

ER-L = Effect Range-Low

ER-M = Effect Range-Median

FDEP = Florida Department of Environmental Protection

ISQG = Interim Sediment Quality Guideline

MDC = Maximum detected concentration.

NEC = High No Effect Concentration

NOAA = National Oceanic and Atmospheric Administration

PEC = Probable Effect Concentration

PEL = Probably Effect Level

SQB = Sediment Quality Benchmark

TEC = Threshold Effect Concentration

TEL = Threshold Effect Level

ARCS, SQB, and Canadian values for freshwater environments.

NOAA and FDEP values for estuarine and marine environments, but may be used for screening purposes.

[A] Screening toxicity values from USEPA Region 3 BTAG, August 2006.

[B] Values from Jones, D.S and Suter, G.W. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4.

[C] The lowest of the Eq P-derived sediment quality benchmarks presented in Jones, D.S and Suter, G.W. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. is presented here (assumed TOC of 1%).

[D] Values from Canadian Council of Ministers of the Environment (CCME). 2002. Canadian Environmental Quality Guidelines. Summary Table Update 2002.

[E] Washington state sediment quality standards as presented in Jones, D.S and Suter, G.W. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4.

[F] Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters, Florida Department of Environmental Protection, 2003. Concensus-based values used.

- The lead MDC exceeded three of the five available benchmarks for direct contact, and the EPC exceeded two of the five. Therefore, there is potential for direct contact toxicity for lead at Area P. This may or may not result in the reduction of terrestrial invertebrates as a food source at Area P.
- The manganese MDC and EPC exceeded the two available benchmarks. The EcoSSL and ORNL exceedances were for plant toxicity, and as discussed in *Section 7.2.3.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at Area P.
- The selenium MDC and EPC exceeded three of the four available benchmarks for direct contact for selenium. Therefore, there is potential for direct contact toxicity for selenium at Area P. This may or may not result in the reduction of terrestrial invertebrates as a food source at Area P.
- The vanadium MDC and EPC exceeded one (for plant toxicity) of the two available benchmarks, and the EcoSSL guidance (USEPA, 2008c) indicates data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at Area P.
- The zinc MDC exceeded all five available benchmarks for direct contact, and the EPC exceeded four of the five. Therefore, there is potential for direct contact toxicity for zinc at Area P. This may or may not result in the reduction of terrestrial invertebrates as a food source at Area P.
- None of the other COPECs selected in the first screening step had any benchmark exceedance.

These results suggest that direct contact toxicity for COPECs in soil may be a concern for copper, lead, selenium, and zinc. It should also be noted that toxicity to terrestrial invertebrates is assessed indirectly, as terrestrial invertebrates such as earthworms are included in the food chain models used in the assessments.

7.2.4.2 Sediment

Using the sediment benchmarks discussed in *Section 7.1.8*, direct contact exposure to aquatic biota was assessed. As shown in **Table 7-14**, up to 11 benchmarks were potentially available for comparison purposes for sediment COPECs. Using a weight-of-evidence approach, based on the MDC, 22 sediment COPECs did not exceeded any of the available sediment benchmarks or did not have a benchmark available. Based on the 95% EPC, 22 sediment COPECs also did not exceed any of the available sediment benchmarks or did not have a benchmark available (note: only one sediment sample was collected, therefore, the sediment EPC equals the sediment MDC). Based on the weight-of-evidence, the following COPECs did not exceed more than 50 percent of their respective sediment benchmarks when compared to both the MDC and 95% EPC, and the potential for direct contact toxicity is not significant enough to recommend further action at Area P: Aroclor 1254 and Aroclor 1260.

TCDD, lead, manganese, selenium, and zinc each exceeded more than 50 percent of their respective sediment benchmarks when compared to both the MDC and/or 95% EPC. The results of the screening are as follows:

- The TCDD MDC and EPC exceeded two of the three available benchmarks for TCDD, but two of the benchmarks were based on the same value (8.5E-07 mg/kg), therefore only one of two benchmarks were exceeded. However, the benchmark exceeded was a PEL. Therefore, there is potential for direct contact toxicity for TCDD at Area P. Based on this finding, it is possible that organisms inhabiting the stream sediment near Area P may be adversely impacted by levels of TCDD.
- The lead MDC and EPC exceeded seven of the ten available benchmarks for lead. Therefore, there is potential for direct contact toxicity for lead at Area P. Based on this finding, it is possible that organisms inhabiting the stream sediment near Area P may be adversely impacted by levels of lead.
- The manganese MDC and EPC exceeded three of the four available benchmarks for manganese. Therefore, there is potential for direct contact toxicity for manganese at Area P. Based on this finding, it is possible that organisms inhabiting the stream sediment near Area P may be adversely impacted by levels of manganese.
- The selenium MDC and EPC exceeded the only available benchmark for selenium. Therefore, there is potential for direct contact toxicity for selenium at Area P. Based on this finding, it is possible that organisms inhabiting the stream sediment near Area P may be adversely impacted by levels of selenium.
- The zinc MDC and EPC exceeded eight of the ten available benchmarks for zinc. Therefore, there is potential for direct contact toxicity for zinc at Area P. Based on this finding, it is possible that organisms inhabiting the stream sediment near Area P may be adversely impacted by levels of zinc.

These results suggest that direct contact toxicity for COPECs in sediment at Area P may be a concern for TCDD, lead, manganese, selenium, and zinc.

7.2.5 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to determine if any inorganic COPEC drivers discussed in the previous sections were potentially related to naturally-occurring soil concentrations. From the Tier 2 LOAEL assessment, there were three inorganic COPEC drivers (copper, selenium, and zinc) with EEQs greater than 1 for the food chain assessment. COPEC hazard drivers for the direct contact assessment were: copper, lead, selenium, and zinc. Inorganic COPECs that were not statistically different based on appropriate statistical tests are considered background related (see *HHRA Section 6.4.3* for details). Based on information presented in **Table 7-15**, copper, lead, selenium, and zinc are the direct contact and/or food chain COPECs in Area P surface soil considered to be potentially site related and not attributed to background. Details of the background evaluation are presented in *Section 6, Tables 6-4 and 6-5 and Appendix E-5*.

Table 7-15
Background Comparison for Surface Soil at Area P

Soil COPEC	Gehan Test [a, b] Site > Background?	Considered to be Background?
Copper	Yes	No
Lead	Yes	No
Selenium	Yes	No
Zinc [c]	Yes	No

[a] Gehan test used unless otherwise noted. See Appendix for backup statistics.
[b] If both site and Background data sets had normal distribution with 100% detects, the t-test was used.
[c] Wilcoxin-Mann Whitney test used for 100% detected data sets.

7.2.6 Groundwater Evaluation

Groundwater samples were collected from four direct-push well points at Area P (APGW02, APGW03, APGW04, and APGW05). Area P is located in close proximity of the New River (approximately 125 to 150 ft), and the fact that groundwater flows directly toward the New River, it is possible that COPECs in groundwater are migrating to the New River and potentially having an adverse impact on aquatic life or wildlife that use the New River. This section evaluates these potential exposure pathways.

Chemicals detected in groundwater were compared with direct contact surface water screening values and were also evaluated to determine if they were important bioaccumulative compounds (**Table 7-16**). Filtered results for metals detected in groundwater samples are preferred for this assessment as filtered results are more indicative of concentrations available for possible transport to the New River; therefore, filtered groundwater results were used in the assessment. No upgradient groundwater data were available for Area P.

Detected groundwater constituents were compared to the Region 3 BTAG surface water screening values. If the concentration of a chemical exceeded its BTAG concentration, it was selected for further consideration in the surface water evaluation. Additionally, chemicals that are considered to be bioaccumulative based on USEPA (2000c) are selected as COPECs. Ten groundwater COPECs (chloroform, aluminum, barium, chromium, copper, iron, lead, manganese, nickel, and zinc) were selected as COPECs, six of which are a concern for direct contact. Using the maximum and average groundwater concentrations of these COPECs that had concentrations that exceeded the BTAG surface water screening criteria, HQs were estimated using the direct contact surface water screening values (**Table 7-17**). Results of this initial assessment showed that if measured groundwater concentrations occur in the New River surface water without any dilution, HQs would range from 1.1 to 71 using maximum concentrations, and from 0.8 to 43 using average concentrations (**Table 7-17**).

As discussed in *Section 7.1.10*, the dilution factor for Area P groundwater discharging to the New River is assumed to be 100. This dilution factor is used in **Table 7-17** to estimate the potential concentration of groundwater COPECs in the New River during low flow conditions (i.e., the August-September period). Revised HQs, taking into account this conservative dilution factor, are all less than 1.0. This finding supports the conclusion that groundwater COPECs in surface water are not expected to adversely impact sensitive aquatic biota residing in the New River.

Table 7-16
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Exposure at Area P

Scenario Timeframe: Current/Future
Medium: Water
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Upgradient Well Value (2)	Screening Toxicity Value (3)	Important Bioaccumulative Compound (4) ? (Y/N)	COPEC Flag (Y/N)	Rationale for Selection or Deletion (5)
Groundwater	67-66-3	Chloroform	7.10E-04 J	1.90E-03	mg/l	APGW04	4/4	N/A	1.90E-03	N/A	1.80E-03	No	Yes	ASL
	127-18-4	Tetrachloroethene	1.30E-03	2.00E-03	mg/l	APGW02	4/4	N/A	2.00E-03	N/A	1.11E-01	No	No	BSL
	7429-90-5	Aluminum	2.18E+00	6.16E+00	mg/l	APGW02-Diss	3/4	7.90E-02 - 7.90E-02	6.16E+00	N/A	8.70E-02	No	Yes	ASL
	7440-39-3	Barium	5.52E-02 J	9.70E-02 J	mg/l	APGW02-Diss	4/4	N/A	9.70E-02	N/A	4.00E-03	No	Yes	ASL
	7440-70-2	Calcium	3.75E+01 J	4.41E+01 J	mg/l	APGW05-Diss	4/4	N/A	4.41E+01	N/A	1.16E+02	No	No	BSL
	7440-47-3	Chromium	2.60E-03 J	1.10E-02	mg/l	APGW04-Diss	4/4	N/A	1.10E-02	N/A	1.10E-02	Yes	Yes	IBC, BSL
	7440-48-4	Cobalt	1.10E-03 J	4.60E-03 J	mg/l	APGW02-Diss	3/4	1.00E-03 - 1.00E-03	4.60E-03	N/A	2.30E-02	No	No	BSL
	7440-50-8	Copper	3.80E-03 J	3.80E-03 J	mg/l	APGW02-Diss	1/4	1.20E-03 - 1.20E-03	3.80E-03	N/A	9.00E-03	Yes	Yes	IBC, BSL
	7439-89-6	Iron	1.45E+00	8.27E+00	mg/l	APGW02-Diss	3/4	1.50E-02 - 1.50E-02	8.27E+00	N/A	3.00E-01	No	Yes	ASL
	7439-92-1	Lead	4.40E-03 J	4.40E-03 J	mg/l	APGW02-Diss	1/4	2.10E-03 - 2.10E-03	4.40E-03	N/A	2.50E-03	Yes	Yes	IBC, ASL
	7439-95-4	Magnesium	1.50E+01	1.61E+01	mg/l	APGW04-Diss	4/4	N/A	1.61E+01	N/A	8.20E+01	No	No	BSL
	7439-96-5	Manganese	2.70E-02	1.97E-01	mg/l	APGW02-Diss	4/4	N/A	1.97E-01	N/A	1.20E-01	No	Yes	ASL
	7440-02-0	Nickel	2.70E-03 J	6.70E-03 J	mg/l	APGW02-Diss	3/4	1.00E-03 - 1.00E-03	6.70E-03	N/A	5.20E-02	Yes	Yes	IBC, BSL
	7440-09-7	Potassium	2.44E+00	3.26E+00	mg/l	APGW02-Diss	4/4	N/A	3.26E+00	N/A	5.30E+01	No	No	BSL
	7440-23-5	Sodium	6.70E+00 J	7.14E+00 J	mg/l	APGW04-Diss	4/4	N/A	7.14E+00	N/A	6.80E+02	No	No	BSL
	7440-62-2	Vanadium	3.50E-03 J	1.47E-02 J	mg/l	APGW02-Diss	3/4	1.10E-03 - 1.10E-03	1.47E-02	N/A	2.00E-02	No	No	BSL
	7440-66-6	Zinc	6.70E-03 J	2.10E-02	mg/l	APGW02-Diss	3/4	5.00E-03 - 5.00E-03	2.10E-02	N/A	1.20E-01	Yes	Yes	IBC, BSL
	14797-73-0	Perchlorate	3.27E-04	3.90E-04	mg/l	APGW05	4/4	N/A	3.90E-04	N/A	NVA	No	No	BSL

(1) Maximum concentration of filtered metal and unfiltered organic samples used for screening.
(2) No upgradient wells are available for Area P.
(3) Screening toxicity values are Freshwater Screening Benchmarks from Region III BTAG (2009).

Definitions:
N/A = Not Applicable or Not Available
NVA = No Value Available
COPEC = Chemical of Potential Ecological Concern
J, K, L = Estimated Values
ND = Not Detected

(4) Important Bioaccumulative Compound, per USEPA (2000)
(5) Rationale Codes
Selection Reason: Toxicity Information Available (TX)
Above Screening Level (ASL)
Important Bioaccumulative Compound (IBC)
Deletion Reason: Below Screening Level (BSL)
Physical/Chemical (PHYS)
Nutrient (NUT)

Table 7-17
Impact Evaluation of Groundwater COPEC Concentrations in Surface Water Adjacent to Area P

COPEC [a]	Ground-water MDC (mg/L) [b]	Groundwater Mean of Detected Data (mg/L) [b]	Screening Value (mg/L) [c]	HQ [d] Estimated Using MDC	HQ [d] Estimated Using Mean Concentration	Ground-water to Surface Water Dilution Factor [e]	HQ Estimated Using MDC and DF	HQ Estimated Using Mean Concentration and DF	Potential Surface Water Concern From SWMU 43 Groundwater COPECs?
Chloroform	1.90E-03	1.35E-03	1.80E-03	1.1	0.8	100	0.011	0.008	No, HQs < 1 when DF used
Aluminum	6.16E+00	3.74E+00	8.70E-02	71	43	100	0.71	0.43	No, HQs < 1 when DF used
Barium	9.70E-02	8.12E-02	4.00E-03	24	20	100	0.24	0.20	No, HQs < 1 when DF used
Iron	8.27E+00	4.18E+00	3.00E-01	28	14	100	0.28	0.14	No, HQs < 1 when DF used
Lead	4.40E-03	4.40E-03	2.50E-03	1.8	1.8	100	0.018	0.018	No, HQs < 1 when DF used
Manganese	1.97E-01	9.57E-02	1.20E-01	1.6	0.8	100	0.016	0.008	No, HQs < 1 when DF used

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from the screening assessment (excluding important bioaccumulative compunds that did not exceed the direct contact screening criterion).

[b] Metals results are based on dissolved data for Area P.

[c] Direct contact screening value (Table 7-16).

[d] HQ = hazard quotient (groundwater concentration divided by screening value)

[e] Mixing zone dilution factor of 100 based on site-specific groundwater flow rate and New River low flow rate (see text for discussion).

Notes:

MDC = maximum detection concentration

DF = Dilution Factor

An additional assessment was performed to evaluate COPECs potentially partitioning to sediment from pore water and overlying water influenced by groundwater migrating from the site, per a request from McCloskey (2006) following the approach used by TetraTech (2005). This assessment utilized soil/water portioning theory, where the Freundlich soil/water partition coefficient (K_d) is multiplied by the water (solution) concentration to estimate the sorbed sediment concentration (USEPA, 2002b). The K_d values for organics were estimated by multiplying the organic carbon partition coefficient (K_{oc}) by the sediment fraction of organic carbon (f_{oc}). The K_{oc} values used in this assessment are taken from EPI Suite (USEPA, 2007b). As no site-specific f_{oc} results are readily available for New River sediment adjacent to the site, a default value of 0.01 recommended in Appendix E of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997e) was used to estimate the K_d values for organic COPECs. Inorganic COPEC K_d values were obtained from the following hierarchy: (1) Risk Assessment Information System (RAIS) (ORNL, 2006) on-line database, (2) Baes et al. (1984).

To estimate the impact of the discharge of contaminated groundwater on the sediments in the riverbed, three different methods of calculating the concentrations in the riverbed sediments were used, following the approach used by TetraTech (2005) recommended by McCloskey (2006). The most conservative method of calculating the predicted sediment concentrations was based on the assumption that the sediment equilibrates directly with the groundwater seepage (i.e., pore water). The second method assumes that the riverbed sediments equilibrate with the surface water ("diluted groundwater"). To estimate the impact of the long-term discharge of groundwater on New River sediments, the groundwater concentrations were divided by the estimated dilution factor of 100 to yield the predicted concentrations in the New River. A long-term dilution factor of 100 is actually conservative, as the calculated dilution factor for Area P was 8.95E+6 (see *Section 7.1.10*). The third method is simply the arithmetic mean of the calculated values determined by the first two methods. The third method is considered to be the best representation of actual site conditions because sediment chemistry is affected by both the pore water and the overlying surface water column. These three methods were used to calculate the predicted sediment concentrations presented in **Tables 7-18, 7-19, and 7-20**.

The predicted COPEC sediment concentrations were compared with BTAG (USEPA, 2006b) sediment screening values and HQs were calculated (**Tables 7-18 through 7-20**). If no BTAG sediment screening value was available, the lowest sediment screening value from the sediment direct contact evaluation was used. As shown in the tables, no COPECs had HQs that exceeded 1.0 when the conservative pore water method was used (**Table 7-18**), no COPEC HQs exceeded 1.0 when the dilution method was used (**Table 7-19**), and no COPECs had HQs exceeding 1.0 when the recommended average of the pore water and dilution methods was used (**Table 7-20**). HQs could not be estimated for chloroform and barium since no appropriate sediment screening value was available.

In addition to potential hazards associated with direct contact with COPECs in sediments from groundwater, there is also the concern for bioaccumulation of COPECs from sediment to fish and potential adverse food chain impacts to higher order wildlife such as mink or great blue heron. As recommended by McCloskey (2006), this exposure pathway was also evaluated following the general approach used by TetraTech (2005). Based on the MDC and average sediment COPEC concentrations using the pore water method (**Table 7-18**) and using the dilution method (**Table 7-19**), sediment to fish BAFs were used to estimate COPEC concentrations of important bioaccumulative compounds in fish tissue. Sediment to fish BAFs were primarily from *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997e) and, if not available from this source, *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation* (Bechtel Jacobs, 1998b) was used as a surrogate. The estimated fish tissue concentrations (**Table 7-21**) were compared with NOAEL-based benchmarks for fish as food for the mink and great blue heron, using benchmarks from Table 12 of *Toxicological Benchmarks for Wildlife* (Sample et al.,1996). HQs were calculated for each bioaccumulative COPEC and for those COPECs that have available benchmark, HQs were below 1.0 (**Table 7-21**). These findings demonstrate that bioaccumulation of COPECs from sediments to fish, and subsequent higher order food chain impacts to wildlife receptors such as mink and great blue heron, are not a concern for the site.

Table 7-18
Evaluation of Groundwater COPECs That May Partition to Sediment at Area P - Pore Water Method

COPEC [a]	Ground-water MDC (mg/L) [b]	Ground-water Mean (mg/L) [b]	K_{oc} (L/kg)	K_d (L/kg) [c]	Source of K_{oc} or K_d Data [d]	Predicted Sediment Concentration Using MDC (mg/kg) [e]	Predicted Sediment Concentration Using Mean (mg/kg) [e]	Sediment Screening Value (mg/kg) [f]	HQ [g] Estimated Using MDC	HQ [g] Estimated Using Mean Concentration
Chloroform	1.90E-03	1.35E-03	3.50E+01	3.50E-01	1	6.65E-04	4.73E-04	NVA	NVA	NVA
Aluminum	6.16E+00	3.74E+00	NA	1.50E+03	2	9.24E+03	5.61E+03	5.80E+04	0.16	0.10
Barium	9.70E-02	8.12E-02	NA	4.10E+01	2	3.98E+00	3.33E+00	NVA	NVA	NVA
Chromium	1.10E-02	7.83E-03	NA	8.50E+02	2	9.35E+00	6.65E+00	4.34E+01	0.22	0.15
Copper	3.80E-03	3.80E-03	NA	3.50E+01	2	1.33E-01	1.33E-01	3.16E+01	0.0042	0.0042
Iron	8.27E+00	4.18E+00	NA	2.50E+01	2	2.07E+02	1.05E+02	2.00E+04	0.010	0.0052
Lead	4.40E-03	4.40E-03	NA	9.00E+02	2	3.96E+00	3.96E+00	3.58E+01	0.11	0.11
Manganese	1.97E-01	9.57E-02	NA	6.50E+01	2	1.28E+01	6.22E+00	4.60E+02	0.028	0.014
Nickel	6.70E-03	4.50E-03	NA	6.50E+01	2	4.36E-01	2.93E-01	2.27E+01	0.019	0.013
Zinc	2.10E-02	1.33E-02	NA	6.20E+01	2	1.30E+00	8.25E-01	1.21E+02	0.011	0.0068

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-16.

[b] Filtered metals results and unfiltered organics results. Filtered metals results are more indicative of concentrations available for transport in groundwater to surface water.

[c] Organic K_d estimated by multiplying K_{oc} by the fraction of organic carbon (foc), estimated to be 0.01, per Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997).

[d] (1) Organic K_{oc} values from EPI Suite (USPEA, 2007). (2) Inorganic K_d values from The Risk Assessment Information System (RAIS) ORNL, 2009 on-line database.

[e] Predicted sediment concentration = K_d x COPEC concentration in groundwater, per Equation 4-12 in USEPA (2002).

[f] Sediment screening concentration from USEPA Region III BTAG (USEPA, 2005).

[g] HQ = hazard quotient (predicted sediment concentration divided by screening value)

Notes:

MDC = maximum detection concentration

NA = not available

NVA = no value available

Table 7-19
Evaluation of Groundwater COPECs That May Partition to Sediment at Area P - Dilution Method

COPEC [a]	Ground-water MDC (mg/L) [b]	Ground-water Mean (mg/L) [b]	Predicted Water Column Concentration Using MDC (mg/L) [c]	Predicted Water Column Concentration Using Mean (mg/L) [c]	K_{oc} (L/kg)	K_d (L/kg) [d]	Source of K_{oc} or K_d Data [e]	Predicted Sediment Concentration Using MDC (mg/kg) [f]	Predicted Sediment Concentration Using Mean (mg/kg) [f]	Sediment Screening Value (mg/kg) [g]	HQ [h] Estimated Using MDC	HQ [h] Estimated Using Mean Concentration
Chloroform	1.90E-03	1.35E-03	1.90E-05	1.35E-05	3.50E+01	3.50E-01	1	6.65E-06	4.73E-06	NVA	NVA	NVA
Aluminum	6.16E+00	3.74E+00	6.16E-02	3.74E-02	NA	1.50E+03	2	9.24E+01	5.61E+01	5.80E+04	0.0016	0.00097
Barium	9.70E-02	8.12E-02	9.70E-04	8.12E-04	NA	4.10E+01	2	3.98E-02	3.33E-02	NVA	NVA	NVA
Chromium	1.10E-02	7.83E-03	1.10E-04	7.83E-05	NA	8.50E+02	2	9.35E-02	6.65E-02	4.34E+01	0.0022	0.0015
Copper	3.80E-03	3.80E-03	3.80E-05	3.80E-05	NA	3.50E+01	2	1.33E-03	1.33E-03	3.16E+01	0.000042	0.000042
Iron	8.27E+00	4.18E+00	8.27E-02	4.18E-02	NA	2.50E+01	2	2.07E+00	1.05E+00	2.00E+04	0.00010	0.000052
Lead	4.40E-03	4.40E-03	4.40E-05	4.40E-05	NA	9.00E+02	2	3.96E-02	3.96E-02	3.58E+01	0.0011	0.0011
Manganese	1.97E-01	9.57E-02	1.97E-03	9.57E-04	NA	6.50E+01	2	1.28E-01	6.22E-02	4.60E+02	0.00028	0.00014
Nickel	6.70E-03	4.50E-03	6.70E-05	4.50E-05	NA	6.50E+01	2	4.36E-03	2.93E-03	2.27E+01	0.00019	0.00013
Zinc	2.10E-02	1.33E-02	2.10E-04	1.33E-04	NA	6.20E+01	2	1.30E-02	8.25E-03	1.21E+02	0.00011	0.000068

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-16.

[b] Filtered metals results and unfiltered organics results. Filtered metals results are more indicative of concentrations available for transport in groundwater to surface water.

[c] Dilution factor of 100 used, see text for discussion.

[d] Organic K_d estimated by multiplying K_{oc} by the fraction of organic carbon (foc), estimated to be 0.01, per Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997).

[e] (1) Organic K_{oc} values from EPI Suite (USPEA, 2007). (2) Inorganic K_d values from The Risk Assessment Information System (RAIS) ORNL, 2009 on-line database.

[f] Predicted sediment concentration = K_d x COPEC concentration in groundwater, per Equation 4-12 in USEPA (2002).

[g] Sediment screening concentration from USEPA Region III BTAG (USEPA, 2005).

[h] HQ = hazard quotient (predicted sediment concentration divided by screening value)

[i] Benzo(a)anthracene and acenaphthylene mean concentrations = MDC, to compensate for influence of elevated detection limit results.

Notes:

MDC = maximum detection concentration

NA = not available

NVA = no value available

Table 7-20
Evaluation of Groundwater COPECs That May Partition to Sediment at Area P
Average of Pore Water Method and Dilution Method

COPEC [a]	HQ [b] Estimated Using MDC and Pore Water Method	HQ [b] Estimated Using Mean Concentration and Pore Water Method	HQ [c] Estimated Using MDC and Dilution Method	HQ [c] Estimated Using Mean Concentration and Dilution Method	HQ Estimated Using MDC and Average of Pore Water Method and Dilution Method	HQ Estimated Using Mean Concentration and Average of Pore Water Method and Dilution Method
Chloroform	NVA	NVA	NVA	NVA	NVA	NVA
Aluminum	0.16	0.097	0.0016	0.00097	0.080	0.049
Barium	NVA	NVA	NVA	NVA	NVA	NVA
Chromium	0.22	0.15	0.0022	0.0015	0.1088	0.0774
Copper	0.0042	0.0042	0.000042	0.000042	0.0021	0.0021
Iron	0.010	0.0052	0.00010	0.000052	0.0052	0.0026
Lead	0.11	0.11	0.0011	0.0011	0.0559	0.0559
Manganese	0.028	0.014	0.00028	0.00014	0.0141	0.0068
Nickel	0.019	0.013	0.00019	0.00013	0.0097	0.0065
Zinc	0.011	0.0068	0.00011	0.000068	0.0054	0.0034

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-16.

[b] HQs from Table 7-18.

[c] HQs from Table 7-19.

Notes:

MDC = maximum detection concentration in groundwater.

HQ = hazard quotient

NA = not available

NVA = no value available

Table 7-21
Evaluation of Groundwater COPECs That May Partition to Sediment at Area P and Bioaccumulate in Fish Tissue

COPEC [a]	Sediment Concentration Estimated Using MDC in Groundwater and Average of Pore Water and Dilution Methods (mg/kg) [b]	Sediment Concentration Estimated Using Mean Groundwater Concentration and Average of Pore Water and Dilution Methods (mg/kg) [c]	Sediment to Fish Biaccumlation Factors	Reference [d]	Estimated Fish Concentration Using MDC in Groundwater (mg/kg) [e]	Estimated Fish Concentration Using Mean Concentration in Groundwater (mg/kg) [e]	NOAEL-Based Benchmark for Fish as Food for Mink (mg/kg) [f]	NOAEL-Based Benchmark for Fish as Food for Great Blue Heron (mg/kg) [f]	HQ for Mink Estimated Using Highest Fish Tissue Concentration	HQ for Great Blue Heron Estimated Using Highest Fish Tissue Concentration
Chromium	4.72	3.36	0.1	2	4.72E-01	3.36E-01	15366	14	0.000031	0.034
Copper	0.067	0.067	1.556	2	1.05E-01	1.05E-01	85.4	267.5	0.0012	0.00039
Lead	2.00	2.00	0.071	2	1.42E-01	1.42E-01	44.91	6.43	0.0032	0.022
Nickel	0.22	0.15	0.486	2	1.07E-01	7.18E-02	224.57	440.44	0.00048	0.00024
Zinc	0.66	0.42	1.936	2	1.27E+00	8.06E-01	898.30	82.5	0.0014	0.015

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 7-16, that are important bioaccumulative compounds.

[b] Sediment concentrations are means from MDC columns in Tables 7-18 and 7-19.

[c] Sediment concentrations are means from Mean columns in Tables 7-18 and 7-19.

[d] (1)*The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997); and, if not available, then surrogate used from
(2) *Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation* (Bechtel Jacobs, 1998).

[e] Sediment concentration times sediment to fish bioaccumulation factor

[f] *Toxicological Benchmarks for Wildlife* (Table 12) (Sample, B.E., D.M. Opresko, and G.W. Suter, 1996).

Notes:
MDC = maximum detected concentration.
NA = not avaiable.
HQ = hazard quotient

7.2.7 Uncertainty Analysis

There were 151 and 150 chemical constituents not detected in surface soil and sediment analytical samples, respectively. **Appendix F-2, Tables F-24** (surface soil) and **F-25** (sediment) evaluate the uncertainty associated with these constituents' detection limits by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value. Region III BTAG soil SLs are antiquated (last published in 1995) relative to Region III BTAG sediment values (updated in 2006); therefore, non-detect soil values were compared to BTAG soil levels as well as additional soil screening values presented in **Appendix F-2, Table F-26**. Region III BTAG sediment screening values were used for the sediment comparison.

Thirty-one of the non-detect surface soil and 46 of the non-detect sediment constituents had maximum detection limits that exceeded the screening criteria, respectively. These findings are not unexpected, given the conservative and numerically low screening values.

Three inorganics (copper, selenium, and zinc) had Tier 2 LOAEL-based EEQs that exceeded 1 when round to one significant figure. Given the uncertainties associated with the SLERA process, the key parameters associated with these slightly elevated EEQs were examined in more detail in the following sections.

<u>Copper</u>. For copper, the slightly elevated short-tailed shrew EEQ of 3.1 was primarily from the plant ingestion pathway (83 percent) and the meadow vole EEQ of 2.1 was also primarily from the plant ingestion pathway (79 percent). The LOAEL of 15.1 mg/kg-day that was used was based on a mink study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 for both receptors (**Appendix F-2, Tables F-2 and F-4**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 3 or 4 would result in the copper EEQs dropping to 1 or less when rounded to one significant figure.

<u>Selenium</u>. For selenium, the slightly elevated meadow vole EEQ of 5.9 was primarily from the plant ingestion pathway (96 percent) and short-tailed shrew EEQ of 3.9 was primarily from the earthworm ingestion pathway (86 percent). The LOAEL of 0.33 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 4 for the meadow vole and 8 for the short-tailed shrew (**Appendix F-2, Tables F-2 and F-4**). The use of these UFs is conservative, and the use of alternative UFs of 1 and 2 for the meadow vole and short-tailed shrew, respectively, would result in the selenium EEQs dropping to 1 when rounded to one significant figure.

<u>Zinc</u>. For zinc, the slightly elevated the American robin EEQ of 1.6 was primarily from the earthworm ingestion pathway (67 percent). The LOAEL of 131 mg/kg-day that was used was based on a laboratory chicken study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-6**). The use of this UF is conservative, and the use of an alternative UF of approximately 4 would result in the zinc EEQ dropping to less than 1.

Based on this evaluation for LOAEL-based risk drivers (EEQs >1), copper, selenium and zinc, the use of alternative factors (e.g., an alternative UF for TRV species extrapolation), would reduce the estimated LOAEL-based EEQs to 1 (when rounded to one significant figure) for all receptors.

7.2.8 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting Area P. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-12**, and direct contact exposure results, which may serve as a food source for wildlife, are summarized in **Tables 7-13** (surface soil) and **7-14** (sediment) and discussed in *Section 7.2.4*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (copper, selenium, and zinc) in surface soil.

However, when alternative toxicity adjustment factors were used in the Tier 2 LOAEL-based EEQ calculations, estimated EEQs would be expected to drop to one or less for all constituents. The direct contact assessment results suggest a potential reduction in wildlife food supply due to copper, lead, selenium, and zinc in surface soil and TCDD, lead, manganese, selenium, and zinc in sediment. However, due to the small size of the site (0.38 acres) and unsuitable habitat (gravel) this potential reduction in food is not considered biologically significant. In addition, although five COPECs in sediment had concentrations that exceeded more than 50 percent of the available screening benchmarks, the small size of the site (0.38 acres), the lack of aquatic habitat and the associated small size of the aquatic habitat (dry drainage ditch), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, no Tier 2 LOAEL EEQs exceeding 1 (when rounded to one significant figure) when using alternative TRV species extrapolation UFs, the fact that no wildlife rare, threatened, or endangered (RTE) species have been found at the Area P study area, and the relatively small size of the SWMU (0.38 acres), and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, sediment, or groundwater. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

8.0 SUMMARY AND CONCLUSIONS

Area P is the center of a scrap metal yard that was formerly used for storage of shredded scrap metals, decommissioned tanks, powder cans, and batteries prior to off-post shipment. The land slopes gently to the North toward the New River, which is about 200 ft from the storage area.

Data from a previous investigation at Area P was combined with data from the current (2007) investigation to evaluate the nature and extent of contamination (*Section 4.0*) and to assess potential impacts to human health (*Section 6.0*) and/or ecological receptors (*Section 7.0*).

8.1 Contamination Assessment

The contamination assessment indicated that VOCs, SVOCs, pesticides, and herbicides are not a concern in soil at Area P since they were not greater than SLs in any soil samples. Additionally, PAHs and explosives are not a concern in Area P soil. VOCs, SVOCs, pesticides, herbicides, explosives, metals, and dioxins/furans are not a concern in sediment at Area P since they were not greater than SLs in any soil samples. In groundwater, SVOCs, PAHs, pesticides, PCBs, herbicides, explosives, and perchlorate are not a concern at Area P.

The soil at Area P was investigated during the 1992 sampling event and then again in 2007 in support of draft RFIs. The Area P data set from all soil investigations indicates that one PCB and two metals were found above their screening limits in soil samples collected for this site. PCB-1254 was detected above its r-SL in two surface soil samples. Antimony and copper were found above their r-SLs, both in one 1992 surface soil sample. The only compound that was found to be greater than its SSLs and also identified by the HHRA or SLERA as posing a significant risk to human health or the environment was PCB-1254 in surface soil. The soil analytes that were above their SLs in previous investigations and were also detected in 2007 groundwater samples were only PCE and copper. The results from the investigations at Area P indicate that there are no major concerns in soil because of the relatively low concentrations and sparsely located constituents of concern.

The sediment at Area P was only investigated, by means of one sample, collected from accumulated sediment at the end of a site drainage pipe during the 2007 sampling event. The data from that sediment sample indicates that one PAH [benzo(a)pyrene] and one PCB (PCB-1254) were detected above their r-SLs. The only compound found to be greater than its SLs and was also identified by the HHRA as posing a significant risk to human health was PCB-1254 in surface soil. Sediment analytes that were found above their SLs were not also found in site groundwater.

Area P groundwater was investigated only during the 2007 investigation. Four direct-push groundwater samples were collected to determine if site soil was impacting groundwater. Groundwater results indicated that two VOCs and 11 metals were detected above their screening limits. The two VOCs (chloroform and PCE) were found at concentrations above their tw-SLs in all four samples. Five of the 11 metals (aluminum, beryllium, chromium, iron, and manganese) were detected above both their tw-SLs and MCLs, five metals (barium, cobalt, mercury, nickel, and vanadium) were only above their tw-SLs, and lead was only detected above its MCL. However, beryllium was detected in all four samples, but with a “B” validation qualifier in all of them – indicating that this compound was also detected in associated laboratory blanks. It should be noted that the samples were collected from direct-push well points. These groundwater samples are collected without a sand-pack, which increases the amount of sediment in the sample. It is likely that the high concentration of metals in these samples is due to the sediment entrained in the sample. In filtered groundwater samples, only five metals (aluminum, chromium, cobalt, iron, and manganese) were greater than their SLs. PAHs, SVOCs, pesticides, PCBs, explosives, and herbicides were not detected. Some of the compounds (chloroform, PCE, aluminum, chromium, cobalt, iron, manganese, and vanadium) that were found to be greater than SLs were also identified by the HHRA as posing a significant risk to human health.

8.2 Human Health Risk Assessment

An HHRA (*Section 6.0*) was performed to evaluate the potential human health effects associated with previous activities at Area P. Receptors evaluated included current/future maintenance worker, future industrial worker, future excavation worker, future adult resident, future child resident, and lifetime resident. Off-site adult and child residents were also evaluated for potential exposures to groundwater in the event that groundwater migrates off site in the future.

8.2.1 HHRA Summary

The total cancer risk for current maintenance worker exposures to surface soil and groundwater were both below the target risk ranges and their HIs were below 1.

For the future maintenance worker, the total cancer risk for exposures to surface soil, total soil, and groundwater were below their target risk ranges and their HIs were below 1.

For future industrial worker exposures to surface soil, total soil, and groundwater were within their target risk ranges (above the lower end of the range due to arsenic in soil and PCE in groundwater). The soils were within their ranges due to arsenic and groundwater due to PCE. The HIs were below 1.

For future excavation worker, total cancer risk for exposures to total soil was below the target risk range. The total cancer risk associated with groundwater was equal to the lower limit of the target risk range. Both HIs were less than 1.

For the future lifetime resident, the total cancer risk for exposures to surface soil, total soil, and groundwater were within the target risk ranges (above the lower end of the range due to Aroclor-1254 and arsenic for surface soil, arsenic in total soil, and chloroform and PCE for groundwater). The HI for soil was less than 1. The HI for groundwater was equal to 1, with none of the HIs for individual COPCs equal to 1.

For the child resident, the total cancer risk for exposures to surface soil, total soil, and groundwater were within the target risk range, due to Aroclor 1254 and arsenic for surface soil, arsenic for total soil, and PCE for groundwater. The total HIs for surface and total soil were above 1; however, no individual COPC had an HI above 1. Aluminum, antimony, arsenic, cobalt, iron, manganese, and vanadium are within background concentrations for surface and total soil. If the HQs for background-related metals were excluded, the total HIs for surface and total soil would be less than 1. The HI for groundwater was above 1; however, none of the HIs for individual COPCs were above 1. In addition, if the target organ HQs for background-related metals were excluded, the HIs for individual target organ HIs would be less than 1.

Off-site recreational users were evaluated to address potential future migration of COPCs in groundwater to surface water at the New River. For the future adult recreational user, the total cancer risk for exposures to off-site surface water was equal to the lower limit of the target risk range. The total HI was below 1. For the future adolescent recreational user, the total cancer risk for exposures to off-site surface water was less than the lower limit of the target risk range. The total HI was below 1.

Overall, therefore, it appears that arsenic and Aroclor-1254 are the main risk-drivers in soil and PCE and chloroform are the main risk-drivers in groundwater.

8.3 Screening Level Ecological Risk Assessment

A SLERA (*Section 7.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at Area P. Common methods and procedures are presented in *Section 7.1,* and individual results for Area P are presented in *Section 7.2*.

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting Area P. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints.

8.3.1 SLERA Summary

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (copper, selenium, and zinc) in surface soil.

However, when alternative toxicity adjustment factors were used in the Tier 2 LOAEL-based EEQ calculations, estimated EEQs would be expected to drop to one or less for all constituents. The direct contact assessment results suggest a potential reduction in wildlife food supply due to copper, lead, selenium, and zinc in surface soil and TCDD, lead, manganese, selenium, and zinc in sediment. However, due to the small size of the site (0.38 acres) and unsuitable habitat (gravel) this potential reduction in food is not considered biologically significant. In addition, although five COPECs in sediment had concentrations that exceeded more than 50 percent of the available screening benchmarks, the small size of the site (0.38 acres), the lack of aquatic habitat and the associated small size of the aquatic habitat (dry drainage ditch), and the migration of COPECs in groundwater to surface water and sediment of the New River was determined not to be a significant ecological concern, suggests further ecological assessment is not warranted.

Based on uncertainties of toxicity, no Tier 2 LOAEL EEQs exceeding 1 (when rounded to one significant figure) when using alternative TRV species extrapolation UFs, the fact that no wildlife RTE species have been confirmed at the Area P study area, and the relatively small size of the SWMU (0.38 acres), and groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures solely to address ecological concerns are not warranted for soil, sediment, or groundwater. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

8.4 Conclusion

Total risks associated with exposures to COPCs in soil were within the target risk range for the future industrial worker, future lifetime resident, and future child resident. For the future industrial worker, these risks were attributable to arsenic in soil. For the future lifetime and child resident, these risks were attributable to Aroclor 1254 and arsenic. However, the arsenic soil concentrations were within background levels at the site.

The total HIs for soil were below 1 for all receptors except the child resident. For the child resident, however, individual HQs for metals in soil were less than 1. Furthermore, when the background-related target organ HQs were excluded, the total HI for soil was less than 1.

Total risks associated with exposures to COPCs in groundwater were within the target risk range for the future industrial worker, future lifetime resident, and future child resident and were attributable primarily to PCE and chloroform. PCE and chloroform were only detected above their tw-SLs, and not above their MCLs in site groundwater samples.

The total HI for groundwater was below 1 for the future industrial worker. For the future adult resident, the total HI was equal to 1; however, none of the HIs for individual COPCs or target organs exceeded 1. For the future child resident, the total HI for groundwater was above 1, with none of the HIs for individual COPCs exceeding 1.

For the child resident, some target organs HIs exceeded 1. If the target organ HQs for background-related metals were excluded, however, these target organ HIs would be less than 1. There seems to be no unacceptable risk or hazard for the current site workers. The SLERA concluded that there may be potential adverse impacts to terrestrial wildlife from site media. However, because no RTE wildlife species have been confirmed at the site, because of the relatively small size of the site, and because groundwater migration to the New River was determined not to be a significant ecological concern, remedial measures to address ecological concerns are not warranted.

Based on the results of the Nature and Extent of Contamination Assessment, as well as the results of Human Health and Ecological Risk Assessments, both of which show limited risk to theoretical receptors, no further action is recommended for these sites.

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