# RADFORD ARMY AMMUNITION PLANT, VIRGINIA

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## SWMU 31
## RCRA Facility Investigation Report

**Prepared for:**

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

**Prepared by:**

Shaw Environmental, Inc.
2113 Emmorton Park Rd.
Edgewood, MD  21040
Contract No. DACA31-01-F-0085

**Final Document**

**July 2007**

received 10-1-07

07-129

COMMONWEALTH of VIRGINIA

L. Preston Bryant, Jr.
Secretary of Natural Resources

*DEPARTMENT OF ENVIRONMENTAL QUALITY*
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David K. Paylor
Director

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September 26, 2007

Mr. Jim McKenna
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, Virginia 24143-0100

Re: RCRA Facility Investigation Report-SWMU 31, Radford Army Ammunition Plant

Dear Mr. McKenna:

The Virginia Department of Environmental Quality (VDEQ) has reviewed the Final RCRA Facility Investigation Report for SWMU 31 at Radford Army Ammunition Plant and approves the report as revised.

Please contact me at (804) 698-4498 if you have any questions or comments regarding the above site.

James L. Cutler, Jr., CPG
Federal Facilities Project Manager

cc: Paige Holt, ATK
Will Geiger, US EPA Region 3
Richard Criqui, DEQ
Norman Auldridge, VDEQ-WCRO

received 9-24-07

07-127

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

September 20, 2007

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.
Solid Waste Management Unit (SWMU) 31
Review of the Army's RCRA Facility Investigation Report

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) July, 2007 Final RCRA Facility Investigation Report for SWMU 31, located at the Radford Army Ammunition Plant (RFAAP). 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
General Operations Branch (3WC23)

cc: Russell Fish, EPA
James Cutler, VDEQ
Leslie Romanchik, VDEQ

ATK
ALLIANT TECHSYSTEMS

Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
USA

July 24, 2007

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

Subject: With Certification, SWMU 31 RCRA Facility Investigation Report Final Document, July 2007
Radford Army Ammunition Plant Installation Action Plan
EPA ID# VA1 210020730

Dear Mr. Geiger:

Enclosed is the certification for the subject document that was sent to you on July 24, 2007.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

P.W. Holt

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

c: Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

Durwood Willis
Virginia Department of Environmental Quality
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5158 Blackhawk Road, Attn: MCHB-TS-REH
Aberdeen Proving Ground, MD 21010-5403

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

bc:
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J. McKenna, ACO Staff
Rob Davie-ACO Staff
M.A. Miano
P.W. Holt
J. J. Redder
Env. File

Coordination:
J. McKenna

M. Miano by Joe Yoakley
M. A. Miano

07-815-149a
JMcKenna

Concerning the following:

*SWMU 31RCRA Facility Investigation Report,*
*Final Document, July 2007*
*Radford Army Ammunition Plant*

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:
PRINTED NAME: for Jon R. Drushal
TITLE: Lieutenant Colonel, US Army
Commanding

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

07-815-149a
JMcKenna

ATK
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Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
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July 24, 2007

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

Subject: SWMU 31 RCRA Facility Investigation Report, Final Document, July 2007
Radford Army Ammunition Plant Installation Action Plan
EPA ID# VA1 210020730

Dear Mr. Geiger:

Enclosed is one copy of the subject document. Your additional two copies and the certification will be sent under separate cover. Also under separate cover one copy each will be sent to the distribution below.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

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

c: Jim Cutler
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

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Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
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May 1, 2007

Mr. Jim Cutler
Virginia Department of Environmental Quality
629 East Main Street
Richmond, VA 23219

Subject: Response to comments from DEQ letter dated April 20, 2007 for SWMU 31
RCRA Facility Investigation Report, Final Document, December 2006
Radford Army Ammunition Plant Installation Action Plan
EPA ID# VA1 210020730

Dear Mr. Cutler:

Enclosed are the subject responses. Note SWMU 31 is on the agenda for the stakeholder meeting scheduled for Wednesday May 16, 2007 in Philadelphia, PA.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

Gary W. Holt

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

c: William Geiger, EPA Region III, 3CW23

Russell Fish, P.E., EPA Region III, 3WC23

Durwood Willis
Virginia Department of Environmental Quality
P. O. Box 10009
Richmond, VA 23240-0009

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J. McKenna

07-815-93
JMcKenna

## Response to VDEQ Comments received dated April 20, 2007
for
Final SWMU 31 RCRA Facility Investigation Report
December 2006

### VDEQ Comment 1

*Section 2.1* – The report should include a rough calculation and discussion of the water balance of the lagoon system. Considering there have been no direct discharges it is important to know the extent of potential ground water infiltration at the site.

#### RFAAP Response

A rough calculation of the water balance will be included. The water "balance" will include rainfall and the amount of water discharged from the drinking water plant. These inputs will be balanced against the water that flows through the unconsolidated sediment into the New River. Average flow rates of the New River will also be included for comparison purposes. This information will be added to *Section 2.4* and will be used to support the discussion of the groundwater/surface water interaction requested in Comment 4.

### VDEQ Comment 2

*Section 2.1* – A schematic showing the water flow dynamics of the lagoon system should be included in the report. What happened to Figure 1-2 that was included in the previous draft report?

#### RFAAP Response

Shaw is moving from CADD-based figures to GIS-based figures with aerial photography. Some features from the old CADD based figures were not displayed on the new figures. Figure 1-2 from the Draft Final report will be added into the Final report to support the discussion of the water balance and lagoon/groundwater interaction that will be incorporated into *Section 2.4* (Also, see Response to Comment 1).

### VDEQ Comment 3

*Section 2.1* – The discussion of the discharge history for Outfall 024 is incomplete. My initial contact with the West Central Regional Office of VDEQ indicated that there have been two discharges since 1994 including one in 2003. The results of any required sampling should be reported. The status of any ground water monitoring requirements in conjunction with the permit should also be included in the report.

#### RFAAP Response

Additional information provided by Alliant TechSystems (ATK) on discharges from Outfall 024 that occurred in February 2003, February 2005, December 2005 and January 2006 will be incorporated into *Section 2.1*. ATK has also provided information that states that Outfall 024 was plugged on February 3, 2006 to prevent future discharges. The plug was pressurized and the air pressure within the plug is monitored as part of the water plant operations.

**VDEQ Comment 4**

*Section 2.4* – The ground water/surface water (lagoon) interaction at the site needs to be discussed as part of the site hydrogeology.

**RFAAP Response**

A discussion of the lagoon/groundwater interaction will be included as part of the discussion of the water budget (see Response to Comments 1&2).

**VDEQ Comment 5**

*Section 2.6* – It would be appropriate to include VDEQ's position on MCL compliance as it relates to the Commonwealth's position on the beneficial use of ground water.

**RFAAP Response**

The following information was provided by VDEQ to clarify the Commonwealth's position on MCL compliance and the beneficial reuse of groundwater. This text will be incorporated into the RFI report:

> *In the process of providing oversight for activities at federal facilities, the Federal Facilities (FFR) staff has relied on the various ARARs to guide the action being taken. When addressing actions related to groundwater, it has been the staff's practice to consider the groundwater quality standards in conjunction with other groundwater related ARARs. As noted in the State Water Control Law, "groundwater quality standards" means provision of state law which consist of a designated use and the water quality criteria for those uses. It has been program practice that all current and potential future uses of the resource are considered and protective levels are established to preserve the priority usage. The question has been raised as whether all groundwaters of the state have been formally designated as drinkable waters. The Commonwealth does not have an aquifer classification framework and therefore all waters shall be protected to the highest beneficial use.*
>
> *The Virginia Water Control Law prohibits wastes discharges or other quality alterations of state water except as authorized by permit. The Law also states it is unlawful for any person to alter the physical, chemical or biological properties of state waters and make them detrimental to the public health, or to animal or aquatic life, or to the uses of such waters for domestic or industrial consumption. Clearly, the Water Control Law intends to protect water for domestic uses. The Water Control Board Policy provides additional information that can be applied to interpret the Law. The Policy defines "water" as all waters, on the surface and under the ground, wholly or partially within or bordering the Commonwealth or within its jurisdiction and which affect the public welfare. The Policy also defines "beneficial" uses as domestic (including public water supply), agricultural, electric power generation, commercial and industrial uses. The Policy leaves no question about the relative importance of water supply. The Policy states "Public water supply uses for human consumption shall be considered the highest priority".*

> *Accordingly, when addressing constituents in groundwater the staff refers to those ARARs protective of the use. As a drinking water source, levels of constituents are compared to maximum contaminant levels (MCLs) or secondary maximum contaminant levels (SMCLs). The purpose of requiring treatment to MCLs is to accomplish the policy of the Commonwealth of Virginia, which is to protect existing high quality state waters and restore other state waters to such condition of quality that any such water will permit all reasonable public use.*

**VDEQ Closing Remarks**

Overall the report appears to reflect the general consensus of the previous team discussions (although I can't comment on additional BTAG and/or HHRA communications with Shaw) however, as the conclusions indicate, there is future potential risk at this site which requires further evaluation of various remedial alternatives. A central issue will be the integration of any proposed remedy with the current use and regulatory authority at the site.

**RFAAP Response**

No response required.

received
4-26-07

07-68

c: Holt
Lockard
McKenna
Flint
Glover
ENV file

COMMONWEALTH of VIRGINIA

L. Preston Bryant, Jr.
Secretary of Natural Resources

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April 20, 2007

Mr. Jim McKenna
Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, Virginia 24143-0100

Re: RCRA Facility Investigation Report-SWMU 31, Radford Army Ammunition Plant

Dear Mr. McKenna:

The Virginia Department of Environmental Quality (VDEQ) has reviewed the RCRA Facility Investigation Report for SWMU 31 at Radford Army Ammunition Plant and offers the following comments:

1. Section 2.1- The report should include a rough calculation and discussion of the water balance of the lagoon system. Considering there have been no direct discharges it is important to know the extent of potential ground water infiltration at the site.

2. Section 2.1- A schematic showing the water flow dynamics of the lagoon system should be included in the report. What happened to Figure 1-2 that was included in the previous draft report?

3. Section 2.1- The discussion of the discharge history for Outfall 024 is incomplete. My initial contact with the West Central Regional Office of VDEQ indicated that there have been two discharges since 1994 including one in 2003. The results of any required sampling should be reported. The status of any ground water monitoring requirements in conjunction with the permit should also be included in the report.

4. Section 2.4- The ground water/surface water (lagoon) interaction at the site needs to be discussed as part of the site hydrogeology.

5. Section 2.6- It would be appropriate to include VDEQ's position on MCL compliance as it relates to the Commonwealth's position on the beneficial use of ground water.

Overall the report appears to reflect the general consensus of the previous team discussions (although I can't comment on additional BTAG and/or HHRA communications with Shaw) however, as the conclusions indicate, there is future potential risk at this site which requires further evaluation of various remedial alternatives. A central issue will be the integration of any proposed remedy with the current use and regulatory authority at the site.

Please contact me at (804) 698-4498 if you have any questions or comments regarding the above site.

James L. Cutler, Jr., CPG
Federal Facilities Project Manager

cc: Paige Holt, ATK
Will Geiger, US EPA Region 3
Durwood Willis, DEQ
Norman Auldridge, VDEQ-WCRO

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Radford Army Ammunition Plant
Route 114, P.O. Box 1
Radford, VA 24143-0100
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April 20, 2007

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

Subject: Response to comments from EPA received April 11, 2007 for SWMU 31 RCRA Facility Investigation Report, Final Document, December 2006
Radford Army Ammunition Plant Installation Action Plan
EPA ID# VA1 210020730

Dear Mr. Geiger:

Enclosed are the subject responses. The referenced EPA comment letter was not dated but was received April 11, 2007 via email by Mr. McKenna with a hard copy being received April 16, 2007. Note SWMU 31 is on the agenda for the stakeholder meeting scheduled for Wednesday May 16, 2007 in Philadelphia, PA.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

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

c: Russell Fish, P.E., EPA Region III, 3WC23

Jim Cutler
Virginia Department of Environmental Quality
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Coordination: J McKenna
J. McKenna

07-815-81
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# Response to USEPA Comments received via email on April 11, 2007
# for
# Final SWMU 31 RCRA Facility Investigation Report
# December 2006

## General Comments

## Relevant to the RFI

### EPA Comment 1

The RFI Report states that the solid waste management unit (SWMU) 31 lagoons historically received waters carrying fly ash and bottom ash from Power House No. 2. Typically, fly ash contains elevated levels of metals. Although several metals (aluminum, arsenic, iron, manganese, and vanadium) were detected at elevated levels in and around SWMU 31, no discussion of the potential for these elevated levels having resulted from the historical management of ash is presented. Additionally, the dioxin compounds and bis(2-ethylhexyl)phthalate (BEHP) could have also originated from these historical operations. Please revise the RFI Report to account for the possibility that conditions may have been different over the operational time frame of this unit. Ensure that future discussions address the potential impact past releases could have had on the contaminants being detected.

> **RFAAP Response**
>
> Elevated metals concentrations due to fly ash would be expected to be the highest in the sediment in the settling lagoons. Sediment samples showed concentrations that were, in general, below background concentrations. There were single industrial exceedances of aluminum and thallium. The sample with elevated thallium was collected in 1992, and the elevated concentration could not be duplicated during more recent sampling efforts, indicating it is likely a false positive. Table 3-8 gives a summary of the sediment sample results, and shows that there are not widespread elevated metals in the pond sediment. It is agreed that the presence of dioxins in the soil is likely related to power plant operations (although not necessarily the settling ponds). There was only one residential exceedance of the summed TE, and no individual congeners exceeded screening criteria. Detections of bis(2-ethylhexyl)phthalate were "B" flagged during data validation , indicating that this compound was also detected in associated laboratory blanks. This compound is a common laboratory contaminant and its presence in the samples is unlikely to be site related. The Army could find no evidence linking bis(2-ethylhexyl)phthalate with the burning of coal. Please provide references to support this claim.

### EPA Comment 2

The tables of analytical results presented in Section 2.0 lack several features that aid in interpretation of the results. First, none of the tables in this section include a legend or notes section. A legend should be used to define the meaning of acronyms or data qualifiers used throughout the tables. It should also be used to define the meaning of the shaded cells or bold text. Additionally, it appears that non-detect results have been identified with an "nd" in most of the tables. However, if a result is non-detect, the reporting limit for that particular analyte should be presented. This will allow one to compare the reporting limits to the applicable screening criteria. Please revise the tables of analytical results presented in Section 2.0 to include the above information.

> **RFAAP Response**
>
> A legend will be provided in Section 2 that describes the shading, acronyms and data qualifiers used in the tables. Where possible, RLs are reported for non-detects (*e.g.* Tables 2-6, 2-7, 2-8 and 2-9). In some of the older data sets, the information is not available. In these cases, "nd" was used for non-detects.

### EPA Comment 3

The RFI Report lacks a discussion of the interaction between groundwater and the surface water of the lagoons. Page 2-6 notes that "seasonal groundwater elevations have been observed to fluctuate 2 to 7 feet at this SWMU," but no data has been provided to support this statement. Additionally, the report has not presented any surface water measurements of the lagoons. There is also some concern, given the location of the lagoons at a topographic low, that surface water run-off could collect in the lagoons in the absence of catch basins or other drainage features in the vicinity of the SWMU (page 2-8). Please revise the RFI Report to present a discussion of the groundwater/surface water interaction at the lagoons. This discussion should be supported with groundwater and surface water elevation data collected at different times of the year. Additionally, please discuss the potential impact of surface water run-off collecting in the lagoons.

**RFAAP Response**

Groundwater contour maps for one year of monthly groundwater elevation data are contained in the previously submitted *Current Conditions Report – Horseshoe Area* (Shaw, 2005). Maps showing the range of elevations will be presented. Elevations within the ponds will primarily be driven by the rate of flow from the water treatment plant into the ponds. A brief discussion of the surface water/groundwater interaction will be added.

**EPA Comment 4**

It appears that several data gaps still exist with respect to defining the current nature and extent of contamination at SWMU 31. During the 2002 RFI, several deeper sediment samples were collected within each of the three lagoons, but it is not clear that the locations and depths sampled provide adequate characterization of the site. For example, the deeper samples collected in the primary lagoon (31SE13 and 31SE14) do not appear to have been collected near the outfall, which is a likely location for contaminated sediments to accumulate over time (Figure 3-3). Additionally, it is not clear why the 2-4 foot interval was not sampled at 31SE13. As noted by the analytical results for the secondary lagoon presented in Table 3-3, some of the highest concentrations of polynuclear aromatic hydrocarbons (PAHs) were detected in sediment collected from the 2-4 foot interval at location 31SE12B (believed to have been collected at the outfall of the secondary lagoon based on information presented in Section 2.7.4). A similar evaluation of deeper sediments near the outfall in the primary lagoon should be considered.

Also, as mentioned above, several PAHs in sediment sample 31SE12B exceeded Region 3 residential and/or industrial soil risk-based concentrations (RBCs). The lateral and vertical extent of this contamination has not been adequately characterized as none of the other samples in this lagoon were collected at depths greater than 3 feet below grade.

An additional data gap exists with respect to characterizing groundwater contamination. It is noted that monitoring well 31MW2 was not sampled during the 2002 RFI since the well was dry at that time. When the well was sampled during the 1998 investigation, benzo(a)pyrene as well as several metals were detected above the tapwater RBCs and/or federal maximum contaminant levels (MCLs). Groundwater data from this well or another in the vicinity is necessary to characterize the current extent of groundwater contamination. It appears that a groundwater elevation measurement was collected from this well in September 2003 (as shown on Figure 2-3), so it is not clear why this data gap has not already been filled. Please revise the RFI Report to address this and the previously noted data gaps with respect to characterizing the extent of contamination at SWMU 31.

**RFAAP Response**

Sediment boring 31SE14 was collected at the outfall. The sample location map will be revised (See Response to Comments 9 & 10) to show the location of the outfall, which should clarify this issue.

A sample was not collected from 2-4 ft from sediment boring 31SE13 due to no recovery in the sample in the coring device. Several attempts were made to collect a sample from this interval. This information will be added to *Section 1.3 - Modifications to the Sampling Plan.*

One PAH (benzo(a)pyrene) exceeded the industrial RBC in 1 of 14 sediment samples. Benzo(a)pyrene exceeded its tap water RBC in 2 of 7 groundwater samples collected at the site. Concentrations did not exceed the MCL. The groundwater results are discussed in more detail in Response to Comment 19. Based on the low concentrations of PAHs in the sediment and groundwater and their prevalence in asphalt, PAHs do not appear to represent a major concern at the site. Additionally, the EPA agreed in the March 2006 quarterly partnering meeting that no additional groundwater investigation would be required.

**EPA Comment 5**

The Site Screening Process (SSP) for the RFAAP, dated October 26, 2001, states that groundwater parameters measured during field activities should include pH, Eh, dissolved oxygen, specific conductance, temperature, salinity, and turbidity, as appropriate (page 3-1). The RFI Report does not present the results of any such measurements conducted during groundwater sampling, so it is not apparent whether the SSP has been followed. Please revise the RFI Report to include these measurements, if they were collected. If not, please provide the rationale for deviating from the SSP.

**RFAAP Response**

The SSP is only used to screen in or out sites prior to the performance of an RFI and is not applicable to RFIs. Water quality parameters from the 2002 sampling event will be provided in an Appendix to the RFI report.

## Relevant to the Human Health Risk Assessment

**EPA Comment 6**

In Section 5.0, *Human Health Risk Assessment*, there are several inconsistencies between Table 5-1 (Selection of Exposure Pathways); Figure 5-1 (Conceptual Site Model for SWMU 31); and discussions in the text that identify the human receptors and exposure pathways evaluated in the human health risk assessment (HHRA). Please revise the HHRA section to ensure that Table 5-1, Figure 5-1, and the associated text present consistent information about the selected receptors and exposure pathways, including, but not limited to, the inconsistency issues identified in the Specific Comments section of this document.

**RFAAP Response**

Table 5-1, Figure 5-1, and the corresponding text will be reviewed and revised, as necessary.

**EPA Comment 7**

Human exposure to sediment was evaluated for relevant receptors using only data from samples collected from the 0-2 feet below ground surface (ft bgs) depth interval (i.e., surface sediment), including one sediment sample that was collected from the 1- 3 ft bgs depth interval. The seven selected surface sediment samples are identified in Table 5-5 (SWMU 31 Sample Groupings). However, no rationale is provided to support the exclusion of the remaining data points collected from deeper depths. If any of the sediment data pertains to deposited sediment that could be considered industrial soil, the HHRA should address the potential for receptors to be exposed to deeper sediments under future potential land use activities associated with intrusive operations or the mixing of shallow and deeper sediment horizons. These considerations were addressed in evaluation of the soil data set and comprised the basis for evaluation of "total soil" for potential future receptors. Concerns related to potential exposure to subsurface sediment at the site are made more significant by the detection of high concentrations of PAHs in deeper sediment. Please revise the HHRA to evaluate the entire sediment data set for potential future receptors, based on the potential for surface and subsurface sediment to be mixed during future redevelopment of the site.

**RFAAP Response**

In cases where we are dealing with sediment that is covered by water most of the time (e.g., the SWMU 31 lagoons), we typically evaluate contact with sediment samples collected at depths down to one or two feet. It is assumed that contact would occur as a result of activities such as wading or swimming.

As SWMU 31 is currently an operating facility (and is anticipated to remain active in the future), the sediment in the lagoons is unlikely to be disturbed under typical operating conditions. If development were to occur at SWMU 31, it is more reasonable to assume that the lagoons would be filled in. Therefore, it is not necessary to evaluate exposures to total sediment.

If an alternative that involves excavation or dredging of the lagoons is considered in the Corrective Measures Study for SWMU 31, then the risks associated with exposure to total sediment will be evaluated.

See the Response to Comment 20 as well, since these comments deal with similar issues.

**EPA Comment 8**

The HHRA evaluates potential off-site residential exposure to volatile organic compounds (VOCs) in groundwater via inhalation in indoor air and at the showerhead. It is assumed that groundwater that is used for showering would also be used for other domestic activities, such as ingestion (as drinking water). Please revise the evaluation of off-site residential exposure to groundwater to address the spectrum of potential domestic groundwater usage, including drinking water.

**RFAAP Response**

Future off-site residential exposures to SWMU 31 groundwater included exposures via ingestion, dermal absorption, inhalation of COPCs in indoor air, and inhalation of COPCs in shower air. The results are shown in Tables E-68 and E-69 and discussed in Sections 5.4.7 and 5.4.8. No additional evaluation is necessary.

## SPECIFIC COMMENTS

### Relevant to the RFI

**EPA Comment 9**
**Section 2.1: Site Description and History, page 2-1:** It is noted that Power House No. 2 formerly discharged water carrying fly ash to the lagoons until the late 1980s. Figure 2-1 (SWMU 31 Site Map) shows the former power plant approximately 150 feet away from the primary lagoon. The figure does not show the former discharge point or the location of any discharge lines connecting the former power plant and the lagoon. The location, construction, and integrity of these discharge lines should be discussed within the RFI Report. If the integrity of these lines was ever impaired during their operation, the potential for contamination exists in areas of the site that have not been investigated. Please revise the RFI report to address these concerns. A figure depicting the locations of the discharge lines and their final discharge point should be presented.

**RFAAP Response**
A map showing the locations and discharge points for the pipes connecting the ponds, the water treatment plant and the power house will be presented.

**EPA Comment 10**
**Section 2.1: Site Description and History, page 2-1:** The last paragraph on this page mentions that effluent from the secondary and tertiary settling lagoons is designed to discharge to the New River through Outfall 024. The location of this outfall has not been provided on a site figure. Additionally, it is not clear whether this outfall also existed when the power plant discharged to the lagoons. Please revise the RFI Report to include a figure which shows the location of Outfall 024 and clarify whether this outfall or any others were operational during the time period when the power plant discharged to the lagoons.

**RFAAP Response**
A map showing the outfall will be provided on the same figure as discussed in the Response to Comment 9. All available information about the outfall's historic use is provided in Section 2.1.

**EPA Comment 11**
**Section 2.1: Site Description and History, page 2-1**: The site description does not include a description of the surrounding area. Site features, such as buildings, roads, and other important site features, should be described in the RFI Report and clearly depicted on site figures. A description of the surrounding land use should also be provided as this may help to identify potential receptors. Please revise the RFI Report to include a description of the area surrounding SWMU 31.

**RFAAP Response**
Additional information about surrounding land use will be provided. Receptors and exposure scenarios were presented and agreed upon by EPA and VDEQ during the development of the EPA approved work plan for this investigation (Work Plan Addendum 009, IT, 2002) and also during three quarterly partnering meetings in 2006 (March, June and October).

**EPA Comment 12**
**Section 2.4: Site Hydrogeology, page 2-7:** Hydraulic data is presented for other SWMU at RFAAP to describe the site hydrogeology, but the RFI report does not clearly indicate the relevance of this data with respect to SWMU 31. The locations of these other SWMUs relative to SWMU 31 are not presented. Additionally, it appears that these data pertain to the alluvium sediments. It is noted on Page 2-6 that the secondary and tertiary lagoons were excavated to the bedrock surface. If groundwater is expected to migrate through this weathered bedrock beneath the lagoons, hydraulic data pertinent to this material should be presented. Please revise the RFI Report to provide further information on the hydraulic properties of the weathered bedrock beneath the site.

**RFAAP Response**

Section 2.3, Site Geology, indicates that SWMU 31 is located on a river terrace consisting of flood plain alluvium sediments. Section 2.4 states that the hydraulic data is from other sites that are located within the floodplain alluvium sediments. Additional information from the *Current Conditions Report* (Shaw, 2005) can be added that show that groundwater flows towards the New River from the bedrock highlands located in the center of the HSA. The groundwater flow near the river is upwards, out of the bedrock and into the unconsolidated sediments. The hydraulic data for the sediments is the appropriate data for this site.

**EPA Comment 13**

**Figure 2-4: SWMU 31 Groundwater Contour Map:** Groundwater contour lines are presented northeast and southwest of upgradient well 31MW1. However, it does not appear that data has been collected in these areas to support these solid contour lines. Typically, inferred groundwater contour lines are presented with a dashed line. Please revise Figure 2-4 to present inferred groundwater contour lines in areas that are not entirely supported to by data.

**RFAAP Response**

We agree and the figure will be revised.

**EPA Comment 14**

**Section 2.6: Selection of Chemical-Specific Comparison Criteria, page 2-8:** The RFI Report notes that data are compared to Soil Screening Levels (SSLs), but the report does not address how these evaluation criteria will be used to guide site decisions. Further, it appears that the SSLs used in the evaluation are based on a dilution attenuation factor (DAF) of 20. A DAF of 20 may not be appropriate at this site as the unconsolidated aquifer thickness is negligible beneath the secondary and tertiary lagoons (which were excavated to bedrock). Please provide further justification for use of SSLs based on a DAF of 20. Also, please indicate how the comparison to SSLs guided site decisions.

**RFAAP Response**

No site management decisions are made at the RFI stage in the investigation, other than recommending a CMS or No Further Action. EPA SSL guidance indicates that SSLs are intended to be used as a preliminary screen at sites where no subsurface soil or groundwater data are available. SSLs are intended to give a theoretical impact to groundwater from soil contamination and the assumptions built into the SSL IGW equations assume that contamination is uniformly distributed throughout the unsaturated zone. Subsurface soil data does not support this assumption. Therefore, the DAF of 20 seems reasonable. Actual groundwater data is available and should supersede the theoretical values.

**EPA Comment 15**

**Section 2.6: Selection of Chemical-Specific Comparison Criteria, page 2-8:** It is noted that "exceedances of the SSLs are noted in the analytical tables throughout the report by white text in a shaded cell." This approach does not appear to have been consistently applied throughout the document. For example, no SSL comparison is provided for soil data presented in Table 2-8 and no white text with shaded cells were used where SSLs are listed. Please revise the RFI Report to compare all soil data to SSLs and highlight exceedances..

**RFAAP Response**

SSLs were inadvertently omitted form Table 2-8 and will be added. The remaining soil tables do use the approach outlined in Section 2.6.

**EPA Comment 16**

**Section 2.6.2: Comparison Criteria and Previous Investigations, page 2-10:** It is noted that the April 2004 version of screening levels (EPA Region 3 RBCs) were used in the evaluation of data. The Region 3 RBCs are updated semiannually in April and October of every year. After reviewing the screening levels used in this evaluation, it does appear that the data were appropriately screened against the October 2006 version of the RBCs. Revise Section 2.6.2 to remove the reference to the April 2004 screening levels unless additional justification is provided.

**RFAAP Response**

The reference to the April 2004 RBCs will be changed to October 2006.

**EPA Comment 17**

**Section 2.7.3: RCRA Facility Investigation – Parsons, 1996, page 2-15:** It is noted that four monitoring wells were installed for this investigation - one upgradient (31MW-1) and three downgradient (31MW2, 31MW3, and 31MW-4). Based on the geologic cross sections provided (Figures 1-3 and 2-3), it appears that the upgradient well was installed entirely in the bedrock while the downgradient wells were installed across the soil/bedrock interface. A comparison of the upgradient and downgradient results may not be appropriate if the groundwater samples are representative of different aquifer zones. Please provide the rationale for installing the upgradient well entirely within bedrock when the other wells were installed across the soil/bedrock interface.

**RFAAP Response**

The four wells were installed at the first water encountered. Groundwater flows from the bedrock aquifer into the unconsolidated sediments near the New River. The conceptual site model (Figure 1-3) will be revised to more accurately reflect where groundwater was encountered in the well boring and the slope of the bedrock.

**EPA Comment 18**

**Section 2.7.3: RCRA Facility Investigation – Parsons, 1996, page 2-18:** The Parsons report recommended that surface water and sediment samples be collected from the New River. However, it does not appear that any of the subsequent investigations discussed in this RFI Report include data from the New River. Given that SWMU 31 is approximately 200 feet away from the New River, data from the New River near SWMU 31 should be included in the RFI Report to allow for the assessment of the impact this unit has on the New River. Please revise the RFI Report to present data and a discussion that defines the interaction between the SWMU 31 lagoons and the New River.

**RFAAP Response**

There do not appear to be high concentrations of concern in the lagoons and there is no evidence of a release from the site related to the power plant coal ash settling. THMs detected in surface water and groundwater are related to the drinking water treatment plant and are below MCLs. Metal concentrations in groundwater are similar in the upgradient and downgradient wells, suggesting that these concentrations are background related.

**EPA Comment 19**

**Section 3.2.7: Nature and Extent Conclusions, page 3-44:** It is stated that "the low frequency of exceedances in sediment and the lack of reproducibility in the groundwater samples suggest that PAHs are not a concern at this site." This conclusion does not appear to be entirely supported. As previously noted, there is considerable uncertainty associated with the characterization of contamination at SWMU 31 with respect to PAHs. A low frequency of detection may have been observed for sediment samples collected from the 0-1 foot depth interval, but results from deeper samples, particularly in the secondary lagoon, need to be addressed. Additional lateral and horizontal delineation of PAHs is necessary in the vicinity of sample 31SE12B. Additionally, the "lack of reproducibility in the groundwater samples" is, in part, due to the fact that one of the wells in which benzo(a)pyrene was detected (31MW2) has never been resampled. Please revise the RFI Report to remove the statement that PAHs are not a concern at this site until additional evaluation of data gaps is conducted.

**RFAAP Response**

Benzo(a)pyrene was detected in two wells during the 1998 investigation (31MW-2 and 31MW-3) at concentrations approximately half the MRL. The higher concentration was found in 31MW-3 (0.061 ug/L). This well was resampled in 2002 for PAHs and benzo(a)pyrene was not detected. The benzo(a)pyrene result for 31MW-2 was 0.022 ug/L, approximately 1/3 the concentration detected in 31MW-3. The comment is correct in stating that 31MW-2 was not resampled – due to the fact that the well was dry in 2002. Given the fact that the highest concentration detected in groundwater was well below the MCL for this compound, we believe we are justified in stating that this compound is not a concern in groundwater.

**EPA Comment 20**

**Section 4.0: Contaminant Fate and Transport, page 4-1:** Only one PAH (benzo(a)pyrene) was identified as a chemical of potential concern (COPC) in the HHRA, and therefore, it is the only PAH included in the discussion of fate and transport. It is not clear why other PAHs are also not discussed in this section as several PAHs exceeded applicable screening criteria in the data comparisons included in Sections 2 and 3. page 3-6 notes that benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected in sediment sample 31SE12B above the residential RBCs. Upon further evaluation of the screening process in Section 5 (Table 5-5), it appears that this sample was not included in the selection of COPCs or the risk screening process. Justification for not including this sample in the risk screening process has not been provided. Please re-evaluate the samples used in the COPC selection process or provide additional justification for the exclusion of some samples from this process. If additional COPC are identified, they should be included in the discussion of contaminant fate and transport in Section 4.0.

**RFAAP Response**
There do not seem to be any reasonable exposure routes for deep sediment. Swimmers or site workers would not be exposed to buried sediment. It does not seem reasonable to assume that someone wading in the pond would be exposed to sediment more than one foot below the sediment surface (Wading would be extremely difficult under those circumstances). Also, see Response to Comment 7.

## Relevant to the Human Health Risk Assessment

### EPA Comment 21

**Figure 5-1, Conceptual Site Model for SWMU 31, page 5-8:** This figure presents the sources, release mechanisms, exposure pathways and routes, and current and future human receptors evaluated in the HHRA. Comparison of this figure with Table 5-1 and the text revealed several inconsistencies with respect to receptor populations and associated exposure pathways. Please make the following revisions to this figure for clarification and to improve consistency in this section:

- This figure outlines complete and potentially complete exposure pathways. Please revise the title of the "Pathway" column to read "Contact Medium."

  **RFAAP Response**
  The term "Pathway" will be replaced. However, we prefer to use the term "Exposure Medium" to match the term used in Table 5-1.

- Under the Sources and Release Mechanisms portion of the Figure, please add Groundwater as a Secondary Source → Volatile Emissions as a Secondary Release Mechanism → Air as the Contact Medium→ Inhalation as the Exposure Route. This would more clearly indicate that, for example, the Maintenance Worker receptor inhales air containing volatile emissions from groundwater, rather than directly inhaling groundwater.

  **RFAAP Response**
  The figure will be revised, as requested.

- Under "Current Receptors," please revise the Industrial Worker column to present solid circles for inhalation of dust/volatile emissions from soil, ingestion of soil, dermal contact with soil, inhalation of volatile emissions from groundwater, dermal contact with surface water, ingestion of sediments, and dermal contact with sediments. Table 5-1 and the text identified these as complete exposure pathways for the Industrial Worker receptor under current conditions.

  **RFAAP Response**
  The figure will be revised, as requested.

- Although Trespasser exposures were not quantitatively evaluated in the HHRA (based on the assumption that evaluation of the Maintenance Worker and future Resident receptors would incorporate more conservative exposure parameters) it is relevant to present an outline of the potentially complete exposure pathways associated with this receptor population. Such complete exposure pathways are currently outlined in Table 5-1.

  **RFAAP Response**
  The figure will be revised, as requested.

- Under "Current Receptors" and "Future Receptors," please add columns for off-site Adult and Child Resident to show their potential exposure to volatile emissions from groundwater in indoor air and at the showerhead (and drinking water, as indicated in General Comments above). Table 5-1 and the text identified these as complete exposure pathways for the off-site Adult and Child Resident receptors under future conditions.

**RFAAP Response**
The figure will be revised to distinguish between on-site versus off-site exposure to groundwater.

- Please add notes (in parentheses or as footnotes in the Figure) to distinguish between indoor and outdoor Industrial Worker populations. For example, an outdoor Industrial Worker was evaluated under current conditions, and both outdoor and indoor Industrial Workers were evaluated under future conditions. These distinctions are important because incurred exposures and associated intake parameter values are evaluated differently for indoor and outdoor subpopulations.

  **RFAAP Response**
  The figure will be revised to distinguish between outdoor and indoor exposures for the industrial worker.

- Please add notes (in parentheses or as footnotes in the Figure) for the Adult and Child Resident receptors to distinguish between on-site and off-site receptors. Groundwater is the only relevant medium of concern to off-site Resident receptors, while other media and pathways are relevant only to the on-site Resident receptors.

  **RFAAP Response**
  The figure will be revised to distinguish between on-site versus off-site exposure to groundwater.

**EPA Comment 22**
**Section 5.2.1, Potential Human Exposure Pathways, Exposure Pathway Identification, pages 5-25 to 5-26:** Please revise the first line of this subsection to read "maintenance and industrial workers" instead of "...and excavation workers." Excavation Workers were not evaluated under current site conditions. The subsection on *Off-site Groundwater* states that an off-site residential scenario was evaluated with respect to groundwater use. Please specify what exposure pathways were evaluated for the off-site residential scenario.

**RFAAP Response**
The text will be clarified, as requested.

**EPA Comment 23**
**Section 5.2.1.2, Potential Exposure Pathways under Future Land-Use Conditions, page 5-27:** For consistency with Table 5-1 (Selection of Exposure Pathways), please include a current Industrial Worker receptor as being potentially exposed to volatile emissions stemming from groundwater in the subsection titled *On-Site Groundwater*.

**RFAAP Response**
The current Industrial Worker will be evaluated for inhalation of VOC emissions from groundwater, as requested.

**EPA Comment 24**
**Section 5.2.1.2, Potential Exposure Pathways under Future Land-Use Conditions, Off-Site Groundwater, page 5-28:** As part of the discussion of future *off-site groundwater* exposure pathways, this section states that "There is no current use of off-site groundwater in the vicinity of SWMU 31." However, in the similar discussion of current *off-site groundwater* in Section 5.2.1, evaluation of an off-site residential scenario is mentioned. This scenario should be evaluated under a future scenario as well. Please clarify that the off-site residential scenario was evaluated as both current and future potential exposure pathways for off-site groundwater.

**RFAAP Response**
The text in Section 5.2.1 will be corrected to reflect that there are no current off-site residential exposures to groundwater. Groundwater at SWMU 31 flows toward the river and there are no wells in the flow path. Furthermore, groundwater for SWMU 31 is not being used for any purpose. Future off-site residential exposures have been evaluated in the document.

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4-16-07

07-61

C: Holt
Lockard
McKenna
Flint
EW file

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Commander,
Radford Army Ammunition Plant
Attn: SJMRF-OP-EQ (Jim McKenna)
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Radford, VA 24141-0099

P.W. Holt
Environmental Manager
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Re: Radofrd Army Ammunition Plant, Va.
SWMU 31
Coal Ash Settling Lagoons
Review of the Army's Final RCRA Facility Investigation Report

Dear Mr. McKenna and Ms. Holt:

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Army's (Army's) December, 2006 Final RCRA Facility Investigation (RFI) Report for the investigation of SWMU 31, located at the Radford Army Ammunition Plant (RFAAP). Outlined below, please find EPA's comments based upon that review.

## GENERAL COMMENTS

### Relevant to the RFI

1. The RFI Report states that the solid waste management unit (SWMU) 31 lagoons historically received waters carrying fly ash and bottom ash from Power House No. 2. Typically, fly ash contains elevated levels of metals. Although several metals (aluminum, arsenic, iron, manganese, and vanadium) were detected at elevated levels in and around SWMU 31, no discussion of the potential for these elevated levels having resulted from the historical management of ash is presented. Additionally, the dioxin compounds and bis(2-ethylhexyl)phthalate (BEHP) could have also originated from these historical operations. Please revise the RFI Report to account for the possibility that conditions may have been different over the operational time frame of this unit. Ensure that future

discussions address the potential impact past releases could have had on the contaminants being detected.

2. The tables of analytical results presented in Section 2.0 lack several features that aid in interpretation of the results. First, none of the tables in this section include a legend or notes section. A legend should be used to define the meaning of acronyms or data qualifiers used throughout the tables. It should also be used to define the meaning of the shaded cells or bold text. Additionally, it appears that non-detect results have been identified with an "nd" in most of the tables. However, if a result is non-detect, the reporting limit for that particular analyte should be presented. This will allow one to compare the reporting limits to the applicable screening criteria. Please revise the tables of analytical results presented in Section 2.0 to include the above information.

3. The RFI Report lacks a discussion of the interaction between groundwater and the surface water of the lagoons. Page 2-6 notes that "seasonal groundwater elevations have been observed to fluctuate 2 to 7 feet at this SWMU," but no data has been provided to support this statement. Additionally, the report has not presented any surface water measurements of the lagoons. There is also some concern, given the location of the lagoons at a topographic low, that surface water run-off could collect in the lagoons in the absence of catch basins or other drainage features in the vicinity of the SWMU (page 2-8). Please revise the RFI Report to present a discussion of the groundwater/surface water interaction at the lagoons. This discussion should be supported with groundwater and surface water elevation data collected at different times of the year. Additionally, please discuss the potential impact of surface water run-off collecting in the lagoons.

4. It appears that several data gaps still exist with respect to defining the current nature and extent of contamination at SWMU 31. During the 2002 RFI, several deeper sediment samples were collected within each of the three lagoons, but it is not clear that the locations and depths sampled provide adequate characterization of the site. For example, the deeper samples collected in the primary lagoon (31SE13 and 31SE14) do not appear to have been collected near the outfall, which is a likely location for contaminated sediments to accumulate over time (Figure 3-3). Additionally, it is not clear why the 2-4 foot interval was not sampled at 31SE13. As noted by the analytical results for the secondary lagoon presented in Table 3-3, some of the highest concentrations of polynuclear aromatic hydrocarbons (PAHs) were detected in sediment collected from the 2-4 foot interval at location 31SE12B (believed to have been collected at the outfall of the secondary lagoon based on information presented in Section 2.7.4). A similar evaluation of deeper sediments near the outfall in the primary lagoon should be considered.

   Also, as mentioned above, several PAHs in sediment sample 31SE12B exceeded Region 3 residential and/or industrial soil risk-based concentrations (RBCs). The lateral and vertical extent of this contamination has not been adequately characterized as none of the other samples in this lagoon were collected at depths greater than 3 feet below grade.

   An additional data gap exists with respect to characterizing groundwater contamination. It is noted that monitoring well 31MW2 was not sampled during the 2002 RFI since the well was dry at that time. When the well was sampled during the 1998 investigation, benzo(a)pyrene as well as several metals were detected above the tapwater RBCs and/or federal maximum contaminant levels (MCLs). Groundwater data from this well or another in the vicinity is necessary to characterize the current extent of groundwater contamination. It appears that a groundwater elevation measurement was collected from this well in September 2003 (as shown on Figure 2-3), so it is not clear why this data gap has not already been filled. Please revise the RFI Report to address this and the previously noted data gaps with respect to characterizing the extent of contamination at SWMU 31.

5. The Site Screening Process (SSP) for the RFAAP, dated October 26, 2001, states that groundwater parameters measured during field activities should include pH, Eh, dissolved oxygen, specific conductance, temperature, salinity, and turbidity, as appropriate (page 3-1). The RFI Report does not present the results of any such measurements conducted during groundwater sampling, so it is not apparent whether the SSP has been followed. Please revise the RFI Report to include these measurements, if they were collected. If not, please provide the rationale for deviating from the SSP.

## Relevant to the Human Health Risk Assessment

6. In Section 5.0, *Human Health Risk Assessment*, there are several inconsistencies between Table 5-1 (Selection of Exposure Pathways); Figure 5-1 (Conceptual Site Model for SWMU 31); and discussions in the text that identify the human receptors and exposure pathways evaluated in the human health risk assessment (HHRA). Please revise the HHRA section to ensure that Table 5-1, Figure 5-1, and the associated text present consistent information about the selected receptors and exposure pathways, including, but not limited to, the inconsistency issues identified in the Specific Comments section of this document.

7. Human exposure to sediment was evaluated for relevant receptors using only data from samples collected from the 0-2 feet below ground surface (ft bgs) depth interval (i.e., surface sediment), including one sediment sample that was collected from the 1- 3 ft bgs depth interval. The seven selected surface sediment samples are identified in Table 5-5 (SWMU 31 Sample Groupings). However, no rationale is provided to support the exclusion of the remaining data points collected from deeper depths. If any of the sediment data pertains to deposited sediment that could be considered industrial soil, the HHRA should address the potential for receptors to be exposed to deeper sediments under future potential land use activities associated with intrusive operations or the mixing of shallow and deeper sediment horizons. These considerations were addressed in evaluation of the soil data set and comprised the basis for evaluation of "total soil" for potential future receptors. Concerns related to potential exposure to subsurface sediment at the site are made more significant by the detection of high concentrations of PAHs in deeper sediment. Please revise the HHRA to evaluate the entire sediment data set for potential future receptors, based on the potential for surface and subsurface sediment to be mixed during future redevelopment of the site.

8. The HHRA evaluates potential off-site residential exposure to volatile organic compounds (VOCs) in groundwater via inhalation in indoor air and at the showerhead. It is assumed that groundwater that is used for showering would also be used for other domestic activities, such as ingestion (as drinking water). Please revise the evaluation of

off-site residential exposure to groundwater to address the spectrum of potential domestic groundwater usage, including drinking water.

## SPECIFIC COMMENTS

### Relevant to the RFI

9. **Section 2.1: Site Description and History, page 2-1:** It is noted that Power House No. 2 formerly discharged water carrying fly ash to the lagoons until the late 1980s. Figure 2-1 (SWMU 31 Site Map) shows the former power plant approximately 150 feet away from the primary lagoon. The figure does not show the former discharge point or the location of any discharge lines connecting the former power plant and the lagoon. The location, construction, and integrity of these discharge lines should be discussed within the RFI Report. If the integrity of these lines was ever impaired during their operation, the potential for contamination exists in areas of the site that have not been investigated. Please revise the RFI report to address these concerns. A figure depicting the locations of the discharge lines and their final discharge point should be presented.

10. **Section 2.1: Site Description and History, page 2-1:** The last paragraph on this page mentions that effluent from the secondary and tertiary settling lagoons is designed to discharge to the New River through Outfall 024. The location of this outfall has not been provided on a site figure. Additionally, it is not clear whether this outfall also existed when the power plant discharged to the lagoons. Please revise the RFI Report to include a figure which shows the location of Outfall 024 and clarify whether this outfall or any others were operational during the time period when the power plant discharged to the lagoons.

11. **Section 2.1: Site Description and History, page 2-1:** The site description does not include a description of the surrounding area. Site features, such as buildings, roads, and other important site features, should be described in the RFI Report and clearly depicted on site figures. A description of the surrounding land use should also be provided as this may help to identify potential receptors. Please revise the RFI Report to include a description of the area surrounding SWMU 31.

12. **Section 2.4: Site Hydrogeology, page 2-7:** Hydraulic data is presented for other SWMU at RFAAP to describe the site hydrogeology, but the RFI report does not clearly indicate the relevance of this data with respect to SWMU 31. The locations of these other SWMUs relative to SWMU 31 are not presented. Additionally, it appears that these data pertain to the alluvium sediments. It is noted on Page 2-6 that the secondary and tertiary lagoons were excavated to the bedrock surface. If groundwater is expected to migrate through this weathered bedrock beneath the lagoons, hydraulic data pertinent to this material should be presented. Please revise the RFI Report to provide further information on the hydraulic properties of the weathered bedrock beneath the site.

13. **Figure 2-4: SWMU 31 Groundwater Contour Map:** Groundwater contour lines are presented northeast and southwest of upgradient well 31MW1. However, it does not appear that data has been collected in these areas to support these solid contour lines. Typically, inferred groundwater contour lines are presented with a dashed line. Please

revise Figure 2-4 to present inferred groundwater contour lines in areas that are not entirely supported to by data.

14. **Section 2.6: Selection of Chemical-Specific Comparison Criteria, page 2-8**: The RFI Report notes that data are compared to Soil Screening Levels (SSLs), but the report does not address how these evaluation criteria will be used to guide site decisions. Further, it appears that the SSLs used in the evaluation are based on a dilution attenuation factor (DAF) of 20. A DAF of 20 may not be appropriate at this site as the unconsolidated aquifer thickness is negligible beneath the secondary and tertiary lagoons (which were excavated to bedrock). Please provide further justification for use of SSLs based on a DAF of 20. Also, please indicate how the comparison to SSLs guided site decisions.

15. **Section 2.6: Selection of Chemical-Specific Comparison Criteria, page 2-8:** It is noted that "exceedances of the SSLs are noted in the analytical tables throughout the report by white text in a shaded cell." This approach does not appear to have been consistently applied throughout the document. For example, no SSL comparison is provided for soil data presented in Table 2-8 and no white text with shaded cells were used where SSLs are listed. Please revise the RFI Report to compare all soil data to SSLs and highlight exceedances.

16. **Section 2.6.2: Comparison Criteria and Previous Investigations, page 2-10**: It is noted that the April 2004 version of screening levels (EPA Region 3 RBCs) were used in the evaluation of data. The Region 3 RBCs are updated semiannually in April and October of every year. After reviewing the screening levels used in this evaluation, it does appear that the data were appropriately screened against the October 2006 version of the RBCs. Revise Section 2.6.2 to remove the reference to the April 2004 screening levels unless additional justification is provided.

17. **Section 2.7.3: RCRA Facility Investigation – Parsons, 1996, page 2-15:** It is noted that four monitoring wells were installed for this investigation - one upgradient (31MW-1) and three downgradient (31MW2, 31MW3, and 31MW-4). Based on the geologic cross sections provided (Figures 1-3 and 2-3), it appears that the upgradient well was installed entirely in the bedrock while the downgradient wells were installed across the soil/bedrock interface. A comparison of the upgradient and downgradient results may not be appropriate if the groundwater samples are representative of different aquifer zones. Please provide the rationale for installing the upgradient well entirely within bedrock when the other wells were installed across the soil/bedrock interface.

18. **Section 2.7.3: RCRA Facility Investigation – Parsons, 1996, page 2-18:** The Parsons report recommended that surface water and sediment samples be collected from the New River. However, it does not appear that any of the subsequent investigations discussed in this RFI Report include data from the New River. Given that SWMU 31 is approximately 200 feet away from the New River, data from the New River near SWMU 31 should be included in the RFI Report to allow for the assessment of the impact this unit has on the New River. Please revise the RFI Report to present data and a discussion that defines the interaction between the SWMU 31 lagoons and the New River.

19. **Section 3.2.7: Nature and Extent Conclusions, page 3-44:** It is stated that "the low frequency of exceedances in sediment and the lack of reproducibility in the groundwater samples suggest that PAHs are not a concern at this site." This conclusion does not appear to be entirely supported. As previously noted, there is considerable uncertainty associated with the characterization of contamination at SWMU 31 with respect to PAHs. A low frequency of detection may have been observed for sediment samples collected from the 0-1 foot depth interval, but results from deeper samples, particularly in the secondary lagoon, need to be addressed. Additional lateral and horizontal delineation of PAHs is necessary in the vicinity of sample 31SE12B. Additionally, the "lack of reproducibility in the groundwater samples" is, in part, due to the fact that one of the wells in which benzo(a)pyrene was detected (31MW2) has never been resampled. Please revise the RFI Report to remove the statement that PAHs are not a concern at this site until additional evaluation of data gaps is conducted.

20. **Section 4.0: Contaminant Fate and Transport, page 4-1:** Only one PAH (benzo(a)pyrene) was identified as a chemical of potential concern (COPC) in the HHRA, and therefore, it is the only PAH included in the discussion of fate and transport. It is not clear why other PAHs are also not discussed in this section as several PAHs exceeded applicable screening criteria in the data comparisons included in Sections 2 and 3. page 3-6 notes that benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected in sediment sample 31SE12B above the residential RBCs. Upon further evaluation of the screening process in Section 5 (Table 5-5), it appears that this sample was not included in the selection of COPCs or the risk screening process. Justification for not including this sample in the risk screening process has not been provided. Please re-evaluate the samples used in the COPC selection process or provide additional justification for the exclusion of some samples from this process. If additional COPC are identified, they should be included in the discussion of contaminant fate and transport in Section 4.0.

**Relevant to the Human Health Risk Assessment**

21. **Figure 5-1, Conceptual Site Model for SWMU 31, page 5-8:** This figure presents the sources, release mechanisms, exposure pathways and routes, and current and future human receptors evaluated in the HHRA. Comparison of this figure with Table 5-1 and the text revealed several inconsistencies with respect to receptor populations and associated exposure pathways. Please make the following revisions to this figure for clarification and to improve consistency in this section:
    - This figure outlines complete and potentially complete exposure pathways. Please revise the title of the "Pathway" column to read "Contact Medium."
    - Under the Sources and Release Mechanisms portion of the Figure, please add Groundwater as a Secondary Source → Volatile Emissions as a Secondary Release Mechanism → Air as the Contact Medium→ Inhalation as the Exposure Route. This would more clearly indicate that, for example, the Maintenance Worker receptor inhales air containing volatile emissions from groundwater, rather than directly inhaling groundwater.
    - Under "Current Receptors," please revise the Industrial Worker column to present solid circles for inhalation of dust/volatile emissions from soil, ingestion of soil,

dermal contact with soil, inhalation of volatile emissions from groundwater, dermal contact with surface water, ingestion of sediments, and dermal contact with sediments. Table 5-1 and the text identified these as complete exposure pathways for the Industrial Worker receptor under current conditions.

- Although Trespasser exposures were not quantitatively evaluated in the HHRA (based on the assumption that evaluation of the Maintenance Worker and future Resident receptors would incorporate more conservative exposure parameters) it is relevant to present an outline of the potentially complete exposure pathways associated with this receptor population. Such complete exposure pathways are currently outlined in Table 5-1.
- Under "Current Receptors" and "Future Receptors," please add columns for off-site Adult and Child Resident to show their potential exposure to volatile emissions from groundwater in indoor air and at the showerhead (and drinking water, as indicated in General Comments above). Table 5-1 and the text identified these as complete exposure pathways for the off-site Adult and Child Resident receptors under future conditions.
- Please add notes (in parentheses or as footnotes in the Figure) to distinguish between indoor and outdoor Industrial Worker populations. For example, an outdoor Industrial Worker was evaluated under current conditions, and both outdoor and indoor Industrial Workers were evaluated under future conditions. These distinctions are important because incurred exposures and associated intake parameter values are evaluated differently for indoor and outdoor subpopulations.
- Please add notes (in parentheses or as footnotes in the Figure) for the Adult and Child Resident receptors to distinguish between on-site and off-site receptors. Groundwater is the only relevant medium of concern to off-site Resident receptors, while other media and pathways are relevant only to the on-site Resident receptors.

22. **Section 5.2.1, Potential Human Exposure Pathways, Exposure Pathway Identification, pages 5-25 to 5-26:** Please revise the first line of this subsection to read "maintenance and industrial workers" instead of "...and excavation workers." Excavation Workers were not evaluated under current site conditions. The subsection on *Off-site Groundwater* states that an off-site residential scenario was evaluated with respect to groundwater use. Please specify what exposure pathways were evaluated for the off-site residential scenario.

23. **Section 5.2.1.2, Potential Exposure Pathways under Future Land-Use Conditions, page 5-27:** For consistency with Table 5-1 (Selection of Exposure Pathways), please include a current Industrial Worker receptor as being potentially exposed to volatile emissions stemming from groundwater in the subsection titled *On-Site Groundwater.*

24. **Section 5.2.1.2, Potential Exposure Pathways under Future Land-Use Conditions, Off-Site Groundwater, page 5-28:** As part of the discussion of future *off-site groundwater* exposure pathways, this section states that "There is no current use of off-site groundwater in the vicinity of SWMU 31." However, in the similar discussion of current *off-site groundwater* in Section 5.2.1, evaluation of an off-site residential scenario is mentioned. This scenario should be evaluated under a future scenario as well. Please

clarify that the off-site residential scenario was evaluated as both current and future potential exposure pathways for off-site groundwater.

Please revise the referenced RFI report to reflect the comments above. If you have any questions, please call me at 215-814-3413. Thanks.

Sincerely,

William Geiger
RCRA Project Manager
General Operations Branch (3WC23)

cc: Russell Fish, EPA
James Cutler, VDEQ
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January 5, 2007

Mr. Robert Thomson
U. S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Subject: SWMU 31 RCRA Facility Investigation Report, Final Document, December 2006
Radford Army Ammunition Plant Installation Action Plan
EPA ID# VA1 210020730

Dear Mr. Thomson:

Enclosed is one copy of the subject document. Your additional four copies will be sent under separate cover . Also under separate cover, one copy each will be sent to the distribution below.

This document has been revised per the agreements reached at meetings held in Philadelphia, PA on March 29 and 30, June 21 and October 4, 2006 among the stakeholders to address the comments in Environmental Protection Agency letters dated April 25, May 8 and June 19, 2006 and Virginia Department of Environmental Quality letter dated March 21, 2006. As there was substantial revision to the draft it was agreed that a detailed response to comments would not be productive. Note the recommendation has changed from no further action in the draft report to conduct a corrective measures study in the final report.

Please coordinate with and provide any questions or comments to myself at (540) 639-8658, Jerry Redder of my staff (540) 639-7536 or Jim McKenna, ACO Staff (540) 639-8641.

Sincerely,

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07-815-5
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Concerning the following:

## *Radford Army Ammunition Plant*
## *SWMU 31 RCRA Facility Investigation Report*
## *Final Document December 2006*

*Radford Army Ammunition Plant*

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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07-815-5
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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/L | micrograms per liter |
| ADD | Average Daily Dose |
| ADI | Allowable Daily Intake |
| BAF | Bioaccumulation Factor |
| BCF | Bioconcentration Factor |
| bgs | below ground surface |
| BTAG | Biological Technical Assistance Group |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| COPC | Chemical of Potential Concern |
| COPEC | Chemical of Potential Ecological Concern |
| CSEM | Conceptual Site Exposure Model |
| CSF | Cancer Slope Factor |
| CSM | Conceptual Site Model |
| DAF | Dilution Attenuation Factor |
| EcoSSL | Ecological Soil Screening Level |
| EEQ | Environmental Effects Quotient |
| EPC | Exposure Point Concentration |
| ft | feet |
| FWBSR | Facility-Wide Background Study Report |
| gpm | gallons per minute |
| HEAST | Health Effects Assessment Summary Tables |
| HHRA | Human Health Risk Assessment |
| HI | Hazard Index |
| HQ | Hazard Quotient |
| HSA | Horseshoe Area |
| ICF KE | ICF Kaiser Engineers, Inc. |
| IRIS | Integrated Risk Information System |
| IT | IT Corporation |
| LADD | Lifetime Average Daily Dose |
| LOAEL | Lowest Observable Adverse Effect Level |
| MCL | Maximum Contaminant Level |
| MCLG | Maximum Contaminant Level Goal |
| MDC | Maximum Detected Concentration |
| MG | Million Gallons |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per Liter |
| MHSP | Master Health and Safety Plan |
| MMA | Main Manufacturing Area |
| MQAP | Master Quality Assurance Plan |
| msl | mean sea level |
| MWP | Master Work Plan |
| NCEA | National Center for Environmental Assessment |
| NCP | National Contingency Plan |
| NG | Nitroglycerin |
| NOAEL | No Observable Adverse Effect Level |
| PAH | Polynuclear Aromatic Hydrocarbon |
| PCB | Polychlorinated Biphenyl |
| PEF | Particulate Emission Factor |
| PETN | Pentaerythritol tetranitrate |
| PPRTV | Provisional Peer Reviewed Toxicity Value |
| RBC | Risk-Based Concentration |
| RCRA | Resource Conservation and Recovery Act |
| RFAAP | Radford Army Ammunition Plant |
| RfC | Risk Reference Concentration |
| RfD | Risk Reference Dose |
| RFI | RCRA Facility Investigation |
| RME | Reasonable Maximum Exposure |
| RTE | Rare, Threatened, or Endangered |
| SLERA | Screening Level Ecological Risk Assessment |

| | |
|---|---|
| SQL | Sample Quantitation Limit |
| SSL | Soil Screening Level |
| SVOC | Semivolatile Organic Compound |
| TAL | Target Analyte List |
| TCL | Target Compound List |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TE | Toxicity Equivalent |
| TEF | Toxicity Equivalency Factor |
| TOC | Total Organic Carbon |
| TOX | Total Organic Halides |
| TRV | Toxicity Reference Value |
| UCL | Upper Confidence Limit |
| USEPA | U.S. Environmental Protection Agency |
| UTL | Upper Tolerance Limit |
| VDEQ | Virginia Department of Environmental Quality |
| VI | Verification Investigation |
| VOC | Volatile Organic Compound |
| WPA | Work Plan Addendum |
| VPDES | Virginia Pollutant Discharge Elimination System |

# EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers, Baltimore District, to perform additional characterization activities at nine sites at the Main Manufacturing Area (MMA) of Radford Army Ammunition Plant (RFAAP), in accordance with Contract No. DACA31-01-F-0085. The investigative activities for SWMU 31 were detailed in *Work Plan Addendum (WPA) 009* (IT, 2002) to the *RFAAP Master Work Plan (MWP)* (URS, 2003). Task objectives were to develop and execute investigations to complete characterization of these sites. Investigative activities were conducted in accordance with the MWP, Master Quality Assurance Plan, and the Master Health and Safety Plan.

SWMU 31 consists of three connected unlined settling lagoons that were constructed and first used in the 1950s. The primary settling lagoon received water carrying fly ash and bottom ash from Power House No. 2 from the 1950s until the late 1980s. The secondary and tertiary lagoons were designed to receive the primary lagoon discharge.

Facility representatives indicate that the water currently flowing into the primary settling lagoon consists of either overflow from the drinking water settling tanks or backwash from the cleaning of the filters at the drinking water settling tanks at Water Plant 4330. The water treatment plant has also been active since the 1950s and is the only currently active discharge to the lagoons.

Data from three previous investigations was combined with data from the current (2002) investigation to evaluate the nature and extent of contamination (*Section 3.0*) and to assess potential impacts to human health (*Section 5.0*) and/or ecological receptors (*Section 6.0*).

### *Contamination Assessment*

The contamination assessment indicated that pesticides, herbicides, polychlorinated biphenyls, explosives and perchlorate are not a concern at the site since they did not exceed screening levels in site media. The assessment also indicated that volatile organic compounds (VOCs) detected at the site in surface water and groundwater are water chlorination byproducts, and were detected at concentrations below Maximum Contaminant Levels (MCLs). These compounds were not detected in soil or sediment, indicating that VOCs are not migrating via those pathways.

Polynuclear aromatic hydrocarbons (PAHs) detected in sediment exceeded residential screening levels [industrial screening level for benzo(a)pyrene] in seven out of 14 samples. Benzo(a)pyrene also exceeded the tap water risk-based concentration, but was below the MCL, in two of seven groundwater samples. Although these results indicate that there is some migration of PAHs from sediment to groundwater, the low frequency of exceedances in sediment and the lack of reproducibility in the groundwater samples suggest that PAHs are not a major concern at this site. Non-PAH semivolatile organic compounds (SVOCs) were detected below screening levels in site media, with the exception of bis(2-ethylhexyl)phthalate. This compound is a common laboratory contaminant and was "B" flagged during data validation were it exceeded screening levels, indicating that it was also detected in associated laboratory blanks. Therefore, non-PAH SVOCs are also not considered to be a major concern at the site.

Metals exceeding screening levels in surface water were aluminum, iron and manganese. These metals are likely due to high background levels of these metals in surface water. Filtered groundwater samples show that aluminum was the only constituent to consistently exceed a screening level. As with the surface water, this is likely the result of high naturally occurring levels of aluminum. Sediment also showed aluminum levels greater than background. Soil samples did not contain any metals at concentrations greater than background and residential or industrial screening levels.

The calculated TCDD TE for one soil sample exceeded the residential screening level for TCDD. Individual congeners of dioxins/furans were below screening levels. Deeper samples collected from the same soil boring indicate that dioxins/furans are not migrating vertically. This sample was collected immediately beneath an asphalt road, which limits exposure to human or ecological receptors. The sediments in the lagoons had TCDD TEs below residential screening levels. The lack of an exposure pathway to the sole exceedance of dioxins/furans suggests that dioxins/furans are not a major concern at the site.

### *Human Health Risk Assessment (HHRA)*

An HHRA (*Section 5.0*) was performed to evaluate the potential human health effects associated with past activities at SWMU 31. Using the results of the human exposure assessment and toxicity information, potential human health risks for each chemical of potential concern (COPC) and selected exposure pathway were evaluated.

The potential risks for maintenance workers (current and future) for exposure to surface soil were below the target risk range and hazard indices (HIs) were less than 1. The risk range for exposure to sediment was slightly elevated at $2.0\text{x}10^{-6}$; the major risk driver was arsenic. The total HI was less than 1. Current and future maintenance exposure risks associated with surface water were also below the target risk range with an HI less than 1. Current and future maintenance exposure risks associated with groundwater were below the target risk range with an HI of less than 1.

The cumulative risk for maintenance workers exposure to soil, sediment, surface water and groundwater is $2.9\text{x}10^{-6}$, with an HI of less than 1. These results indicate potentially slightly elevated risk to current workers, with the major COPC being arsenic, which was determined to be within background.

For the current/future outdoor industrial worker, total cancer risk from exposure to total soil and surface soil was slightly elevated at $3.8\text{x}10^{-6}$, but again the major risk driver was arsenic, which is below background at the site. The total HIs were less than 1. Current/future exposure risks associated with sediment were also slightly elevated due to arsenic at $9.2\text{x}10^{-6}$, with an HI of less than 1. Risks from exposure to surface water were below the target risk range with an HI of less than 1. For current outdoor industrial worker exposures, the total cancer risk associated with groundwater ($8.3\text{x}10^{-8}$) was below the target risk range. The total HI was less than 1. For future outdoor industrial worker exposures to groundwater, total cancer risk was elevated at $4.6\text{x}10^{-5}$ with benzo[a]pyrene and arsenic as the major drivers. The total HI was less than 1.

For future indoor industrial worker exposures, risk from exposure to groundwater was elevated at $4.7\text{x}10^{-5}$, with the major risk drivers being benzo(a)pyrene, arsenic, and chloroform. However, chloroform in groundwater is related to the site's current use as part of the water treatment plant. The total HI was less than 1.

For the future excavation worker (based on 1.25 acres), risk from exposure to total soil was below the target range; however, the HI (HI = 5.96) was greater than 1. Risk from exposure to sediment was $1.0\text{x}10^{-6}$, with an HI of less than 1. Risks from exposure to surface water and groundwater were below the target range, with HIs of less than 1.

Although a residential scenario at SWMU 31 is unlikely, both future lifetime/adult and child residents were evaluated. For future lifetime/adult residents, potential exposure to soil, sediment and surface water all produced HIs of less than 1. Cancer risks from exposure to soil ($1.7\text{x}10^{-5}$) and sediment ($3.8\text{x}10^{-6}$) were slightly elevated, again with the major risk driver being arsenic. Cancer risks from surface water were below the target range. Risks from exposure to groundwater ($3.7\text{x}10^{-4}$) were above the target risk range, with the major risk drivers being benzo(a)pyrene, arsenic, and chloroform. As noted above; however, chloroform in groundwater is related to the site's current use as part of the water treatment plant. The total HI (HI = 2.4) was above 1; there was no major risk driver. For future off-site residents, the cancer risks and HIs associated with groundwater exposures are assumed to be the same as those for future on-site residents.

For the future child resident, total soil cancer risk was in the target range ($1.2\text{x}10^{-5}$) with the major risk drivers being dioxins/furans and arsenic. The HI was 3.4, primarily due to iron (determined from margin of exposure evaluation to be within the allowable range) and vanadium (which was determined to be within the range of background concentrations). Potential child resident exposure to sediment was slightly elevated ($2.5\text{x}10^{-6}$) again due to arsenic, with a total HI less than 1. There were no risks associated with surface water. Risks from exposure to groundwater ($1.3\text{x}10^{-4}$) were above the target risk range, with the major risk drivers being benzo(a)pyrene and arsenic. The total HI (HI = 5.7) was above 1, primarily due to arsenic, iron (determined from margin of exposure evaluation to be within the allowable range), and vanadium. Although the individual hazard quotients for manganese do not exceed 1, the target organ HI for the central nervous system (1.2) was greater than 1, primarily due to manganese. For future off-site residents, the cancer risks and HIs associated with groundwater exposures are assumed to be the same as those for future on-site residents.

### *Screening Level Ecological Risk Assessment (SLERA)*

A SLERA (*Section 6.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 31. Although four metals were initially identified as risk drivers in soil for the food chain pathway, all of these metals were subsequently determined to be related to background. The Tier 2 food chain assessment results suggested potential adverse impacts to terrestrial wildlife, such as the shrew and American robin, for modeled contact with 2,3,7,8-TCDD and DDT, respectively.

The direct contact assessment results for soil invertebrates suggested that a reduction in wildlife food supply, due to chemicals of potential ecological concern (COPECs) in surface soil, was unlikely. The direct contact results for surface water and sediment, however, indicated that aluminum, barium, iron, lead, endosulfan II, endrin, and pyrene in surface water, and 24 COPECs in sediment, may potentially affect aquatic biota.

Potential adverse impacts to amphibians in the lagoons were not expected to be a significant concern, as the results of the amphibian evaluation suggested that local populations of amphibians are not being significantly impacted by surface water or sediment COPECs. However, several screening COPEC concentrations were exceeded.

Migration of COPECs in groundwater to surface waters and sediment of the New River was determined not to be a significant ecological concern.

### *Conclusion*

Overall, there appears to be minimal to no risk to current workers at the site with the major risk driver being arsenic. The HHRA calculated elevated risks to future residential receptors. The SLERA concluded that aquatic biota may be impacted by lagoon surface water and sediment. There may be potential impact to amphibians as well from lagoon surface water and sediment.

It is recommended that a CMS be conducted to evaluate potential remedial alternatives for the site.

# 1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers, Baltimore District, to perform additional characterization activities at nine sites at the Main Manufacturing Area (MMA) of Radford Army Ammunition Plant (RFAAP), in accordance with Contract No. DACA31-01-F-0085. The investigative activities for SWMU 31 were detailed in *Work Plan Addendum (WPA) 009* (IT, 2002) to the *RFAAP Master Work Plan (MWP)* (URS, 2003). Task objectives were to develop and execute investigations to complete characterization of these sites. Investigative activities were conducted in accordance with the MWP, Master Quality Assurance Plan (MQAP), and the Master Health and Safety Plan (MHSP).

## 1.1 SWMU 31 OVERVIEW

RFAAP is located in the mountains of southwestern Virginia in Pulaski and Montgomery Counties. It is about 250 miles southwest of our nation's capital, Washington, DC, and 50 miles west of the nearest metropolitan area, Roanoke, VA. The Installation encompasses approximately 7,000 acres in two non-contiguous areas – the larger Radford unit, which is the MMA; and the New River Unit which is presently used for storage only (**Figure 1-1**). Solid Waste Management Unit (SWMU) 31, the Coal Ash Settling Lagoons, is located within the MMA and consists of three connected unlined settling lagoons, with a total area of approximately 72,500 $ft^2$ located in the northwest section of the Horseshoe Area (HSA) on a nearly level river terrace adjacent to the New River (**Figure 1-2**).

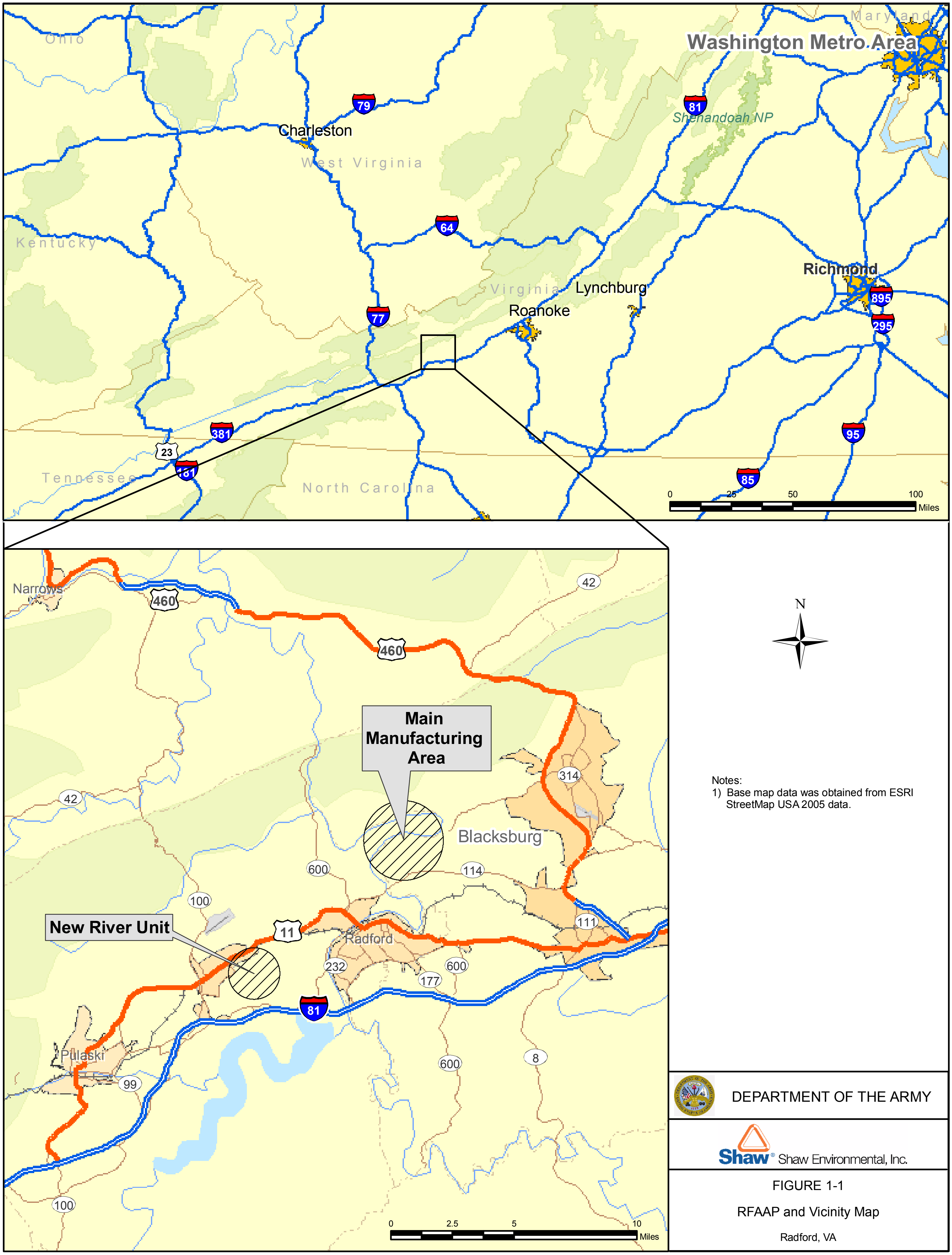
Environmental samples collected during previous investigations suggest potential impacts to lagoon sediments from metals and polynuclear aromatic hydrocarbons (PAHs). These analytical results triggered a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to more completely characterize the site. Investigative activities discussed in this plan were required to augment the existing conceptual site model (CSM) and assess the need for and/or scope of corrective measures. This report is intended to summarize previous investigation data and analyze the data collected at SWMU 31 during the summer of 2002 as part of the WPA 009 field investigation for this purpose.

## 1.2 INVESTIGATION OVERVIEW

The investigation at SWMU 31 was conducted to augment the existing data and fill data gaps. The 2002 field investigation at SWMU 31 was specifically conducted to:

1. Further evaluate potential metal and PAH contamination identified from previous efforts.
2. Characterize site media for previously untested analyte classes which included target compound list (TCL) volatile organic compounds (VOCs), pesticides, polychlorinated biphenyls (PCBs), herbicides, explosives [including nitroglycerin (NG) and pentaerythritol tetranitrate (PETN)], dioxins/furans and perchlorate. In addition, soil samples were analyzed for total organic carbon (TOC), grain size, and pH to assess the bioavailability and mobility of constituents in the soil.

In order to achieve these goals, a sampling program was designed through the development of a CSM, a data gap analysis and negotiations with Commonwealth and Federal regulators. The details of this process are discussed in WPA 009 (IT, 2002).



Notes:
1) Base map data was obtained from ESRI StreetMap USA 2005 data.

DEPARTMENT OF THE ARMY

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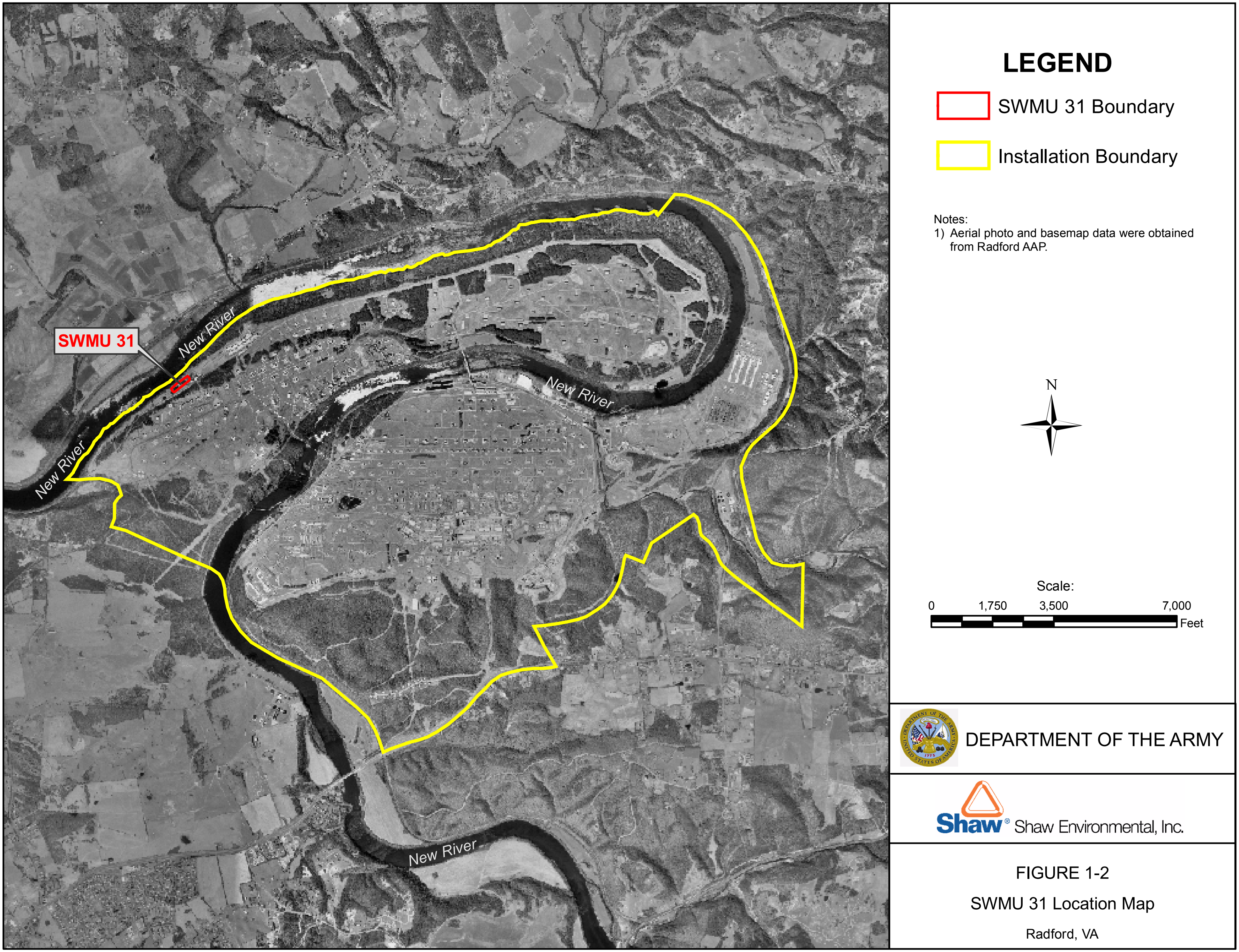
FIGURE 1-1

RFAAP and Vicinity Map

Radford, VA

Date: 11/14/06 GIS File: RFAAP_001_Fig1-1_SWMU31_Vicinity.mxd



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

DEPARTMENT OF THE ARMY

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FIGURE 1-2

SWMU 31 Location Map

Radford, VA

Date: 11/16/06 GIS File: RFAAP_013_Fig1-2_SWMU31_Location.mxd

## 1.3 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. Three adjustments to WPA 009 (IT, 2002) were necessary during sampling activities at SWMU 31, as described below.

1. WPA 009 indicated that groundwater samples would be collected from each of the four wells at the site. Monitoring well 31MW2 was dry at the time of the sampling event, so a groundwater sample was not collected from this well.
2. Depth to bedrock was less than expected under the lagoons. Four sediment samples were collected from sediment borings in the primary lagoon, rather than the five specified in WPA 009.
3. A sample was not collected from 2-4 feet (ft) from sediment boring 31SE13 due to no recovery in the sample in the coring device.

## 1.4 CONCEPTUAL SITE MODEL

A site-specific CSM was developed for the SWMU 31 in WPA 009 (IT, 2002) to identify potential contaminant sources, exposure pathways, and human and ecological receptors. Each media type potentially present at the site (i.e., surface and subsurface soil) was evaluated to assess whether human or biotic receptors would be impacted by contamination. Three exposure routes (ingestion, inhalation and dermal absorption) were evaluated for each media type. Historical site use information was employed to identify types of potential contamination and locations of potentially contaminated areas. Site topography and physical land features, such as creeks, or drainage ditches, were used to approximate contaminant migration pathways.

A CSM figure was also developed for the SWMU 31 in MWP Addendum 009 (IT, 2002). Sampling locations were selected based on previous sample results, site visit observations, negotiations with regulators, and the CSM. Based on the discussions with the regulators, changes to the CSM were required. Evaluation of two additional human receptors (i.e., adult and child residents) was considered. The revised CSM is presented in **Table 1-1** and **Figure 1-3**.

**Figure 1-3** demonstrates that effluent is discharged directly to the lagoons. Because the lagoons were excavated to bedrock, both lagoon surface water and groundwater flow through lagoon sediments to the New River. The area of potentially impacted groundwater (groundwater after it flows through lagoon sediments) is approximately 175 ft between the lagoons and the New River.

# Table 1-1
# Potential Exposure Pathways and Receptors at SWMU 31

| Media | Potentially Affected Media | Exposure Pathways and Receptors | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| | | Human | | | Biota | | | |
| | | Adult Residents | Child Residents | Site Workers | Terrestrial | Aquatic | Benthic | |
| Surface Soil | Yes | IN, INH, DA | IN, INH, DA | IN, INH, DA | IN, INH, DA | — | — | Inhalation of dust. |
| Surface Water | Yes | IN, DA | IN, DA | IN, DA | IN, DA | IN, DA | IN, DA | Water in settling ponds |
| Sediment | Yes | IN, DA | IN, DA | IN, DA | IN, DA | IN, DA | IN, DA | |
| Subsurface Soil | Yes | IN, INH, DA | IN, INH, DA | IN, INH, DA | — | — | — | During construction activity. |
| Groundwater | Yes | IN, DA | IN, DA | IN, DA | — | — | — | Potential future use of groundwater. |

Abbreviations: IN = ingestion, INH = inhalation, DA = dermal absorption.

| DRAWN BY | CHECKED BY | APPROVED BY | DRAWING NUMBER |
|---|---|---|---|
| A. Smith<br>11/30/06 | M. Thomas<br>-- | --<br>-- | 839197-B3 |

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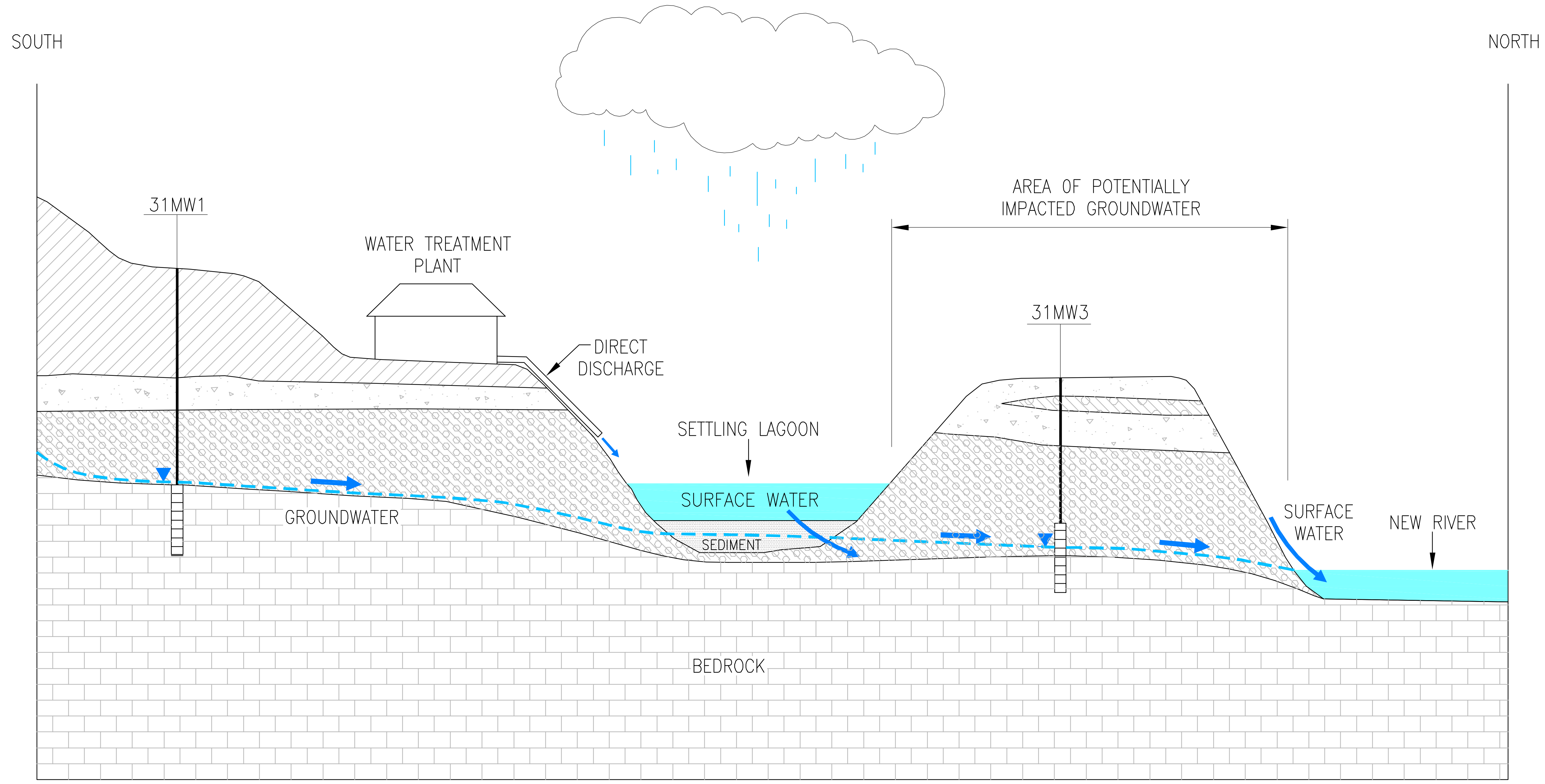


DRAWING NOT TO SCALE

## RADFORD AAP

| | |
|---|---|
| PREPARED BY: SHAW E&I | TASK NO: 83919706000000 |
| CHECKED: M.T. | SHAW E&I DWG NO: 839197-B3 |
| DATE: 11/30/06 | |

FIGURE 1-3

SWMU 31
CONCEPTUAL
SITE MODEL

# 2.0 SITE BACKGROUND

## 2.1 SITE DESCRIPTION AND HISTORY

SWMU 31 is located in the northwest section of the HSA on a nearly level fluvial terrace approximately 175 ft from the New River at an approximate elevation of 1,700 ft mean sea level (msl). The New River flows from northeast to southwest along the northern boundary of the SWMU and is at an elevation of approximately 1,675 ft msl. The site surface is approximately 25 ft above the New River. Because the lagoons were excavated to bedrock and are in contact with groundwater, surface water in the lagoons infiltrates into the subsurface and the lagoons do not completely fill.

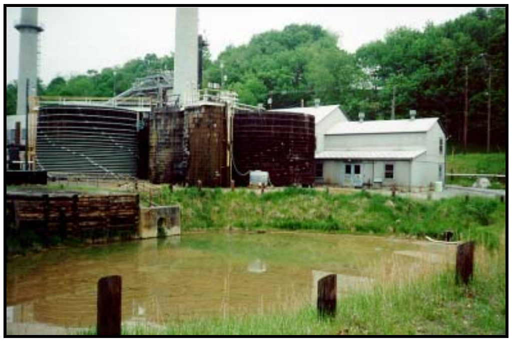


Photo 1: Primary Settling Lagoon. Drinking water plant and boiler in background.

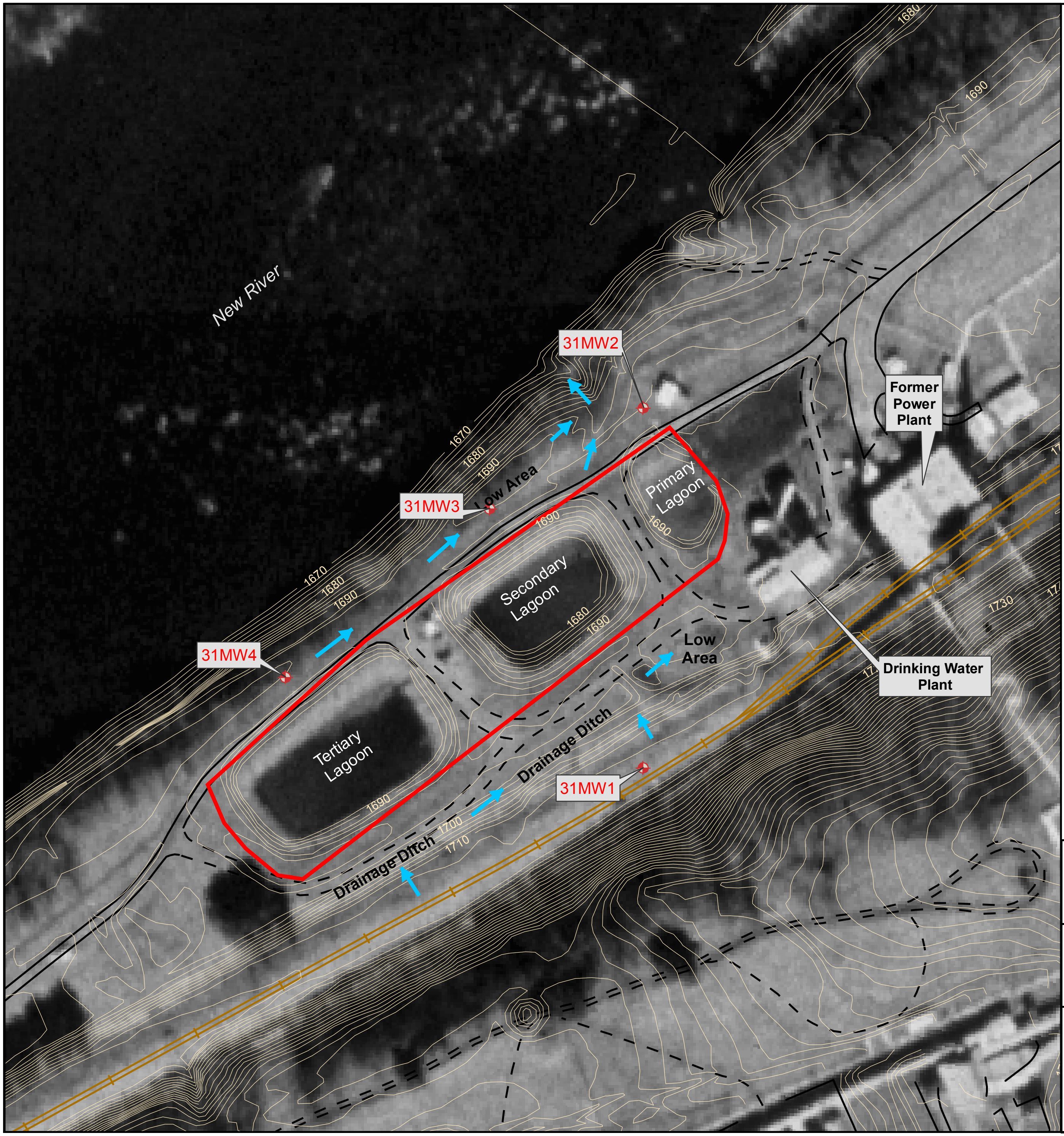
Photo 2: Secondary Settling Lagoon (looking east).

Photo 3: Tertiary Settling Lagoon (looking east).

The land surrounding SWMU 31 is part of the 6,900 acres of manufacturing and storage space facility that consists of RFAAP. RFAAP is a government-owned, contractor-operated Army installation. The present contractor is Alliant Techsystems, Inc. The surrounding areas houses current tenants including; Carilion Wellness Center, a fireworks manufacturer, Virginia Tech, and an Energy Conservation Training Firm. The city of Radford, based on the 2000 census data (U.S. Census Bureau, 2006), has a population of approximately 15, 859 in 2000. The principle land use surrounding RFAAP in Pulaski County is farming and residential use.

SWMU 31 consists of three connected unlined settling lagoons that were constructed and first used in the 1950s (**Figure 2-1** and **Photos 1 through 3**) and designed to receive effluent from both Power House No. 2 and the water treatment plant. The Power House stopped discharging to the settling lagoons in the late 1980s. The water treatment plant is still currently discharging to the lagoons. The primary settling lagoon (approximately 100 ft long by 50 ft wide) received water carrying fly ash and bottom ash from Power House No. 2 (which burned low sulfur coal to generate steam for HSA buildings) and filter backwash from the water treatment plant. The secondary lagoon (approximately 150 ft wide by 200 ft long) and the tertiary lagoon (approximately 150 ft wide by 250 ft long) were designed to receive the primary lagoon discharge if necessary. The ponds have not been used for any other activities.

Facility representatives indicate that the water currently flowing into the primary settling lagoon consists of either overflow from the drinking water settling tanks or backwash from the cleaning



## LEGEND

- Monitoring Well
- Overland Flow Direction
- 2 Ft Contour Line
- Gravel Road
- Paved Road
- Railroad Track
- SWMU 31 Boundary

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

N

Scale:
0 75 150 300 Feet

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FIGURE 2-1

SWMU 31 Site Map

Radford, VA

Date: 11/2/06 GIS File: RFAAP_002_Fig2-1_SWMU31_SiteMap.mxd of the filters at the drinking water settling tanks at Water Plant 4330. On average, 20,000 gallons of overflow water per day is released to the primary lagoon at a relatively constant flow rate. At a minimum, the filters require cleaning once every three days. This process involves passing 2,800 gallons of water per minute through the filters for 20 minutes to remove accumulated river sludge. The 56,000 gallons of turbid sludge-rich water yielded by this process is discharged to the primary settling lagoon.

The effluent from the secondary and tertiary settling lagoons is designed to discharge to the New River through Outfall 024 following pH adjustment with sulfuric acid. The outfall is regulated under a Virginia Pollutant Discharge Elimination System (VPDES) permit, which was issued in 1986. Facility representatives indicate that there have only been five discharges through Outfall 024. The first discharge occurred on July 18, 1992, (flow = 0.0169 mgd, pH = 7.4). Discharges also occurred in February 2003, February 2005, December 2005, and January 2006. The discharge in December 2005 from a pipe break that allowed water (surface/subsurface) to flow into the pipe and through the outfall. On February 03, 2006, the outfall was plugged to prevent future discharges with a pressurized plug with a built in pressure gauge. The pressure gauge is monitored each shift to ensure the pressure in the plug does not drop. According to ATK, flow during each of the discharges was never more than a few hours and the flow was described as a “trickle.” The low flow and short duration made it impossible to collect 24-hr composite samples. Instead, water was collected from the outfall until enough sample volume was obtained for analysis. The monitoring results from these discharges are included in **Appendix A**.

## 2.2 SOIL TYPES

The Soil Conservation Service (SCS) Map (SCS, 1985) for the SWMU 31 area shows that the site is underlain by the Wheeling Sandy Loam (**Figure 2-2**). The Wheeling Sandy Loam comprises approximately 11 percent of the MMA soils and is level to nearly level (slopes ranging from 0 to 2 percent). The seasonal high water table is not within 6 ft of the surface.

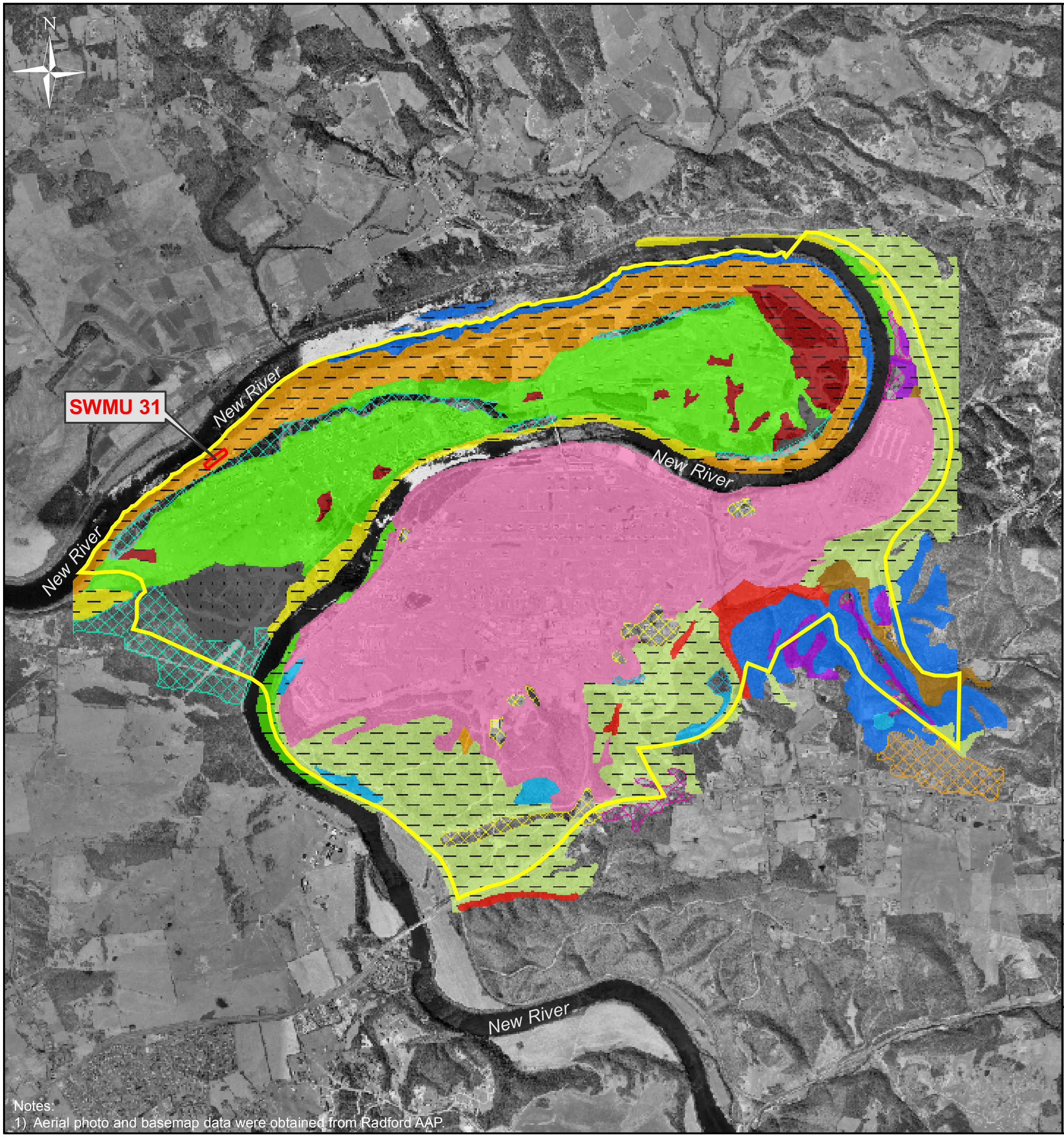
Typically, the surface layer is a 10-inch-thick, dark brown sandy loam underlain by a 42-inch-thick subsoil. The upper part of the subsoil is dark brown gravely sandy loam to a depth of 60 inches or more. At greater than 60 inches in depth, the soil is predominantly a mixture of silt and sand, with minor amounts of clay. Depth to bedrock is at least 60 inches.

Permeability and available water capacity of Wheeling soils is moderate; surface runoff is slow. Natural fertility is medium, organic matter content is moderately low, and soil is moderately to strongly acidic. Hazard of erosion in this soil type is slight.

## 2.3 SITE GEOLOGY

SWMU 31 is located on a fluvial terrace, characteristic of the unconsolidated alluvial sediment at RFAAP. As illustrated on **Figure 2-3**, this sediment layer is 25 to 28 ft thick along the New River. There is a general fining upwards textural sequence as silt and clay overlie gravel and silty sand. Below the gravel and sand, the bedrock interface consists of weathered limestone and dolostone of the Elbrook Formation. A detailed description of the geology on a regional setting is provided below.

Although the area surrounding RFAAP has been mapped geologically in detail (Schultz and Bartholomew, 2000, VDMR open file in preparation; Schultz, 1983; Glass, 1970; Hergenroder, 1957; and Waesche, 1934), the facility itself had not previously undergone rigorous geologic mapping. In June 1995, Parsons Engineering Science, Inc. (Parsons) performed a mapping



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

Date: 11/15/06 GIS File: RFAAP_021_Fig2-2_SWMU31_Soils.mxd

**LEGEND**

- 🟥 SWMU 31 Boundary
- 🟨 Installation Boundary

**SCS Soil Types**

- 🟦 BERKS AND WEIKERT SOILS
- ▨ BERKS AND WEIKERT, VERY STONEY SOILS
- 🟪 BERKS-CLYMER COMPLEX
- ▨ BERKS-GROSECLOSE COMPLEX
- 🟩 BERKS-WEIKERT COMPLEX
- 🟩 BRADDOCK LOAM
- 🟩 CANEYVILLE-OPEQUON-ROCK OUTCROP COMPLEX
- ▨ CARBO AND CHILHOWIE SOILS
- ▨ CARBO-ROCK OUTCROP COMPLEX
- 🟥 COTACO LOAM
- 🟫 CRAIGSVILLE SOIL
- 🟦 FLUVAQUENTS
- 🟧 FREDERICK AND VERTREES SILT LOAMS
- 🟨 FRENCH SOILS
- 🟦 GROSECLOSE AND POPLIMENTO
- 🟪 GUERNSEY SILT LOAM
- ▨ HAYTER LOAM
- ⬛ LOWELL SILT LOAM
- 🟫 McGARY AND PURDY SOILS
- 🟨 ROCK OUTCROP-NEWBERN-CARBO COMPLEX
- 🟩 ROSS SOILS
- ▨ UDORTHENTS AND URBAN LAND
- 🟦 UNISON AND BRADDOCK SOILS
- 🟪 UNISON-URBAN LAND COMPLEX
- 🟥 WEAVER SOILS
- 🟧 WHEELING SANDY LOAM
- ⬛ WURNO-NEWBERN-FAYWOOD SILT LOAMS

Scale:
0 1,750 3,500 7,000
Feet

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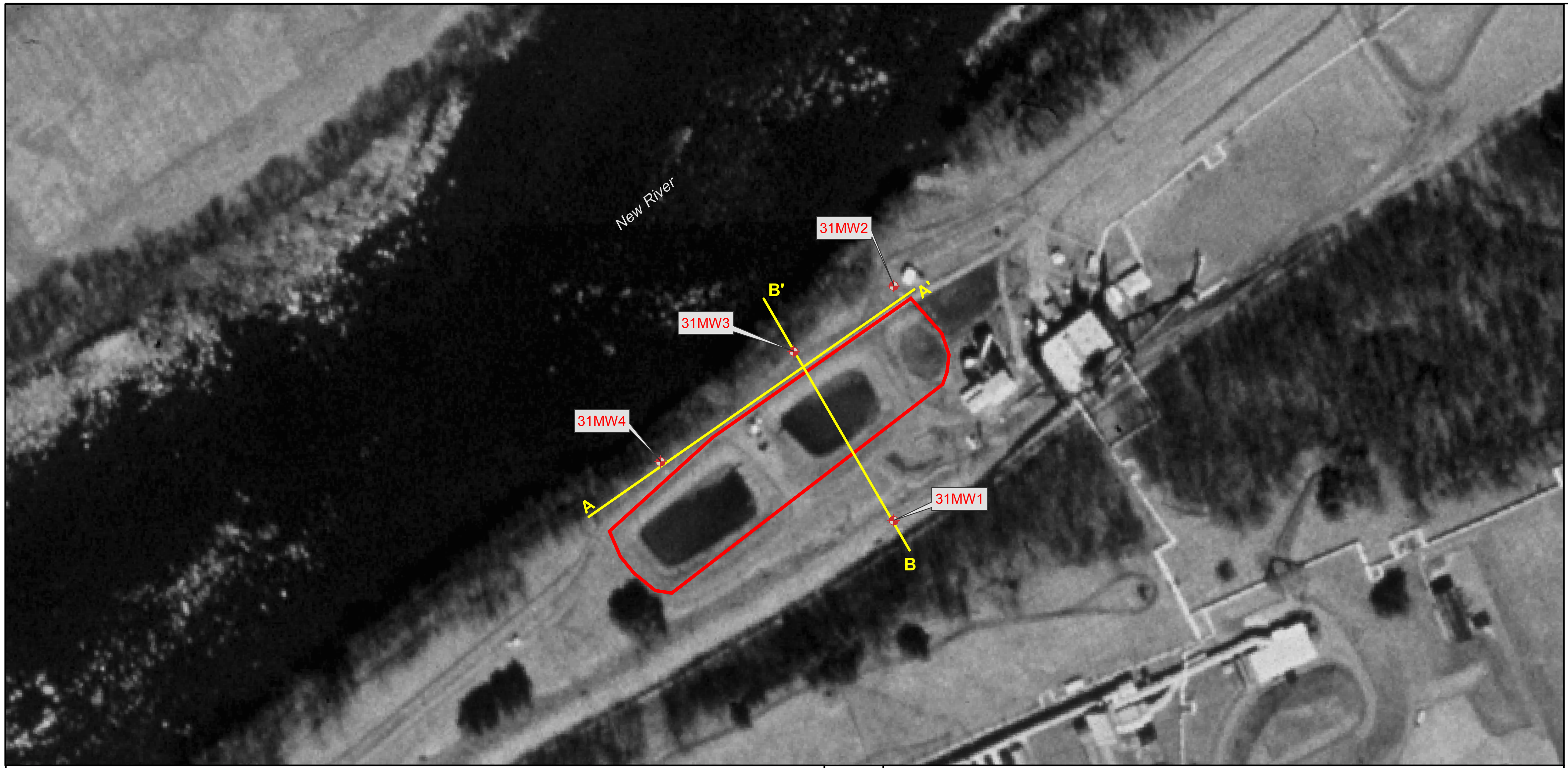
FIGURE 2-2
SCS Soil Types at the
Main Manufacturing Area
Radford, VA



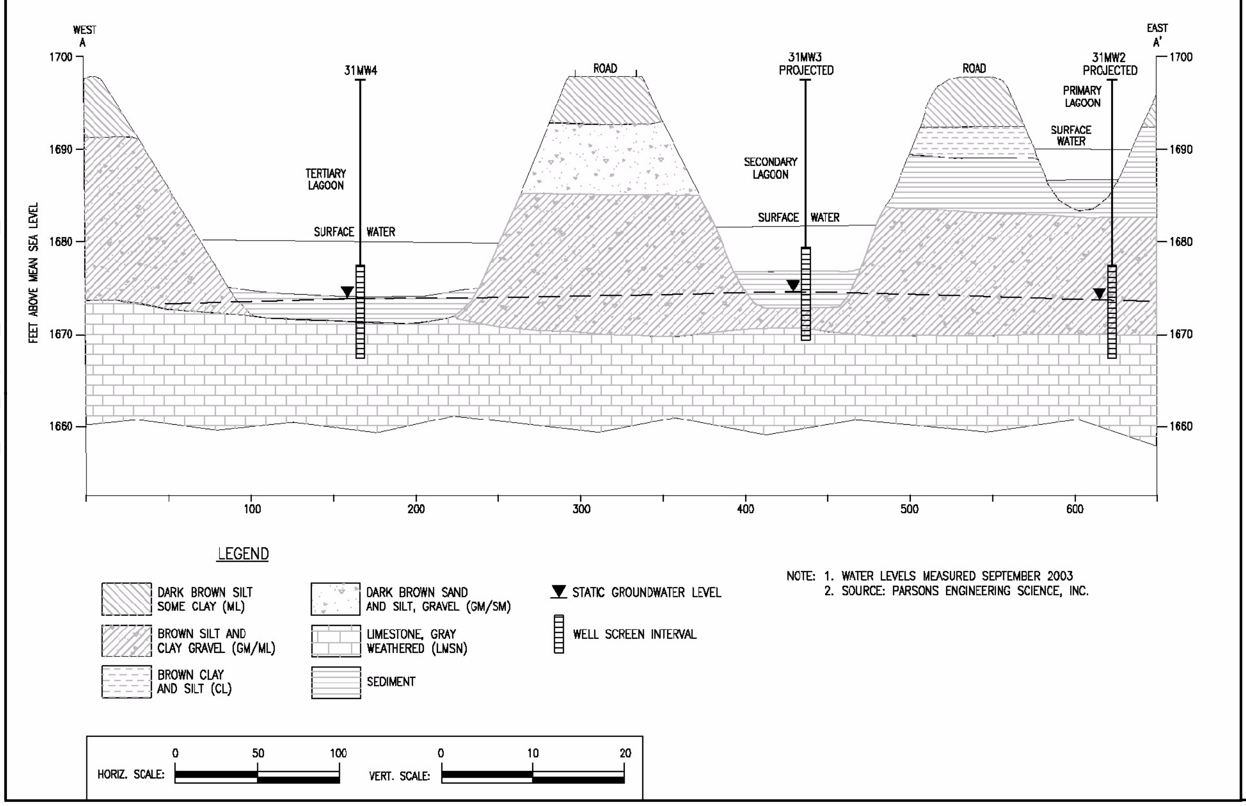
## LEGEND

- 🔴 Monitoring Well
- ━ Geologic Cross Section Line
- ▭ SWMU 31 Boundary

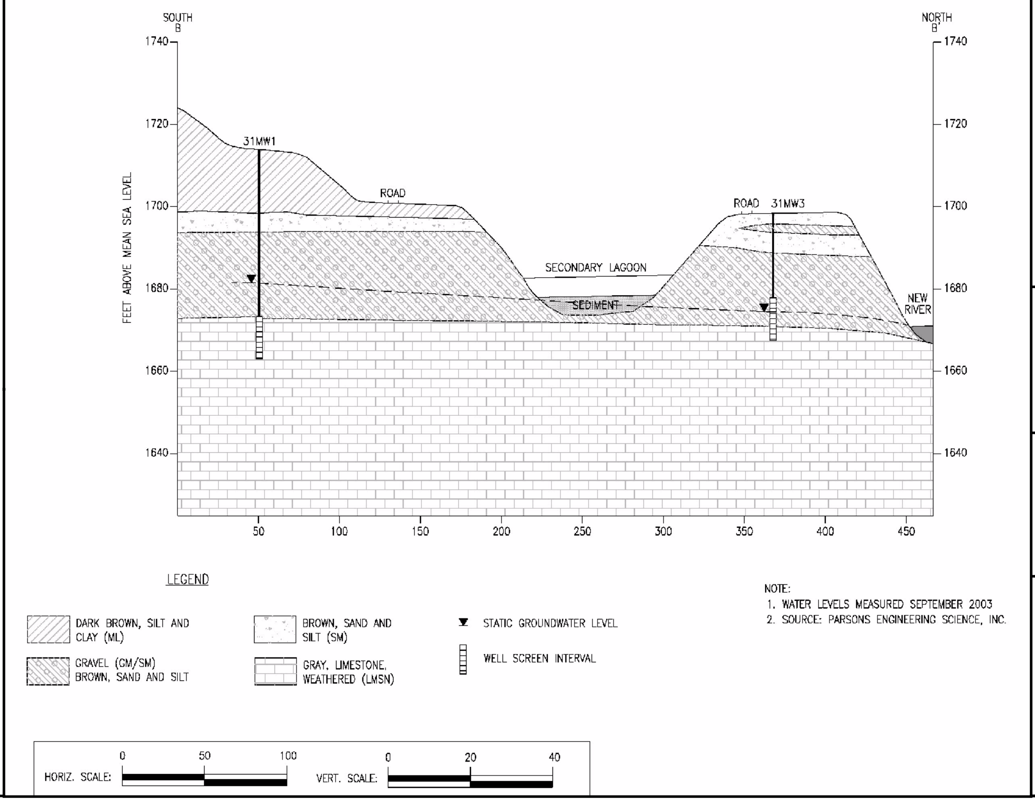
Notes:
1) Aerial photo and basemap data were obtained from Radford AAP.

N

Scale:
0 100 200 400
Feet



NOTE: 1. WATER LEVELS MEASURED SEPTEMBER 2003
2. SOURCE: PARSONS ENGINEERING SCIENCE, INC.



NOTE:
1. WATER LEVELS MEASURED SEPTEMBER 2003
2. SOURCE: PARSONS ENGINEERING SCIENCE, INC.

DEPARTMENT OF THE ARMY

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FIGURE 2-3

SWMU 31 Geologic Cross Sections

Radford, VA

Date: 11/13/06 GIS File: RFAAP_020_Fig2-3_SWMU31_XSect.mxd project of the complex geological structural features at RFAAP. This effort was performed to supplement the existing geologic data for the area and to address site-specific deficiencies in the geologic database (Parsons, 1996).

The fault surfaces of the Pulaski thrust sheet are rarely exposed in the RFAAP area because of development, heavy vegetation, and alluvial fill. When the fault surface is exposed, the types of exposures consist of fractured, veined and folded Cambrian dolomites, argillaceous dolomites and phyllites of the broken formations lying on macerated (soft and highly weathered), fractured, and foliated Mississippian rocks. One type of exposure is the Max Meadows breccia. The breccia ranges in thickness from >3 ft to <10 ft (Schultz, 1983). It is commonly derived from thinly bedded to thinly laminated argillaceous dolomites of the Elbrook Formation. This type of rock consists of poorly sorted, angular to sub-rounded clasts of dolomite in a fine- to very fine-grained matrix of crushed dolomite.

A second type of exposure consists of calcareous phyllite and phyllitic mudstone of the lower part of the Elbrook Formation and the upper part of the Rome Formation. This consists of phyllitic clasts in macerated phyllite and minor crushed dolomite matrix. This type of formation was not evident or observed in the RFAAP area.

The third type of exposure is a 1- to 30-m-thick zone of deformed Cambrian to Devonian tectonic slices in between deformed Mississippian mudstones below and Max Meadow breccias or Cambrian dolomites above. The tectonic slices were derived from the footwall of the Pulaski thrust sheet during the ramp stage of sheet emplacement. Within the stacked tectonic slices, massive dolomites and sandstones are cataclastically (a deformation type characterized by broken or deformed minerals) deformed with originally sedimentary fabrics obliterated by grain-scale fracturing and subsequent comminution (reduce to minute particles) to form suites of cataclasites (Schultz, 1983).

Above the Pulaski fault surface, the broken-formations consist of lesser amounts of folded and faulted phyllitic mudstones and carbonates of the Rome Formation and Max Meadow type breccias in a complexly folded and faulted terrain of carbonates of the Elbrook Formation. The broken formations range from 300 to 500 m thick (Schultz, 1983) and are readily distinguished from rocks structurally above (fold-and-thrust) and below (footwall rocks of the Saltville sheet) by:

1. A sharp increase in the variability of fold and fault morphology.
2. An increase in the variability of fold styles (greater range of fold plunges and dips of axial surfaces).
3. A low degree of preferred orientation to macro- and mesocopic structures.
4. A sharp increase in fold and fault frequency.
5. The presence of Max Meadow–type breccia (Schultz, 1983).

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

## 2.4 SITE HYDROGEOLOGY

Groundwater is present within the relatively shallow unconfined aquifer consisting of unconsolidated alluvial sediment overlying the Elbrook Formation. Groundwater data collected from September 2002 to October 2003 indicate that seasonal groundwater elevations have been observed to fluctuate 2 to 7 ft at this SWMU. Groundwater contour maps from September 2002 to October 2003 are presented in **Appendix A**. Although the location of the lagoons is at a topographic low, most surface water flows directly into the New River and does not collect in the lagoons. The elevations within the lagoons are primarily driven by the rate of flow from the water treatment plan to the lagoons. Because the secondary and tertiary lagoons were excavated to the bedrock surface, the bottoms of the lagoons are essentially at or below the groundwater table. The groundwater gradient is northwest, toward the New River. Stabilized groundwater depths measured in September 2003 ranged from 22 to 33 ft below ground surface (bgs) (1,674 to 1,681 ft msl) (**Figure 2-4**). A detailed description of the hydrogeology on a regional setting is provided below.

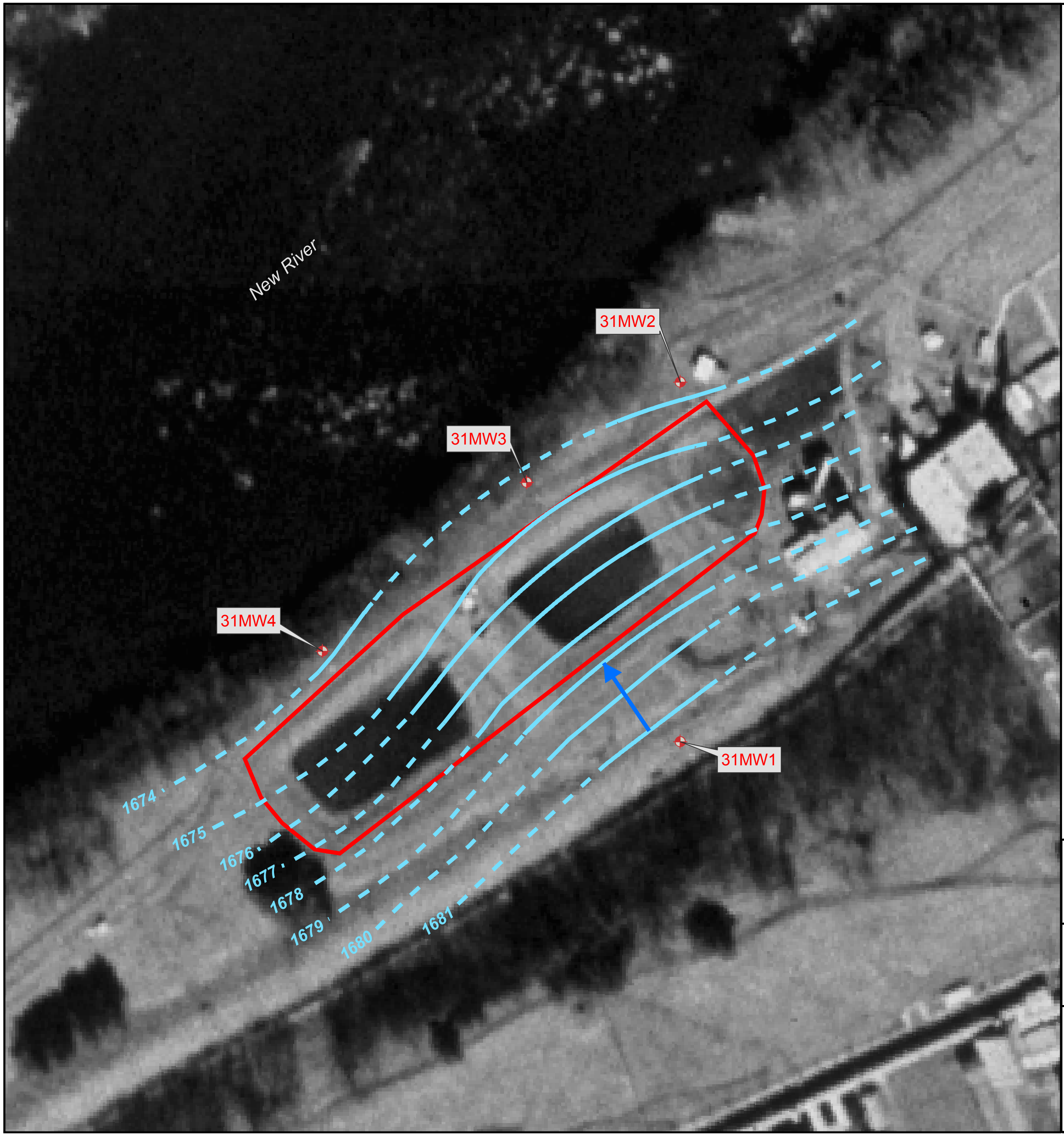
Groundwater at RFAAP occurs in two types of aquifers, an alluvium water table aquifer, which is present in the flood plain areas along the New River, and a bedrock aquifer. SWMU 31 is located in the New River floodplain and is underlain by the alluvium water table aquifer. This water table occurs primarily within the flood plain areas adjacent to the New River. In these areas, groundwater flow occurs within alluvium present above bedrock. A water table within alluvium has been identified both in the MMA (SWMUs 8, 10, 35, 36, 43, and 45) and HSA (SWMUs 13, 31, and 54). Investigations by Dames & Moore (1992), Parsons (1996), and IT Corporation (IT; 2001) indicate that the water table surface within flood plain alluvium is at a relatively shallow depth of 15 to 25 ft at an elevation similar to the New River. In general, the observed saturated thickness of this water table ranges from featheredge to several feet (Dames & Moore, 1992). Unconsolidated sediments generally fine upward and may include basal river jack deposits consisting of sand, gravel, and cobbles. Groundwater flow within the alluvium water table is toward the New River.

Permeability testing of flood plain alluvium sediments (coarse grained) in area of SWMUs 10 and 35 indicated intrinsic permeability values in the range of $1.7\text{x}10^{-4}$ to $2.2\text{x}10^{-3}$ centimeters per second (cm/sec) (Dames & Moore, 1992). Slug testing conducted at the same locations yielded similar hydraulic conductivity results. Hydraulic data specific to the alluvial aquifer are lacking at other locations at RFAAP because monitoring wells are screened across the unconsolidated sediment/bedrock interface. Upland sediments (terrace deposits) at RFAAP may also contain groundwater, which is generally localized or in discontinuous perched zones.

### 2.4.1 Water Budget and Groundwater/Surface Water Interaction

Water inputs to the settling lagoons include rainfall within the footprint of the lagoon area, discharge from the filter backwash, and overflow from the wooden drinking water settling tanks adjacent to the primary lagoon. Since the water level in the lagoons is not continuously rising, these inputs must be balanced by seepage through the permeable unconsolidated river terrace sediments between the settling lagoons and the New River.

The average annual rainfall from the Blacksburg weather Station is 42.6 inches (CityTownInfo, 2007). The surface area of the three settling lagoons and immediate surroundings is 53,548 $\text{ft}^2$. The volume of water entering the lagoons yearly in the form of precipitation is 1,422,000 gallons [1.422 Million Gallons (MG)].



**LEGEND**

- ● Monitoring Well
- ← Groundwater Flow Line
- — Groundwater Contour Line
- - - Inferred Groundwater Contour Line
- ▭ SWMU 31 Boundary

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

N

Scale:
0 75 150 300
Feet

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## FIGURE 2-4

## SWMU 31 Groundwater Contour Map

Radford, VA

Date: 05/17/07 GIS File: RFAAP_003_Fig2-4_SWMU31_GWContours.mxd

The filter backwash operations include the backwash of two filters. Typically, 28,000 gallons are run through each filter one a day. In periods of hot weather, the filters may be backwashed once every other day. In cold weather, they may be done twice a day. Assuming that the filters are backwashed twice a day for three months (winter), once a day for six months (spring and fall) and once every other day for three months (summer), then the average daily input to the lagoons is 63,000 gallons. The total input for the year is 22,995,000 gallons (22.995 MG).

The volume of overflow from the wooden drinking water settling tanks was estimated by ATK to be approximately 10 to 15 gallons per minute (gpm). Over the course of a year, using the high end of the range (15 gpm) and assuming that 100% of the water ends up in the lagoons, the water leakage would add 7,889,400 gallons (7.889 MG).

Based on the assumptions above, the total input to the lagoons in a typical year is 32,306,000 gallons (32.306 MG), or 0.885 MG/day. The amount of water that the lagoons can hold is approximately 3,727,000 (3.727 MG), assuming they are 15 ft deep from the top of the berm to the bottom of the pond.

The following equation can be used to calculate a theoretical hydraulic conductivity for the unconsolidated sediments:

$$K = -V_X \cdot \frac{n_e \cdot dl}{dh}$$

where:

$K$ = hydraulic conductivity (cm/sec)
$V_X$ = average linear velocity (cm/sec)
$n_e$ = effective porosity (0.3)
$dh$ = change in head (elevation) (cm)
$dl$ = change in distance (cm)

The average linear velocity ($V_X$) can be back-calculated from the flow out of the lagoons and the cross-sectional area of the aquifer parallel to the New River.

- Aquifer thickness = 30 ft
- Length of Lagoons parallel to the New River = 500 ft
- Flow from lagoons = 32.306 MG

Using these assumptions, $V_X = 2.78\text{x}10^{-4}$ cm/sec and the hydraulic conductivity (K) is $4.17\text{x}10^{-4}$ cm/sec. This calculated hydraulic conductivity is within the range of conductivities measured in wells screened in the unconsolidated sediments ($1.7\text{x}10^{-4}$ to $2.2\text{x}10^{-3}$ cm/sec) (Dames & Moore, 1992). These calculations demonstrate that the permeablilty of the unconsolidated sediments is great enough to allow the water added to the lagoons from the water treatment plant to seep out to the New River without overflowing the settling ponds.

Flow in the New River is dictated by the dam at Claytor Lake, which is used for power gerneation and can fluctuate significantly throughout the year. An average flow of 5000 cubic ft per second (cfs) was used during water budget calcuations for the Current Conditions Report (Shaw, 2005b) and is also used here. This flow represents base flow from the Lake during a period when the lake was being lowered due to rainfall rather than power generation. Based on this flow rate, the volume of water passing SWMU 31 each day in the New River is 3,234 MG/day. The contribution of water to the New River from the lagoons at SWMU 31 represents 0.003% of the amount of the water in the river.

The influx of water to the settling lagoons is forced to migrate with the groundwater to the northwest. There is a steep rise to the southeast of the site that marks the transition from the unconsolidated river sediements (underlying the site) to the bedrock highlands that form the center of the HSA. This steep rise prevents any mounding of the groundwater under the lagoons from "backing up" the groundwater, while the relatively higher permeability of the unconsolidated sediments allows the groundwater and discharge/backflush water to migrate northwest to the New River, which acts as a sink - removing water from the system. Water levels from the onsite wells demonstrate that the overall gradient (including the added inputs from SWMU 31) is to the northwest and also shows that groundwater flows out of the bedrock aquifer into the uncolidated sediments near the New River.

## 2.5 CLIMATE AND SURFACE WATER HYDROLOGY

Based on topography, surface water in the area of SWMU 31 would flow from the surrounding hillsides and collect in the areas of the lower elevations. This water runoff would probably percolate into the hillsides and subsurface and eventually enter the water table. According to RFAAP utility maps, there are no manholes, catch basins, or storm drains in the vicinity of SWMU 31. Regional climate and surface water hydrology for RFAAP is presented in the MWP (URS, 2003).

## 2.6 SELECTION OF CHEMICAL-SPECIFIC COMPARISON CRITERIA

Comparison criteria are chemical- and media-specific concentrations that are used to provide a reference value for site-specific analytical data. Comparison criteria are typically calculated values that assess the increase in risk to a given population based on the concentrations of constituents in environmental media at the site. These values can be used to assess the risk to a human population [i.e., industrial and residential soil risk-based concentrations (RBCs)] or to an ecological population [i.e., Biological Technical Assistance Group (BTAG) soil criteria]. Comparison criteria used for this investigation include U.S. Environmental Protection Agency (USEPA) Region III industrial and residential RBCs (USEPA, 2006a) for soil and sediment, tap water RBCs and Maximum Contaminant Levels (MCLs) (USEPA, 2004a) for surface water and groundwater, facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria, including Soil Screening Levels (SSLs) and BTAG ecological criteria.

The SSLs used in this evaluation are based on a Dilution Attenuation Factor (DAF) of 20. DAFs are used to account for natural processes that reduce contaminant concentrations in the subsurface. EPA SSL guidance indicates that SSLs are intended to be used as a preliminary screen at sites where no subsurface soil or groundwater data are available. Because actual subsurface soil and groundwater data are available, these data supersede the theoretical SSL values.

All data is screened against these comparison criteria which will aid in determining the recommendation for No Further Action or determine whether a CMS should be conducted to evaluate potential remedial alternatives for the site.

The soil and sediment contamination assessments presented in this report utilize industrial and residential screening levels as comparison criteria. RBCs are calculated to demonstrate the concentration that will not result in an increase in risk beyond a hazard index (HI) of 1.0 for non-carcinogenic compounds and an increase beyond a cancer risk of $1x10^{-6}$. Because SWMU 31 is potentially contaminated with multiple constituents, RBCs for non-carcinogenic constituents have been recalculated to an HI of 0.1. Carcinogenic risks are not necessarily cumulative, and have therefore not been recalculated. The recalculated RBCs are referred to as industrial and residential screening levels in this report. SSLs are generally more conservative than the RBCs and exceedances of the SSLs are noted in analytical tables throughout the report by white text in a shaded cell.

The groundwater and surface water contamination assessments presented in this report utilize drinking water standards and screening levels as comparison criteria. The goal of USEPA's approach to the cleanup of contaminated groundwater is to return usable groundwater to its beneficial use within a reasonable period of time, given the particular circumstances at a site (USEPA, 1988). Where the beneficial use of the groundwater is as a current or potential source of drinking water, USEPA states a preference for Safe Drinking Water Act non-zero Maximum Contaminant Level Goals (MCLGs) and MCLs where they are relevant and appropriate [CERCLA 121(d)(2)(A), as amended, and 40 Code of Federal Regulations (CFR) § 300.430(e)(2)(i)(B) and (C)]. USEPA provides guidance regarding the classifications of groundwater with focus on an aquifer's usability as drinking water (USEPA, 1986). These suggested categories are Class I, IIA, IIB, and III (USEPA, 1986). Classes I and IIA represent current sources of drinking water of varying value; Class IIB represents potential sources of drinking water; and Class III groundwater is not considered to be a potential source of drinking water and is of limited beneficial use (USEPA, 1986). Restoration time periods vary depending on the use classification of the groundwater and may range from one year to several decades. The groundwater at SWMU 31 is not currently used as a source of drinking water, but, due to the potential for future use, could be classified as a Class IIB Aquifer. Therefore, groundwater data were screened against the MCLs as well as the USEPA Region III tap water RBCs. As surface water at SWMU 31 discharges to the New River, which is used as a drinking water source downgradient of RFAAP, surface water was also screened against the drinking water standards.

The Commonwealth of Virginia considers all current and potential future uses of the resource (groundwater) and protective levels are established to preserve the priority usage; therefore, all waters shall be protected to the highest beneficial use.

The Commonwealth defines "water" as all waters, on the surface and under the ground, wholly or partially within or bordering the Commonwealth or within its jurisdiction and which affect the public welfare. The Commonwealth also defines "beneficial" uses as domestic (including public water supply), agricultural, electric power generation, commercial and industrial uses, with human consumption as the highest priority.

Accordingly, when addressing constituents in groundwater, VDEQ refers to those ARARs protective of the use. As a drinking water source, levels of constituents are compared to MCLs or secondary SMCLs.

These comparison criteria are used in the Nature and Extent of Contamination Section (*Section 3.0*) to delineate concentrations and areas of concern and to analyze fate and migration patterns. Complete human health and ecological risk assessments are presented in *Sections 5.0 and 6.0*, respectively.

### 2.6.1 Inorganic Constituents

The Facility-Wide Background Study Report (FWBSR) (IT, 2001) was performed at RFAAP to assess the levels of inorganic constituents naturally occurring in soil at the Installation. Organic constituents included on the analyte lists for the current investigation are not naturally-occurring compounds in the environment and the presence of these constituents is interpreted to be the result of a human impact at the site. Inorganic constituents, however, are naturally occurring and are present at every site. Elevated metals concentrations can be the result of natural environmental processes, or the result of a human impact at the site. In order to differentiate between high concentrations of metals due to these different processes, the FWBSR (IT, 2001) was performed. Samples were collected from areas on the Installation where little to no environmental impact was expected. A 95 percent upper tolerance limit (UTL) was calculated based on the results of these samples. These background levels are the concentrations of inorganic elements currently present in soil that are not attributed to site-related activities.

An analysis of the background concentrations for metals at RFAAP indicates that arsenic has a background concentration [15.8 milligrams per kilogram (mg/kg)] greater than the industrial screening level (1.9 mg/kg). Iron, manganese, and vanadium also have background concentrations greater than industrial screening levels. Three additional metals, summarized in **Table 2-1**, have background concentrations greater than the residential screening level.

In the Nature and Extent of Contamination assessment (*Section 3.0*), to differentiate between naturally-occurring concentrations and concentrations due to human impacts for the contamination assessment, the industrial and residential screening levels were compared to the background concentrations at RFAAP. An inorganic constituent will be considered for fate and migration analysis in *Section 3.0* if:

- The concentration is greater than the background level.
- The concentration is greater than the industrial or residential screening level.

The Nature and Extent section uses exceedances of RBCs to evaluate fate and migration patterns for those chemicals of most concern. Therefore, constituents above background, but below RBCs are not tracked. The Human Health Risk Assessment (HHRA) (*Section 5.0*) and Screening Level Ecological Risk Assessment (SLERA) (*Section 6.0*) evaluate risk; background concentrations are not used to screen out constituents in the risk assessments.

### 2.6.2 Comparison Criteria and Previous Investigations

Previous investigations at SWMU 31 were completed prior to the release of the Facility-Wide Background Study (IT, 2001). The original reports prepared for these investigations included metals as site contaminants where the concentrations exceeded the screening levels. For this report, data from the previous investigations has been re-evaluated to compare the results to the current screening levels (October 2006) and calculated background concentrations (IT, 2001). As with the 2002 data, metals data collected during previous investigations was screened against the FWBSR (IT, 2001) 95 percent UTLs in the contamination assessment to identify inorganics whose concentrations were increased due to site activities. The presence of inorganic constituents at concentrations greater than the background level; however, does not necessarily indicate an environmental concern. Discussions of metals concentrations above background, but below screening levels are intended to demonstrate patterns of migration of inorganics. Inorganic constituents that exceed the background criteria were carried forward and screened against the screening levels (industrial and residential) to evaluate whether there is a potential risk related to these constituents. Background data was not used to prescreen potential contaminants of concern in the human health or ecological risk assessments.

**Table 2-1**
**Summary of Metals with Background Concentrations Greater Than RBCs**

| Metals (mg/kg) | i-RBC | r-RBC | Background |
|---|---|---|---|
| **Aluminum** | 100000 | 7800 | 40041 |
| **Arsenic** | 1.9 | 0.43 | 15.8 |
| Barium | 7200 | 550 | 209 |
| Beryllium | 200 | 16 | 1.02 |
| Cadmium | 51 | 3.9 | 0.69 |
| **Chromium** | 310 | 23 | 65.3 |
| Cobalt | 2000 | 160 | 72.3 |
| Copper | 4100 | 310 | 53.5 |
| **Iron** | 31000 | 2300 | 50962 |
| Lead | 800 | 400 | 26.8 |
| **Manganese** | 2000 | 160 | 2543 |
| Mercury | 31 | 2.3 | 0.13 |
| Nickel | 2000 | 160 | 62.8 |
| **Thallium** | 7.2 | 0.55 | 2.11 |
| **Vanadium** | 102 | 7.8 | 108 |
| Zinc | 31000 | 2300 | 202 |

Note: concentrations are in mg/kg. Bold text indicates that the background concentration is greater than the residential RBC.

## 2.7 PREVIOUS INVESTIGATIONS

Previous investigation activities conducted at SWMU 31 include a RCRA Facility Assessment in 1987 (USEPA, 1987) (no samples collected), a Verification Investigation (VI) in 1992 (Dames & Moore, 1992), an RFI in 1996 (Parsons, 1996), and an RFI in 1998 (ICF KE, 1999).

**Table 2-2** presents an overview of previous field sampling programs designed to meet investigation objectives, including medium sampled, sample identification, sample depth, and laboratory analyses. Corresponding sample locations are illustrated on **Figures 2-5 and 2-6**. A summary of constituents exceeding levels of concern are presented by media on **Figures 3-2 through 3-5**.

### 2.7.1 RCRA Facility Assessment—USEPA, 1987

An assessment was conducted at the unit to evaluate potential hazardous constituent releases to the site and implement corrective actions, as necessary. The assessment consisted of a preliminary review and evaluation of available site information, personnel interviews, and a visual inspection of the site. Environmental samples were not collected as part of the inspection.

The visual inspection of the site suggested that there were no releases at the unit. However, chemical samples were required in accordance with the RFAAP 1989 RCRA permit.

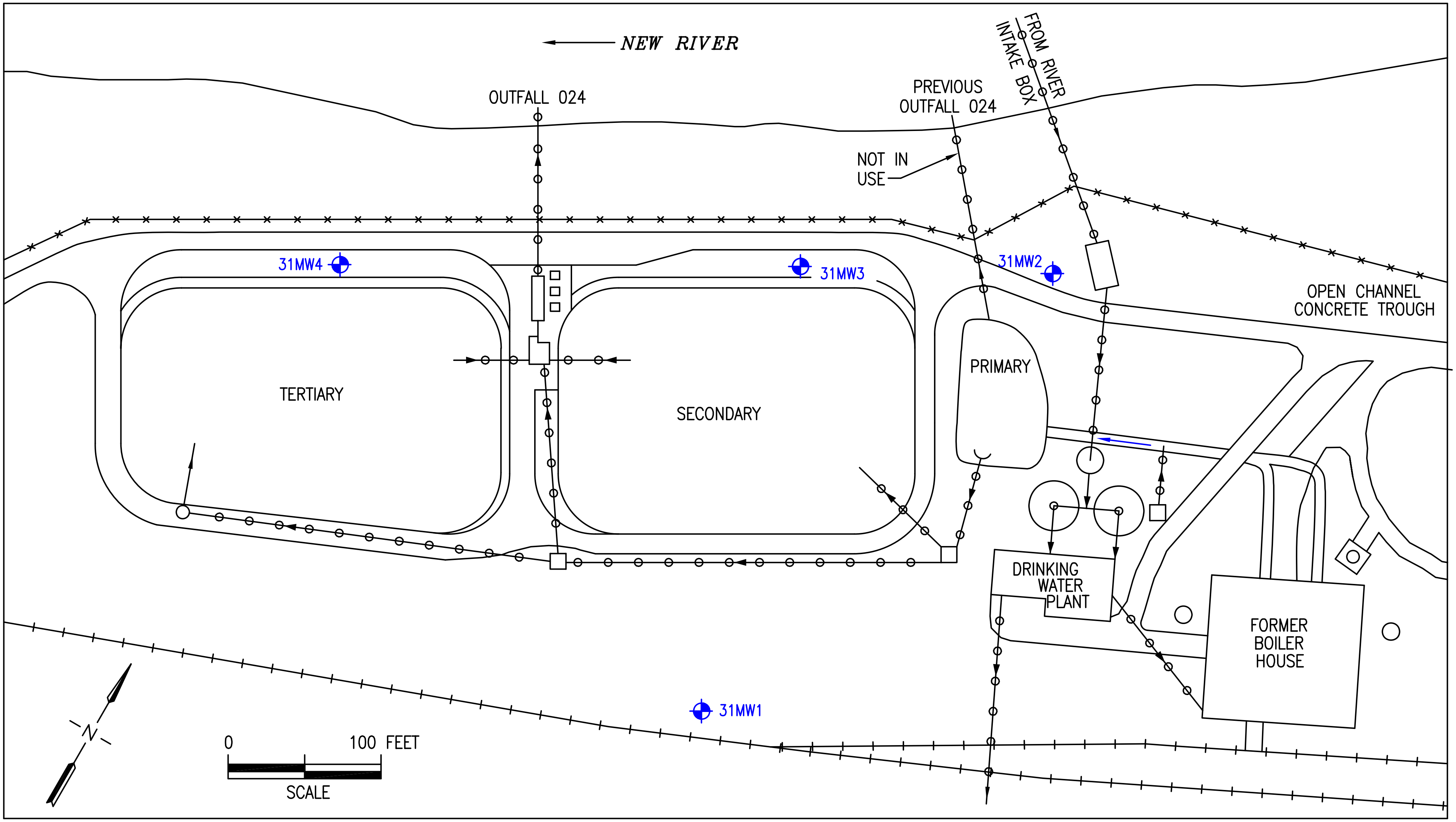
**Table 2-2**
**Field Sampling Program for Previous Investigations at SWMU 31—Coal Ash Settling Lagoons**

| Investigation | Medium Sampled | Sample ID | Sample Depth (ft) | Laboratory Analyses |
|---|---|---|---|---|
| 1992 VI<br>Dames & Moore | Sediment | 31SL1 | 0-1 | Metals, SVOCs |
| | | 31SL2 | 0-1 | |
| | | 31SL3 | 0-1 | |
| 1996 RFI<br>Parsons | Sediment | 31SE1 | 0-0.5 | TCLP Metals, TOC (one sample per lagoon) |
| | | 31SE2 | 0-0.5 | |
| | | 31SE3 | 0-0.5 | |
| | | 31SE4 | 0-0.5 | |
| | | 31SE5 | 0-0.5 | |
| | | 31SE6 | 0-0.5 | |
| | Subsurface Soil | 31MW1A25 | 23-25 | Metals |
| | | 31MW1B35 | 33-35 | |
| | | 31MW2A12 | 10-12 | |
| | | 31MW2B22 | 20-22 | |
| | | 31MW3A10 | 5-10 | |
| | | 31MW3B20 | 15-20 | |
| | | 31MW4A12 | 10-12 | |
| | | 31MW4B22 | 20-22 | |
| | Groundwater | 31MW1 | 42-52 | |
| | | 31MW2 | 20-30 | |
| | | 31MW3 | 22-32 | |
| | | 31MW4 | 20-30 | |
| 1998 RFI<br>ICF KE | Surface Water | 31SW1 | N/A | Metals, SVOCs, PAHs |
| | | 31SW2 | N/A | |
| | | 31SW3 | N/A | |
| | Sediment | 31SL1-2 | 0-0.5 | |
| | | 31SL2-2 | 0-0.5 | |
| | | 31SL3-2 | 0-0.5 | |
| | Subsurface Soil | 31SB1A | 22-23 | |
| | | 31SB1C | 10-12 | |
| | | 31SB2A | 12-14 | |
| | | 31SB2B | 20-22 | |
| | | 31SB3A | 10-12 | |
| | | 31SB3B | 18-20 | |
| | | 31SB4A | 10-12 | |
| | | 31SB4B | 20-24 | |
| | Groundwater | 31MW1-2 | 42-52* | Total and dissolved metals, SVOCs, PAHs, TOC, TOX |
| | | 31MW2-2 | 20-30* | |
| | | 31MW3-2 | 22-32* | |
| | | 31MW4-2 | 20-30* | |

* Well screen interval

### 2.7.2 Verification Investigation—Dames & Moore, 1992

Three composite sediment samples, one from each of the three settling lagoons, were collected for waste characterization. Samples were composited from the top one foot of sediment beneath the water/sediment interface from three locations in each lagoon. Samples were analyzed for metals and semivolatile organic compounds (SVOCs). Analytical results indicated that thallium



LEGEND

| | |
|---|---|
| ⊕ | MONITORING WELL LOCATION |
| —o—o— | UNDERGROUND PIPELINE |
| —x—x— | FENCE |
| —+—+— | RAILROAD TRACKS |

# RADFORD AAP

FIGURE 2–5

PREPARED BY: PH
TASK NO: 82987005000000
CHECKED BY: MT
SHAW DWG NO: Figure 2–5
DATE: REVISED MAY 2007

SWMU 31–
SITE MAP

## LEGEND

⊕ Groundwater Sample Location

▲ Sediment/Surface Water Sample Location

▭ SWMU 31 Boundary

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

N

Scale:

0 75 150 300 Feet

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 2-6
Previous Investigation Sample Locations
Radford, VA

Date: 5/31/07 GIS File: RFAAP_014_Fig2-6_SWMU31_PrevSampLoc.mxd exceeded the industrial screening level in sample 31SL2, collected from the secondary lagoon. Thallium was not detected in samples from the other two lagoons. Beryllium exceeded background in the three samples, but was below residential screening level in all of them. One SVOC (naphthalene) were detected at concentrations above the SSL in the samples from the primary and tertiary lagoons, but was below the SSL in the sample from the secondary lagoon (**Table 2-3**). Naphthalene was below the residential screening level in the three samples. Naphthalene is a PAH associated with petroleum products such as commercial coal tar, gasoline, solvents, power plant emissions, and coal ash and cinders. The remaining metals and SVOCs were below screening levels in the three samples.

The report recommended that groundwater samples be collected to assess whether metals are migrating from the lagoons at significant concentrations.

### 2.7.3 RCRA Facility Investigation—Parsons, 1996

RFI objectives included the assessment of lagoon sediment disposal characteristics and migratory characteristics of metals from the lagoons. Investigative activities included the installation of four monitoring wells and the collection and analysis of sediment, subsurface soil, and groundwater samples.

***Sediment.*** Two composite sediment samples representing the total sediment column were collected from each lagoon to assess potential disposal characteristics of the lagoon sediments. Sample results indicated that the lagoon sediments were within Toxicity Characteristic Leaching Procedure (TCLP) regulatory limits for each parameter. Sediment samples were collected for disposal classification purposes; therefore, analytical results are not suitable for use in a risk assessment.

***Subsurface soil.*** Four soil borings were advanced and sampled for chemical analysis and stratigraphic characterization during the installation of monitoring wells. Two soil samples were collected from each of the borings and analyzed for metals to assess the migration potential of metals from the lagoons. Results from these samples are presented in **Table 2-4**. Metals concentrations were below residential screening levels and SSLs in the samples. Beryllium slightly exceeded the background concentration in two of the eight samples. Lead was also slightly above background in two of the eight samples, and mercury exceeded its background concentration in one sample.

Soil boring 31MW1 was located upgradient from the secondary settling lagoon and was advanced into a wet zone of the bedrock to a depth of 52 ft bgs. Samples were collected at depths of 23-25 ft bgs (31MW1A25) and 33-35 ft bgs (31MW1B35) from this boring.

Soil borings 31MW2, 31MW3, and 31MW4 were located downgradient of the lagoons and were advanced into the alluvial sediments overlying the bedrock to a maximum depth of 32 ft bgs. At borings 31MW2 and 31MW4, samples were collected at 10-12 ft bgs (31MW2A12 and31MW4A12) and 20-22 ft bgs (31MW2B22 and31MW4B22). Samples were collected at 5-10 ft bgs (31MW3A10) and 15-20 ft bgs (31MW3B20) from boring 31MW3.

***Groundwater.*** One upgradient and three downgradient groundwater monitoring wells were installed in the soil borings to a maximum depth of 52 ft bgs to assess the migration potential of metals from the settling lagoons. Upgradient monitoring well 31MW1 was installed approximately 15 ft deeper than the downgradient wells since the land surface elevation was higher

## Table 2-3
## SWMU 31
## 1992 VI Detected Results for Sediment

| **SITE ID**<br>**FIELD ID** | **Comparison Criteria** | | | | **31SL1**<br>**RVFS*27** | **31SL2**<br>**RVFS*28** | **31SL3**<br>**RVFS*114** |
|---|---|---|---|---|---|---|---|
| **SAMPLING DATE**<br>**DEPTH (ft)** | **Industrial RBC** | **Residential RBC** | **Facility-Wide Background** | **SSL Transfers Soil to GW** | **25-FEB-92**<br>**0-1** | **25-FEB-92**<br>**0-1** | **10-MAR-92**<br>**0-1** |
| **Metals (mg/kg)** | | | | | | | |
| Aluminum | na | na | 40041 | na | 8770 | 18900 | 15900 |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 9.8 | 4.6 | 6.5 |
| Barium | 20000 | 1600 | 209 | 6000 | 80.8 | 149 | 118 |
| Beryllium | 200 | 16 | 1.02 | 1200 | **2.3** | **1.4** | **2.3** |
| Calcium | na | na | na | na | 1780 | 3980 | 2130 |
| Chromium | 310 | 23 | 65.3 | 42 | 11.1 | 34.2 | 16.2 |
| Cobalt | na | na | 72.3 | na | 8.2 | 16.1 | 11.0 |
| Copper | 4100 | 310 | 53.5 | 11000 | 26.4 | 27.4 | 32.8 |
| Iron | 31000 | 2300 | 50962 | na | 7380 | 33300 | 10000 |
| Lead | 800 | 400 | 26.8 | na | nd | 19.7 | nd |
| Magnesium | na | na | na | na | 951 | 6620 | 1440 |
| Manganese | 2000 | 160 | 2543 | 950 | 134 | 664 | 347 |
| Mercury | 31 | 2.3 | 0.13 | na | 0.1 | nd | nd |
| Nickel | 2000 | 160 | 62.8 | na | 18.7 | 22.5 | 21.5 |
| Potassium | na | na | na | na | 576 | 2650 | 1030 |
| Selenium | 510 | 39 | na | 19 | nd | nd | 0.9 |
| Silver | 510 | 39 | na | 31 | nd | 1.2 | nd |
| Sodium | na | na | na | na | 370 | 328 | 540 |
| Thallium | 7.2 | 0.55 | 2.11 | 3.6 | nd | **14.5** | nd |
| Vanadium | 102 | 7.8 | 108 | 730 | 21.2 | 64.5 | 33.6 |
| Zinc | 31000 | 2300 | 202 | 14000 | 38.6 | 95.8 | 68.0 |
| **SVOCs (ug/kg)** | | | | | | | |
| 1,2-Dichlorobenzene | 9200000 | 700000 | na | 4600 | nd | nd | 3460 |
| 2-Methylnaphthalene | 410000 | 31000 | na | 4400 | 1150 | 130 | 1530 |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 200 | nd | nd |
| Fluorene | 4100000 | 310000 | na | 140000 | 90 | nd | nd |
| Dibenzofuran | na | na | na | na | 300 | nd | nd |
| Naphthalene | 2000000 | 160000 | na | 150 | **560** | 90 | **1330** |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 740 | 80 | 1180 |

# Table 2-3
# Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an industrial RBC exceedance. |
| 12 | J | Bold outline indicates a residential RBC exceedance. |
| **12** | **J** | Bold, underlined font indicates a background exceedance. |
| 12 | J | White Font with grey background indicates an SSL exceedance. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (April, 1999).
mg/kg = milligrams per kilogram (parts per million).
ug/kg = micrograms per kilogram (parts per billion).
na = not available
nd = not detected.  This is only used for older data sets where reporting limits are not available

# Table 2-4
# SWMU 31
# 1996 RFI Detected Results for Subsurface Soil

| SITE ID | Comparison Criteria | | | | 31MW1 | 31MW1 | 31MW2 | 31MW2 | 31MW3 | 31MW3 | 31MW4 | 31MW4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FIELD ID | | | | | 31MW1A25 | 31MW1B35 | 31MW2A12 | 31MW2B22 | 31MW3A10 | 31MW3B20 | 31MW4A12 | 31MW4B22 |
| SAMPLING DATE | Industrial RBC | Residential RBC | Facility-Wide Background | SSL Transfers Soil to GW | 16-DEC-94 | 16-DEC-94 | 14-DEC-94 | 14-DEC-94 | 14-DEC-94 | 14-DEC-94 | 15-DEC-94 | 15-DEC-94 |
| DEPTH (ft) | | | | | 23-25 | 33-35 | 10-12 | 20-22 | 5-10 | 15-20 | 10-12 | 20-22 |
| **Metals (mg/kg)** | | | | | | | | | | | | |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | nd | nd | nd | 3.67 | nd | nd | nd | nd |
| Barium | 20000 | 1600 | 209 | 6000 | 26.9 | 55 | 109 | 87.6 | 134 | 75.1 | 119 | 76.4 |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0.9 | **1.11** | 0.811 | 0.958 | 0.947 | 0.751 | **1.03** | 0.767 |
| Chromium | 310 | 23 | 65.3 | 42 | 17.7 | 22.7 | 35.5 | 30.6 | 26.8 | 19.5 | 38.2 | 29.6 |
| Lead | 800 | 400 | 26.8 | na | 0.605 | 6.9 | 17.1 | 17.4 | **27** | **36** | 15.4 | 12.9 |
| Mercury | 31 | 2.3 | 0.13 | na | nd | nd | nd | 0.061 | **0.155** | nd | nd | nd |
| Nickel | 2000 | 160 | 62.8 | na | 22.6 | 29.1 | 10.8 | 20.5 | 12.6 | 13.3 | 17.6 | 16.8 |
| Silver | 510 | 39 | na | 31 | nd | 0.021 | nd | nd | nd | 0.098 | nd | nd |

# Table 2-4 Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an industrial RBC exceedance. |
| 12 | J | Bold outline indicates a residential RBC exceedance. |
| **12** | **J** | Bold, underlined font indicates a background exceedance. |
| 12 | J | White Font with grey background indicates an SSL exceedance. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.

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

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

RBC = Risk Based Concentration (October, 2006).

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

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

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

na = not available

nd = not detected. This is only used for older data sets where reporting limits are not available at this upgradient location. Water level measurements in the four wells and groundwater level contouring indicate that the groundwater gradient is to the north/northwest towards the New River. Groundwater samples were collected and sampled for dissolved metals, TOC, and total organic halides (TOX) in January 1995 and sampled in July 1995 for total and dissolved metals. Results for these samples are presented in **Table 2-5**.

Antimony exceeded its tap water RBC and MCL in the January 1995 sampling event in 31MW1, the upgradient well. Antimony was not detected in the three downgradient samples. The remaining metals were below tap water RBCs and MCLs. RBCs and MCLs are not available for TOC or TOX. TOC concentrations ranged from 1,160 micrograms per liter (µg/L) to 2,040 µg/L. TOX concentrations ranged from 15 to 25.3 µg/L.

During the July 1995 sampling round, beryllium and lead exceeded their MCLs, and arsenic, barium, and chromium exceeded their tap water RBCs in the total metals fraction. Beryllium concentrations were fairly consistent across the site, ranging from 5.16 µg/L to 6 µg/L. Lead concentrations exceeded the MCL in wells 31MW2 and 31MW3. Beryllium and lead concentrations in the dissolved metals fraction were below the MCL. Arsenic exceeded the tap water RBC in a single sample (31MW2). Chromium exceeded its tap water RBC in the three downgradient wells.

The report recommended that additional lagoon sediments coupled with New River surface water and sediment samples be collected to define the nature and extent of SWMU contamination and allow for risk assessment of the sediment pathway.

### 2.7.4 RCRA Facility Investigation—ICF KE, 1998

The evaluation of the 1992 and 1996 data indicated the following data gaps requiring further investigation:

- Composite samples were collected during the VI. Discrete samples are required for risk management decisions.
- SVOCs were not analyzed during the 1996 investigation.

Surface water was not evaluated as a potential contamination pathway. The 1998 investigation was performed to augment the existing data set and refine the contamination assessment. Data needs were supplemented through the sampling of surface water/sediment (discrete), subsurface soil, and groundwater for metals, SVOC, and PAH analyses.

***Surface water.*** Three surface water samples (31SW1, 31SW2, and 31SW3) were collected to assess the surface water in the lagoons. One surface water sample was collected at the outfall of each lagoon and analyzed for metals, SVOCs, and PAHs. A summary of detected analytical results for surface water is presented in **Table 2-6**. Analysis of surface water results indicated that aluminum exceeded its MCL in the three samples, with concentrations ranging from 297 µg/L to 738 µg/L. The remaining metals and PAH/SVOCs were below tap water RBCs and MCLs.

***Sediment.*** Three sediment samples (31SL1-2, 31SL2-2, and 31SL3-2) were collocated with the three surface water samples. These samples were collected to assess whether the sediment accumulating in the lagoons is a contamination source for subsurface soil and groundwater. One sediment sample was collected at the outfall of each lagoon and analyzed for metals, SVOCs, and PAHs. A summary of detected analytical results is presented in **Table 2-7**.

# Table 2-5
# SWMU 31
# 1996 RFI Detected Results for Groundwater

| SITE ID<br>FRACTION<br>SAMPLING DATE<br>DEPTH (ft) | Screening Level | | 31MW1<br>DISSOLVED<br>18-JAN-95<br>42-52 | 31MW2<br>DISSOLVED<br>18-JAN-95<br>18-28 | 31MW3<br>DISSOLVED<br>18-JAN-95<br>23-33 | 31MW4<br>DISSOLVED<br>18-JAN-95<br>20-30 | 31MW1<br>TOTAL<br>JUL-95<br>42-52 | 31MW2<br>TOTAL<br>JUL-95<br>18-28 | 31MW3<br>TOTAL<br>JUL-95<br>23-33 | 31MW4<br>TOTAL<br>JUL-95<br>20-30 |
|---|---|---|---|---|---|---|---|---|---|---|
| | MCL | tw-RBC | | | | | | | | |
| **Metals, Total (ug/L)** | | | | | | | | | | |
| Antimony | 6 | 1.5 | nt | nt | nt | nt | nd | nd | nd | nd |
| Arsenic | 10 | 0.045 | nt | nt | nt | nt | nd | 7.44 | nd | nd |
| Barium | 2000 | 730 | nt | nt | nt | nt | 300 | 183 | 257 | 137 |
| Beryllium | 4 | 7.3 | nt | nt | nt | nt | 5.16 | 6 | 5.24 | 5.26 |
| Chromium | 100 | 11 | nt | nt | nt | nt | nd | 97.3 | 89.1 | 31.6 |
| Lead | 15 | na | nt | nt | nt | nt | 7.58 | 41.8 | 36.2 | 11.3 |
| Mercury | 2 | 1.1 | nt | nt | nt | nt | nd | nd | 0.138 | 0.142 |
| Nickel | na | 73 | nt | nt | nt | nt | nd | 49.9 | 58.4 | nd |
| Selenium | 50 | 18 | nt | nt | nt | nt | nd | nd | nd | nd |
| **Metals, Filtered (ug/L)** | | | | | | | | | | |
| Antimony | 6 | 1.5 | 65.2 | nd | nd | nd | nd | nd | nd | nd |
| Arsenic | 10 | 0.045 | nd | nd | nd | nd | nd | nd | nd | nd |
| Barium | 2000 | 730 | 222 | 23.7 | 38.1 | 29.2 | 264 | 27 | 24.7 | 19.7 |
| Beryllium | 4 | 7.3 | 3.84 | 1.56 | 1.86 | 1.1 | 3.98 | 1.63 | 1.86 | nd |
| Chromium | 100 | 11 | nd | nd | nd | nd | nd | nd | nd | nd |
| Lead | 15 | na | 7.58 | nd | nd | nd | nd | nd | nd | nd |
| Mercury | 2 | 1.1 | nd | nd | nd | nd | nd | nd | nd | nd |
| Nickel | na | 73 | nd | nd | nd | nd | nd | nd | nd | nd |
| Selenium | 50 | 18 | nd | nd | nd | nd | nd | 5.4 | nd | nd |
| **Wet Chemistry (ug/L)** | | | | | | | | | | |
| TOC | na | na | 2040 | 1320 | 1160 | nd | nt | nt | nt | nt |
| TOX | na | na | 15.4 | 15 | 25.3 | 15.6 | nt | nt | nt | nt |

# Table 2-5 Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates anMCL exceedance. |
| 12 | J | Bold outline indicates a tap water RBC exceedance. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
ug/L = micrograms per Liter (parts per billion).
na = not available.
nt = not tested.
nd = not detected.  This is only used for older data sets where reporting limits are not available.

# Table 2-6
## SWMU 31
## 1998 RFI Detected Results for Surface Water

| Analyte | Sample ID<br>Sample Date<br>Sample Depth | | **31SW1**<br>**5/14/98**<br>**NA-NA** | | | | | **31SW2**<br>**5/14/98**<br>**NA-NA** | | | | | **31SW3**<br>**5/14/98**<br>**NA-NA** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MCL** | **tw-RBC** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **PAHs (ug/L)** | | | **PAHs were not detected in surface water.** | | | | | | | | | | | | | | |
| **SVOCs (ug/L)** | | | | | | | | | | | | | | | | | |
| Diethylphthalate | na | 2900 | 2 | J | J | *10* | *10* | 3 | J | J | *10* | *10* | 8 | J | J | *10* | *10* |
| Di-n-butylphthalate | na | 360 | 1 | J | J | *10* | *10* | 10 | U | U | *10* | *10* | 10 | U | U | *10* | *10* |
| **Metals (ug/L)** | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 738 | | J | *6* | *6* | 297 | | J | *6* | *6* | 585 | | J | *6* | *6* |
| Barium | 2000 | 730 | 20.2 | B | L | *1* | *1* | 17.5 | B | L | *1* | *1* | 17.5 | B | L | *1* | *1* |
| Calcium | na | na | 11400 | | | *23* | *23* | 10500 | | | *23* | *23* | 9710 | | | *23* | *23* |
| Copper | 1300 | 150 | 19.7 | B | B | *1* | *1* | 7 | B | B | *1* | *1* | 18.6 | B | B | *1* | *1* |
| Iron | 300 | 1100 | 96.2 | B | B | *18* | *18* | 39.5 | B | B | *18* | *18* | 70.6 | B | B | *18* | *18* |
| Magnesium | na | na | 4350 | B | J | *31* | *31* | 4040 | B | J | *31* | *31* | 3670 | B | J | *31* | *31* |
| Manganese | 50 | 73 | 19.1 | | B | *1* | *1* | 10.9 | B | B | *1* | *1* | 21.1 | | | *1* | *1* |
| Nickel | na | 73 | 1 | U | U | *1* | *1* | 1 | U | U | *1* | *1* | 4.1 | B | K | *1* | *1* |
| Potassium | na | na | 1150 | B | K | *44* | *44* | 1210 | B | K | *44* | *44* | 1110 | B | K | *44* | *44* |
| Selenium | 50 | 18 | 4 | U | U | *4* | *4* | 4.6 | B | B | *4* | *4* | 4 | U | U | *4* | *4* |
| Sodium | na | na | 5700 | | K | *30* | *30* | 9660 | | K | *30* | *30* | 8480 | | K | *30* | *30* |
| Vanadium | na | 3.7 | 1.2 | B | B | *1* | *1* | 1 | U | U | *1* | *1* | 1 | U | U | *1* | *1* |
| Zinc | 5000 | 1100 | 5.2 | B | J | *2* | *2* | 3 | B | J | *2* | *2* | 3.1 | B | J | *2* | *2* |

# Table 2-6 Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an MCL exceedance. |
| 12 | J | Bold outline indicates a tap water RBC exceedance. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
ug/L = micrograms per Liter (parts per billion).
na = not available.
nt = not tested.
nd = not detected. This is only used for older data sets where reporting limits are not available.

**LQ = Lab Data Qualifiers**
B = (metals) Value <MRL and >MDL and is considered estimated.
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

**VQ = 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
U = analyte not detected

Benzo(a)pyrene exceeded the residential screening level in samples 31SL2-2 and 31SL3-2. Aluminum, beryllium, copper, and lead exceeded their background concentrations, but were below residential screening levels (where applicable). No other compounds were detected above residential screening criteria in sediment from the lagoons.

***Subsurface soil.*** Two soil samples were collected from each of four soil borings (31SB1, 31SB2, 31SB3, 31SB4) advanced near the existing wells to comply with RCRA permit requirements and to assess the nature and extent of contamination. Samples were analyzed for metals, SVOCs, and PAHs. A summary of detected analytical results for subsurface soil is presented in **Table 2-8**. Organic constituents were not detected above residential screening criteria and metals were below background levels in the samples.

***Groundwater.*** During the previous investigation, samples were not analyzed for SVOCs, which were specified in the RCRA permit for this SWMU. In order to meet the requirements of the RCRA permit for assessing the nature and extent of contamination, groundwater samples were collected from the four existing SWMU 31 wells. Samples were analyzed for total and dissolved metals, SVOCs, PAHs, TOC, and TOX. A summary of detected analytical results for groundwater is presented in **Table 2-9**.

Benzo(a)pyrene exceeded its tap water RBCs in two wells, 31MW2 and 31MW3. Benzo(b)fluoranthene also exceeded its tap water RBC in well 31MW3. Bis(2-ethylhexyl)phthalate exceeded its tap water RBC in upgradient well 31MW1. Concentrations for both of these compounds, however, were below their respective MCLs.

Six metals (aluminum, arsenic, chromium, iron, manganese, and vanadium) exceeded tap water RBCs and/or MCLs in the total metals analysis. Aluminum was the only metal to exceed its MCL in the dissolved metals analysis. None of the metals exceeded tap water RBCs in the dissolved metal analyses.

The report recommended that deep lagoon sediments, coupled with additional surface water and groundwater samples be collected to enhance the current CSM.

# Table 2-7
# SWMU 31
# 1998 RFI Detected Results for Sediment

| Analyte | | | | Sample ID<br>Sample Date<br>Sample Depth | 31SL1-2<br>5/14/98<br>0-0.5 | | | | | 31SL2-2<br>5/14/98<br>0-0.5 | | | | | 31SL3-2<br>5/14/98<br>0-0.5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **i-RBC** | **r-RBC** | **Background** | **SSL Transfer** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **PAHs (ug/kg)** | | | | | | | | | | | | | | | | | | | |
| Acenaphthene | 6100000 | 470000 | na | 100000 | 210 | U | U | 24 | 24 | 280 | | | 24 | 24 | 190 | U | U | 24 | 24 |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 21 | U | U | 21 | 21 | 40 | | | 37 | 37 | 68 | | | 19 | 19 |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 21 | U | U | 21 | 21 | 45 | | | 19 | 19 | 19 | U | U | 210 | 210 |
| Chrysene | 390000 | 22000 | na | 48000 | 21 | U | U | 41 | 41 | 25 | U | U | 550 | 550 | 28 | | | 41 | 41 |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 34 | J | J | 280 | 280 | 76 | | | 37 | 37 | 130 | | | 240 | 240 |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 23 | | | 21 | 21 | 24 | J | J | 280 | 280 | 51 | U | U | 190 | 190 |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 21 | U | U | 41 | 41 | 48 | | K | 19 | 19 | 110 | | K | 240 | 240 |
| Pyrene | 3100000 | 230000 | na | 680000 | 36 | | | 55 | 55 | 76 | | | 37 | 37 | 93 | | | 19 | 19 |
| **SVOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | |
| Di-n-butylphthalate | 10000000 | 780000 | na | 5000000 | 4400 | U | U | 4400 | 4400 | 3300 | U | U | 3300 | 3300 | 430 | J | B | 2800 | 2800 |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | **108000** | | | 7.9 | 7.9 | **82900** | | | 5.9 | 5.9 | **91600** | | | 5.2 | 5.2 |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 7.9 | U | U | 7.9 | 7.9 | 8.6 | B | J | 5.9 | 5.9 | 8.7 | | | 5.2 | 5.2 |
| Barium | 20000 | 1600 | 209 | 6000 | 91.1 | B | L | 1.3 | 1.3 | 111 | B | L | 0.99 | 0.99 | 118 | B | L | 0.86 | 0.86 |
| Beryllium | 200 | 16 | 1.02 | 1200 | 1.3 | U | U | 1.3 | 1.3 | **1.8** | **B** | **J** | 0.99 | 0.99 | 0.95 | B | J | 0.86 | 0.86 |
| Calcium | na | na | na | na | 2760 | B | J | 30.4 | 30.4 | 3580 | B | J | 22.8 | 22.8 | 3980 | B | J | 19.8 | 19.8 |
| Chromium | 310 | 23 | 65.3 | 42 | 26.7 | | | 1.3 | 1.3 | 37.8 | | | 0.99 | 0.99 | 40.6 | | | 0.86 | 0.86 |
| Cobalt | na | na | 72.3 | na | 6.2 | B | L | 1.3 | 1.3 | 13.7 | B | L | 0.99 | 0.99 | 9 | B | L | 0.86 | 0.86 |
| Copper | 4100 | 310 | 53.5 | 11000 | **69.3** | | **B** | 1.3 | 1.3 | **96.6** | | **B** | 0.99 | 0.99 | **65.5** | | **B** | 0.86 | 0.86 |
| Iron | 31000 | 2300 | 50962 | na | 19400 | | | 23.8 | 23.8 | 22000 | | | 17.8 | 17.8 | 23400 | | | 15.5 | 15.5 |
| Lead | 800 | 400 | 26.8 | na | **54.9** | | | 2.6 | 2.6 | **52.3** | | | 2 | 2 | **53** | | | 1.7 | 1.7 |
| Magnesium | na | na | na | na | 2080 | B | J | 40.9 | 40.9 | 2730 | B | J | 30.7 | 30.7 | 2960 | B | J | 26.7 | 26.7 |
| Manganese | 2000 | 160 | 2543 | 950 | 422 | | | 1.3 | 1.3 | 614 | | | 0.99 | 0.99 | 669 | | | 0.86 | 0.86 |
| Nickel | 2000 | 160 | 62.8 | na | 16.5 | B | J | 1.3 | 1.3 | 30.2 | B | J | 0.99 | 0.99 | 32.6 | B | J | 0.86 | 0.86 |
| Potassium | na | na | na | na | 1210 | B | K | 58.1 | 58.1 | 1420 | B | K | 43.6 | 43.6 | 1500 | B | K | 37.9 | 37.9 |
| Sodium | na | na | na | na | 702 | B | B | 39.6 | 39.6 | 1010 | B | B | 29.7 | 29.7 | 785 | B | B | 25.9 | 25.9 |
| Vanadium | 102 | 7.8 | 108 | 730 | 43.1 | B | J | 1.3 | 1.3 | 49.6 | | J | 0.99 | 0.99 | 52.4 | | J | 0.86 | 0.86 |
| Zinc | 31000 | 2300 | 202 | 14000 | 134 | | J | 2.6 | 2.6 | 180 | | J | 2 | 2 | 176 | | J | 1.7 | 1.7 |

# Table 2-8
# SWMU 31
# 1998 RFI Detected Results for Soil

| Analyte | | | | Sample ID | 31SB1A | | | | | 31SB1C | | | | | 31SB2A | | | | | 31SB2B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sample Date | 3/25/98 | | | | | 3/25/98 | | | | | 3/24/98 | | | | | 3/24/98 | | | | |
| | | | | Sample Depth | 22-23 | | | | | 10-12 | | | | | 12-14 | | | | | 20-22 | | | | |
| | **i-RBC** | **r-RBC** | **Background** | **SSL Transfer** | 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 |
| **PAHs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| Benz(a)anthracene | 3900 | 220 | na | 480 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 5.2 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 8.7 | | J | *2.1* | *2.1* | 1.2 | J | J | *1.9* | *1.9* |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1500 | 3.6 | U | UL | *3.6* | *3.6* | 4 | U | UL | *4* | *4* | 9.3 | | J | *4.1* | *4.1* | 3.8 | U | U | *3.8* | *3.8* |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 3.3 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| Chrysene | 390000 | 22000 | na | 48000 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 7.1 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 3.6 | U | UL | *3.6* | *3.6* | 4 | U | UL | *4* | *4* | 8.1 | | J | *4.1* | *4.1* | 3.8 | U | U | *3.8* | *3.8* |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 7.5 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 4.8 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| Pyrene | 3100000 | 230000 | na | 680000 | 1.8 | U | UL | *1.8* | *1.8* | 2 | U | UL | *2* | *2* | 12 | | J | *2.1* | *2.1* | 1.9 | U | U | *1.9* | *1.9* |
| **SVOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| bis(Chloroisopropyl)ether | 41000 | 9100 | na | 1.7 | 360 | U | U | *360* | *360* | 410 | U | U | *410* | *410* | 420 | U | U | *420* | *420* | 370 | U | U | *370* | *370* |
| Di-n-butylphthalate | 10000000 | 780000 | na | 5000000 | 360 | U | U | *360* | *360* | 410 | U | U | *410* | *410* | 420 | U | U | *420* | *420* | 76 | J | J | *370* | *370* |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | 17900 | | | *0.65* | *0.65* | 28400 | | | *0.73* | *0.73* | 30500 | | | *0.76* | *0.76* | 5300 | | | *0.67* | *0.67* |
| Antimony | 41 | 3.1 | na | 13 | 0.85 | B | J | *0.54* | *0.54* | 1.4 | B | J | *0.61* | *0.61* | 1.7 | B | J | *0.64* | *0.64* | 0.33 | U | U | *0.55* | *0.55* |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 1.8 | | | *0.65* | *0.65* | 5.9 | | | *0.73* | *0.73* | 3.7 | | | *0.76* | *0.76* | 0.44 | U | U | *0.67* | *0.67* |
| Barium | 20000 | 1600 | 209 | 6000 | 18.3 | B | L | *0.11* | *0.11* | 76 | | L | *0.12* | *0.12* | 138 | | L | *0.13* | *0.13* | 15.9 | B | L | *0.11* | *0.11* |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0.77 | | K | *0.11* | *0.11* | 0.98 | | K | *0.12* | *0.12* | 0.96 | | K | *0.13* | *0.13* | 0.16 | B | K | *0.11* | *0.11* |
| Calcium | na | na | na | na | 38700 | | | *2.5* | *2.5* | 969 | | | *2.8* | *2.8* | 4570 | | | *2.9* | *2.9* | 175000 | | | *25.5* | *25.5* |
| Chromium | 310 | 23 | 65.3 | 42 | 32.1 | | | *0.11* | *0.11* | 59.2 | | | *0.12* | *0.12* | 34.3 | | | *0.13* | *0.13* | 7 | | | *0.11* | *0.11* |
| Cobalt | na | na | 72.3 | na | 6 | | L | *0.11* | *0.11* | 21.6 | | L | *0.12* | *0.12* | 14 | | L | *0.13* | *0.13* | 1.5 | B | L | *0.11* | *0.11* |
| Copper | 4100 | 310 | 53.5 | 11000 | 0.11 | U | U | *0.11* | *0.11* | 16.9 | | K | *0.12* | *0.12* | 17.2 | | | *0.13* | *0.13* | 6.1 | | K | *0.11* | *0.11* |
| Iron | 31000 | 2300 | 50962 | na | 25600 | | | *2* | *2* | 40200 | | | *2.2* | *2.2* | 36400 | | | *2.3* | *2.3* | 4490 | | | *2* | *2* |
| Lead | 800 | 400 | 26.8 | na | 0.52 | | | *0.22* | *0.22* | 18.5 | | | *0.24* | *0.24* | 13.1 | | | *0.25* | *0.25* | 3.1 | | | *0.22* | *0.22* |
| Magnesium | na | na | na | na | 23600 | | | *3.4* | *3.4* | 2490 | | | *3.8* | *3.8* | 4720 | | | *3.9* | *3.9* | 107000 | | | *34.4* | *34.4* |
| Manganese | 2000 | 160 | 2543 | 950 | 191 | | | *0.11* | *0.11* | 857 | | | *0.12* | *0.12* | 598 | | | *0.13* | *0.13* | 76.5 | | | *0.11* | *0.11* |
| Nickel | 2000 | 160 | 62.8 | na | 42.4 | | K | *0.11* | *0.11* | 20.9 | | K | *0.12* | *0.12* | 19.3 | | K | *0.13* | *0.13* | 2.9 | B | K | *0.11* | *0.11* |
| Potassium | na | na | na | na | 4120 | | K | *4.8* | *4.8* | 2980 | | K | *5.4* | *5.4* | 2410 | | K | *5.6* | *5.6* | 5270 | | K | *4.9* | *4.9* |
| Sodium | na | na | na | na | 180 | B | J | *3.3* | *3.3* | 161 | B | B | *3.7* | *3.7* | 203 | B | K | *3.8* | *3.8* | 404 | B | K | *3.3* | *3.3* |
| Vanadium | 102 | 7.8 | 108 | 730 | 16.7 | | K | *0.11* | *0.11* | 59.1 | | K | *0.12* | *0.12* | 71.4 | | K | *0.13* | *0.13* | 10.5 | | K | *0.11* | *0.11* |
| Zinc | 31000 | 2300 | 202 | 14000 | 11.9 | | K | *0.22* | *0.22* | 40.1 | | K | *0.24* | *0.24* | 62.4 | | K | *0.25* | *0.25* | 0.11 | U | U | *0.22* | *0.22* |

# Table 2-8
# SWMU 31
# 1998 RFI Detected Results for Soil

| Analyte | | | | Sample ID<br>Sample Date<br>Sample Depth | 31SB3A<br>3/24/98<br>10-12 | | | | | 31SB3B<br>3/24/98<br>18-20 | | | | | 31SB4A<br>3/24/98<br>10-12 | | | | | 31SB4B<br>3/24/98<br>20-24 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | i-RBC | r-RBC | Background | SSL Transfer | 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 |
| **PAHs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| Benz(a)anthracene | 3900 | 220 | na | 480 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1500 | 3.6 | U | UL | 3.6 | 3.6 | 3.6 | U | UL | 3.6 | 3.6 | 3.7 | U | UL | 3.7 | 3.7 | 3.8 | U | UL | 3.8 | 3.8 |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Chrysene | 390000 | 22000 | na | 48000 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 3.6 | U | UL | 3.6 | 3.6 | 3.6 | U | UL | 3.6 | 3.6 | 3.7 | U | UL | 3.7 | 3.7 | 3.8 | U | UL | 3.8 | 3.8 |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| Pyrene | 3100000 | 230000 | na | 680000 | 1.8 | U | UL | 1.8 | 1.8 | 1.8 | U | UL | 1.8 | 1.8 | 1.9 | U | UL | 1.9 | 1.9 | 1.9 | U | UL | 1.9 | 1.9 |
| **SVOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| bis(Chloroisopropyl)ether | 41000 | 9100 | na | 1.7 | 370 | U | U | 370 | 370 | 380 | U | U | 380 | 380 | 380 | U | U | 380 | 380 | 400 | U | U | 400 | 400 |
| Di-n-butylphthalate | 10000000 | 780000 | na | 5000000 | 370 | U | U | 370 | 370 | 81 | J | J | 380 | 380 | 110 | J | J | 380 | 380 | 70 | J | J | 400 | 400 |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | 18800 | | | 0.68 | 0.68 | 7010 | | | 0.69 | 0.69 | 15400 | | | 0.69 | 0.69 | 12400 | | | 0.72 | 0.72 |
| Antimony | 41 | 3.1 | na | 13 | 1.4 | B | J | 0.56 | 0.56 | 0.71 | B | J | 0.57 | 0.57 | 1.4 | B | J | 0.57 | 0.57 | 1.1 | B | J | 0.6 | 0.6 |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 3.9 | | | 0.68 | 0.68 | 2.9 | | | 0.69 | 0.69 | 3.4 | | | 0.69 | 0.69 | 6 | | | 0.72 | 0.72 |
| Barium | 20000 | 1600 | 209 | 6000 | 83.1 | | L | 0.11 | 0.11 | 48.7 | | L | 0.11 | 0.11 | 97.6 | | L | 0.11 | 0.11 | 80.4 | | L | 0.12 | 0.12 |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0.35 | B | K | 0.11 | 0.11 | 0.29 | B | K | 0.11 | 0.11 | 0.25 | B | K | 0.11 | 0.11 | 0.74 | | K | 0.12 | 0.12 |
| Calcium | na | na | na | na | 725 | | | 2.6 | 2.6 | 826 | | | 2.6 | 2.6 | 1090 | | | 2.6 | 2.6 | 1550 | | | 2.7 | 2.7 |
| Chromium | 310 | 23 | 65.3 | 42 | 30.3 | | | 0.11 | 0.11 | 16.3 | | | 0.11 | 0.11 | 27.2 | | | 0.11 | 0.11 | 23.3 | | | 0.12 | 0.12 |
| Cobalt | na | na | 72.3 | na | 14.4 | | L | 0.11 | 0.11 | 8.1 | | L | 0.11 | 0.11 | 13.8 | | L | 0.11 | 0.11 | 9.3 | | L | 0.12 | 0.12 |
| Copper | 4100 | 310 | 53.5 | 11000 | 17.1 | | K | 0.11 | 0.11 | 9.3 | | K | 0.11 | 0.11 | 15 | | K | 0.11 | 0.11 | 12.6 | | K | 0.12 | 0.12 |
| Iron | 31000 | 2300 | 50962 | na | 34900 | | | 2 | 2 | 20600 | | | 2.1 | 2.1 | 30800 | | | 2.1 | 2.1 | 37000 | | | 2.1 | 2.1 |
| Lead | 800 | 400 | 26.8 | na | 18.1 | | | 0.23 | 0.23 | 12.1 | | | 0.23 | 0.23 | 12.8 | | | 0.23 | 0.23 | 18.9 | | | 0.24 | 0.24 |
| Magnesium | na | na | na | na | 4630 | | | 3.5 | 3.5 | 1850 | | | 3.5 | 3.5 | 4710 | | | 3.6 | 3.6 | 3370 | | | 3.7 | 3.7 |
| Manganese | 2000 | 160 | 2543 | 950 | 513 | | | 0.11 | 0.11 | 431 | | | 0.11 | 0.11 | 502 | | | 0.11 | 0.11 | 502 | | | 0.12 | 0.12 |
| Nickel | 2000 | 160 | 62.8 | na | 17.8 | | K | 0.11 | 0.11 | 9.8 | | K | 0.11 | 0.11 | 16 | | K | 0.11 | 0.11 | 17.6 | | K | 0.12 | 0.12 |
| Potassium | na | na | na | na | 2340 | | K | 5 | 5 | 1040 | | K | 5 | 5 | 2310 | | K | 5.1 | 5.1 | 1450 | | K | 5.2 | 5.2 |
| Sodium | na | na | na | na | 200 | B | K | 3.4 | 3.4 | 177 | B | K | 3.4 | 3.4 | 230 | B | K | 3.4 | 3.4 | 178 | B | K | 3.6 | 3.6 |
| Vanadium | 102 | 7.8 | 108 | 730 | 56.1 | | K | 0.11 | 0.11 | 22.3 | | K | 0.11 | 0.11 | 48 | | K | 0.11 | 0.11 | 33.7 | | K | 0.12 | 0.12 |
| Zinc | 31000 | 2300 | 202 | 14000 | 67.9 | | K | 0.23 | 0.23 | 37.1 | | K | 0.23 | 0.23 | 60.3 | | K | 0.23 | 0.23 | 93.8 | | K | 0.24 | 0.24 |

# Tables 2-7 and 2-8 Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an industrial RBC exceedance. |
| 12 | J | Bold outline indicates a residential RBC exceedance. |
| **12** | **J** | Bold, underlined font indicates a background exceedance. |
| 12 | J | Shading and white font indicates a SSL Transfer exceedance. |
| *12* | *12* | Shading in the MDL/MRL columns indicates the MDL exceeds a criterion. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (April, 1999).
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.
NT = analyte not tested.
**LQ = Lab Data Qualifiers**
B = (organics) Blank contamination. Value detected in sample and associated blank.
B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
**VQ = 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
U = analyte not detected

# Table 2-9
# SWMU 31
# 1998 RFI Detected Results for Groundwater

| Analyte | | Sample ID | 31MW1-2 | | | | | 31MW2-2 | | | | | 31MW3-2 | | | | | 31MW4-2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample Date | 4/6/98 | | | | | 4/1/98 | | | | | 4/1/98 | | | | | 4/6/98 | | | | |
| | | Sample Depth | 40-50 | | | | | 18.5-19.5 | | | | | 20.5-30.5 | | | | | 19-29 | | | | |
| | MCL | tw-RBC | 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 |
| **PAHs (ug/L)** | | | | | | | | | | | | | | | | | | | | | | |
| Benz(a)anthracene | na | 0.03 | 0.05 | U | U | *0.05* | *0.05* | 0.022 | J | J | *0.05* | *0.05* | 0.05 | U | U | *0.05* | *0.05* | 0.05 | U | U | *0.05* | *0.05* |
| Benzo(a)pyrene | 0.2 | 0.003 | 0.05 | U | U | *0.05* | *0.05* | 0.022 | J | J | *0.05* | *0.05* | 0.061 | J | J | *0.05* | *0.05* | 0.05 | U | U | *0.05* | *0.05* |
| Benzo(b)fluoranthene | na | 0.03 | 0.1 | U | U | *0.1* | *0.1* | 0.027 | J | J | *0.1* | *0.1* | 0.066 | J | J | *0.1* | *0.1* | 0.1 | U | U | *0.1* | *0.1* |
| **SVOCs (ug/L)** | | | | | | | | | | | | | | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 6 | 4.8 | 5 | J | J | *10* | *10* | 10 | U | U | *10* | *10* | 10 | U | U | *10* | *10* | 10 | U | U | *10* | *10* |
| **Metals (ug/L), Total** | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 534 | | | *6* | *6* | 2670 | | | *6* | *6* | 2680 | | | *6* | *6* | 124 | B | B | *6* | *6* |
| Arsenic | 10 | 0.045 | 6 | U | U | *6* | *6* | 9.3 | B | K | *6* | *6* | 9.4 | B | K | *6* | *6* | 6 | U | U | *6* | *6* |
| Barium | 2000 | 730 | 166 | B | J | *1* | *1* | 53.5 | B | J | *1* | *1* | 53.6 | B | J | *1* | *1* | 19.3 | B | J | *1* | *1* |
| Beryllium | 4 | 7.3 | 1.3 | B | K | *1* | *1* | 1.1 | B | K | *1* | *1* | 1.1 | B | K | *1* | *1* | 1.3 | B | K | *1* | *1* |
| Calcium | na | na | 73800 | | | *23* | *23* | 25000 | | | *23* | *23* | 25100 | | | *23* | *23* | 18100 | | | *23* | *23* |
| Chromium | 100 | 11 | 6.1 | B | B | *1* | *1* | 11.3 | | B | *1* | *1* | 11.4 | | B | *1* | *1* | 5.7 | B | B | *1* | *1* |
| Cobalt | na | na | 2.1 | B | J | *1* | *1* | 3.8 | B | J | *1* | *1* | 3.6 | B | J | *1* | *1* | 1 | U | UL | *1* | *1* |
| Copper | 1300 | 150 | 30 | | B | *1* | *1* | 37.3 | | B | *1* | *1* | 37.2 | | B | *1* | *1* | 11 | B | B | *1* | *1* |
| Iron | 300 | 1100 | 860 | | | *18* | *18* | 7080 | | | *18* | *18* | 7080 | | | *18* | *18* | 141 | | B | *18* | *18* |
| Lead | 15 | na | 2.7 | B | L | *2* | *2* | 6.6 | | | *2* | *2* | 6.7 | | | *2* | *2* | 2 | U | UL | *2* | *2* |
| Magnesium | na | na | 51600 | | | *31* | *31* | 12000 | | | *31* | *31* | 12000 | | | *31* | *31* | 6600 | | | *31* | *31* |
| Manganese | 50 | 73 | 26.9 | | | *1* | *1* | 182 | | | *1* | *1* | 183 | | | *1* | *1* | 4.6 | B | B | *1* | *1* |
| Nickel | na | 73 | 4.5 | B | B | *1* | *1* | 7.7 | B | B | *1* | *1* | 7.8 | B | B | *1* | *1* | 2.6 | B | B | *1* | *1* |
| Potassium | na | na | 31900 | | K | *44* | *44* | 1800 | B | K | *44* | *44* | 1810 | B | J | *44* | *44* | 1060 | B | K | *44* | *44* |
| Selenium | 50 | 18 | 4.1 | B | K | *4* | *4* | 4 | U | U | *4* | *4* | 4 | U | U | *4* | *4* | 4 | U | U | *4* | *4* |
| Sodium | na | na | 17600 | | K | *30* | *30* | 11800 | | K | *30* | *30* | 11900 | | J | *30* | *30* | 11900 | | K | *30* | *30* |
| Vanadium | na | 3.7 | 1.2 | B | B | *1* | *1* | 17.3 | B | K | *1* | *1* | 17.4 | B | J | *1* | *1* | 2.9 | B | B | *1* | *1* |
| Zinc | 5000 | 1100 | 20.9 | | B | *2* | *2* | 26.6 | | B | *2* | *2* | 26.5 | | B | *2* | *2* | 9.9 | B | B | *2* | *2* |
| **Metals (ug/L), Filtered** | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 29.7 | B | B | *6* | *6* | 111 | B | B | *6* | *6* | 75.1 | B | B | *6* | *6* | 56.1 | B | B | *6* | *6* |
| Barium | 2000 | 730 | 172 | B | L | *1* | *1* | 14.4 | B | L | *1* | *1* | 18.5 | B | J | *1* | *1* | 17.4 | B | J | *1* | *1* |
| Calcium | na | na | 71800 | | | *23* | *23* | 19900 | | | *23* | *23* | 18600 | | | *23* | *23* | 17200 | | J | *23* | *23* |
| Chromium | 100 | 11 | 1.6 | B | B | *1* | *1* | 6.4 | B | B | *1* | *1* | 1.1 | B | B | *1* | *1* | 2.7 | B | B | *1* | *1* |
| Cobalt | na | na | 3.1 | B | L | *1* | *1* | 3.5 | B | L | *1* | *1* | 2.9 | B | L | *1* | *1* | 2.8 | B | J | *1* | *1* |
| Copper | 1300 | 150 | 15.4 | B | B | *1* | *1* | 31.1 | | B | *1* | *1* | 11.3 | B | B | *1* | *1* | 13.6 | B | B | *1* | *1* |
| Iron | 300 | 1100 | 18 | U | U | *18* | *18* | 148 | | | *18* | *18* | 79.4 | B | J | *18* | *18* | 18 | U | UJ | *18* | *18* |
| Magnesium | na | na | 51800 | | | *31* | *31* | 6540 | | | *31* | *31* | 7350 | | | *31* | *31* | 6270 | | J | *31* | *31* |
| Manganese | 50 | 73 | 11 | B | J | *1* | *1* | 12.7 | B | J | *1* | *1* | 9.3 | B | J | *1* | *1* | 9.3 | B | B | *1* | *1* |
| Nickel | na | 73 | 8.8 | B | K | *1* | *1* | 2.9 | B | B | *1* | *1* | 1 | U | U | *1* | *1* | 2.9 | B | B | *1* | *1* |
| Potassium | na | na | 25400 | | K | *44* | *44* | 1100 | B | K | *44* | *44* | 986 | B | J | *44* | *44* | 1010 | B | J | *44* | *44* |
| Sodium | na | na | 14600 | | K | *30* | *30* | 10800 | J | K | *30* | *30* | 11700 | J | J | *30* | *30* | 11500 | | J | *30* | *30* |
| Vanadium | na | 3.7 | 1 | U | U | *1* | *1* | 2.6 | B | B | *1* | *1* | 2.1 | B | B | *1* | *1* | 1.9 | B | B | *1* | *1* |
| Zinc | 5000 | 1100 | 9.9 | B | B | *2* | *2* | 6.6 | B | B | *2* | *2* | 2.5 | B | B | *2* | *2* | 6.5 | B | B | *2* | *2* |
| **Misc. (ug/L)** | | | | | | | | | | | | | | | | | | | | | | |
| Total Organic Carbon | na | na | 100000 | | | *100000* | *100000* | 100000 | | | *100000* | *100000* | 100000 | | | *100000* | *100000* | 100000 | | | *100000* | *100000* |
| Total Organic Halides | na | na | 110 | | | *50* | *50* | 50 | U | U | *50* | *50* | 50 | U | U | *50* | *50* | 50 | U | U | *50* | *50* |

# Table 2-9 Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an MCL exceedance. |
| 12 | J | Bold outline indicates a tap water RBC exceedance. |

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
ug/L = micrograms per Liter (parts per billion).
na = not available.
nt = not tested.
nd = not detected. This is only used for older data sets where reporting limits are not available.

**LQ = Lab Data Qualifiers**

B = (metals) Value <MRL and >MDL and is considered estimated.
J = (organics) Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

**VQ = 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
U = analyte not detected

# 3.0 NATURE AND EXTENT OF CONTAMINATION

A discussion of the nature and extent of chemicals found in soil, sediment, surface water, and groundwater at SWMU 31 during the previous and current (2002) investigation is presented in this section. Chemical results in this section are compared to the comparison criteria, as described in *Section 2.6*. A complete set of validated analytical data used in this report can be found on a CD located at the back of the appendices in this report.

## 3.1 RCRA FACILITY INVESTIGATION, SHAW ENVIRONMENTAL, INC., 2002

Surface water, sediment, surface and subsurface soil, and groundwater samples were collected for chemical and physical analysis during the 2002 RFI sampling activities at SWMU 31 (**Table 3-1**). Sampling locations were selected based on previous sample results, site visit observations, negotiations with regulators, and the CSM. Investigative activities were conducted in accordance with the MWP, MQAP, and the MHSP. Sample location coordinates and elevations are presented in **Appendix B**.

**Table 3-1**
**2002 RFI Environmental Samples and Analyses – SWMU 31**

| Medium Sampled | Number of Samples | Sample ID | Sample Depth (ft) | Analyses |
|---|---|---|---|---|
| Surface Water | 3 | 31SW10<br>31SW12<br>31SW14 | N/A<br>N/A<br>N/A | TCL VOCs, TCL SVOCs, PAHs, TAL metals, explosives, TCL pesticides/PCBs, herbicides, perchlorate, hardness, TOC, TOX |
| Sediment | 11 | 31SE7B<br>31SE8A<br>31SE9B<br>31SE11A<br>31SE12B<br>31SE13A<br>31SE13B<br>31SE14B<br>31SE14C | 2-4<br>0-0.5<br>2-4<br>0-0.5<br>2-4<br>0-0.5<br>5-7<br>2.5-4.5<br>6-8 | TCL SVOCs, PAHs, TAL metals, explosives, TOC, grain size |
| | | 31SE10B<br>31SE11B<br>31SE13B | 2-4<br>1-3<br>5-7 | TCL VOCs, TCL SVOCs, PAHs, TCL pesticides/PCBs, herbicides, TAL metals, dioxins/furans, explosives, TOC, grain size TCLP SVOCs, TCLP metals |
| Soil | 3 | 31SB05A<br>31SB05B<br>31SB05C | 0-0.5<br>1-3<br>3-5 | TCL VOCs, TAL metals, explosives, TCL pesticides/PCBs, herbicides, dioxins/furans, TOC, pH |
| Groundwater | 4 | 31MW01<br>31MW3<br>31MW04 | 42-52*<br>22-32*<br>20-30* | TCL VOCs, TCL SVOCs, PAHs, total and dissolved TAL metals, explosives, TCL pesticides/PCBs, herbicides, perchlorate, hardness, TOC, TOX |

* Well screen interval

The field sampling program is summarized in **Table 3-1**. The sample locations are presented on **Figure 3-1**. Specific site investigation elements included:

- *Surface Water Sampling*: One surface water sample was collocated with one of the deep sediment samples collected from each lagoon.
- *Sediment Sampling*: Deep sediment samples were not collected during previous investigations;11 samples were collected from eight locations for this investigation.

## LEGEND

⌖ 2002 RFI Groundwater Sample Location

● 2002 RFI Soil Sample Location

▲ 2002 RFI Surface Water/ Sediment Sample Location

▭ SWMU 31 Boundary

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

Scale:

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 3-1

2002 Sample Locations

Radford, VA

Date: 11/2/06 GIS File: RFAAP_004_Fig3-1_SWMU31_2002SampLoc.mxd

- *Soil Sampling*: Three soil samples were collected from one boring to address chemical parameter data gaps. Limited soil sampling was conducted because impacts from site activities would mainly be to the surface water and sediment of the settling lagoons.
- *Groundwater Sampling*: Groundwater samples were collected from three of the four existing wells to assess potential contaminant migration. A sample was not collected from well 31MW2 because the well was dry at the time of the sampling event.
- *Amphibian Survey*: Two separate qualitative amphibian surveys were performed at SWMU 31 on April 12 and April 13, 2006. The surveys consisted of both visual and audible observances to identify and estimate the density of amphibian species at the site. A detailed description of the survey and results is presented in *Section 6.9*.

## 3.2 NATURE AND DISTRIBUTION OF CHEMICALS AT SWMU 31

Surface and subsurface soil, surface water, sediment, and groundwater samples were collected from the SWMU 31 study area to assess the nature and distribution of potential chemical contaminants and to assess potential risk to human health and the environment. Analytical parameters for each sample are presented in **Table 3-1**.

### 3.2.1 Surface Water Sample Results – 2002 RCRA Facility Investigation (Shaw)

Chemical detections are presented in **Table 3-2**. Exceedances of regulatory criteria are presented on **Figure 3-2**.

***VOCs.*** Three VOCs exceeded tap water RBCs in the surface water samples. Bromodichloromethane was detected in all three samples above the tap water RBC (0.17 µg/L). Concentrations ranged from 1.3 µg/L to 3.6 µg/L. Chloroform also exceeded its tap water RBC (0.15 µg/L) in the three samples, with concentrations ranging from 16 µg/L to 30 µg/L. Dibromochloromethane was detected in 31SW12 (0.17 µg/L) and 31SW14 (0.2 µg/L) above its tap water RBC (0.13 µg/L). Concentrations of each of these constituents; however, were below their respective MCLs.

***SVOCs.*** Bis(2-ethylhexyl)phthalate was detected in the three surface water samples at concentrations exceeding the tap water RBC (4.8 µg/L). Concentrations in two of the samples also exceeded the MCL (6 µg/L). Concentrations ranged from 5.1 µg/L to 11 µg/L. No other SVOCs were detected above the tap water RBC or MCL.

***PAHs.*** Three PAHs were detected by this more sensitive method of analyses for PAH SVOCs. No sample concentrations exceeded the tap water RBCs or MCLs.

***Pesticides.*** Five pesticides were detected. No sample concentrations exceeded the tap water RBCs or MCLs.

***PCBs.*** PCBs were not detected in surface water.

***Explosives.*** One explosive, nitrobenzene, was detected in one sample. The concentration was below the tap water RBC.

***Herbicides.*** Two herbicides, dicamba and silvex, were detected. Concentrations were below the tap water RBCs and MCLs.

***TAL Metals.*** Sixteen metals were detected in surface water samples collected from the site. Three metals, aluminum (359 – 13,200 µg/L), iron (50.4 – 1,540 µg/L), and manganese (7.6 –

# Table 3-2
# SWMU 31
# 2002 RFI Detected Results for Surface Water

| Analyte | Sample ID | | 31SW10 | | | | | 31SW12 | | | | | 31SW14 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Date | | 7/9/02 | | | | | 7/10/02 | | | | | 7/10/02 | | | | |
| | Sample Depth | | na-na | | | | | na-na | | | | | na-na | | | | |
| | **MCL** | **tw-RBC** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **VOCs (ug/L)** | | | | | | | | | | | | | | | | | |
| Bromodichloromethane | 80 | 0.17 | 1.3 | | | *0.0581* | *1* | 2.6 | | | *0.0581* | *1* | 3.6 | | | *0.0581* | *1* |
| Carbon disulfide | na | 100 | 0.075 | J | B | *0.0604* | *1* | 1 | U | | *0.0604* | *1* | 1 | U | | *0.0604* | *1* |
| Chloroform | 80 | 0.15 | 16 | | | *0.0776* | *1* | 22 | | | *0.0776* | *1* | 30 | | | *0.0776* | *1* |
| Dibromochloromethane | 80 | 0.13 | 1 | U | | *0.0781* | *1* | 0.17 | J | J | *0.0781* | *1* | 0.2 | J | J | *0.0781* | *1* |
| Methylene chloride | 5 | 4.1 | 0.11 | J | B | *0.0756* | *1* | 1 | U | | *0.0756* | *1* | 0.078 | J | B | *0.0756* | *1* |
| **PAHs (ug/L)** | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | na | 2.4 | 0.031 | J | J | *0.0132* | *0.05* | 0.05 | U | | *0.0132* | *0.05* | 0.05 | U | | *0.0132* | *0.05* |
| Naphthalene | na | 0.65 | 0.031 | JB | B | *0.0191* | *0.05* | 0.029 | JB | B | *0.0191* | *0.05* | 0.022 | JB | B | *0.0191* | *0.05* |
| Pyrene | na | 18 | 0.05 | U | | *0.0123* | *0.05* | 0.05 | U | | *0.0123* | *0.05* | 0.026 | J | J | *0.0123* | *0.05* |
| **SVOCs (ug/L)** | | | | | | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 600 | 27 | 0.25 | J | J | *0.0745* | *5* | 5 | U | | *0.0745* | *5* | 5 | U | | *0.0745* | *5* |
| 1,3-Dichlorobenzene | na | 18 | 0.26 | J | J | *0.0891* | *5* | 5 | U | | *0.0891* | *5* | 5 | U | | *0.0891* | *5* |
| 1,4-Dichlorobenzene | 75 | 0.47 | 0.26 | J | J | *0.0746* | *5* | 5 | U | | *0.0746* | *5* | 5 | U | | *0.0746* | *5* |
| Benzoic acid | na | 15000 | 12 | J | J | *3.14* | *25* | 3.4 | J | J | *3.14* | *25* | 7.6 | J | J | *3.14* | *25* |
| bis(2-Ethylhexyl)phthalate | 6 | 4.8 | 11 | B | B | *1.6* | *5* | 5.1 | B | B | *1.6* | *5* | 7.3 | B | B | *1.6* | *5* |
| Butylbenzylphthalate | na | 730 | 1.2 | J | J | *0.247* | *5* | 0.5 | J | J | *0.247* | *5* | 5 | U | | *0.247* | *5* |
| Di-n-butylphthalate | na | 360 | 0.74 | J | J | *0.489* | *5* | 5 | U | | *0.489* | *5* | 5 | U | | *0.489* | *5* |
| Hexachlorobutadiene | na | 0.73 | 0.26 | J | J | *0.136* | *5* | 5 | U | | *0.136* | *5* | 5 | U | | *0.136* | *5* |
| Hexachloroethane | na | 3.7 | 0.27 | J | J | *0.156* | *5* | 5 | U | | *0.156* | *5* | 5 | U | | *0.156* | *5* |
| Naphthalene | na | 0.65 | 0.23 | J | J | *0.0605* | *5* | 5 | U | | *0.0605* | *5* | 5 | U | | *0.0605* | *5* |
| **Pesticides (ug/L)** | | | | | | | | | | | | | | | | | |
| alpha-BHC | na | 0.011 | 0.02 | U | | *0.00293* | *0.02* | 0.00885 | J | J | *0.00293* | *0.02* | 0.00915 | J | J | *0.00293* | *0.02* |
| delta-BHC | na | na | 0.02 | U | | *0.00338* | *0.02* | 0.0149 | J | J | *0.00338* | *0.02* | 0.0142 | J | J | *0.00338* | *0.02* |
| Endosulfan II | na | 22 | 0.076 | | | *0.00558* | *0.02* | 0.02 | U | | *0.00558* | *0.02* | 0.02 | U | | *0.00558* | *0.02* |
| Endrin | 2 | 1.1 | 0.0834 | | | *0.0126* | *0.02* | 0.02 | U | | *0.0126* | *0.02* | 0.02 | U | | *0.0126* | *0.02* |
| Lindane | na | 0.052 | 0.02 | U | | *0.0027* | *0.02* | 0.02 | U | | *0.0027* | *0.02* | 0.00719 | J | J | *0.0027* | *0.02* |
| **PCBs (ug/L)** | | | PCBs were not detected in the surface water samples. | | | | | | | | | | | | | | |
| **Explosives (ug/L)** | | | | | | | | | | | | | | | | | |
| Nitrobenzene | na | 0.35 | 0.1 | J | J | *0.0809* | *0.26* | 0.26 | U | | *0.0809* | *0.26* | 0.26 | U | | *0.0809* | *0.26* |
| **Herbicides (ug/L)** | | | | | | | | | | | | | | | | | |
| 2,4,5-TP (Silvex) | 50 | 29 | 0.1 | U | | *0.0288* | *0.1* | 0.1 | U | | *0.0288* | *0.1* | 0.029 | J | J | *0.0288* | *0.1* |
| Dicamba | na | 110 | 0.5 | U | UL | *0.05* | *0.5* | 0.5 | U | UL | *0.05* | *0.5* | 0.154 | J | L | *0.05* | *0.5* |
| **Metals (ug/L)** | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 8430 | | | *38.6* | *200* | 359 | | | *38.6* | *200* | 13200 | | | *38.6* | *200* |
| Antimony | 6 | 1.5 | 1.1 | B | B | *0.336* | *5* | 0.72 | B | B | *0.336* | *5* | 0.58 | B | B | *0.336* | *5* |
| Barium | 2000 | 730 | 25.3 | | | *3.11* | *20* | 21.4 | | | *3.11* | *20* | 35.6 | | | *3.11* | *20* |
| Cadmium | 5 | 1.8 | 0.13 | B | B | *0.0651* | *2* | 0.095 | B | B | *0.0651* | *2* | 0.15 | B | B | *0.0651* | *2* |
| Calcium | na | na | 13500 | | | *30.4* | *100* | 14300 | | | *30.4* | *100* | 15800 | | | *30.4* | *100* |
| Chromium | 100 | 11 | 10 | U | | *3.65* | *10* | 10 | U | | *3.65* | *10* | 4.7 | B | J | *3.65* | *10* |
| Iron | 300 | 1100 | 331 | | | *22.7* | *50* | 50.4 | | | *22.7* | *50* | 1540 | | | *22.7* | *50* |
| Lead | 15 | na | 2.51 | | | *0.0765* | *2* | 0.52 | B | B | *0.0765* | *2* | 6.01 | | | *0.0765* | *2* |
| Magnesium | na | na | 5270 | | | *41.1* | *100* | 5250 | | | *41.1* | *100* | 5760 | | | *41.1* | *100* |
| Manganese | 50 | 73 | 86.9 | | | *0.816* | *10* | 7.6 | B | J | *0.816* | *10* | 263 | | | *0.816* | *10* |
| Mercury | 2 | 1.1 | 0.1 | U | | *0.0469* | *0.1* | 0.083 | B | J | *0.0469* | *0.1* | 0.186 | | | *0.0469* | *0.1* |
| Potassium | na | na | 1600 | B | J | *275* | *3000* | 1600 | B | J | *275* | *3000* | 1900 | B | J | *275* | *3000* |
| Silver | 100 | 18 | 7.3 | B | B | *4.45* | *10* | 7.3 | B | B | *4.45* | *10* | 6.3 | B | B | *4.45* | *10* |
| Sodium | na | na | 11900 | | | *42.5* | *200* | 10100 | | | *42.5* | *200* | 10600 | | | *42.5* | *200* |
| Thallium | 2 | 0.26 | 0.14 | B | B | *0.0682* | *2* | 0.076 | B | B | *0.0682* | *2* | 0.11 | B | B | *0.0682* | *2* |
| Zinc | 5000 | 1100 | 20 | U | | *6.71* | *20* | 20 | U | | *6.71* | *20* | 16 | B | J | *6.71* | *20* |
| **Misc.** | | | | | | | | | | | | | | | | | |
| Hardness (mg/L) | na | na | 55400 | | | *245* | *662* | 57300 | | | *245* | *662* | 63200 | | | *245* | *662* |
| Total Organic Carbon (ug/L) | na | na | 2530 | | | *62.5* | *1000* | 1710 | | | *62.5* | *1000* | 5080 | | | *62.5* | *1000* |
| Total Organic Halides (ug/L) | na | na | 110 | J | J | *35* | *175* | 140 | J | J | *35* | *175* | 130 | J | J | *35* | *175* |

## LEGEND

**Surface Water Sample Exceedance Location**

▲ >= MCL

▲ >= tw-RBC

▭ SWMU 31 Boundary

**Sample Results**

| Sample ID | SW MCL Exceedances |
|---|---|
| 31SW1 | 1 metal |
| 31SW2 | 1 metal |
| 31SW3 | 1 metal |
| 31SW10 | 1 SVOC, 3 metals |
| 31SW12 | 1 metal |
| 31SW14 | 1 SVOC, 3 metals |

| Sample ID | SW tw-RBC Exceedances |
|---|---|
| 31SW10 | 2 VOCs, 1 SVOC, 1 metal |
| 31SW12 | 3 VOCs, 1 SVOC |
| 31SW14 | 3 VOCs, 1 SVOC, 2 metals |

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

N

Scale:

0 100 200 400 Feet

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Shaw® Shaw Environmental, Inc.

### FIGURE 3-2

### Surface Water Sampling Locations and Results

Radford, VA

Date: 11/7/06 GIS File: RFAAP_006_Fig3-2_SWMU31_SW_Results.mxd

263 µg/L) exceeded their respective tap water RBCs and/or MCLs. There is not an established background level for inorganics in surface water. No other metals exceeded the screening levels.

***Perchlorate.*** Perchlorate was not detected in the surface water samples.

***Hardness/TOC/TOX.*** The three samples were analyzed for hardness, TOC, and TOX. Hardness concentrations ranged from 55,400 milligrams per liter (mg/L) to 63,200 mg/L. TOC concentrations ranged from 1,710 µg/L to 5,080 µg/L. TOX concentrations ranged form 110 µg/L to 140 µg/L. MCLs and tap water RBCs are not available for these parameters.

### 3.2.2 Sediment Sample Results – 2002 RCRA Facility Investigation (Shaw)

Eleven sediment samples were collected during the RFI. The samples were analyzed for TCL SVOCs, PAHs, explosives, target analyte list (TAL) metals, TOC, and pH. Detected results for these constituents are presented in **Table 3-3**. In addition, samples 31SE10B, 31SE11B, and 31SE13B (one from each lagoon) were analyzed for TCL VOCs, TCL pesticides/PCBs, herbicides, and dioxins/furans. These results are presented in **Table 3-4**. Exceedances of regulatory criteria are presented on **Figure 3-3**.

***VOCs.*** One VOC (acetone) was detected. Results were below industrial and residential screening levels.

***SVOCs/PAHs.*** One PAH [benzo(a)pyrene] exceeded its industrial screening level in sample 31SE12B and its residential screening level in samples 31SE8A, 31SE11A, 31SE11B, and 31SE14B. Four PAHs [benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] were detected above the residential screening level in 31SE12B. Benzo(a)pyrene was also detected in samples 31SE8A, 31SE10B, 31SE11B, 31SE12B, and 31SE14B above the residential screening level in the SVOC analysis. The concentration of benzo(a)anthracene in the SVOC analysis was equal to its residential screening level in sample 31SE11B. Sample concentrations were below the residential and industrial screening levels in the remaining sediment samples. According to previous site operations, the lagoons received waters carrying fly ash and bottom ash, which typically contain high quantities of the SVOC, bis(2-ethylhexyl)phthalate. However, all samples were detected below residential screening levels for bis(2-ethylhexyl)phthalate and all detections were "B" flagged during data validation, indicating that this compound was also detected in associated laboratory blanks. This compound is also a common laboratory contaminant; therefore, its presence in samples is unlikely to be site related.

***Pesticides.*** Six pesticides were detected. Sample results were below industrial and residential screening levels.

***PCBs.*** PCBs were not detected in the sediment samples.

***Explosives.*** Three explosives were detected. No sample concentrations exceeded industrial or residential screening levels.

***Herbicides.*** One herbicide (2,4-DB) was detected. Results were below industrial and residential screening levels.

***TAL Metals.*** Twenty-two metals were detected in sediment samples collected from the site. Antimony was the only metal that exceeded its residential screening level in sample 31SE11A. There were single industrial exceedances of aluminum and thallium. The sample with elevated thallium was collected in 1992 (31SL2), and the elevated concentration could not be duplicated during more recent sampling efforts, indicating it is likely a false positive. A summary of

# Table 3-3
# SWMU 31
# 2002 RFI Detected Results for Sediment
# SVOCs, PAHs, Explosives, Metals, TOC and pH

| Analyte | | | Sample ID | 31SE7B | | | | | 31SE8A | | | | | 31SE9B | | | | | 31SE10B | | | | | 31SE11A | | | | | 31SE11B | | | | | 31SE12B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Date | 7/9/02 | | | | | 7/9/02 | | | | | 7/9/02 | | | | | 7/9/02 | | | | | 7/10/02 | | | | | 7/10/02 | | | | | 7/10/02 | | | | |
| | | | Sample Depth | 2-4 | | | | | 0-0.5 | | | | | 2-4 | | | | | 2-4 | | | | | 0-0.5 | | | | | 1-3 | | | | | 2-4 | | | | |
| | **i-RBC** | **r-RBC** | **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 | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **PAHs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 410000 | 31000 | na | 1.3 | J | B | *0.72* | *2.1* | 1300 | | | *1.2* | *3.6* | 2.8 | | B | *0.66* | *2* | 80 | | | *0.75* | *2.2* | 140 | | K | *0.19* | *0.72* | 790 | | K | *0.057* | *0.22* | 810 | | K | *0.038* | *0.14* |
| Acenaphthene | 6100000 | 470000 | na | 2.1 | U | | *1.2* | *2.1* | 20 | | B | *2* | *3.6* | 2 | U | | *1.1* | *2* | 10 | | B | *1.2* | *2.2* | 50 | | B | *0.19* | *0.72* | 21 | | B | *0.056* | *0.22* | 14 | | B | *0.037* | *0.14* |
| Acenaphthylene | 3100000 | 230000 | na | 2.1 | U | | *0.28* | *2.1* | 23 | | | *0.48* | *3.6* | 2 | U | | *0.26* | *2* | 11 | | | *0.29* | *2.2* | 46 | | | *0.19* | *0.72* | 19 | | | *0.057* | *0.22* | 24 | | | *0.038* | *0.14* |
| Anthracene | 31000000 | 2300000 | na | 2.1 | U | | *0.23* | *2.1* | 59 | | | *0.39* | *3.6* | 2 | U | | *0.22* | *2* | 8 | | | *0.24* | *2.2* | 15 | | | *0.15* | *0.72* | 41 | | | *0.046* | *0.22* | 55 | | | *0.031* | *0.14* |
| Benz(a)anthracene | 3900 | 220 | na | 2.1 | U | | *0.28* | *2.1* | 150 | | | *0.48* | *3.6* | 2 | U | | *0.26* | *2* | 14 | | | *0.29* | *2.2* | 27 | | | *0.1* | *0.72* | 67 | | | *0.031* | *0.22* | 1100 | | | *0.02* | *0.14* |
| Benzo(a)pyrene | 390 | 22 | na | 2.1 | U | | *0.24* | *2.1* | 86 | | | *0.4* | *3.6* | 2 | U | | *0.22* | *2* | 11 | | | *0.25* | *2.2* | 27 | | | *0.25* | *0.72* | 54 | | | *0.075* | *0.22* | 840 | | | *0.05* | *0.14* |
| Benzo(b)fluoranthene | 3900 | 220 | na | 2.1 | U | | *0.41* | *2.1* | 140 | | | *0.68* | *3.6* | 2 | U | | *0.37* | *2* | 15 | | | *0.42* | *2.2* | 52 | | | *0.21* | *0.72* | 120 | | | *0.064* | *0.22* | 1300 | | | *0.043* | *0.14* |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 2.1 | U | | *0.75* | *2.1* | 54 | | | *1.3* | *3.6* | 2 | U | | *0.69* | *2* | 12 | | | *0.78* | *2.2* | 17 | | | *0.28* | *0.72* | 42 | | | *0.083* | *0.22* | 260 | | | *0.055* | *0.14* |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 2.1 | U | | *0.37* | *2.1* | 22 | | | *0.63* | *3.6* | 2 | U | | *0.34* | *2* | 2.5 | | | *0.39* | *2.2* | 14 | | | *0.22* | *0.72* | 24 | | | *0.067* | *0.22* | 340 | | | *0.045* | *0.14* |
| Chrysene | 390000 | 22000 | na | 2.1 | U | | *0.34* | *2.1* | 210 | | | *0.57* | *3.6* | 2 | U | | *0.31* | *2* | 16 | | | *0.36* | *2.2* | 36 | | | *0.15* | *0.72* | 68 | | | *0.045* | *0.22* | 860 | | | *0.03* | *0.14* |
| Dibenz(a,h)anthracene | 390 | 22 | na | 2.1 | U | | *0.73* | *2.1* | 19 | | J | *1.2* | *3.6* | 2 | U | | *0.67* | *2* | 2.7 | | J | *0.76* | *2.2* | 0.72 | U | | *0.29* | *0.72* | 12 | | J | *0.088* | *0.22* | 100 | | J | *0.059* | *0.14* |
| Fluoranthene | 4100000 | 310000 | na | 2.1 | U | | *0.37* | *2.1* | 80 | | | *0.62* | *3.6* | 2 | U | | *0.34* | *2* | 12 | | | *0.38* | *2.2* | 55 | | | *0.15* | *0.72* | 82 | | | *0.044* | *0.22* | 240 | | | *0.029* | *0.14* |
| Fluorene | 4100000 | 310000 | na | 2.1 | U | | *0.57* | *2.1* | 87 | | | *0.96* | *3.6* | 0.93 | J | J | *0.52* | *2* | 13 | | | *0.59* | *2.2* | 38 | | | *0.22* | *0.72* | 68 | | | *0.067* | *0.22* | 81 | | | *0.044* | *0.14* |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 2.1 | U | | *0.69* | *2.1* | 31 | | | *1.2* | *3.6* | 2 | U | | *0.63* | *2* | 8.2 | | | *0.71* | *2.2* | 25 | | | *0.26* | *0.72* | 26 | | | *0.077* | *0.22* | 260 | | | *0.052* | *0.14* |
| Naphthalene | 2000000 | 160000 | na | 2.7 | B | B | *0.83* | *2.1* | 690 | B | | *1.4* | *3.6* | 2.3 | B | B | *0.76* | *2* | 54 | B | | *0.86* | *2.2* | 130 | | | *0.28* | *0.72* | 470 | | | *0.083* | *0.22* | 460 | | | *0.055* | *0.14* |
| Phenanthrene | 3100000 | 230000 | na | 0.88 | J | J | *0.33* | *2.1* | 710 | | | *0.55* | *3.6* | 2.1 | | | *0.3* | *2* | 48 | | | *0.34* | *2.2* | 57 | | | *0.24* | *0.72* | 410 | | | *0.071* | *0.22* | 420 | | | *0.048* | *0.14* |
| Pyrene | 3100000 | 230000 | na | 2.1 | U | | *0.48* | *2.1* | 150 | | J | *0.81* | *3.6* | 1.2 | J | J | *0.44* | *2* | 17 | | J | *0.5* | *2.2* | 67 | | | *0.18* | *0.72* | 89 | | | *0.053* | *0.22* | 370 | | J | *0.036* | *0.14* |
| **SVOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2,4-Dimethylphenol | 2000000 | 160000 | na | 210 | U | | *40* | *210* | 350 | U | | *67* | *350* | 190 | U | | *37* | *190* | 220 | U | | *42* | *220* | 2400 | U | | *460* | *2400* | 200 | J | J | *140* | *720* | 120 | J | J | *92* | *480* |
| 2-Methylnaphthalene | 410000 | 31000 | na | 210 | U | | *8.1* | *210* | 580 | | | *14* | *350* | 190 | U | | *7.5* | *190* | 100 | J | J | *8.4* | *220* | 2400 | U | | *93* | *2400* | 1400 | | | *28* | *720* | 1300 | | | *19* | *480* |
| 2-Methylphenol | 5100000 | 390000 | na | 210 | U | | *8.6* | *210* | 24 | J | B | *14* | *350* | 190 | U | | *7.9* | *190* | 220 | U | | *8.9* | *220* | 2400 | U | | *99* | *2400* | 140 | J | B | *30* | *720* | 61 | J | B | *20* | *480* |
| 4-Methylphenol | 510000 | 39000 | na | 210 | U | | *7.5* | *210* | 48 | J | B | *13* | *350* | 190 | U | | *6.9* | *190* | 24 | J | B | *7.8* | *220* | 110 | J | B | *86* | *2400* | 230 | J | B | *26* | *720* | 110 | J | B | *17* | *480* |
| Acenaphthene | 6100000 | 470000 | na | 210 | U | | *5.9* | *210* | 350 | U | | *9.9* | *350* | 190 | U | | *5.4* | *190* | 220 | U | | *6.1* | *220* | 2400 | U | | *68* | *2400* | 40 | J | J | *20* | *720* | 42 | J | J | *14* | *480* |
| Anthracene | 31000000 | 2300000 | na | 210 | U | | *6.2* | *210* | 21 | J | J | *10* | *350* | 190 | U | | *5.7* | *190* | 9.3 | J | J | *6.4* | *220* | 2400 | U | | *71* | *2400* | 94 | J | J | *21* | *720* | 42 | J | J | *14* | *480* |
| Benz(a)anthracene | 3900 | 220 | na | 210 | U | | *6.1* | *210* | 76 | J | J | *10* | *350* | 190 | U | | *5.6* | *190* | 34 | J | J | *6.3* | *220* | 2400 | U | | *70* | *2400* | 220 | J | J | *21* | *720* | 130 | J | J | *14* | *480* |
| Benzo(a)pyrene | 390 | 22 | na | 210 | U | | *5.2* | *210* | 55 | J | J | *8.8* | *350* | 190 | U | | *4.8* | *190* | 25 | J | J | *5.5* | *220* | 2400 | U | | *60* | *2400* | 180 | J | J | *18* | *720* | 110 | J | J | *12* | *480* |
| Benzo(b)fluoranthene | 3900 | 220 | na | 210 | U | | *4.5* | *210* | 69 | J | J | *7.6* | *350* | 190 | U | | *4.1* | *190* | 31 | J | J | *4.7* | *220* | 2400 | U | | *52* | *2400* | 170 | J | J | *16* | *720* | 150 | J | J | *10* | *480* |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 210 | U | | *6* | *210* | 71 | J | J | *10* | *350* | 190 | U | | *5.5* | *190* | 42 | J | J | *6.2* | *220* | 2400 | U | | *69* | *2400* | 720 | U | | *21* | *720* | 170 | J | J | *14* | *480* |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 210 | U | | *6* | *210* | 350 | U | | *10* | *350* | 190 | U | | *5.5* | *190* | 14 | J | J | *6.3* | *220* | 2400 | U | | *69* | *2400* | 42 | J | J | *21* | *720* | 23 | J | J | *14* | *480* |
| Benzoic acid | 4.1E+08 | 31000000 | na | 1000 | U | | *140* | *1000* | 1800 | U | | *240* | *1800* | 960 | U | | *130* | *960* | 1100 | U | UJ | *150* | *1100* | 12000 | U | | *1700* | *12000* | 540 | J | B | *500* | *3600* | 340 | J | B | *330* | *2400* |
| bis(2-Ethylhexyl)phthalate | 200000 | 46000 | na | 30 | J | B | *14* | *210* | 200 | J | B | *24* | *350* | 20 | J | B | *13* | *190* | 54 | J | B | *15* | *220* | 310 | J | B | *160* | *2400* | 300 | J | B | *49* | *720* | 260 | J | B | *33* | *480* |
| Butylbenzylphthalate | 1500000 | 340000 | na | 210 | U | | *8.3* | *210* | 350 | U | | *14* | *350* | 190 | U | | *7.6* | *190* | 220 | U | | *8.6* | *220* | 2400 | U | | *96* | *2400* | 720 | U | | *29* | *720* | 480 | U | | *19* | *480* |
| Carbazole | 140000 | 32000 | na | 210 | U | | *9.2* | *210* | 20 | J | J | *16* | *350* | 190 | U | | *8.5* | *190* | 220 | U | | *9.6* | *220* | 2400 | U | | *110* | *2400* | 79 | J | J | *32* | *720* | 47 | J | J | *21* | *480* |
| Chrysene | 390000 | 22000 | na | 210 | U | | *4.9* | *210* | 96 | J | J | *8.2* | *350* | 190 | U | | *4.5* | *190* | 33 | J | J | *5.1* | *220* | 2400 | U | | *56* | *2400* | 280 | J | J | *17* | *720* | 230 | J | J | *11* | *480* |
| Dibenz(a,h)anthracene | 390 | 22 | na | 210 | U | | *6.1* | *210* | 350 | U | | *10* | *350* | 190 | U | | *5.6* | *190* | 16 | J | J | *6.4* | *220* | 2400 | U | | *71* | *2400* | 720 | U | | *21* | *720* | 480 | U | | *14* | *480* |
| Dibenzofuran | 200000 | 16000 | na | 210 | U | | *6.1* | *210* | 120 | J | J | *10* | *350* | 190 | U | | *5.6* | *190* | 25 | J | J | *6.3* | *220* | 2400 | U | | *70* | *2400* | 300 | J | J | *21* | *720* | 260 | J | J | *14* | *480* |
| Fluoranthene | 4100000 | 310000 | na | 210 | U | | *7* | *210* | 50 | J | J | *12* | *350* | 190 | U | | *6.4* | *190* | 42 | J | J | *7.2* | *220* | 2400 | U | | *80* | *2400* | 150 | J | J | *24* | *720* | 94 | J | J | *16* | *480* |
| Fluorene | 4100000 | 310000 | na | 210 | U | | *6.9* | *210* | 350 | U | | *12* | *350* | 190 | U | | *6.4* | *190* | 11 | J | J | *7.2* | *220* | 2400 | U | | *80* | *2400* | 160 | J | J | *24* | *720* | 130 | J | J | *16* | *480* |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 210 | U | | *8.2* | *210* | 31 | J | J | *14* | *350* | 190 | U | | *7.5* | *190* | 40 | J | J | *8.5* | *220* | 2400 | U | | *94* | *2400* | 720 | U | | *28* | *720* | 110 | J | J | *19* | *480* |
| Naphthalene | 2000000 | 160000 | na | 210 | U | | *7.8* | *210* | 300 | J | J | *13* | *350* | 190 | U | | *7.1* | *190* | 63 | J | J | *8.1* | *220* | 2400 | U | | *89* | *2400* | 760 | | | *27* | *720* | 760 | | | *18* | *480* |
| N-nitrosodiphenylamine | 580000 | 130000 | na | 210 | U | | *10* | *210* | 350 | U | | *17* | *350* | 190 | U | | *9.2* | *190* | 13 | J | J | *10* | *220* | 2400 | U | | *120* | *2400* | 230 | J | J | *35* | *720* | 97 | J | J | *23* | *480* |
| Phenanthrene | 3100000 | 230000 | na | 210 | U | | *6.6* | *210* | 380 | | | *11* | *350* | 190 | U | | *6.1* | *190* | 83 | J | J | *6.9* | *220* | 2400 | U | | *76* | *2400* | 870 | | | *23* | *720* | 820 | | | *15* | *480* |
| Pyrene | 3100000 | 230000 | na | 210 | U | | *6.5* | *210* | 69 | J | J | *11* | *350* | 190 | U | | *6* | *190* | 42 | J | J | *6.7* | *220* | 2400 | U | | *75* | *2400* | 230 | J | J | *22* | *720* | 180 | J | J | *15* | *480* |
| **Explosives (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1,3,5-Trinitrobenzene | 3100 | 230 | na | 0.1 | U | | *0.0246* | *0.1* | 0.1 | U | | *0.0246* | *0.1* | 0.1 | U | | *0.0246* | *0.1* | 0.1 | U | | *0.0246* | *0.1* | 0.2 | U | | *0.0492* | *0.2* | 0.1 | U | | *0.0246* | *0.1* | 0.167 | | | *0.0246* | *0.1* |
| 2,4,6-Trinitrotoluene | 51 | 3.9 | na | 0.2 | U | | *0.0187* | *0.2* | 0.2 | U | | *0.0187* | *0.2* | 0.2 | U | | *0.0187* | *0.2* | 0.2 | U | | *0.0187* | *0.2* | 0.21 | J | J | *0.0374* | *0.4* | 0.2 | U | | *0.0187* | *0.2* | 0.2 | U | | *0.0187* | *0.2* |
| Nitrobenzene | 51 | 3.9 | na | 0.2 | U | | *0.0583* | *0.2* | 0.2 | U | | *0.0583* | *0.2* | 0.2 | U | | *0.0583* | *0.2* | 0.2 | U | | *0.0583* | *0.2* | 0.15 | J | J | *0.117* | *0.4* | 0.2 | U | | *0.0583* | *0.2* | 0.2 | U | | *0.0583* | *0.2* |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | 18700 | | | *7* | *25.2* | 19100 | | | *12* | *42.4* | 7260 | | | *6.4* | *23.1* | 14700 | | | *7.2* | *26.2* | **95000** | | | *80* | *290* | 39400 | | | *24* | *87* | 30600 | | | *16* | *58* |
| Antimony | 41 | 3.1 | na | 0.63 | U | UJ | *0.21* | *0.63* | 1.06 | U | UJ | *0.36* | *1.06* | 0.579 | U | UJ | *0.19* | *0.579* | 0.655 | U | UJ | *0.22* | *0.655* | 3.5 | B | B | *2.4* | *7.25* | 0.73 | B | B | *0.73* | *2.17* | 1.63 | | J | *0.49* | *1.45* |
| Arsenic | 1.9 | 0.43 | 15.8 | 2.3 | | J | *0.44* | *0.63* | 2.74 | | J | *0.74* | *1.06* | 4.14 | | J | *0.4* | *0.579* | 5000 | U | | *500* | *5000* | 9.17 | | | *5.1* | *7.25* | 5.58 | | | *1.5* | *2.17* | 7.75 | | | *1* | *1.45* |
| Barium | 20000 | 1600 | 209 | 128 | | | *0.42* | *2.52* | 120 | | | *0.71* | *4.24* | 75.6 | | | *0.39* | *2.31* | **1140** | | | *20* | *100000* | 133 | | | *4.8* | *29* | 106 | | | *1.5* | *8.7* | 174 | | | *0.97* | *5.8* |
| Beryllium | 200 | 16 | 1.02 | **1.03** | | | *0.0435* | *0.63* | **1.32** | | | *0.0731* | *106* | 0.629 | | | *0.0399* | *0.579* | 0.813 | | | *0.0452* | *0.655* | 0.95 | B | J | *0.5* | *7.25* | **1.1** | **B** | **J** | *0.15* | *2.17* | **1.84** | | | *0.1* | *1.45* |
| Cadmium | 51 | 3.9 | 0.69 | 0.126 | U | UJ | *0.06* | *0.126* | 0.19 | B | J | *0.1* | *0.212* | 0.073 | B | B | *0.055* | *0.116* | 1000 | U | | *10* | *1000* | 1.45 | U | | *0.69* | *1.45* | 0.25 | B | B | *0.21* | *0.435* | 0.399 | | J | *0.14* | *0.29* |
| Calcium | na | na | na | 1330 | | | *3.5* | *12.6* | 1700 | | | *5.9* | *21.2* | 654 | | | *3.2* | *11.6* | 11000 | | | *3.7* | *13.1* | 4120 | | J | *40* | *150* | 1730 | | J | *12* | *44* | 2270 | | J | *8.1* | *29* |
| Chromium | 310 | 23 | 65.3 | 33.3 | | J | *0.47* | *1.26* | 23.2 | | J | *0.79* | *2.12* | 17.1 | | J | *0.43* | *1.16* | 5000 | U | | *20* | *5000* | 37 | | B | *5.4* | *15* | 26.5 | | | *1.6* | *4.4* | 37.7 | | | *1.1* | *2.9* |
| Cobalt | na | na | 72.3 | 21.3 | | | *1* | *6.3* | 15.5 | | | *1.7* | *10.6* | 9.36 | | | *0.94* | *5.79* | 15.4 | | | *1.1* | *6.55* | 16 | B | J | *12* | *73* | 15 | B | J | *3.5* | *22* | 25 | | | *2.3* | *15* |
| Copper | 4100 | 310 | 53.5 | 20.7 | | | *0.78* | *2.52* | 30.5 | | | *1.3* | *4.24* | 11.3 | | | *0.71* | *2.31* | 15.4 | | | *0.81* | *2.62* | 50 | | | *8.9* | *29* | 29.9 | | | *2.7* | *8.7* | 37.7 | | | *1.8* | *5.8* |
| Iron | 31000 | 2300 | 50962 | 32900 | | | *4.2* | *6.3* | 17600 | | | *7.1* | *10.6* | 20700 | | | *3.9* | *5.79* | 22200 | | | *4.4* | *6.55* | 22200 | | | *49* | *73* | 18200 | | | *15* | *22* | 29400 | | | *9.7* | *15* |
| Lead | 800 | 400 | 26.8 | 15.1 | | | *0.038* | *0.378* | 14.2 | | | *0.064* | *0.636* | **41.7** | | | *0.035* | *0.347* | 5000 | U | | *100* | *5000* | **82.4** | | | *0.44* | *4.35* | **36.2** | | | *0.13* | *1.3* | **40** | | | *0.088* | *0.87* |
| Magnesium | na | na | na | 5150 | | J | *3* | *12.6* | 3150 | | J | *5* | *21.2* | 2300 | | J | *2.7* | *11.6* | 8890 | | J | *3.1* | *13.1* | 3150 | | | *34* | *150* | 2520 | | | *10* | *44* | 4360 | | | *6.8* | *29* |
| Manganese | 2000 | 160 | 2543 | 655 | | | *0.07* | *1.26* | 221 | | | *0.12* | *2.12* | 514 | | | *0.065* | *1.16* | 346 | | | *0.073* | *1.31* | 596 | | | *0.81* | *15* | 330 | | | *0.24* | *4.4* | 524 | | | *0.16* | *2.9* |
| Mercury | 31 | 2.3 | 0.13 | 0.029 | B | J | *0.025* | *0.063* | 0.087 | B | J | *0.042* | *0.106* | 0.0579 | U | | *0.023* | *0.0579* | 0.042 | B | J | *0.026* | *0.0655* | **0.53** | **B** | **J** | *0.29* | *0.725* | **0.18** | **B** | **J** | *0.086* | *0.217* | **0.174** | | | *0.057* | *0.145* |
| Nickel | 2000 | 160 | 62.8 | 19.3 | | J | *1.2* | *5.04* | 17.2 | | J | *1.9* | *8.47* | 11.6 | | J | *1.1* | *4.63* | 14 | | J | *1.2* | *5.24* | 32 | B | J | *13* | *58* | 17 | B | J | *4* | *17* | 27 | | | *2.7* | *12* |
| Potassium | na | na | na | 3080 | | | *42* | *378* | 1700 | | | *71* | *636* | 856 | | | *39* | *347* | 1820 | | | *44* | *393* | 1800 | B | J | *480* | *4400* | 1600 | | | *150* | *1300* | 2750 | | | *97* | *870* |
| Selenium | 510 | 39 | na | 1.26 | U | | *0.41* | *1.26* | 2.12 | U | | *0.69* | *2.12* | 1.16 | U | | *0.38* | *1.16* | 1000 | U | | *300* | *1000* | 14.5 | U | | *4.7* | *14.5* | 4.35 | U | | *1.4* | *4.35* | 2.9 | U | | *0.95* | *2.9* |
| Sodium | na | na | na | 67.8 | | | *4.7* | *25.2* | 116 | | | *7.9* | *42.4* | 34.1 | | | *4.3* | *23.1* | 70.1 | | | *4.9* | *26.2* | 230 | B | B | *54* | *290* | 115 | | | *16* | *87* | 147 | | | *11* | *58* |
| Thallium | 7.2 | 0.55 | 2.11 | 0.24 | B | J | *0.038* | *0.378* | 0.28 | B | J | *0.064* | *0.636* | 0.16 | B | J | *0.035* | *0.347* | 0.21 | B | J | *0.039* | *0.393* | 1.9 | B | J | *0.44* | *4.35* | 0.62 | B | J | *0.13* | *1.3* | 0.49 | B | J | *0.087* | *0.87* |
| Vanadium | 102 | 7.8 | 108 | 57.2 | | | *0.73* | *6.3* | 33.8 | | | *1.2* | *10.6* | 22.4 | | | *0.67* | *5.79* | 38.2 | | | *0.76* | *6.55* | 41 | B | J | *8.4* | *73* | 35 | | | *2.5* | *22* | 59 | | | *1.7* | *15* |
| Zinc | 31000 | 2300 | 202 | 69.9 | | J | *0.45* | *2.52* | 59 | | J | *0.76* | *4.24* | 36.4 | | J | *0.41* | *2.31* | 53 | | J | *0.47* | *2.62* | 177 | | J | *5.2* | *29* | 97.1 | | J | *1.6* | *8.7* | 136 | | J | *1* | *5.8* |
| **Misc.** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | 1570 | | | *213* | *1260* | 44100 | | | *358* | *2120* | 750 | B | B | *196* | *1160* | 20600 | | | *221* | *1310* | 74500 | | | *2450* | *14500* | 49500 | | | *735* | *4350* | 48100 | | | *490* | *2900* |
| pH | na | na | na | 7.03 | | J | *+/- 0.1* | *+/- 0.1* | 6.97 | | J | *+/- 0.1* | *+/- 0.1* | 6.95 | | J | *+/- 0.1* | *+/- 0.1* | 6.88 | | J | *+/- 0.1* | *+/- 0.1* | 6.78 | | J | *+/- 0.1* | *+/- 0.1* | 6.74 | | J | *+/- 0.1* | *+/- 0.1* | 6.53 | | J | *+/- 0.1* | *+/- 0.1* |

# Table 3-3
## SWMU 31
## 2002 RFI Detected Results for Sediment
## SVOCs, PAHs, Explosives, Metals, TOC and pH

| Analyte | | | Sample ID | 31SE13A | | | | | 31SE13B | | | | | 31SE14B | | | | | 31SE14C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Date | 7/10/02 | | | | | 7/10/02 | | | | | 7/10/02 | | | | | 7/10/02 | | | | |
| | | | Sample Depth | 0-0.5 | | | | | 5-7 | | | | | 2.5-4.5 | | | | | 6-8 | | | | |
| | **i-RBC** | **r-RBC** | **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 |
| **PAHs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 410000 | 31000 | na | 5.7 | J | B | 3.8 | 11 | 1.1 | J | B | 0.73 | 2.2 | 340 | | K | 1.3 | 4 | 130 | | K | 0.9 | 2.7 |
| Acenaphthene | 6100000 | 470000 | na | 11 | U | | 6.2 | 11 | 2.2 | U | | 1.2 | 2.2 | 8.3 | | B | 2.2 | 4 | 2.9 | | B | 1.5 | 2.7 |
| Acenaphthylene | 3100000 | 230000 | na | 11 | U | | 1.5 | 11 | 2.2 | U | | 0.28 | 2.2 | 9.1 | | | 0.53 | 4 | 2.8 | | | 0.35 | 2.7 |
| Anthracene | 31000000 | 2300000 | na | 11 | U | | 1.2 | 11 | 2.2 | U | | 0.24 | 2.2 | 19 | | | 0.44 | 4 | 5.4 | | | 0.29 | 2.7 |
| Benz(a)anthracene | 3900 | 220 | na | 14 | | | 1.5 | 11 | 2.2 | U | | 0.28 | 2.2 | 55 | | | 0.53 | 4 | 9.5 | | | 0.35 | 2.7 |
| Benzo(a)pyrene | 390 | 22 | na | 13 | | | 1.3 | 11 | 2.2 | U | | 0.24 | 2.2 | 45 | | | 0.45 | 4 | 6.8 | | | 0.3 | 2.7 |
| Benzo(b)fluoranthene | 3900 | 220 | na | 27 | | | 2.1 | 11 | 2.2 | U | | 0.41 | 2.2 | 71 | | | 0.76 | 4 | 12 | | | 0.51 | 2.7 |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 9.5 | J | J | 4 | 11 | 2.2 | U | | 0.76 | 2.2 | 25 | | | 1.4 | 4 | 5.6 | | | 0.94 | 2.7 |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 6.6 | J | J | 2 | 11 | 2.2 | U | | 0.37 | 2.2 | 19 | | | 0.7 | 4 | 2.3 | J | J | 0.47 | 2.7 |
| Chrysene | 390000 | 22000 | na | 19 | | | 1.8 | 11 | 2.2 | U | | 0.34 | 2.2 | 64 | | | 0.64 | 4 | 10 | | | 0.43 | 2.7 |
| Dibenz(a,h)anthracene | 390 | 22 | na | 11 | U | | 3.8 | 11 | 2.2 | U | | 0.73 | 2.2 | 8.2 | | J | 1.4 | 4 | 1 | J | J | 0.91 | 2.7 |
| Fluoranthene | 4100000 | 310000 | na | 26 | | | 1.9 | 11 | 2.2 | U | | 0.37 | 2.2 | 74 | | | 0.69 | 4 | 10 | | | 0.46 | 2.7 |
| Fluorene | 4100000 | 310000 | na | 11 | U | | 3 | 11 | 2.2 | U | | 0.57 | 2.2 | 24 | | | 1.1 | 4 | 8 | | | 0.71 | 2.7 |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 11 | | | 3.6 | 11 | 2.2 | U | | 0.69 | 2.2 | 21 | | | 1.3 | 4 | 3.6 | | | 0.86 | 2.7 |
| Naphthalene | 2000000 | 160000 | na | 11 | | B | 4.3 | 11 | 1.5 | J | B | 0.83 | 2.2 | 220 | | | 1.5 | 4 | 88 | | | 1 | 2.7 |
| Phenanthrene | 3100000 | 230000 | na | 13 | | | 1.7 | 11 | 2.2 | U | | 0.33 | 2.2 | 220 | | | 0.61 | 4 | 53 | | | 0.41 | 2.7 |
| Pyrene | 3100000 | 230000 | na | 30 | | | 2.5 | 11 | 2.2 | U | | 0.48 | 2.2 | 93 | | | 0.9 | 4 | 16 | | | 0.6 | 2.7 |
| **SVOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | | | | | |
| 2,4-Dimethylphenol | 2000000 | 160000 | na | 1100 | U | | 210 | 1100 | 210 | U | | 40 | 210 | 390 | U | | 75 | 390 | 260 | U | | 50 | 260 |
| 2-Methylnaphthalene | 410000 | 31000 | na | 1100 | U | | 43 | 1100 | 210 | U | | 8.2 | 210 | 320 | J | J | 15 | 390 | 140 | J | J | 10 | 260 |
| 2-Methylphenol | 5100000 | 390000 | na | 1100 | U | | 45 | 1100 | 210 | U | | 8.6 | 210 | 17 | J | B | 16 | 390 | 11 | J | B | 11 | 260 |
| 4-Methylphenol | 510000 | 39000 | na | 1100 | U | | 39 | 1100 | 210 | U | | 7.5 | 210 | 19 | J | B | 14 | 390 | 260 | U | | 9.3 | 260 |
| Acenaphthene | 6100000 | 470000 | na | 1100 | U | | 31 | 1100 | 210 | U | | 5.9 | 210 | 390 | U | | 11 | 390 | 260 | U | | 7.3 | 260 |
| Anthracene | 31000000 | 2300000 | na | 1100 | U | | 33 | 1100 | 210 | U | | 6.2 | 210 | 22 | J | J | 12 | 390 | 260 | U | | 7.7 | 260 |
| Benz(a)anthracene | 3900 | 220 | na | 55 | J | J | 32 | 1100 | 210 | U | | 6.1 | 210 | 60 | J | J | 11 | 390 | 18 | J | J | 7.6 | 260 |
| Benzo(a)pyrene | 390 | 22 | na | 1100 | U | | 28 | 1100 | 210 | U | | 5.3 | 210 | 51 | J | J | 9.8 | 390 | 260 | U | | 6.5 | 260 |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1100 | U | | 24 | 1100 | 210 | U | | 4.5 | 210 | 61 | J | J | 8.4 | 390 | 260 | U | | 5.6 | 260 |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 1100 | U | | 31 | 1100 | 210 | U | | 6 | 210 | 39 | J | J | 11 | 390 | 260 | U | | 7.5 | 260 |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 1100 | U | | 32 | 1100 | 210 | U | | 6.1 | 210 | 23 | J | J | 11 | 390 | 260 | U | | 7.5 | 260 |
| Benzoic acid | 4.1E+08 | 31000000 | na | 1200 | J | B | 760 | 5500 | 1100 | U | | 150 | 1100 | 340 | J | B | 270 | 2000 | 1300 | U | | 180 | 1300 |
| bis(2-Ethylhexyl)phthalate | 200000 | 46000 | na | 500 | J | B | 75 | 1100 | 130 | J | B | 14 | 210 | 350 | J | B | 27 | 390 | 260 | | B | 18 | 260 |
| Butylbenzylphthalate | 1500000 | 340000 | na | 1100 | U | | 44 | 1100 | 210 | U | | 8.3 | 210 | 23 | J | B | 16 | 390 | 260 | U | | 10 | 260 |
| Carbazole | 140000 | 32000 | na | 1100 | U | | 48 | 1100 | 210 | U | | 9.3 | 210 | 23 | J | J | 17 | 390 | 260 | U | | 12 | 260 |
| Chrysene | 390000 | 22000 | na | 1100 | U | | 26 | 1100 | 210 | U | | 4.9 | 210 | 74 | J | J | 9.2 | 390 | 260 | U | | 6.1 | 260 |
| Dibenz(a,h)anthracene | 390 | 22 | na | 1100 | U | | 32 | 1100 | 210 | U | | 6.2 | 210 | 390 | U | | 11 | 390 | 260 | U | | 7.7 | 260 |
| Dibenzofuran | 200000 | 16000 | na | 1100 | U | | 32 | 1100 | 210 | U | | 6.1 | 210 | 71 | J | J | 11 | 390 | 23 | J | J | 7.6 | 260 |
| Fluoranthene | 4100000 | 310000 | na | 55 | J | J | 37 | 1100 | 210 | U | | 7 | 210 | 86 | J | J | 13 | 390 | 12 | J | J | 8.7 | 260 |
| Fluorene | 4100000 | 310000 | na | 1100 | U | | 36 | 1100 | 210 | U | | 7 | 210 | 390 | U | | 13 | 390 | 260 | U | | 8.6 | 260 |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 1100 | U | | 43 | 1100 | 210 | U | | 8.2 | 210 | 29 | J | J | 15 | 390 | 260 | U | | 10 | 260 |
| Naphthalene | 2000000 | 160000 | na | 1100 | U | | 41 | 1100 | 210 | U | | 7.8 | 210 | 210 | J | J | 14 | 390 | 110 | J | J | 9.7 | 260 |
| N-nitrosodiphenylamine | 580000 | 130000 | na | 1100 | U | | 53 | 1100 | 210 | U | | 10 | 210 | 29 | J | J | 19 | 390 | 260 | U | | 13 | 260 |
| Phenanthrene | 3100000 | 230000 | na | 1100 | U | | 35 | 1100 | 210 | U | | 6.6 | 210 | 220 | J | J | 12 | 390 | 59 | J | J | 8.3 | 260 |
| Pyrene | 3100000 | 230000 | na | 1100 | U | | 34 | 1100 | 210 | U | | 6.5 | 210 | 78 | J | J | 12 | 390 | 12 | J | J | 8.1 | 260 |
| **Explosives (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | |
| 1,3,5-Trinitrobenzene | 3100 | 230 | na | 0.1 | U | | 0.0246 | 0.1 | 0.1 | U | | 0.0246 | 0.1 | 0.081 | J | J | 0.0246 | 0.1 | 0.1 | U | | 0.0246 | 0.1 |
| 2,4,6-Trinitrotoluene | 51 | 3.9 | na | 0.2 | U | | 0.0187 | 0.2 | 0.2 | U | | 0.0187 | 0.2 | 0.2 | U | | 0.0187 | 0.2 | 0.2 | U | | 0.0187 | 0.2 |
| Nitrobenzene | 51 | 3.9 | na | 0.2 | U | | 0.0583 | 0.2 | 0.2 | U | | 0.0583 | 0.2 | 0.2 | U | | 0.0583 | 0.2 | 0.2 | U | | 0.0583 | 0.2 |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | **98500** | | | 37 | 130 | 21900 | | | 7 | 25 | 8610 | | | 13 | 47 | 27000 | | | 8.7 | 31 |
| Antimony | 41 | 3.1 | na | 3.31 | U | UL | 1.1 | 3.31 | 0.633 | U | UL | 0.21 | 0.633 | 0.97 | B | J | 0.4 | 1.18 | 0.47 | B | B | 0.26 | 0.786 |
| Arsenic | 1.9 | 0.43 | 15.8 | 12.5 | | | 2.3 | 3.31 | 0.633 | U | | 0.44 | 0.633 | 8.03 | | | 0.82 | 1.18 | 13.1 | | | 0.55 | 0.786 |
| Barium | 20000 | 1600 | 209 | 150 | | | 2.2 | 13 | 107 | | | 0.42 | 2.5 | 133 | | | 0.79 | 4.7 | 71.8 | | | 0.53 | 3.1 |
| Beryllium | 200 | 16 | 1.02 | **1.3** | **B** | **J** | 0.228 | 3.31 | **1.03** | | | 0.0437 | 0.633 | **3.09** | | | 0.0812 | 1.18 | 0.78 | B | J | 0.0542 | 0.786 |
| Cadmium | 51 | 3.9 | 0.69 | 0.662 | U | | 0.32 | 0.662 | 0.127 | U | | 0.06 | 0.127 | 0.235 | U | | 0.11 | 0.235 | 0.14 | B | J | 0.075 | 0.157 |
| Calcium | na | na | na | 2570 | | J | 19 | 66 | 1390 | | J | 3.5 | 13 | 1370 | | J | 6.6 | 24 | 875 | | J | 4.4 | 16 |
| Chromium | 310 | 23 | 65.3 | 56.6 | | | 2.5 | 6.6 | 34.1 | | | 0.47 | 1.3 | 16.2 | | | 0.88 | 2.4 | 13 | | | 0.59 | 1.6 |
| Cobalt | na | na | 72.3 | 18 | B | J | 5.4 | 33 | 19.8 | | | 1 | 6.3 | 19 | | | 1.9 | 12 | 8.1 | | | 1.3 | 7.9 |
| Copper | 4100 | 310 | 53.5 | 50 | | | 4.1 | 13 | 22.3 | | | 0.78 | 2.5 | 38.1 | | | 1.5 | 4.7 | 18.9 | | | 0.97 | 3.1 |
| Iron | 31000 | 2300 | 50962 | 28300 | | | 22 | 33 | 33800 | | | 4.3 | 6.3 | 6990 | | | 7.9 | 12 | 9110 | | | 5.3 | 7.9 |
| Lead | 800 | 400 | 26.8 | **98.2** | | | 0.2 | 1.99 | 15.9 | | | 0.038 | 0.38 | 18.5 | | | 0.071 | 0.706 | 14.7 | | | 0.048 | 0.472 |
| Magnesium | na | na | na | 3590 | | | 16 | 66 | 4640 | | | 3 | 13 | 605 | | | 5.6 | 24 | 1100 | | | 3.7 | 16 |
| Manganese | 2000 | 160 | 2543 | 370 | | | 0.37 | 6.6 | 684 | | | 0.071 | 1.3 | 49.3 | | | 0.13 | 2.4 | 70.3 | | | 0.088 | 1.6 |
| Mercury | 31 | 2.3 | 0.13 | **0.25** | **B** | **J** | 0.13 | 0.331 | 0.04 | B | J | 0.025 | 0.0633 | **0.184** | | | 0.047 | 0.118 | 0.109 | | | 0.031 | 0.0786 |
| Nickel | 2000 | 160 | 62.8 | 25 | B | J | 6.1 | 27 | 19.7 | | | 1.2 | 5.1 | 30.5 | | | 2.2 | 9.4 | 11.3 | | | 1.4 | 6.3 |
| Potassium | na | na | na | 1800 | B | J | 220 | 2000 | 2600 | | | 42 | 380 | 600 | B | J | 79 | 710 | 770 | | | 53 | 470 |
| Selenium | 510 | 39 | na | 2.3 | B | B | 2.2 | 6.62 | 1.27 | U | | 0.41 | 1.27 | 2.35 | U | | 0.77 | 2.35 | 0.64 | B | B | 0.51 | 1.57 |
| Sodium | na | na | na | 180 | | | 25 | 130 | 68 | | | 4.7 | 25 | 265 | | | 8.8 | 47 | 70 | | | 5.9 | 31 |
| Thallium | 7.2 | 0.55 | 2.11 | 0.63 | B | J | 0.2 | 1.99 | 0.24 | B | J | 0.038 | 0.38 | 0.18 | B | J | 0.071 | 0.706 | 0.17 | B | J | 0.047 | 0.472 |
| Vanadium | 102 | 7.8 | 108 | 68 | | | 3.8 | 33 | 58.2 | | | 0.73 | 6.3 | 20 | | | 1.4 | 12 | 28.1 | | | 0.91 | 7.9 |
| Zinc | 31000 | 2300 | 202 | 173 | | J | 2.4 | 13 | 72.5 | | J | 0.45 | 2.5 | 43.1 | | J | 0.84 | 4.7 | 47.1 | | J | 0.56 | 3.1 |
| **Misc.** | | | | | | | | | | | | | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | 61300 | | | 1120 | 6620 | 1310 | | | 214 | 1270 | 185000 | | | 398 | 2350 | 88800 | | | 266 | 1570 |
| pH | na | na | na | 6.14 | | J | +/-0.1 | +/-0.1 | 7.02 | | J | +/-0.1 | +/-0.1 | 6.48 | | J | +/-0.1 | +/-0.1 | 6.51 | | J | +/-0.1 | +/-0.1 |

# Table 3-4
# SWMU 31
# 2002 RFI Detected Results for Sediment
# VOCs, Pesticides, PCBs, Herbicides and Dioxins/Furans

| Analyte | Sample ID<br>Sample Date<br>Sample Depth | | 31SE10B<br>7/9/02<br>2-4 | | | | | 31SE11B<br>7/10/02<br>1-3 | | | | | 31SE13B<br>7/10/02<br>5-7 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **i-RBC** | **r-RBC** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **VOCs (ug/kg)** | | | | | | | | | | | | | | | | | |
| Acetone | 92000000 | 7000000 | 6.6 | U | UJ | 3 | 6.6 | 120 | | B | 9.9 | 22 | 6.3 | U | UJ | 2.9 | 6.3 |
| **Pesticides (ug/kg)** | | | | | | | | | | | | | | | | | |
| 4,4'-DDD | 12000 | 2700 | 0.21 | J | NJ | 0.185 | 0.874 | 0.7 | J | J | 0.613 | 2.9 | 0.844 | U | | 0.178 | 0.844 |
| 4,4'-DDE | 8400 | 1900 | 0.874 | U | | 0.183 | 0.874 | 1.76 | J | J | 0.609 | 2.9 | 0.844 | U | | 0.177 | 0.844 |
| 4,4'-DDT | 8400 | 1900 | 0.979 | | B | 0.309 | 0.874 | 2.9 | U | | 1.03 | 2.9 | 0.844 | U | | 0.299 | 0.844 |
| alpha-Chlordane | 8200 | 1800 | 0.574 | J | J | 0.161 | 0.874 | 2.9 | U | | 0.535 | 2.9 | 0.844 | U | | 0.156 | 0.844 |
| Endrin | 31000 | 2300 | 0.874 | U | | 0.21 | 0.874 | 0.978 | J | J | 0.696 | 2.9 | 0.844 | U | | 0.203 | 0.844 |
| Methoxychlor | 510000 | 39000 | 1.45 | B | B | 0.667 | 0.874 | 2.9 | U | | 2.21 | 2.9 | 0.844 | U | | 0.644 | 0.844 |
| **PCBs (mg/kg)** | | | PCBs were not detected in the sediment samples. | | | | | | | | | | | | | | |
| **Herbicides (ug/kg)** | | | | | | | | | | | | | | | | | |
| 2,4-DB | 820000 | 63000 | 1310 | U | UJ | 185 | 1310 | 107 | J | B | 61.3 | 435 | 127 | U | UL | 17.8 | 127 |
| **Dioxins/Furans (ng/kg)** | | | | | | | | | | | | | | | | | |
| 2,3,7,8-TCDF | na | na | 0.136 | U | | 0.19 | 0.136 | 0.342 | | J | 0.19 | 0.129 | 0.312 | | J | 0.19 | 0.04 |
| 2,3,7,8-TCDD | 19 | 4.3 | 0.14 | U | | 0.13 | 0.14 | 0.094 | U | | 0.13 | 0.094 | 0.426 | | | 0.13 | 0.068 |
| 1,2,3,7,8-PECDD | na | na | 0.241 | U | | 0.19 | 0.241 | 0.795 | | | 0.19 | 0.122 | 1.973 | | | 0.19 | 0.068 |
| 1,2,3,4,7,8-HXCDD | na | na | 0.363 | U | | 0.53 | 0.363 | 1.963 | | | 0.53 | 0.303 | 0.073 | U | | 0.53 | 0.073 |
| 1,2,3,6,7,8-HXCDD | na | na | 0.284 | U | | 0.57 | 0.284 | 3.576 | | | 0.57 | 0.223 | 1.194 | | | 0.57 | 0.054 |
| 1,2,3,7,8,9-HXCDD | 460 | 100 | 0.275 | U | | 0.68 | 0.275 | 4.105 | | | 0.68 | 0.246 | 0.312 | X | J | 0.68 | 0.059 |
| 1,2,3,4,6,7,8-HPCDD | na | na | 11.75 | | | 0.63 | 0.464 | 89.11 | B | | 0.63 | 0.282 | 7.494 | B | | 0.63 | 0.078 |
| OCDD | na | na | 639.6 | B | | 6.86 | 0.355 | 1431 | B | | 6.86 | 0.191 | 643.5 | B | J | 6.86 | 0.067 |
| 1,2,3,7,8-PECDF | na | na | 0.164 | U | | 0.28 | 0.164 | 0.225 | | | 0.28 | 0.073 | 0.748 | | | 0.28 | 0.036 |
| 2,3,4,7,8-PECDF | na | na | 0.172 | U | | 0.56 | 0.172 | 0.294 | | | 0.56 | 0.079 | 0.038 | U | | 0.56 | 0.038 |
| 1,2,3,4,7,8-HXCDF | na | na | 0.161 | U | | 0.34 | 0.161 | 5.039 | I | J | 0.34 | 0.051 | 0.135 | | | 0.34 | 0.035 |
| 1,2,3,6,7,8-HXCDF | na | na | 0.157 | U | | 0.49 | 0.157 | 0.472 | | | 0.49 | 0.05 | 0.991 | | | 0.49 | 0.034 |
| 2,3,4,6,7,8-HXCDF | na | na | 0.184 | U | | 0.47 | 0.184 | 0.794 | | | 0.47 | 0.065 | 0.044 | U | | 0.47 | 0.044 |
| 1,2,3,4,6,7,8-HPCDF | na | na | 1.461 | | | 0.33 | 0.184 | 14.69 | B | | 0.33 | 0.094 | 1.523 | B | | 0.33 | 0.028 |
| 1,2,3,4,7,8,9-HPCDF | na | na | 0.238 | U | | 0.5 | 0.238 | 1.206 | | | 0.5 | 0.14 | 0.042 | U | | 0.5 | 0.042 |
| OCDF | na | na | 5.939 | | | 0.79 | 0.444 | 41.83 | B | | 0.79 | 0.149 | 2.384 | B | J | 0.79 | 0.05 |
| TOTAL TCDD | na | na | 0.14 | U | | | 0.14 | 0.409 | | | | 0.094 | 0.426 | | | | 0.068 |
| TOTAL PECDD | na | na | 0.241 | U | | | 0.241 | 0.795 | | | | 0.122 | 1.973 | | | | 0.068 |
| TOTAL HXCDD | na | na | 2.058 | | | | 0.275 | 24.33 | | | | 0.223 | 1.194 | | | | 0.054 |
| TOTAL HPCDD | na | na | 21.42 | | | | 0.464 | 152.6 | | | | 0.282 | 13.82 | | | | 0.078 |
| TOTAL TCDF | na | na | 0.136 | U | | | 0.136 | 3.831 | | | | 0.057 | 0.312 | | | | 0.04 |
| TOTAL PECDF | na | na | 0.164 | U | | | 0.164 | 4.782 | | | | 0.073 | 0.748 | | | | 0.036 |
| TOTAL HXCDF | na | na | 0.709 | | | | 0.157 | 24.42 | | | | 0.05 | 1.125 | | | | 0.034 |
| TOTAL HPCDF | na | na | 4.542 | | | | 0.184 | 47.13 | | | | 0.094 | 1.928 | | | | 0.028 |
| TCDD TE | 19 | 4.3 | 0.8487 | | | | | 3.881 | | | | | 2.922 | | | | |
| TCDD RME | 19 | 4.3 | 0.5227 | | | | | 3.830 | | | | | 2.904 | | | | |

# Tables 3-3 & 3-4
# Table Legend

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

RBCs for non-carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedances on the table.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (April, 1999).
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.
NT = analyte not tested.

**LQ = Lab Data Qualifiers**

B = (organics) Blank contamination. Value detected in sample and associated blank.
B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
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.

**VQ = 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

**Sediment Sample Non-Exceedance Location**

▲

**Sediment Sample Exceedance Location**

▲ >= Residential RBC

▲ >= Industrial RBC

▭ SWMU 31 Boundary

**Sample Results**

| Sample ID | Soil r-RBC Exceedances |
|---|---|
| 31SL2 | 1 metal |
| 31SL2-2 | 1 PAH |
| 31SL3-2 | 1 PAH |
| 31SE8A | 1 PAH, 1 SVOC |
| 31SE10B | 1 SVOC |
| 31SE11A | 1 PAH, 1 metal |
| 31SE11B | 1 PAH, 2 SVOCs |
| 31SE12B | 5 PAHs, 1 SVOC |
| 31SE14B | 1 PAH |

| Sample ID | Soil i-RBC Exceedances |
|---|---|
| 31SL2 | 1 metal |
| 31SE12B | 1 PAH |

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

Scale:
0 100 200 400
Feet

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 3-3

Sediment Sampling Locations
and Results

Radford, VA

Date: 11/7/06 GIS File: RFAAP_005_Fig3-3_SWMU31_SD_Results.mxd sediment sample results is presented in **Table 3-8**. These data indicate that elevated metals are not widespread in the sediment of the settling lagoons despite historical information indicating that the lagoons received fly ash which typically contains elevated levels of metals. No other metals were detected at concentrations exceeding both background (IT, 2001) and residential screening levels. Concentrations of aluminum, barium, beryllium, lead, and mercury exceeded background SSLs in the sediment samples.

***Dioxins/Furans.*** Sixteen dioxins/furans were detected. No sample toxicity equivalent (TE) concentrations exceeded the industrial or residential screening levels of 19 and 4.3 ng/kg, respectively. Dioxin-like compounds were treated according to procedures provided by USEPA and WHO (USEPA, 1989b, 1994a; WHO, 1998). An explanation of the calculation of the TEQs for dioxin/furans is discussed in *Section 5.1.1*.

### 3.2.3 Soil Sample Results – 2002 RCRA Facility Investigation (Shaw)

Soil samples were collected to characterize the site soil for parameter groups that were not analyzed for during previous investigations. One surface soil and two subsurface soil samples were collected from one soil boring. Samples were analyzed for TCL VOCs, TCL pesticides/PCBs, explosives, herbicides, TAL metals, TOC, pH, and dioxins/furans. Results are presented below and in **Table 3-5**. Exceedances of regulatory criteria are presented on **Figure 3-4**.

***VOCs.*** One VOC, acetone, was detected in one of the three soil samples. Results were below the industrial and residential screening levels and the SSL.

***Pesticides.*** Eight pesticides were detected. Sample concentrations were below industrial and residential screening levels and the SSL in surface and subsurface soil samples.

***PCBs.*** One PCB, PCB-1254, was detected. No sample concentrations exceeded industrial or residential screening levels or the SSL in surface or subsurface soil.

***Explosives.*** One explosive, NG, was detected. No sample concentrations exceeded industrial or residential screening levels in surface or subsurface soil. There is no SSL for this compound.

***Herbicides.*** Herbicides were not detected in surface or subsurface soil.

***TAL Metals.*** Twenty-three metals were detected in soil samples collected from the site. None of the detected concentrations were found to exceed both background (IT, 2001) and residential screening levels or SSLs. Lead slightly exceeded the background concentration of 26.8 mg/kg in the surface soil sample (31SB05A), with a concentration of 28 mg/kg. This concentration is below the residential screening level of 400 mg/kg.

***TOC/pH.*** Comparison criteria are not available for these analytes. TOC was detected in two of the three samples and ranged from 5910 mg/kg to 53300 mg/kg. pH ranged from 6.96 to 7.37.

***Dioxins/Furans.*** Sixteen dioxins/furans were detected. The presence of dioxins/furans in the soil is likely related to power plant operations (although not necessarily the settling ponds). The sample toxicity equivalent (TE) exceeded the residential screening level of 4.3 ng/kg in the surface soil sample (31SB05A – 8.375 ng/kg). This TE is below the industrial screening level of 19 ng/kg and the SSL (8.6 ng/kg). Subsurface soil samples were below the residential screening level. Dioxin-like compounds were treated according to procedures provided by USEPA and WHO (USEPA, 1989b, 1994a; WHO, 1998). The calculated TCDD TE for one soil sample exceeded the residential screening level for TCDD. No individual congeners exceeded screening

### Table 3-5
### SWMU 31
### 2002 RFI Detected Results for Soil

| Analyte | Sample ID<br>Sample Date<br>Sample Depth | | | | 31SB05A<br>7/8/02<br>0-0.5 | | | | | 31SB05B<br>7/8/02<br>1-3 | | | | | 31SB05C<br>7/8/02<br>3-5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **i-RBC** | **r-RBC** | **Background** | **SSL Transfer** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **VOCs (ug/kg)** | | | | | | | | | | | | | | | | | | | |
| Acetone | 92000000 | 7000000 | na | 22000 | 5.5 | U | UJ | *2.5* | *5.5* | 4.6 | U | UJ | *2.1* | *4.6* | 42 | | B | *2.3* | *5.2* |
| **Pesticides (ug/kg)** | | | | | | | | | | | | | | | | | | | |
| 4,4'-DDD | 12000 | 2700 | na | 11000 | 0.698 | J | J | *0.156* | *0.74* | 0.768 | U | | *0.162* | *0.768* | 0.307 | J | J | *0.163* | *0.772* |
| 4,4'-DDE | 8400 | 1900 | na | 35000 | 2.26 | | | *0.155* | *0.74* | 0.768 | U | | *0.161* | *0.768* | 0.772 | U | | *0.162* | *0.772* |
| 4,4'-DDT | 8400 | 1900 | na | 1200 | 13.3 | | | *0.262* | *0.74* | 0.768 | U | | *0.272* | *0.768* | 0.772 | U | | *0.273* | *0.772* |
| Endosulfan II | 610000 | 47000 | na | 20000 | 2.28 | | | *0.264* | *0.74* | 0.768 | U | | *0.274* | *0.768* | 0.772 | U | | *0.275* | *0.772* |
| Endosulfan sulfate | na | na | na | na | 0.893 | | | *0.233* | *0.74* | 0.768 | U | | *0.242* | *0.768* | 0.772 | U | | *0.243* | *0.772* |
| Endrin aldehyde | na | na | na | na | 1.79 | | L | *0.374* | *0.74* | 0.768 | U | UL | *0.388* | *0.768* | 0.772 | U | UL | *0.39* | *0.772* |
| Endrin | 31000 | 2300 | na | 5400 | 0.74 | U | | *0.178* | *0.74* | 0.768 | U | | *0.184* | *0.768* | 0.271 | J | J | *0.185* | *0.772* |
| Methoxychlor | 510000 | 39000 | na | 310000 | 7.65 | | | *0.565* | *0.74* | 0.768 | U | | *0.586* | *0.768* | 0.889 | | | *0.589* | *0.772* |
| **PCBs (mg/kg)** | | | | | | | | | | | | | | | | | | | |
| PCB-1254 | 1.4 | 0.16 | na | 1.1 | 0.0931 | | | *0.0109* | *0.037* | 0.0383 | U | | *0.0113* | *0.0383* | 0.0385 | U | | *0.0114* | *0.0385* |
| **Explosives (mg/kg)** | | | | | | | | | | | | | | | | | | | |
| Nitroglycerin | 1700 | 130 | na | na | 0.42 | | | *0.111* | *0.333* | 0.345 | U | | *0.115* | *0.345* | 0.347 | U | | *0.116* | *0.347* |
| **Herbicides (ug/kg)** | Herbicides were not detected in the soil samples. | | | | | | | | | | | | | | | | | | |
| **Metals (mg/kg)** | | | | | | | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | 7210 | | | *6.1* | *22.2* | 15500 | | | *6.4* | *23* | 17000 | | | *6.4* | *23.1* |
| Antimony | 41 | 3.1 | na | 13 | 0.35 | B | B | *0.19* | *0.555* | 0.586 | | L | *0.19* | *0.575* | 0.26 | B | B | *0.19* | *0.579* |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 5.9 | | | *0.39* | *0.555* | 1.07 | | | *0.4* | *0.575* | 0.807 | | | *0.4* | *0.579* |
| Barium | 20000 | 1600 | 209 | 6000 | 90.4 | | | *0.37* | *2.22* | 96.4 | | | *0.38* | *2.3* | 107 | | | *0.39* | *2.31* |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0.634 | | | *0.0383* | *0.555* | 0.735 | | | *0.0397* | *0.575* | 0.767 | | | *0.0399* | *0.579* |
| Cadmium | 51 | 3.9 | 0.69 | 27 | 0.462 | | J | *0.053* | *0.111* | 0.083 | B | J | *0.055* | *0.115* | 0.099 | B | J | *0.055* | *0.116* |
| Calcium | na | na | na | na | 56700 | | | *3.1* | *11.1* | 1960 | | | *3.2* | *11.5* | 5090 | | | *3.2* | *11.6* |
| Chromium | 310 | 23 | 65.3 | 42 | 15.8 | | | *0.42* | *1.11* | 28.2 | | | *0.43* | *1.15* | 29.7 | | | *0.43* | *1.16* |
| Cobalt | na | na | 72.3 | na | 7.69 | | | *0.9* | *5.55* | 17.8 | | | *0.93* | *5.75* | 18.5 | | | *0.94* | *5.79* |
| Copper | 4100 | 310 | 53.5 | 11000 | 17.1 | | | *0.69* | *2.22* | 17.7 | | | *0.71* | *2.3* | 18.2 | | | *0.71* | *2.31* |
| Iron | 31000 | 2300 | 50962 | na | 9580 | | J | *3.7* | *5.55* | 27800 | | J | *3.9* | *5.75* | 28400 | | J | *3.9* | *5.79* |
| Lead | 800 | 400 | 26.8 | na | **28** | | **J** | *0.034* | *0.333* | 14.6 | | J | *0.035* | *0.345* | 16.2 | | J | *0.035* | *0.347* |
| Magnesium | na | na | na | na | 25000 | | | *2.6* | *11.1* | 4650 | | | *2.7* | *11.5* | 6310 | | | *2.7* | *11.6* |
| Manganese | 2000 | 160 | 2543 | 950 | 203 | | J | *0.062* | *1.11* | 495 | | J | *0.064* | *1.15* | 489 | | J | *0.065* | *1.16* |
| Mercury | 31 | 2.3 | 0.13 | na | 0.121 | | L | *0.022* | *0.0555* | 0.035 | B | L | *0.023* | *0.0575* | 0.027 | B | L | *0.023* | *0.0579* |
| Nickel | 2000 | 160 | 62.8 | na | 11.5 | | | *1* | *4.44* | 14.8 | | | *1.1* | *4.6* | 15.6 | | | *1.1* | *4.63* |
| Potassium | na | na | na | na | 938 | | | *37* | *333* | 2120 | | | *38* | *345* | 2200 | | | *39* | *347* |
| Selenium | 510 | 39 | na | 19 | 0.46 | B | B | *0.36* | *1.11* | 1.15 | U | | *0.38* | *1.15* | 1.16 | U | | *0.38* | *1.16* |
| Silver | 510 | 39 | na | 31 | 0.59 | B | B | *0.55* | *1.11* | 0.92 | B | B | *0.57* | *1.15* | 0.68 | B | B | *0.57* | *1.16* |
| Sodium | na | na | na | na | 77.5 | | | *4.1* | *22.2* | 29.8 | | | *4.3* | *23* | 34.6 | | | *4.3* | *23.1* |
| Thallium | 7.2 | 0.55 | 2.11 | 3.6 | 0.34 | | J | *0.033* | *0.333* | 0.23 | B | J | *0.035* | *0.345* | 0.24 | B | J | *0.035* | *0.347* |
| Vanadium | 102 | 7.8 | 108 | 730 | 22 | | | *0.64* | *5.55* | 47.5 | | | *0.67* | *5.75* | 49.2 | | | *0.67* | *5.79* |
| Zinc | 31000 | 2300 | 202 | 14000 | 98.5 | | J | *0.4* | *2.22* | 60.2 | | J | *0.41* | *2.3* | 64.3 | | J | *0.41* | *2.31* |
| **Misc.** | | | | | | | | | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | na | 53300 | | | *188* | *1110* | 1150 | U | | *194* | *1150* | 5910 | | | *196* | *1160* |
| pH | na | na | na | na | 7.37 | | J | *+/- 0.1* | *+/- 0.1* | 7.13 | | J | *+/- 0.1* | *+/- 0.1* | 6.96 | | J | *+/- 0.1* | *+/- 0.1* |
| **Dioxins/Furans (ng/kg)** | | | | | | | | | | | | | | | | | | | |
| 2,3,7,8-TCDF | na | na | na | na | 0.74 | | J | *0.19* | *0.14* | 0.027 | U | | *0.19* | *0.027* | 0.026 | U | | *0.19* | *0.026* |
| 2,3,7,8-TCDD | 19 | 4.3 | na | 8.6 | 0.713 | X | J | *0.13* | *0.054* | 0.038 | U | | *0.13* | *0.038* | 0.036 | U | | *0.13* | *0.036* |
| 1,2,3,7,8-PECDD | na | na | na | na | 1.633 | | | *0.19* | *0.108* | 0.037 | U | | *0.19* | *0.037* | 0.039 | U | | *0.19* | *0.039* |

### Table 3-5
### SWMU 31
### 2002 RFI Detected Results for Soil

| Analyte | | | | Sample ID | 31SB05A | | | | | 31SB05B | | | | | 31SB05C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sample Date | 7/8/02 | | | | | 7/8/02 | | | | | 7/8/02 | | | | |
| | | | | Sample Depth | 0-0.5 | | | | | 1-3 | | | | | 3-5 | | | | |
| | **i-RBC** | **r-RBC** | **Background** | **SSL Transfer** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| 1,2,3,4,7,8-HXCDD | 460 | 100 | na | na | 4.049 | | | *0.53* | *0.099* | 0.047 | U | | *0.53* | *0.047* | 0.116 | | | *0.53* | *0.041* |
| 1,2,3,6,7,8-HXCDD | 460 | 100 | na | na | 6.711 | | | *0.57* | *0.073* | 0.135 | | | *0.57* | *0.034* | 0.176 | | | *0.57* | *0.03* |
| 1,2,3,7,8,9-HXCDD | 460 | 100 | na | na | 8.482 | | | *0.68* | *0.08* | 0.384 | | | *0.68* | *0.038* | 0.381 | | | *0.68* | *0.033* |
| 1,2,3,4,6,7,8-HPCDD | na | na | na | na | 191.4 | B | | *0.63* | *0.059* | 7.732 | B | | *0.63* | *0.045* | 10.3 | B | | *0.63* | *0.03* |
| OCDD | na | na | na | na | 1851 | B | | *6.86* | *0.148* | 538.9 | B | | *6.86* | *0.04* | 813.5 | B | J | *6.86* | *0.031* |
| 1,2,3,7,8-PECDF | na | na | na | na | 0.559 | | | *0.28* | *0.045* | 0.02 | U | | *0.28* | *0.02* | 0.02 | U | | *0.28* | *0.02* |
| 2,3,4,7,8-PECDF | na | na | na | na | 0.678 | | | *0.56* | *0.049* | 0.022 | U | | *0.56* | *0.022* | 0.022 | U | | *0.56* | *0.022* |
| 1,2,3,4,7,8-HXCDF | na | na | na | na | 8.597 | I | J | *0.34* | *0.077* | 0.221 | I | J | *0.34* | *0.02* | 0.292 | I | J | *0.34* | *0.019* |
| 1,2,3,6,7,8-HXCDF | na | na | na | na | 1.235 | | | *0.49* | *0.075* | 0.02 | U | | *0.49* | *0.02* | 0.019 | U | | *0.49* | *0.019* |
| 2,3,4,6,7,8-HXCDF | na | na | na | na | 1.572 | | | *0.47* | *0.098* | 0.026 | U | | *0.47* | *0.026* | 0.025 | U | | *0.47* | *0.025* |
| 1,2,3,7,8,9-HXCDF | na | na | na | na | 0.111 | U | | *0.25* | *0.111* | 0.03 | U | | *0.25* | *0.03* | 0.028 | U | | *0.25* | *0.028* |
| 1,2,3,4,6,7,8-HPCDF | na | na | na | na | 37.59 | B | | *0.33* | *0.061* | 0.965 | BX | J | *0.33* | *0.021* | 1.112 | B | | *0.33* | *0.019* |
| 1,2,3,4,7,8,9-HPCDF | na | na | na | na | 2.5 | | | *0.5* | *0.091* | 0.032 | U | | *0.5* | *0.032* | 0.028 | U | | *0.5* | *0.028* |
| OCDF | na | na | na | na | 127.6 | B | | *0.79* | *0.1* | 3.453 | B | | *0.79* | *0.025* | 3.976 | B | J | *0.79* | *0.022* |
| TOTAL TCDD | na | na | na | na | 2.084 | | | | *0.054* | 0.038 | U | | | *0.038* | 0.036 | U | | | *0.036* |
| TOTAL PECDD | na | na | na | na | 1.94 | | | | *0.108* | 0.037 | U | | | *0.037* | 0.039 | U | | | *0.039* |
| TOTAL HXCDD | 460 | 100 | na | na | 79.31 | | | | *0.073* | 1.455 | | | | *0.034* | 1.292 | | | | *0.03* |
| TOTAL HPCDD | na | na | na | na | 454.2 | | | | *0.059* | 14.03 | | | | *0.045* | 18.8 | | | | *0.03* |
| TOTAL TCDF | na | na | na | na | 5.142 | | | | *0.059* | 0.085 | | | | *0.027* | 0.026 | U | | | *0.026* |
| TOTAL PECDF | na | na | na | na | 13.04 | | | | *0.045* | 0.092 | | | | *0.02* | 0.02 | U | | | *0.02* |
| TOTAL HXCDF | na | na | na | na | 53.43 | | | | *0.075* | 0.976 | | | | *0.02* | 1.331 | | | | *0.019* |
| TOTAL HPCDF | na | na | na | na | 40.09 | | | | *0.061* | 0.021 | U | | | *0.021* | 1.112 | | | | *0.019* |
| TCDD TE | 19 | 4.3 | na | 8.6 | 8.375 | | | | | 0.3175 | | | | | 0.3894 | | | | |
| TCDD RME | 19 | 4.3 | na | 8.6 | 8.370 | | | | | 0.2664 | | | | | 0.3409 | | | | |

# Table 3-5
# Table Legend

| | | |
|---|---|---|
| 12 | J | Shading and black font indicates an industrial RBC exceedance. |
| 12 | J | Bold outline indicates a residential RBC exceedance. |
| **12** | **J** | Bold, underlined font indicates a background exceedance. |
| 12 | J | Shading and white font indicates an SSL exceedance. |
| 12 | J | Mixed shading indicates an industrial RBC and an SSL exceedance. |
| *12* | *12* | Shading in the MDL/MRL columns indicates the MDL exceeds a criterion. |

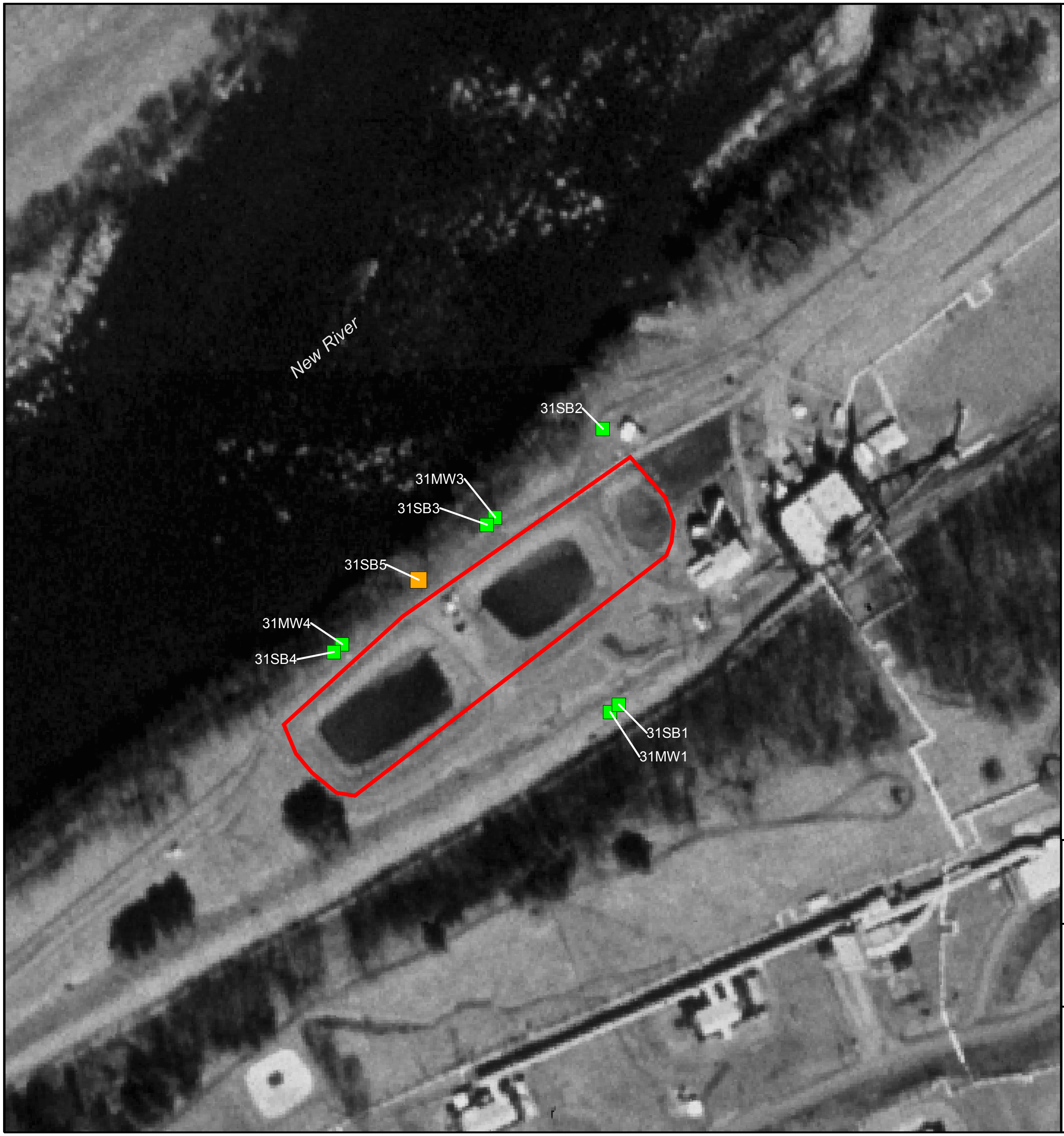
RBCs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene RBCs and SSL were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene.
Inorganic results below background UTLs are not indicated as exceedences on the table.
RBC = Risk Based Concentration (October, 2006).
RBC values in table are for the more conservative chromium VI.
RBC 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 (April, 1999).
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.
NT = analyte not tested.

**LQ = Lab Data Qualifiers**

B = (organics) Blank contamination. Value detected in sample and associated blank.
B = (metals) Value <MRL and >MDL and is considered estimated.
E (metals) = Reported value is estimated because of the presence of interferences.
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.

**VQ = 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

🟩 Soil Sample Non-Exceedance Location

🟧 Soil Sample r-RBC Exceedance Location

🟥 SWMU 31 Boundary

Sample Results

| Sample ID | Soil r-RBC Exceedances |
|---|---|
| 31SB05A | TCDD TE |

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

N

Scale:
0 100 200 400
Feet

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 3-4

Soil Sampling Locations and Results

Radford, VA

Date: 11/7/06 GIS File: RFAAP_007_Fig3-4_SWMU31_Soil_Results.mxd criteria. An explanation of the calculation of the TEs for dioxin/furans is discussed in *Section 5.1.1*.

### 3.2.4 Groundwater Sample Results – 2002 RCRA Facility Investigation (Shaw)

Chemical detections are presented in **Table 3-6**. Exceedances of regulatory criteria are presented on **Figure 3-5**.

***VOCs.*** Two VOCs, carbon disulfide and chloroform, were detected. Chloroform was detected above the tap water RBC in two samples, 31MW3 (6.3 µg/L) and 31MW04 (11 µg/L), but below the MCL.

***SVOCs/PAHs.*** One SVOC, bis(2-ethylhexyl)phthalate, was detected above the MCL (6 µg/L) and tap water RBC (4.8 µg/L) in sample 31MW04 (7.4 µg/L). Five PAHs were detected in the more sensitive PAH analytical method. These PAHs were detected at concentrations below their tap water RBCs. MCLs are not available for the detected PAHs.

***Pesticides.*** Endrin ketone was detected in one of the samples at a concentration of 0.00466 µg/L. There is no tap water RBC or MCL for this compound.

***PCBs.*** PCBs were not detected in the groundwater samples.

***Explosives.*** One explosive, NG, was detected in one of the groundwater samples at a concentration of 0.42 µg/L. This concentration is below the tap water RBC of 4.8 µg/L. NG does not have an MCL.

***Herbicides.*** Herbicides were not detected in the groundwater samples.

***TAL Metals.*** Fifteen metals were detected in the total metals analysis and ten metals were detected in the filtered metals analysis. Aluminum exceeded the MCL in the three wells in both the total and filtered analysis. Aluminum results were below the tap water RBC. Iron exceeded the MCL in one of the three samples (31MW3) in the total analysis. Iron concentrations were below the MCL in the filtered metals analysis. The remaining metals were detected at concentrations below MCLs and tap water RBCs in both the total and filtered analysis. There are no established background levels for groundwater.

***Perchlorate.*** Perchlorate was not detected in the groundwater samples.

***Hardness/TOC/TOX.*** There are no comparison criteria for these parameters. Hardness concentrations ranged from 80,100 µg/L to 414,000 µg/L. TOC ranged from 620 µg/L to 740 µg/L. TOX was not detected.

### 3.2.5 BTAG Screening

Chemical concentrations detected in surface soil, surface water, and sediment samples collected from the SWMU 31 study area were compared to USEPA Region III BTAG screening levels. Soil sample concentrations were compared to USEPA Region III BTAG SSLs (USEPA, 1995d) and Ecological SSLs (EcoSSLs; USEPA, 2005a). Surface water samples were compared to USEPA Region III BTAG freshwater screening benchmarks (USEPA, 2004b). Sediment samples were compared to USEPA Region III BTAG sediment screening benchmarks (USEPA, 2005b). **Figures 3-6, 3-7, and 3-8** illustrate the BTAG screening results for soil, surface water, and sediment samples collected at SWMU 31.

## Table 3-6
## SWMU 31
## 2002 RFI Detected Results for Groundwater

| Analyte | Sample ID | | **31MW01** | | | | | **31MW3** | | | | | **31MW04** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Date | | **7/11/02** | | | | | **7/11/02** | | | | | **7/11/02** | | | | |
| | Sample Depth | | **0-0** | | | | | **0-0** | | | | | **0-0** | | | | |
| | **MCL** | **tw-RBC** | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL | Result | Lab Q | Val Q | MDL | MRL |
| **VOCs (ug/L)** | | | | | | | | | | | | | | | | | |
| Carbon disulfide | na | 100 | 0.091 | J | B | *0.0604* | *1* | 0.17 | J | B | *0.0604* | *1* | 0.2 | J | B | *0.0604* | *1* |
| Chloroform | 80 | 0.15 | 1 | U | | *0.0776* | *1* | 6.3 | | | *0.0776* | *1* | 11 | | | *0.0776* | *1* |
| **PAHs (ug/L)** | | | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | na | 2.4 | 0.05 | U | | *0.0132* | *0.05* | 0.061 | | B | *0.0132* | *0.05* | 0.05 | U | | *0.0132* | *0.05* |
| Acenaphthene | na | 36 | 0.05 | U | | *0.0129* | *0.05* | 0.038 | J | B | *0.0129* | *0.05* | 0.05 | U | | *0.0129* | *0.05* |
| Acenaphthylene | na | 18 | 0.05 | U | | *0.0131* | *0.05* | 0.027 | J | J | *0.0131* | *0.05* | 0.05 | U | | *0.0131* | *0.05* |
| Fluorene | na | 24 | 0.05 | U | | *0.0153* | *0.05* | 0.024 | J | J | *0.0153* | *0.05* | 0.05 | U | | *0.0153* | *0.05* |
| Naphthalene | na | 0.65 | 0.03 | JB | B | *0.0191* | *0.05* | 0.062 | B | B | *0.0191* | *0.05* | 0.028 | JB | B | *0.0191* | *0.05* |
| **SVOCs (ug/L)** | | | | | | | | | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 6 | 4.8 | 4.4 | JB | B | *1.6* | *5* | 4.5 | JB | B | *1.6* | *5* | 7.4 | B | B | *1.6* | *5* |
| **Pesticides (ug/L)** | | | | | | | | | | | | | | | | | |
| Endrin ketone | na | na | 0.00466 | J | J | *0.00417* | *0.02* | 0.02 | U | | *0.00417* | *0.02* | 0.02 | U | | *0.00417* | *0.02* |
| **PCBs (ug/L)** | | | PCBs were not detected in the groundwater samples. | | | | | | | | | | | | | | |
| **Explosives (ug/L)** | | | | | | | | | | | | | | | | | |
| Nitroglycerin | na | 62 | 0.42 | J | B | *0.207* | *0.97* | 0.97 | U | | *0.207* | *0.97* | 0.97 | U | | *0.207* | *0.97* |
| **Herbicides (ug/L)** | | | Herbicides were not detected in the groundwater samples. | | | | | | | | | | | | | | |
| **Metals, Total (ug/L)** | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 414 | | | *38.6* | *200* | 348 | | | *38.6* | *200* | 100 | B | J | *38.6* | *200* |
| Antimony | 6 | 1.5 | 0.44 | B | R | *0.336* | *5* | 0.4 | B | B | *0.336* | *5* | 0.54 | B | B | *0.336* | *5* |
| Barium | 2000 | 730 | 214 | | | *3.11* | *20* | 25.6 | | | *3.11* | *20* | 26 | | | *3.11* | *20* |
| Cadmium | 5 | 1.8 | 0.069 | B | B | *0.0651* | *2* | 0.1 | B | B | *0.0651* | *2* | 2 | U | | *0.0651* | *2* |
| Calcium | na | na | 76500 | | | *30.4* | *100* | 26200 | | | *30.4* | *100* | 20100 | | | *30.4* | *100* |
| Chromium | 100 | 11 | 8.9 | B | J | *3.65* | *10* | 5.2 | B | J | *3.65* | *10* | 6.4 | B | J | *3.65* | *10* |
| Copper | 1300 | 150 | 20 | U | | *8.42* | *20* | 36 | | | *8.42* | *20* | 20 | U | | *8.42* | *20* |
| Iron | 300 | 1100 | 274 | | | *22.7* | *50* | 364 | | | *22.7* | *50* | 78.1 | | | *22.7* | *50* |
| Lead | 15 | na | 1.1 | B | B | *0.0765* | *2* | 1.7 | B | J | *0.0765* | *2* | 0.52 | B | B | *0.0765* | *2* |
| Magnesium | na | na | 54200 | | | *41.1* | *100* | 9760 | | | *41.1* | *100* | 7270 | | | *41.1* | *100* |
| Manganese | 50 | 73 | 7.1 | B | J | *0.816* | *10* | 6.4 | B | J | *0.816* | *10* | 2 | B | J | *0.816* | *10* |
| Potassium | na | na | 4560 | | | *275* | *3000* | 1800 | B | J | *275* | *3000* | 1500 | B | J | *275* | *3000* |
| Selenium | 50 | 18 | 5 | U | UJ | *0.413* | *5* | 5 | U | | *0.413* | *5* | 0.44 | B | B | *0.413* | *5* |
| Silver | 100 | 18 | 6.8 | B | B | *4.45* | *10* | 6.3 | B | B | *4.45* | *10* | 5.7 | B | B | *4.45* | *10* |
| Sodium | na | na | 5310 | | | *42.5* | *200* | 10900 | | | *42.5* | *200* | 11500 | | | *42.5* | *200* |
| **Metals, Filtered (ug/L)** | | | | | | | | | | | | | | | | | |
| Aluminum | 50 | na | 160 | B | J | *38.6* | *200* | 215 | | | *38.6* | *200* | 78 | B | J | *38.6* | *200* |
| Antimony | 6 | 1.5 | 1.6 | B | R | *0.336* | *5* | 0.42 | B | B | *0.336* | *5* | 0.48 | B | B | *0.336* | *5* |
| Barium | 2000 | 730 | 202 | | | *3.11* | *20* | 24.8 | | | *3.11* | *20* | 25.3 | | | *3.11* | *20* |
| Cadmium | 5 | 1.8 | 0.082 | B | B | *0.0651* | *2* | 2 | U | | *0.0651* | *2* | 2 | U | | *0.0651* | *2* |
| Calcium | na | na | 72300 | | | *30.4* | *100* | 25700 | | | *30.4* | *100* | 19200 | | | *30.4* | *100* |
| Chromium | 100 | 11 | 4.2 | B | J | *3.65* | *10* | 7.3 | B | J | *3.65* | *10* | 5.9 | B | J | *3.65* | *10* |
| Iron | 300 | 1100 | 89.9 | | | *22.7* | *50* | 162 | | | *22.7* | *50* | 104 | | | *22.7* | *50* |
| Lead | 15 | na | 0.94 | B | B | *0.0765* | *2* | 0.45 | B | B | *0.0765* | *2* | 0.46 | B | B | *0.0765* | *2* |
| Magnesium | na | na | 53000 | | | *41.1* | *100* | 9570 | | | *41.1* | *100* | 7000 | | | *41.1* | *100* |
| Manganese | 50 | 73 | 2 | B | J | *0.816* | *10* | 2 | B | J | *0.816* | *10* | 10 | U | | *0.816* | *10* |
| Potassium | na | na | 5380 | | | *275* | *3000* | 1900 | B | J | *275* | *3000* | 1200 | B | J | *275* | *3000* |
| Selenium | 50 | 18 | 0.55 | B | B | *0.413* | *5* | 5 | U | | *0.413* | *5* | 0.47 | B | B | *0.413* | *5* |
| Silver | 100 | 18 | 7.3 | B | B | *4.45* | *10* | 7.8 | B | B | *4.45* | *10* | 6.8 | B | B | *4.45* | *10* |
| Sodium | na | na | 6420 | | | *42.5* | *200* | 10900 | | | *42.5* | *200* | 11300 | | | *42.5* | *200* |
| **Misc.** | | | | | | | | | | | | | | | | | |
| Hardness | na | na | 414000 | | | *245* | *662* | 106000 | | | *245* | *662* | 80100 | | | *245* | *662* |
| Total Organic Carbon (ug/L) | na | na | 620 | B | J | *62.5* | *1000* | 740 | B | J | *62.5* | *1000* | 700 | B | J | *62.5* | *1000* |

## LEGEND

**Groundwater Sample Exceedance Location**

● >= MCL

● >= tw-RBC

☐ SWMU 31 Boundary

Sample Results

| Well ID | GW MCL Exceedances |
|---|---|
| 31MW1 | 4 metals |
| 31MW2 | 5 metals |
| 31MW3 | 5 metals |
| 31MW4 | 1 SVOC, 2 metals |

| Well ID | GW tw-RBC Exceedances |
|---|---|
| 31MW1 | 1 SVOC, 1 metal |
| 31MW2 | 1 PAH, 5 metals |
| 31MW3 | 1 VOC, 2 PAHs, 5 metals |
| 31MW4 | 1 VOC, 1 SVOC, 1 metal |

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

N

Scale:
0 100 200 400 Feet

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FIGURE 3-5

Groundwater Sampling Locations and Results

Radford, VA

*Date: 11/7/06 GIS File: RFAAP_008_Fig3-5_SWMU31_GW_Results.mxd*

## LEGEND

**Soil Sample Exceedance Location**

- 🟨 >=Eco-SSL
- 🟥 >=BTAG-Soil
- ▭ SWMU 31 Boundary

**Sample Results**

| Sample ID | BTAG-Soil Exceedances |
|---|---|
| 31SB05A | 3 metals |
| 31SB05B | 3 metals |

| Sample ID | Eco-SSL Exceedances |
|---|---|
| 31SB05A | 2 metals |
| 31SB05B | 1 metal |

Notes:
1) Aerial photo was obtained from Radford AAP.
2) Sample intervals limited to 0-4 ft for ecological purposes (see section 3.2.5.1).

N

Scale:
0 100 200 400
Feet

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 3-6

Eco-SSL and BTAG Soil Screening Results

Radford, VA

Date: 11/7/06 GIS File: RFAAP_022_Fig3-6_SWMU31_Soil_BTAG_Eco_Results.mxd

## LEGEND

**Surface Water Sample Exceedance Location**

▲ >= BTAG-AQ

□ SWMU 31 Boundary

**Sample Results**

| Sample ID | BTAG-Aq Exceedances |
|---|---|
| 31SW1 | 3 metals |
| 31SW2 | 3 metals |
| 31SW3 | 3 metals |
| 31SW10 | 1 VOC, 2 pesticides, 5 metals |
| 31SW12 | 1 VOC, 3 metals |
| 31SW14 | 1 VOC, 1 PAH, 7 metals |

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

N

Scale:

0 100 200 400 Feet

DEPARTMENT OF THE ARMY

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FIGURE 3-7

BTAG Aqueous
Screening Results

Radford, VA

Date: 11/7/06 GIS File: RFAAP_023_Fig3-7_SWMU31_SW_BTAG.mxd

## LEGEND

**Sediment Sample Exceedance Location**

△ >= BTAG-Sed

▭ SWMU 31 Boundary

**Sample Results**

| Sample ID | BTAG-Sed Exceedances |
|---|---|
| 31SL1 | 4 SVOCs |
| 31SL2 | 1 SVOC |
| 31SL3 | 4 SVOCs |
| 31SL1-2 | 1 PAH, 2 metals |
| 31SL2-2 | 2 PAHs, 2 metals |
| 31SL3-2 | 2 metals |
| 31SE8A | 9 PAHs, 5 SVOCs |
| 31SE11A | 5 PAHs, 1 SVOC, 1 explosive, 3 metals |
| 31SE13A | 2 SVOCs, 3 metals |

Notes:
1) Aerial photo was obtained from Radford AAP.
2) Sample intervals limited to 0-12 inches for ecological purposes (see section 3.2.5.3).

N

Scale:
0 100 200 400 Feet

DEPARTMENT OF THE ARMY

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FIGURE 3-8

BTAG Sediment
Screening Results

Radford, VA

*Date: 11/7/06 GIS File: RFAAP_024_Fig3-8_SWMU31_SD_BTAG.mxd*

#### 3.2.5.1 Soil

For ecological assessment purposes, samples found between 0-4 ft were used at this site to be conservatively protective of any burrowing animals that might inhabit SWMU 31. It is anticipated there are generally no complete ecological pathways for chemicals below a depth of 4 ft. In the case of SWMU 31, only two surface soil samples (31SB05A and 31SB05B) were collected from depth intervals in the 0-4 ft bgs range.

A summary of the detected compounds in SWMU 31 surface soil samples and their respective BTAG SSLs is provided in **Table 3-11**. A summary of the screening results are illustrated on **Figure 3-6**. The number of exceedances, number of detections, and number of samples for each analyte, as well as the range of concentrations and the location of the maximum concentration, are also provided in **Table 3-11**.

***Organics.*** BTAG screening criteria are not available for the organics detected in SWMU 31 surface soil samples.

***Metals.*** Antimony and iron exceeded both background and BTAG soil screening criteria in SWMU 31 surface soil samples.

#### 3.2.5.2 Surface Water

A summary of the detected compounds in SWMU 31 surface water samples and their respective BTAG aqueous screening levels is provided in **Table 3-12**. A summary of the screening results are illustrated on **Figure 3-7**. The number of exceedances, number of detections, and number of samples for each analyte, as well as the range of concentrations and the location of the maximum concentration, are also provided in **Table 3-12**.

***Organics.*** One VOC (chloroform), one PAH (pyrene), and two pesticides (Endosulfan II and endrin) exceeded BTAG aqueous screening criteria in SWMU 31 surface water samples. SVOCs detected in SWMU 31 surface water samples were below BTAG aqueous screening criteria. PCBs were not detected in surface water at SWMU 31.

***Metals.*** Nine metals (aluminum, barium, copper, iron, lead, manganese, mercury, selenium, and silver) were detected at concentrations above BTAG aqueous screening criteria in SWMU 31 surface water samples.

#### 3.2.5.3 Sediment

Generally the "bioactive" zone in sediment is selected for consideration of the potential adverse ecological effects of chemical constituents. This zone includes surficial sediments to a depth of approximately 6 inches, in which aquatic macroinvertebrates may burrow and live, and which may allow chemicals that have equilibrated into sediment pore water to diffuse or migrate to overlying surface water. In the case of SWMU 31, six sediment samples were collected from depth intervals in the 0-6 inch range. Although sample results from 0-6 inches are generally considered the most appropriate for the bioactive zone, three sediment samples (31SL1, 31SL2, and 31SL3) collected from 0-12 inches have also been included in the screening, as a portion of this interval includes the bioactive zone.

A summary of the detected compounds in SWMU 31 sediment samples and their respective BTAG sediment screening levels is provided in **Table 3-13**. A summary of the screening results are illustrated on **Figure 3-8**. The number of exceedances, number of detections, and number of samples for each analyte, as well as the range of concentrations and the location of the maximum concentration, are also provided in **Table 3-13**.

***Organics.*** Concentrations of eleven PAHs [2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, chrysene, fluorine, indeno(1,2,3-cd)pyrene, naphthalene, and phenanthrene), three SVOCs [1,2-dichlorobenzene, benzoic acid, and bis(2-ethylhexyl)phthalate], and one explosive (2,4,6-trinitrotoluene) exceeded BTAG sediment criteria in SWMU 31 sediment samples.

***Metals.*** Six metals (antimony, copper, lead, mercury, selenium, and silver) were detected at concentrations above BTAG sediment screening criteria in SWMU 31 sediment samples.

### 3.2.6 Nature and Extent Summary

This section evaluates the combined analytical data collected from previous investigations and the 2002 RFI. Analytical data collected during the 2002 RFI are presented in **Tables 3-2 through 3-6**. Previous investigation analytical data is presented in *Section 2*, **Tables 2-3 through 2-9**. **Figures 3-2 through 3-5** present exceedances of screening levels from both the current and previous investigations by media.

Evaluating the combined chemical database from each of the SWMU 31 investigations (**Tables 3-7 through 3-10**), pesticides, PCBs, explosives, herbicides, and non-PAH SVOCs do not appear to be a concern at the site. Bis(2-ethylhexyl)phthalate (an SVOC) was detected in surface water and groundwater at levels exceeding the MCL and tap water RBC. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and the exceedances were "B" flagged during data validation, indicating that this compound was also detected in associated laboratory blanks, and is not likely attributable to the site.

Metals, VOCs, PAHs, and dioxins/furans were detected above residential screening levels (sediment or soil) or tap water RBCs/MCLs (surface water or groundwater) and are discussed below.

***Surface Water***

Surface water samples were collected in 1998 and 2002 from the three lagoons. One sample was collected from each lagoon during each of the investigations, for a total of six samples. Three metals (aluminum, iron, and manganese) exceeded MCLs and tap water RBCs in the surface water samples. Remaining metals were detected at concentrations below these criteria. Aluminum exceeded the MCL (50 µg/L) in all six samples. Aluminum, iron, and manganese are common replacement metals in the carbonate rocks in the Radford area. Aluminum is commonly elevated in surface water at RFAAP.

Three VOCs (bromodichloromethane, chloroform, and dibromochloromethane) exceeded tap water RBCs in the 2002 investigation surface water samples. None of these compounds exceeded their respective MCLs. Concentrations of chloroform are highest in the primary lagoon and lowest in the tertiary lagoon. Concentrations of bromodichloromethane and dibromochloromethane also follow this pattern. According to *The Virginia Department of Health – Division of Health Hazards Control*, these compounds can be formed during the chlorination of drinking water, formed when the chlorine reacts with organics in the water. (Virginia Department of Health, 2001). The presence of these compounds in the lagoons is likely due to the current operations associated with the Water Treatment Plant and are not related to the former use as settling lagoons for fly ash and bottom ash from the power plant.

### Table 3-7
### SWMU 31
### Detected Constituents in Surface Water Summary

| Analyte | MCL | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|
| ***VOCs (ug/L)*** | | | | | | | | | |
| Bromodichloromethane | 80 | 0.17 | 0 | 3 | 3 | 3 | 1.3 | 3.6 | 31SW14 |
| Carbon disulfide | na | 100 | na | 0 | 1 | 3 | 0.075 | 0.075 | 31SW10 |
| Chloroform | 80 | 0.15 | 0 | 3 | 3 | 3 | 16 | 30 | 31SW14 |
| Dibromochloromethane | 80 | 0.13 | 0 | 2 | 2 | 3 | 0.17 | 0.2 | 31SW14 |
| Methylene chloride | 5 | 4.1 | 0 | 0 | 2 | 3 | 0.078 | 0.11 | 31SW10 |
| ***PAHs (ug/L)*** | | | | | | | | | |
| 2-Methylnaphthalene | na | 2.4 | na | 0 | 1 | 3 | 0.031 | 0.031 | 31SW10 |
| Naphthalene | na | 0.65 | na | 0 | 3 | 6 | 0.022 | 0.031 | 31SW10 |
| Pyrene | na | 18 | na | 0 | 1 | 6 | 0.026 | 0.026 | 31SW14 |
| ***SVOCs (ug/L)*** | | | | | | | | | |
| 1,2-Dichlorobenzene | 600 | 27 | 0 | 0 | 1 | 6 | 0.25 | 0.25 | 31SW10 |
| 1,3-Dichlorobenzene | na | 18 | na | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| 1,4-Dichlorobenzene | 75 | 0.47 | 0 | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| Benzoic acid | na | 15000 | 0 | 0 | 3 | 6 | 3.4 | 12 | 31SW10 |
| bis(2-Ethylhexyl)phthalate | 6 | 4.8 | 2 | 3 | 3 | 6 | 5.1 | 11 | 31SW10 |
| Butylbenzylphthalate | na | 730 | na | 0 | 2 | 6 | 0.5 | 1.2 | 31SW10 |
| Diethylphthalate | na | 2900 | na | 0 | 3 | 6 | 2 | 8 | 31SW3 |
| Di-n-butylphthalate | na | 360 | na | 0 | 2 | 6 | 0.74 | 1 | 31SW1 |
| Hexachlorobutadiene | na | 0.73 | na | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| Hexachloroethane | na | 3.7 | na | 0 | 1 | 6 | 0.27 | 0.27 | 31SW10 |
| Naphthalene | na | 0.65 | na | 0 | 1 | 3 | 0.23 | 0.23 | 31SW10 |
| ***Pesticides (ug/L)*** | | | | | | | | | |
| alpha-BHC | na | 0.011 | na | 0 | 2 | 3 | 0.00885 | 0.00915 | 31SW14 |
| delta-BHC | na | na | 0 | na | 2 | 3 | 0.0142 | 0.0149 | 31SW12 |
| Endosulfan II | na | 22 | na | 0 | 1 | 3 | 0.076 | 0.076 | 31SW10 |
| Endrin | 2 | 1.1 | 0 | 0 | 1 | 3 | 0.0834 | 0.0834 | 31SW10 |
| Lindane | na | 0.052 | 0 | 0 | 1 | 3 | 0.00719 | 0.00719 | 31SW14 |
| ***PCBs (ug/L)*** | | ***PCBs were not detected in the surface water samples.*** | | | | | | | |
| ***Explosives (ug/L)*** | | | | | | | | | |
| Nitrobenzene | na | 0.35 | na | 0 | 1 | 3 | 0.1 | 0.1 | 31SW10 |
| ***Herbicides (ug/L)*** | | | | | | | | | |
| 2,4,5-TP (Silvex) | 50 | 29 | 0 | 0 | 1 | 3 | 0.029 | 0.029 | 31SW14 |
| Dicamba | na | 110 | na | 0 | 1 | 3 | 0.154 | 0.154 | 31SW14 |
| ***Metals (ug/L)*** | | | | | | | | | |
| Aluminum | 50 | na | 6 | na | 6 | 6 | 297 | 13200 | 31SW14 |
| Antimony | 6 | 1.5 | 0 | 0 | 3 | 6 | 0.58 | 1.1 | 31SW10 |
| Barium | 2000 | 730 | 0 | 0 | 6 | 6 | 17.5 | 35.6 | 31SW14 |
| Cadmium | 5 | 1.8 | 0 | 0 | 3 | 6 | 0.095 | 0.15 | 31SW14 |
| Calcium | na | na | na | na | 6 | 6 | 9710 | 15800 | 31SW14 |
| Chromium | 100 | 11 | 0 | 0 | 1 | 6 | 4.7 | 4.7 | 31SW14 |
| Copper | 1300 | 150 | 0 | 0 | 3 | 6 | 7 | 19.7 | 31SW1 |
| Iron | 300 | 1100 | 2 | 1 | 6 | 6 | 39.5 | 1540 | 31SW14 |
| Lead | 15 | na | 0 | na | 3 | 6 | 0.52 | 6.01 | 31SW14 |
| Magnesium | na | na | na | na | 6 | 6 | 3670 | 5760 | 31SW14 |
| Manganese | 50 | 73 | 2 | 2 | 6 | 6 | 7.6 | 263 | 31SW14 |
| Mercury | 2 | 1.1 | 0 | 0 | 2 | 6 | 0.083 | 0.186 | 31SW14 |
| Nickel | na | 73 | na | 0 | 1 | 6 | 4.1 | 4.1 | 31SW3 |
| Potassium | na | na | na | na | 6 | 6 | 1110 | 1900 | 31SW14 |
| Selenium | 50 | 18 | 0 | 0 | 1 | 6 | 4.6 | 4.6 | 31SW2 |
| Silver | 100 | 18 | 0 | 0 | 3 | 6 | 6.3 | 7.3 | 31SW10 |
| Sodium | na | na | na | na | 6 | 6 | 5700 | 11900 | 31SW10 |
| Thallium | 2 | 0.26 | 0 | 0 | 3 | 6 | 0.076 | 0.14 | 31SW10 |
| Vanadium | na | 3.7 | na | 0 | 1 | 6 | 1.2 | 1.2 | 31SW1 |
| Zinc | 5000 | 1100 | 0 | 0 | 4 | 6 | 3 | 16 | 31SW14 |
| ***Misc.*** | | | | | | | | | |
| Hardness | na | na | 3 | 3 | 3 | 3 | 55400 | 63200 | 31SW14 |
| Total Organic Carbon (ug/L) | na | na | 3 | 3 | 3 | 3 | 1710 | 5080 | 31SW14 |

## Table 3-8
## SWMU 31
## Detected Constituents in Sediment Summary

| Analyte | i-RBC | r-RBC | Background | SSL Transfer | # of i-RBC Exceedances | # of r-RBC Exceedances | # of Background Exceedances | # of SSL Transfer Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***VOCs (ug/kg)*** | | | | | | | | | | | | | |
| Acetone | 92000000 | 7000000 | na | 22000 | 0 | 0 | na | 0 | 1 | 3 | 120 | 120 | 31SE11B |
| ***PAHs (ug/kg)*** | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 410000 | 31000 | na | 4400 | 0 | 0 | na | 0 | 11 | 11 | 1.1 | 1300 | 31SE8A |
| Acenaphthene | 6100000 | 470000 | na | 100000 | 0 | 0 | na | 0 | 8 | 14 | 2.9 | 280 | 31SL2-2 |
| Acenaphthylene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 7 | 14 | 2.8 | 46 | 31SE11A |
| Anthracene | 31000000 | 2300000 | na | 470000 | 0 | 0 | na | 0 | 7 | 14 | 5.4 | 59 | 31SE8A |
| Benz(a)anthracene | 3900 | 220 | na | 480 | 0 | 1 | na | 0 | 8 | 14 | 9.5 | 1100 | 31SE12B |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 1 | 7 | na | 1 | 10 | 14 | 6.8 | 840 | 31SE12B |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1500 | 0 | 1 | na | 0 | 8 | 14 | 12 | 1300 | 31SE12B |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 8 | 14 | 5.6 | 260 | 31SE12B |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 0 | 0 | na | 0 | 9 | 14 | 2.3 | 340 | 31SE12B |
| Chrysene | 390000 | 22000 | na | 48000 | 0 | 0 | na | 0 | 9 | 14 | 10 | 860 | 31SE12B |
| Dibenz(a,h)anthracene | 390 | 22 | na | 460 | 0 | 1 | na | 0 | 6 | 14 | 1 | 100 | 31SE12B |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 0 | 0 | na | 0 | 11 | 14 | 10 | 240 | 31SE12B |
| Fluorene | 4100000 | 310000 | na | 140000 | 0 | 0 | na | 0 | 8 | 14 | 0.93 | 87 | 31SE8A |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 0 | 1 | na | 0 | 10 | 14 | 3.6 | 260 | 31SE12B |
| Naphthalene | 2000000 | 160000 | na | 150 | 0 | 0 | na | 4 | 11 | 14 | 1.5 | 690 | 31SE8A |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 12 | 14 | 0.88 | 710 | 31SE8A |
| Pyrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 12 | 14 | 1.2 | 370 | 31SE12B |
| ***SVOCs (ug/kg)*** | | | | | | | | | | | | | |
| 1,2-Dichlorobenzene | 9200000 | 700000 | na | 4600 | 0 | 0 | na | 0 | 1 | 17 | 3460 | 3460 | 31SL3 |
| 2,4-Dimethylphenol | 2000000 | 160000 | na | 6700 | 0 | 0 | na | 0 | 2 | 17 | 120 | 200 | 31SE11B |
| 2-Methylnaphthalene | 410000 | 31000 | na | 4400 | 0 | 0 | na | 0 | 9 | 17 | 100 | 1530 | 31SL3 |
| 2-Methylphenol | 5100000 | 390000 | na | na | 0 | 0 | na | na | 5 | 17 | 11 | 140 | 31SE11B |
| 4-Methylphenol | 510000 | 39000 | na | na | 0 | 0 | na | na | 6 | 17 | 19 | 230 | 31SE11B |
| Acenaphthene | 6100000 | 470000 | na | 100000 | 0 | 0 | na | 0 | 2 | 14 | 40 | 42 | 31SE12B |
| Anthracene | 31000000 | 2300000 | na | 470000 | 0 | 0 | na | 0 | 5 | 14 | 9.3 | 94 | 31SE11B |
| Benz(a)anthracene | 3900 | 220 | na | 480 | 0 | 1 | na | 0 | 7 | 14 | 18 | 220 | 31SE11B |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 0 | 5 | na | 0 | 5 | 14 | 25 | 180 | 31SE11B |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1500 | 0 | 0 | na | 0 | 5 | 14 | 31 | 170 | 31SE11B |
| Benzo(g,h,i)perylene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 4 | 14 | 39 | 170 | 31SE12B |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 0 | 0 | na | 0 | 4 | 14 | 14 | 42 | 31SE11B |
| Benzoic acid | 410000000 | 31000000 | na | na | 0 | 0 | na | na | 4 | 17 | 340 | 1200 | 31SE13A |
| bis(2-Ethylhexyl)phthalate | 200000 | 46000 | na | 2900000 | 0 | 0 | na | 0 | 11 | 17 | 20 | 500 | 31SE13A |
| Butylbenzylphthalate | 20000000 | 1600000 | na | 17000000 | 0 | 0 | na | 0 | 1 | 17 | 23 | 23 | 31SE14B |
| Carbazole | 140000 | 32000 | na | 470 | 0 | 0 | na | 0 | 4 | 17 | 20 | 79 | 31SE11B |
| Chrysene | 390000 | 22000 | na | 48000 | 0 | 0 | na | 0 | 5 | 14 | 33 | 280 | 31SE11B |
| Dibenz(a,h)anthracene | 390 | 22 | na | 460 | 0 | 0 | na | 0 | 1 | 14 | 16 | 16 | 31SE10B |
| Dibenzofuran | na | na | na | 3800 | na | na | na | 0 | 7 | 17 | 23 | 300 | 31SE11B |
| Di-n-butylphthalate | 10000000 | 780000 | na | 5000000 | 0 | 0 | na | 0 | 1 | 17 | 430 | 430 | 31SL3-2 |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 0 | 0 | na | 0 | 8 | 11 | 12 | 200 | 31SL1 |
| Fluorene | 4100000 | 310000 | na | 140000 | 0 | 0 | na | 0 | 4 | 11 | 11 | 160 | 31SE11B |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 0 | 0 | na | 0 | 4 | 11 | 29 | 110 | 31SE12B |
| Naphthalene | 2000000 | 160000 | na | 150 | 0 | 0 | na | 4 | 9 | 11 | 63 | 1330 | 31SL3 |
| N-nitrosodiphenylamine | 580000 | 130000 | na | 760 | 0 | 0 | na | 0 | 4 | 17 | 13 | 230 | 31SE11B |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 9 | 14 | 59 | 1180 | 31SL3 |
| Pyrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 6 | 14 | 12 | 230 | 31SE11B |

**Table 3-8**
**SWMU 31**
**Detected Constituents in Sediment Summary**

| Analyte | i-RBC | r-RBC | Background | SSL Transfer | # of i-RBC Exceedances | # of r-RBC Exceedances | # of Background Exceedances | # of SSL Transfer Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Pesticides (ug/kg)*** | | | | | | | | | | | | | |
| 4,4'-DDD | 12000 | 2700 | na | 11000 | 0 | 0 | na | 0 | 2 | 3 | 0.21 | 0.7 | 31SE11B |
| 4,4'-DDE | 8400 | 1900 | na | 35000 | 0 | 0 | na | 0 | 1 | 3 | 1.76 | 1.76 | 31SE11B |
| 4,4'-DDT | 8400 | 1900 | na | 1200 | 0 | 0 | na | 0 | 1 | 3 | 0.979 | 0.979 | 31SE10B |
| alpha-Chlordane | 8200 | 1800 | na | 920 | 0 | 0 | na | 0 | 1 | 3 | 0.574 | 0.574 | 31SE10B |
| Endrin | 31000 | 2300 | na | 5400 | 0 | 0 | na | 0 | 1 | 3 | 0.978 | 0.978 | 31SE11B |
| Methoxychlor | 510000 | 39000 | na | 310000 | 0 | 0 | na | 0 | 1 | 3 | 1.45 | 1.45 | 31SE10B |
| ***PCBs (mg/kg)*** | ***PCBs were not detected in the sediment samples.*** | | | | | | | | | | | | |
| ***Explosives (mg/kg)*** | | | | | | | | | | | | | |
| 1,3,5-Trinitrobenzene | 3100 | 230 | na | na | 0 | 0 | na | na | 2 | 11 | 0.081 | 0.167 | 31SE12B |
| 2,4,6-Trinitrotoluene | 51 | 3.9 | na | na | 0 | 0 | na | na | 1 | 11 | 0.21 | 0.21 | 31SE11A |
| Nitrobenzene | 51 | 3.9 | na | 0.023 | 0 | 0 | na | 1 | 1 | 11 | 0.15 | 0.15 | 31SE11A |
| ***Herbicides (ug/kg)*** | | | | | | | | | | | | | |
| 2,4-DB | 820000 | 63000 | na | na | 0 | 0 | na | na | 1 | 3 | 107 | 107 | 31SE11B |
| ***Metals (mg/kg)*** | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | na | na | 5 | na | 17 | 17 | 7260 | 108000 | 31SL1-2 |
| Antimony | 41 | 3.1 | na | 13 | 0 | 1 | na | 0 | 5 | 17 | 0.47 | 3.5 | 31SE11A |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 0 | 0 | 0 | 0 | 14 | 17 | 2.3 | 13.1 | 31SE14C |
| Barium | 20000 | 1600 | 209 | 6000 | 0 | 0 | 1 | 0 | 17 | 17 | 71.8 | 1140 | 31SE10B |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0 | 0 | 8 | 0 | 16 | 17 | 0.629 | 3.09 | 31SE14B |
| Cadmium | 51 | 3.9 | 0.69 | 27 | 0 | 0 | 0 | 0 | 5 | 17 | 0.073 | 0.399 | 31SE12B |
| Calcium | na | na | na | na | na | na | na | na | 17 | 17 | 654 | 11000 | 31SE10B |
| Chromium | 310 | 23 | 65.3 | 42 | 0 | 0 | 0 | 0 | 16 | 17 | 13 | 56.6 | 31SE13A |
| Cobalt | na | na | 72.3 | na | na | na | 0 | na | 17 | 17 | 6.2 | 25 | 31SE12B |
| Copper | 4100 | 310 | 53.5 | 11000 | 0 | 0 | 3 | 0 | 17 | 17 | 11.3 | 96.6 | 31SL2-2 |
| Iron | 31000 | 2300 | 50962 | na | 0 | 0 | 0 | na | 17 | 17 | 6990 | 33800 | 31SE13B |
| Lead | 800 | 400 | 26.8 | na | 0 | 0 | 8 | na | 14 | 17 | 14.2 | 98.2 | 31SE13A |
| Magnesium | na | na | na | na | na | na | na | na | 17 | 17 | 605 | 8890 | 31SE10B |
| Manganese | 2000 | 160 | 2543 | 950 | 0 | 0 | 0 | 0 | 17 | 17 | 49.3 | 684 | 31SE13B |
| Mercury | 31 | 2.3 | 0.13 | na | 0 | 0 | 5 | na | 11 | 17 | 0.029 | 0.53 | 31SE11A |
| Nickel | 2000 | 160 | 62.8 | na | 0 | 0 | 0 | na | 17 | 17 | 11.3 | 32.6 | 31SL3-2 |
| Potassium | na | na | na | na | na | na | na | na | 17 | 17 | 600 | 3080 | 31SE7B |
| Selenium | 510 | 39 | na | 19 | 0 | 0 | na | 0 | 3 | 17 | 0.64 | 2.3 | 31SE13A |
| Silver | 510 | 39 | na | 31 | 0 | 0 | na | 0 | 1 | 17 | 1.2 | 1.2 | 31SL2 |
| Sodium | na | na | na | na | na | na | na | na | 17 | 17 | 34.1 | 1010 | 31SL2-2 |
| Thallium | 7.2 | 0.55 | 2.11 | 3.6 | 1 | 1 | 1 | 1 | 12 | 17 | 0.16 | 14.5 | 31SL2 |
| Vanadium | 102 | 7.8 | 108 | 730 | 0 | 0 | 0 | 0 | 17 | 17 | 20 | 68 | 31SE13A |
| Zinc | 31000 | 2300 | 202 | 14000 | 0 | 0 | 0 | 0 | 17 | 17 | 36.4 | 180 | 31SL2-2 |
| ***Misc.*** | | | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | na | na | na | na | na | 11 | 11 | 750 | 185000 | 31SE14B |
| pH | na | na | na | na | na | na | na | na | 11 | 11 | 6.14 | 7.03 | 31SE7B |

### Table 3-8
### SWMU 31
### Detected Constituents in Sediment Summary

| Analyte | i-RBC | r-RBC | Background | SSL Transfer | # of i-RBC Exceedances | # of r-RBC Exceedances | # of Background Exceedances | # of SSL Transfer Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Dioxins/Furans (ng/kg)*** | | | | | | | | | | | | | |
| 2,3,7,8-TCDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.312 | 0.342 | 31SE11B |
| 2,3,7,8-TCDD | 19 | 4.3 | na | 8.6 | 0 | 0 | na | 0 | 1 | 3 | 0.426 | 0.426 | 31SE13B |
| 1,2,3,7,8-PECDD | na | na | na | na | na | na | na | na | 2 | 3 | 0.795 | 1.973 | 31SE13B |
| 1,2,3,4,7,8-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 1 | 3 | 1.963 | 1.963 | 31SE11B |
| 1,2,3,6,7,8-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 2 | 3 | 1.194 | 3.576 | 31SE11B |
| 1,2,3,7,8,9-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 2 | 3 | 0.312 | 4.105 | 31SE11B |
| 1,2,3,4,6,7,8-HPCDD | na | na | na | na | na | na | na | na | 3 | 3 | 7.494 | 89.11 | 31SE11B |
| OCDD | na | na | na | na | na | na | na | na | 3 | 3 | 639.6 | 1431 | 31SE11B |
| 1,2,3,7,8-PECDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.225 | 0.748 | 31SE13B |
| 2,3,4,7,8-PECDF | na | na | na | na | na | na | na | na | 1 | 3 | 0.294 | 0.294 | 31SE11B |
| 1,2,3,4,7,8-HXCDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.135 | 5.039 | 31SE11B |
| 1,2,3,6,7,8-HXCDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.472 | 0.991 | 31SE13B |
| 2,3,4,6,7,8-HXCDF | na | na | na | na | na | na | na | na | 1 | 3 | 0.794 | 0.794 | 31SE11B |
| 1,2,3,7,8,9-HXCDF | na | na | na | na | na | na | na | na | 0 | 3 | na | na | na |
| 1,2,3,4,6,7,8-HPCDF | na | na | na | na | na | na | na | na | 3 | 3 | 1.461 | 14.69 | 31SE11B |
| 1,2,3,4,7,8,9-HPCDF | na | na | na | na | na | na | na | na | 1 | 3 | 1.206 | 1.206 | 31SE11B |
| OCDF | na | na | na | na | na | na | na | na | 3 | 3 | 2.384 | 41.83 | 31SE11B |
| TOTAL TCDD | na | na | na | na | na | na | na | na | 2 | 3 | 0.409 | 0.426 | 31SE13B |
| TOTAL PECDD | na | na | na | na | na | na | na | na | 2 | 3 | 0.795 | 1.973 | 31SE13B |
| TOTAL HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 3 | 3 | 1.194 | 24.33 | 31SE11B |
| TOTAL HPCDD | na | na | na | na | na | na | na | na | 3 | 3 | 13.82 | 152.6 | 31SE11B |
| TOTAL TCDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.312 | 3.831 | 31SE11B |
| TOTAL PECDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.748 | 4.782 | 31SE11B |
| TOTAL HXCDF | na | na | na | na | na | na | na | na | 3 | 3 | 0.709 | 24.42 | 31SE11B |
| TOTAL HPCDF | na | na | na | na | na | na | na | na | 3 | 3 | 1.928 | 47.13 | 31SE11B |
| TCDD TE | 19 | 4.3 | na | 8.6 | 0 | 0 | na | 0 | 3 | 3 | 0.8487 | 3.881 | 31SE11B |
| TCDD RME | 19 | 4.3 | na | 8.6 | 0 | 0 | na | 0 | 3 | 3 | 0.5227 | 3.83 | 31SE11B |

### Table 3-9
### SWMU 31
### Detected Consituents in Soil Summary

| Analyte | i-RBC | r-RBC | Background | SSL Transfer | # of i-RBC exceedances | # of r-RBC exceedances | # of Background exceedances | # of SSL Transfer exceedances | # of detections | # of samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***VOCs (ug/kg)*** | | | | | | | | | | | | | |
| Acetone | 92000000 | 7000000 | na | 22000 | 0 | 0 | na | 0 | 1 | 3 | 42 | 42 | 31SB05C |
| ***PAHs (ug/kg)*** | | | | | | | | | | | | | |
| Benz(a)anthracene | 3900 | 220 | na | 480 | 0 | 0 | na | 0 | 1 | 8 | 5.2 | 5.2 | 31SB2A |
| Benzo(a)pyrene | 390 | 22 | na | 120 | 0 | 0 | na | 0 | 2 | 8 | 1.2 | 8.7 | 31SB2A |
| Benzo(b)fluoranthene | 3900 | 220 | na | 1500 | 0 | 0 | na | 0 | 1 | 8 | 9.3 | 9.3 | 31SB2A |
| Benzo(k)fluoranthene | 39000 | 2200 | na | 15000 | 0 | 0 | na | 0 | 1 | 8 | 3.3 | 3.3 | 31SB2A |
| Chrysene | 390000 | 22000 | na | 48000 | 0 | 0 | na | 0 | 1 | 8 | 7.1 | 7.1 | 31SB2A |
| Fluoranthene | 4100000 | 310000 | na | 6300000 | 0 | 0 | na | 0 | 1 | 8 | 8.1 | 8.1 | 31SB2A |
| Indeno(1,2,3-cd)pyrene | 3900 | 220 | na | 4200 | 0 | 0 | na | 0 | 1 | 8 | 7.5 | 7.5 | 31SB2A |
| Phenanthrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 1 | 8 | 4.8 | 4.8 | 31SB2A |
| Pyrene | 3100000 | 230000 | na | 680000 | 0 | 0 | na | 0 | 1 | 8 | 12 | 12 | 31SB2A |
| ***SVOCs (ug/kg)*** | | | | | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 200000 | 46000 | na | 2900000 | 0 | 0 | na | 0 | 3 | 8 | 54 | 110 | 31SB4B |
| Di-n-butylphthalate | 10000000 | 780000 | na | 5000000 | 0 | 0 | na | 0 | 4 | 8 | 70 | 110 | 31SB4A |
| ***Pesticides (ug/kg)*** | | | | | | | | | | | | | |
| 4,4'-DDD | 12000 | 2700 | na | 11000 | 0 | 0 | na | 0 | 2 | 3 | 0.307 | 0.698 | 31SB05A |
| 4,4'-DDE | 8400 | 1900 | na | 35000 | 0 | 0 | na | 0 | 1 | 3 | 2.26 | 2.26 | 31SB05A |
| 4,4'-DDT | 8400 | 1900 | na | 1200 | 0 | 0 | na | 0 | 1 | 3 | 13.3 | 13.3 | 31SB05A |
| Endosulfan II | 610000 | 47000 | na | 20000 | 0 | 0 | na | 0 | 1 | 3 | 2.28 | 2.28 | 31SB05A |
| Endosulfan sulfate | na | na | na | na | na | na | na | na | 1 | 3 | 0.893 | 0.893 | 31SB05A |
| Endrin aldehyde | na | na | na | na | na | na | na | na | 1 | 3 | 1.79 | 1.79 | 31SB05A |
| Endrin | 31000 | 2300 | na | 5400 | 0 | 0 | na | 0 | 1 | 3 | 0.271 | 0.271 | 31SB05C |
| Methoxychlor | 510000 | 39000 | na | 310000 | 0 | 0 | na | 0 | 2 | 3 | 0.889 | 7.65 | 31SB05A |
| ***PCBs (mg/kg)*** | | | | | | | | | | | | | |
| PCB-1254 | 1.4 | 0.16 | na | 1.1 | 0 | 0 | na | 0 | 1 | 3 | 0.0931 | 0.0931 | 31SB05A |
| ***Explosives (mg/kg)*** | | | | | | | | | | | | | |
| Nitroglycerin | 1700 | 130 | na | na | na | na | na | na | 1 | 3 | 0.42 | 0.42 | 31SB05A |
| ***Herbicides (ug/kg)*** | | | | | | ***Herbicides were not detected in the soil samples.*** | | | | | | | |
| ***Metals (mg/kg)*** | | | | | | | | | | | | | |
| Aluminum | na | na | 40041 | na | na | na | 0 | na | 11 | 11 | 5300 | 30500 | 31SB2A |
| Antimony | 41 | 3.1 | na | 13 | 0 | 0 | na | 0 | 10 | 11 | 0.26 | 1.7 | 31SB2A |
| Arsenic | 1.9 | 0.43 | 15.8 | 0.026 | 0 | 0 | 0 | 0 | 11 | 19 | 0.807 | 6 | 31SB4B |
| Barium | 20000 | 1600 | 209 | 6000 | 0 | 0 | 0 | 0 | 19 | 19 | 15.9 | 138 | 31SB2A |
| Beryllium | 200 | 16 | 1.02 | 1200 | 0 | 0 | 2 | 0 | 19 | 19 | 0.16 | 11 | 31MW1B35 |
| Cadmium | 51 | 3.9 | 0.69 | 27 | 0 | 0 | 0 | 0 | 3 | 11 | 0.083 | 0.462 | 31SB05A |
| Calcium | na | na | na | na | na | na | na | na | 11 | 11 | 725 | 175000 | 31SB2B |
| Chromium | 310 | 23 | 65.3 | 42 | 0 | 0 | 0 | 0 | 19 | 19 | 7 | 59.2 | 31SB1C |
| Cobalt | na | na | 72.3 | na | na | na | 0 | na | 11 | 11 | 1.5 | 21.6 | 31SB1C |
| Copper | 4100 | 310 | 53.5 | 11000 | 0 | 0 | 0 | 0 | 10 | 11 | 6.1 | 18.2 | 31SB05C |
| Iron | 31000 | 2300 | 50962 | na | 0 | 0 | 0 | na | 11 | 11 | 4490 | 40200 | 31SB1C |
| Lead | 800 | 400 | 26.8 | na | 0 | 0 | 3 | na | 19 | 19 | 0.52 | 36 | 31MW3B20 |
| Magnesium | na | na | na | na | na | na | na | na | 11 | 11 | 1850 | 107000 | 31SB2B |
| Manganese | 2000 | 160 | 2543 | 950 | 0 | 0 | 0 | 0 | 11 | 11 | 76.5 | 857 | 31SB1C |
| Mercury | 31 | 2.3 | 0.13 | na | 0 | 0 | 1 | na | 5 | 19 | 0.027 | 0.155 | 31MW3A10 |
| Nickel | 2000 | 160 | 62.8 | na | 0 | 0 | 0 | na | 19 | 19 | 2.9 | 42.4 | 31SB1A |
| Potassium | na | na | na | na | na | na | na | na | 11 | 11 | 938 | 5270 | 31SB2B |
| Selenium | 510 | 39 | na | 19 | 0 | 0 | na | 0 | 1 | 11 | 0.46 | 0.46 | 31SB05A |
| Silver | 510 | 39 | na | 31 | 0 | 0 | na | 0 | 4 | 19 | 0.021 | 0.92 | 31SB05B |
| Sodium | na | na | na | na | na | na | na | na | 11 | 11 | 29.8 | 404 | 31SB2B |
| Thallium | 7.2 | 0.55 | 2.11 | 3.6 | 0 | 0 | 0 | 0 | 3 | 11 | 0.23 | 0.34 | 31SB05A |
| Vanadium | 102 | 7.8 | 108 | 730 | 0 | 0 | 0 | 0 | 11 | 11 | 10.5 | 71.4 | 31SB2A |
| Zinc | 31000 | 2300 | 202 | 14000 | 0 | 0 | 0 | 0 | 10 | 11 | 11.9 | 98.5 | 31SB05A |
| ***Misc.*** | | | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | na | na | na | na | na | 2 | 3 | 5910 | 53300 | 31SB05A |
| pH | na | na | na | na | na | na | na | na | 3 | 3 | 6.96 | 7.37 | 31SB05A |

# Table 3-9
## SWMU 31
## Detected Consituents in Soil Summary

| Analyte | i-RBC | r-RBC | Background | SSL Transfer | # of i-RBC exceedances | # of r-RBC exceedances | # of Background exceedances | # of SSL Transfer exceedances | # of detections | # of samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Dioxins/Furans (ng/kg)*** | | | | | | | | | | | | | |
| 2,3,7,8-TCDF | na | na | na | na | na | na | na | na | 1 | 3 | 0.74 | 0.74 | 31SB05A |
| 2,3,7,8-TCDD | 19 | 4.3 | na | 8.6 | 0 | 0 | na | 0 | 1 | 3 | 0.713 | 0.713 | 31SB05A |
| 1,2,3,7,8-PECDD | na | na | na | na | na | na | na | na | 1 | 3 | 1.633 | 1.633 | 31SB05A |
| 1,2,3,4,7,8-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 2 | 3 | 0.116 | 4.049 | 31SB05A |
| 1,2,3,6,7,8-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 3 | 3 | 0.135 | 6.711 | 31SB05A |
| 1,2,3,7,8,9-HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 3 | 3 | 0.381 | 8.482 | 31SB05A |
| 1,2,3,4,6,7,8-HPCDD | na | na | na | na | na | na | na | na | 3 | 3 | 7.732 | 191.4 | 31SB05A |
| OCDD | na | na | na | na | na | na | na | na | 3 | 3 | 538.9 | 1851 | 31SB05A |
| 1,2,3,7,8-PECDF | na | na | na | na | na | na | na | na | 1 | 3 | 0.559 | 0.559 | 31SB05A |
| 2,3,4,7,8-PECDF | na | na | na | na | na | na | na | na | 1 | 3 | 0.678 | 0.678 | 31SB05A |
| 1,2,3,4,7,8-HXCDF | na | na | na | na | na | na | na | na | 3 | 3 | 0.221 | 8.597 | 31SB05A |
| 1,2,3,6,7,8-HXCDF | na | na | na | na | na | na | na | na | 1 | 3 | 1.235 | 1.235 | 31SB05A |
| 2,3,4,6,7,8-HXCDF | na | na | na | na | na | na | na | na | 1 | 3 | 1.572 | 1.572 | 31SB05A |
| 1,2,3,7,8,9-HXCDF | na | na | na | na | na | na | na | na | 0 | 3 | na | na | na |
| 1,2,3,4,6,7,8-HPCDF | na | na | na | na | na | na | na | na | 3 | 3 | 0.965 | 37.59 | 31SB05A |
| 1,2,3,4,7,8,9-HPCDF | na | na | na | na | na | na | na | na | 1 | 3 | 2.5 | 2.5 | 31SB05A |
| OCDF | na | na | na | na | na | na | na | na | 3 | 3 | 3.453 | 127.6 | 31SB05A |
| TOTAL TCDD | na | na | na | na | na | na | na | na | 1 | 3 | 2.084 | 2.084 | 31SB05A |
| TOTAL PECDD | na | na | na | na | na | na | na | na | 1 | 3 | 1.94 | 1.94 | 31SB05A |
| TOTAL HXCDD | 460 | 100 | na | na | 0 | 0 | na | na | 3 | 3 | 1.292 | 79.31 | 31SB05A |
| TOTAL HPCDD | na | na | na | na | na | na | na | na | 3 | 3 | 14.03 | 454.2 | 31SB05A |
| TOTAL TCDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.085 | 5.142 | 31SB05A |
| TOTAL PECDF | na | na | na | na | na | na | na | na | 2 | 3 | 0.092 | 13.04 | 31SB05A |
| TOTAL HXCDF | na | na | na | na | na | na | na | na | 3 | 3 | 0.976 | 53.43 | 31SB05A |
| TOTAL HPCDF | na | na | na | na | na | na | na | na | 2 | 3 | 1.112 | 40.09 | 31SB05A |
| TCDD TE | 19 | 4.3 | na | 8.6 | 0 | 1 | na | 0 | 3 | 3 | 0.3175 | 8.375 | 31SB05A |
| TCDD RME | 19 | 4.3 | na | 8.6 | 0 | 1 | na | 0 | 3 | 3 | 0.2664 | 8.37 | 31SB05A |

## Table 3-10
## SWMU 31
## Detected Constituents in Groundwater Summary

| Analyte | MCL | tw-RBC | # of MCL Exceedances | # of tw-RBC Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|
| ***VOCs (ug/L)*** | | | | | | | | | |
| Carbon disulfide | na | 100 | na | 0 | 3 | 3 | 0.091 | 0.2 | 31MW04 |
| Chloroform | 80 | 0.15 | 0 | 2 | 2 | 3 | 6.3 | 11 | 31MW04 |
| ***PAHs (ug/L)*** | | | | | | | | | |
| 2-Methylnaphthalene | na | 2.4 | na | 0 | 1 | 3 | 0.061 | 0.061 | 31MW3 |
| Acenaphthene | na | 36 | na | 0 | 1 | 7 | 0.038 | 0.038 | 31MW3 |
| Acenaphthylene | na | 18 | na | 0 | 1 | 7 | 0.027 | 0.027 | 31MW3 |
| Benz(a)anthracene | na | 0.03 | na | 0 | 1 | 7 | 0.022 | 0.022 | 31MW2-2 |
| Benzo(a)pyrene | 0.2 | 0.003 | 0 | 2 | 2 | 7 | 0.022 | 0.061 | 31MW3-2 |
| Benzo(b)fluoranthene | na | 0.03 | na | 1 | 2 | 7 | 0.027 | 0.066 | 31MW3-2 |
| Fluorene | na | 24 | na | 0 | 1 | 7 | 0.024 | 0.024 | 31MW3 |
| Naphthalene | na | 0.65 | na | 0 | 3 | 7 | 0.028 | 0.062 | 31MW3 |
| ***SVOCs (ug/L)*** | | | | | | | | | |
| bis(2-Ethylhexyl)phthalate | 6 | 4.8 | 1 | 2 | 4 | 7 | 4.4 | 7.4 | 31MW04 |
| ***Pesticides (ug/L)*** | | | | | | | | | |
| Endrin ketone | na | na | na | na | 1 | 3 | 0.00466 | 0.00466 | 31MW01 |
| ***PCBs (ug/L)*** | | ***PCBs were not detected in the groundwater samples.*** | | | | | | | |
| ***Explosives (ug/L)*** | | | | | | | | | |
| Nitroglycerin | na | na | na | na | 1 | 3 | 0.42 | 0.42 | 31MW01 |
| ***Herbicides (ug/L)*** | | ***Herbicides were not detected in the groundwater samples.*** | | | | | | | |
| ***Metals, Total (ug/L)*** | | | | | | | | | |
| Aluminum | 50 | na | 7 | na | 7 | 7 | 100 | 2680 | 31MW3-2 |
| Antimony | 6 | 1.5 | 0 | 0 | 2 | 11 | 0.4 | 0.54 | 31MW04 |
| Arsenic | 10 | 0.045 | 0 | 2 | 3 | 11 | 9.3 | 9.4 | 31MW3-2 |
| Barium | 2000 | 730 | 0 | 0 | 11 | 11 | 19.3 | 300 | 31MW1 |
| Beryllium | 4 | 7.3 | 4 | 0 | 8 | 11 | 1.1 | 6 | 31MW2 |
| Cadmium | 5 | 1.8 | 0 | 0 | 2 | 7 | 0.069 | 0.1 | 31MW3 |
| Calcium | na | na | na | na | 7 | 7 | 18100 | 76500 | 31MW01 |
| Chromium | 100 | 11 | 0 | 5 | 10 | 11 | 5.2 | 97.3 | 31MW2 |
| Cobalt | na | na | na | na | 3 | 7 | 2.1 | 3.8 | 31MW2-2 |
| Copper | 1300 | 150 | 0 | 0 | 5 | 7 | 11 | 37.3 | 31MW2-2 |
| Iron | 300 | 1100 | 4 | 2 | 7 | 7 | 78.1 | 7080 | 31MW2-2 |
| Lead | 15 | na | 2 | na | 10 | 11 | 0.52 | 41.8 | 31MW2 |
| Magnesium | na | na | na | na | 7 | 7 | 6600 | 54200 | 31MW01 |
| Manganese | 50 | 73 | 2 | 2 | 7 | 7 | 2 | 183 | 31MW3-2 |
| Mercury | 2 | 1.1 | 0 | 0 | 2 | 11 | 0.138 | 0.142 | 31MW4 |
| Nickel | na | 73 | na | 0 | 6 | 11 | 2.6 | 58.4 | 31MW3 |
| Potassium | na | na | na | na | 7 | 7 | 1060 | 31900 | 31MW1-2 |
| Selenium | 50 | 18 | 0 | 0 | 2 | 11 | 0.44 | 4.1 | 31MW1-2 |
| Silver | 100 | 18 | 0 | 0 | 3 | 7 | 5.7 | 6.8 | 31MW01 |
| Sodium | na | na | na | na | 7 | 7 | 5310 | 17600 | 31MW1-2 |
| Vanadium | na | 3.7 | na | 2 | 4 | 7 | 1.2 | 17.4 | 31MW3-2 |
| Zinc | 5000 | 1100 | 0 | 0 | 4 | 7 | 9.9 | 26.6 | 31MW2-2 |
| ***Metals, Filtered (ug/L)*** | | | | | | | | | |
| Aluminum | 50 | na | 6 | na | 7 | 7 | 29.7 | 215 | 31MW3 |
| Antimony | 6 | 1.5 | 1 | 1 | 3 | 15 | 0.42 | 65.2 | 31MW1 |
| Barium | 2000 | 730 | 0 | 1 | 15 | 15 | 14.4 | 264 | 31MW1 |
| Beryllium | 4 | 7.3 | 0 | 0 | 7 | 15 | 1.1 | 3.84 | 31MW1 |
| Cadmium | 5 | 1.8 | 0 | 0 | 1 | 7 | 0.082 | 0.082 | 31MW01 |
| Calcium | na | na | na | na | 7 | 7 | 17200 | 72300 | 31MW01 |
| Chromium | 100 | 11 | 0 | 0 | 7 | 15 | 1.1 | 7.3 | 31MW3 |
| Cobalt | na | na | na | na | 4 | 7 | 2.8 | 3.5 | 31MW2-2 |
| Copper | 1300 | 150 | 0 | 0 | 4 | 7 | 11.3 | 31.1 | 31MW2-2 |
| Iron | 300 | 1100 | 0 | 0 | 5 | 7 | 79.4 | 162 | 31MW3 |
| Lead | 15 | na | 0 | na | 4 | 15 | 0.45 | 7.58 | 31MW1 |
| Magnesium | na | na | na | na | 7 | 7 | 6270 | 53000 | 31MW01 |
| Manganese | 50 | 73 | 0 | 0 | 6 | 7 | 2 | 12.7 | 31MW2-2 |
| Nickel | na | 73 | na | 0 | 3 | 7 | 2.9 | 8.8 | 31MW1-2 |
| Potassium | na | na | na | na | 7 | 7 | 986 | 25400 | 31MW1-2 |
| Selenium | 50 | 18 | 0 | 0 | 3 | 15 | 0.47 | 5.4 | 31MW2 |
| Silver | 100 | 18 | 0 | 0 | 3 | 7 | 6.8 | 7.8 | 31MW3 |
| Sodium | na | na | na | na | 7 | 7 | 6420 | 14600 | 31MW1-2 |
| Vanadium | na | 3.7 | na | 0 | 3 | 7 | 1.9 | 2.6 | 31MW2-2 |
| Zinc | 5000 | 1100 | 0 | 0 | 4 | 7 | 2.5 | 9.9 | 31MW1-2 |
| ***Misc.*** | | | | | | | | | |
| Hardness | na | na | na | na | 3 | 3 | 80100 | 414000 | 31MW01 |
| Total Organic Carbon (ug/L) | na | na | na | na | 7 | 7 | 620 | 100000 | 31MW1-2 |
| Total Organic Halides (ug/L) | na | na | na | na | 1 | 4 | 110 | 110 | 31MW1-2 |

# Table 3-11
# SWMU 31
# BTAG Soil Screening Summary

| Analyte | BTAG Soil | Eco-SSLs | Background | # of BTAG Soil Exceedances | # of Eco-SSLs Exceedances | # of Background Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***VOCs (ug/kg)*** | | ***VOCs were not detected in the surface soil samples*** | | | | | | | | | |
| ***Pesticides (ug/kg)*** | | | | | | | | | | | |
| 4,4'-DDD | 100 | na | na | na | na | 0 | 1 | 2 | 0.698 | 0.698 | 31SB05A |
| 4,4'-DDE | 100 | na | na | na | na | 0 | 1 | 2 | 2.26 | 2.26 | 31SB05A |
| 4,4'-DDT | 100 | na | na | na | na | 0 | 1 | 2 | 13.3 | 13.3 | 31SB05A |
| Endosulfan II | na | na | na | na | na | na | 1 | 2 | 2.28 | 2.28 | 31SB05A |
| Endosulfan sulfate | na | na | na | na | na | na | 1 | 2 | 0.893 | 0.893 | 31SB05A |
| Endrin aldehyde | na | na | na | na | na | na | 1 | 2 | 1.79 | 1.79 | 31SB05A |
| Methoxychlor | 100 | na | na | na | na | 0 | 1 | 2 | 7.65 | 7.65 | 31SB05A |
| ***PCBs (mg/kg)*** | | | | | | | | | | | |
| PCB-1254 | 0.1 | na | na | na | na | 0 | 1 | 2 | 0.0931 | 0.0931 | 31SB05A |
| ***Explosives (mg/kg)*** | | | | | | | | | | | |
| Nitroglycerin | na | na | na | na | na | na | 1 | 2 | 0.42 | 0.42 | 31SB05A |
| ***Herbicides (ug/kg)*** | | ***Herbicides were not detected in the surface soil samples*** | | | | | | | | | |
| ***Metals (mg/kg)*** | | | | | | | | | | | |
| Aluminum | 1 | na | 40041 | na | 0 | 0 | 2 | 2 | 7210 | 15500 | 31SB05B |
| Antimony | 0.48 | 0.27 | na | 2 | na | 1 | 2 | 2 | 0.35 | 0.586 | 31SB05B |
| Arsenic | 328 | 18 | 15.8 | 0 | 0 | 0 | 2 | 2 | 1.07 | 5.9 | 31SB05A |
| Barium | 440 | 330 | 209 | 0 | 0 | 0 | 2 | 2 | 90.4 | 96.4 | 31SB05B |
| Beryllium | 0.02 | 21 | 1.02 | 0 | 0 | 0 | 2 | 2 | 0.634 | 0.735 | 31SB05B |
| Cadmium | 3 | 0.36 | 0.69 | 0 | 0 | 0 | 2 | 2 | 0.083 | 0.462 | 31SB05A |
| Calcium | na | na | na | na | na | na | 2 | 2 | 1960 | 56700 | 31SB05A |
| Chromium | 0.02 | 26 | 65.3 | 0 | 0 | 0 | 2 | 2 | 15.8 | 28.2 | 31SB05B |
| Cobalt | 0.1 | 13 | 72.3 | 0 | 0 | 0 | 2 | 2 | 7.69 | 17.8 | 31SB05B |
| Copper | 15 | na | 53.5 | na | 0 | 0 | 2 | 2 | 17.1 | 17.7 | 31SB05B |
| Iron | 3260 | na | 50962 | na | 0 | 0 | 2 | 2 | 9580 | 27800 | 31SB05B |
| Lead | 2 | 11 | 26.8 | 1 | 1 | 1 | 2 | 2 | 14.6 | 28 | 31SB05A |
| Magnesium | 4400 | na | na | na | na | 2 | 2 | 2 | 4650 | 25000 | 31SB05A |
| Manganese | 330 | na | 2543 | na | 0 | 0 | 2 | 2 | 203 | 495 | 31SB05B |
| Mercury | 0.058 | na | 0.13 | na | 0 | 0 | 2 | 2 | 0.035 | 0.121 | 31SB05A |
| Nickel | 2 | na | 62.8 | na | 0 | 0 | 2 | 2 | 11.5 | 14.8 | 31SB05B |
| Potassium | na | na | na | na | na | na | 2 | 2 | 938 | 2120 | 31SB05B |
| Selenium | 1.8 | na | na | na | na | 0 | 1 | 2 | 0.46 | 0.46 | 31SB05A |
| Silver | 0.0000098 | na | na | na | na | 2 | 2 | 2 | 0.59 | 0.92 | 31SB05B |
| Sodium | na | na | na | na | na | na | 2 | 2 | 29.8 | 77.5 | 31SB05A |
| Thallium | 0.001 | na | 2.11 | na | 0 | 0 | 2 | 2 | 0.23 | 0.34 | 31SB05A |
| Vanadium | 0.5 | 7.8 | 108 | 0 | 0 | 0 | 2 | 2 | 22 | 47.5 | 31SB05B |
| Zinc | 10 | na | 202 | na | 0 | 0 | 2 | 2 | 60.2 | 98.5 | 31SB05A |
| ***Misc.*** | | | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | na | na | na | 1 | 2 | 53300 | 53300 | 31SB05A |
| pH | na | na | na | na | na | na | 2 | 2 | 7.13 | 7.37 | 31SB05A |

# Table 3-12
# SWMU 31
# BTAG Surface Water Screening Summary
Page 1 of 2

| Analyte | BTAG Aqueous | # of BTAG Aqueous Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|
| ***VOCs (ug/L)*** | | | | | | | |
| Bromodichloromethane | na | na | 3 | 3 | 1.3 | 3.6 | 31SW14 |
| Carbon disulfide | 0.92 | 0 | 1 | 3 | 0.075 | 0.075 | 31SW10 |
| Chloroform | 1.8 | 3 | 3 | 3 | 16 | 30 | 31SW14 |
| Dibromochloromethane | na | na | 2 | 3 | 0.17 | 0.2 | 31SW14 |
| Methylene chloride | 98.1 | 0 | 2 | 3 | 0.078 | 0.11 | 31SW10 |
| ***PAHs (ug/L)*** | | | | | | | |
| 2-Methylnaphthalene | 4.7 | 0 | 1 | 3 | 0.031 | 0.031 | 31SW10 |
| Naphthalene | 1.1 | 0 | 3 | 6 | 0.022 | 0.031 | 31SW10 |
| Pyrene | 0.025 | 1 | 1 | 6 | 0.026 | 0.026 | 31SW14 |
| ***SVOCs (ug/L)*** | | | | | | | |
| 1,2-Dichlorobenzene | 0.7 | 0 | 1 | 6 | 0.25 | 0.25 | 31SW10 |
| 1,3-Dichlorobenzene | 150 | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| 1,4-Dichlorobenzene | 26 | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| Benzoic acid | 42 | 0 | 3 | 6 | 3.4 | 12 | 31SW10 |
| bis(2-Ethylhexyl)phthalate | 16 | 0 | 3 | 6 | 5.1 | 11 | 31SW10 |
| Butylbenzylphthalate | 19 | 0 | 2 | 6 | 0.5 | 1.2 | 31SW10 |
| Diethylphthalate | 210 | 0 | 3 | 6 | 2 | 8 | 31SW3 |
| Di-n-butylphthalate | 19 | 0 | 2 | 6 | 0.74 | 1 | 31SW1 |
| Hexachlorobutadiene | 1.3 | 0 | 1 | 6 | 0.26 | 0.26 | 31SW10 |
| Hexachloroethane | 12 | 0 | 1 | 6 | 0.27 | 0.27 | 31SW10 |
| Naphthalene | 1.1 | 0 | 1 | 3 | 0.23 | 0.23 | 31SW10 |
| ***Pesticides (ug/L)*** | | | | | | | |
| alpha-BHC | 2.2 | 0 | 2 | 3 | 0.00885 | 0.00915 | 31SW14 |
| delta-BHC | 141 | 0 | 2 | 3 | 0.0142 | 0.0149 | 31SW12 |
| Endosulfan II | 0.051 | 1 | 1 | 3 | 0.076 | 0.076 | 31SW10 |
| Endrin | 0.036 | 1 | 1 | 3 | 0.0834 | 0.0834 | 31SW10 |
| Lindane | 0.01 | 0 | 1 | 3 | 0.00719 | 0.00719 | 31SW14 |
| ***PCBs (ug/L)*** | | ***PCBs were not detected in the surface water samples*** | | | | | |
| ***Explosives (ug/L)*** | | | | | | | |
| Nitrobenzene | na | na | 1 | 3 | 0.1 | 0.1 | 31SW10 |

# Table 3-12
# SWMU 31
# BTAG Surface Water Screening Summary
Page 2 of 2

| Analyte | BTAG Aqueous | # of BTAG Aqueous Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|
| ***Herbicides (ug/L)*** | | | | | | | |
| 2,4,5-TP (Silvex) | 30 | 0 | 1 | 3 | 0.029 | 0.029 | 31SW14 |
| Dicamba | na | na | 1 | 3 | 0.154 | 0.154 | 31SW14 |
| ***Metals (ug/L)*** | | | | | | | |
| Aluminum | 87 | 6 | 6 | 6 | 297 | 13200 | 31SW14 |
| Antimony | 30 | 0 | 3 | 6 | 0.58 | 1.1 | 31SW10 |
| Barium | 4 | 6 | 6 | 6 | 17.5 | 35.6 | 31SW14 |
| Cadmium | 0.25 | 0 | 3 | 6 | 0.095 | 0.15 | 31SW14 |
| Calcium | 116000 | 0 | 6 | 6 | 9710 | 15800 | 31SW14 |
| Chromium | 85 | 0 | 1 | 6 | 4.7 | 4.7 | 31SW14 |
| Copper | 9 | 2 | 3 | 6 | 7 | 19.7 | 31SW1 |
| Iron | 300 | 2 | 6 | 6 | 39.5 | 1540 | 31SW14 |
| Lead | 2.5 | 2 | 3 | 6 | 0.52 | 6.01 | 31SW14 |
| Magnesium | 82000 | 0 | 6 | 6 | 3670 | 5760 | 31SW14 |
| Manganese | 120 | 1 | 6 | 6 | 7.6 | 263 | 31SW14 |
| Mercury | 0.1 | 1 | 2 | 6 | 0.083 | 0.186 | 31SW14 |
| Nickel | 52 | 0 | 1 | 6 | 4.1 | 4.1 | 31SW3 |
| Potassium | 53000 | 0 | 6 | 6 | 1110 | 1900 | 31SW14 |
| Selenium | 1 | 1 | 1 | 6 | 4.6 | 4.6 | 31SW2 |
| Silver | 3.2 | 3 | 3 | 6 | 6.3 | 7.3 | 31SW10 |
| Sodium | 680000 | 0 | 6 | 6 | 5700 | 11900 | 31SW10 |
| Thallium | 0.8 | 0 | 3 | 6 | 0.076 | 0.14 | 31SW10 |
| Vanadium | 20 | 0 | 1 | 6 | 1.2 | 1.2 | 31SW1 |
| Zinc | 120 | 0 | 4 | 6 | 3 | 16 | 31SW14 |
| ***Misc.*** | | | | | | | |
| Hardness (mg/L) | na | na | 3 | 3 | 55400 | 63200 | 31SW14 |
| Total Organic Carbon (ug/L) | na | na | 3 | 3 | 1710 | 5080 | 31SW14 |
| Total Organic Halides (ug/L) | na | na | 3 | 3 | 110 | 140 | 31SW12 |

## Table 3-13
## SWMU 31
## BTAG Sediment Screening Summary
Page 1 of 2

| Analyte | BTAG Sed | Background | # of BTAG Sed Exceedances | # of Background Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|
| ***PAHs (ug/kg)*** | | | | | | | | | |
| 2-Methylnaphthalene | 20.2 | na | 2 | na | 3 | 3 | 5.7 | 1300 | 31SE8A |
| Acenaphthene | 6.7 | na | 3 | na | 3 | 6 | 20 | 280 | 31SL2-2 |
| Acenaphthylene | 5.9 | na | 2 | na | 2 | 6 | 23 | 46 | 31SE11A |
| Anthracene | 57.2 | na | 1 | na | 2 | 6 | 15 | 59 | 31SE8A |
| Benz(a)anthracene | 108 | na | 1 | na | 3 | 6 | 14 | 150 | 31SE8A |
| Benzo(a)pyrene | 150 | na | 0 | na | 5 | 6 | 13 | 86 | 31SE8A |
| Benzo(b)fluoranthene | 27.2 | na | 2 | na | 3 | 6 | 27 | 140 | 31SE8A |
| Benzo(g,h,i)perylene | 170 | na | 0 | na | 3 | 6 | 9.5 | 54 | 31SE8A |
| Benzo(k)fluoranthene | 240 | na | 0 | na | 4 | 6 | 6.6 | 45 | 31SL2-2 |
| Chrysene | 166 | na | 1 | na | 4 | 6 | 19 | 210 | 31SE8A |
| Dibenz(a,h)anthracene | 33 | na | 0 | na | 1 | 6 | 19 | 19 | 31SE8A |
| Fluoranthene | 423 | na | 0 | na | 6 | 6 | 26 | 130 | 31SL3-2 |
| Fluorene | 77.4 | na | 1 | na | 2 | 6 | 38 | 87 | 31SE8A |
| Indeno(1,2,3-cd)pyrene | 17 | na | 4 | na | 5 | 6 | 11 | 31 | 31SE8A |
| Naphthalene | 176 | na | 1 | na | 3 | 6 | 11 | 690 | 31SE8A |
| Phenanthrene | 204 | na | 1 | na | 5 | 6 | 13 | 710 | 31SE8A |
| Pyrene | 195 | na | 0 | na | 6 | 6 | 30 | 150 | 31SE8A |
| ***SVOCs (ug/kg)*** | | | | | | | | | |
| 1,2-Dichlorobenzene | 16.5 | na | 1 | na | 1 | 9 | 3460 | 3460 | 31SL3 |
| 2-Methylnaphthalene | 20.2 | na | 4 | na | 1 | 9 | 130 | 1530 | 31SL3 |
| 2-Methylphenol | na | na | na | na | 1 | 6 | 24 | 24 | 31SE8A |
| 4-Methylphenol | 670 | na | 0 | na | 2 | 6 | 48 | 110 | 31SE11A |
| Anthracene | 57.2 | na | 0 | na | 1 | 3 | 21 | 21 | 31SE8A |
| Benz(a)anthracene | 108 | na | 0 | na | 2 | 3 | 55 | 76 | 31SE8A |
| Benzo(a)pyrene | 150 | na | 0 | na | 1 | 3 | 55 | 55 | 31SE8A |
| Benzo(b)fluoranthene | na | na | na | na | 1 | 3 | 69 | 69 | 31SE8A |
| Benzo(g,h,i)perylene | 170 | na | 0 | na | 1 | 3 | 71 | 71 | 31SE8A |
| Benzoic acid | 650 | na | 1 | na | 1 | 6 | 1200 | 1200 | 31SE13A |
| bis(2-Ethylhexyl)phthalate | 180 | na | 3 | na | 3 | 6 | 200 | 500 | 31SE13A |
| Carbazole | na | na | na | na | 1 | 6 | 20 | 20 | 31SE8A |
| Chrysene | 166 | na | 0 | na | 1 | 3 | 96 | 96 | 31SE8A |
| Dibenzofuran | 415 | na | 0 | na | 2 | 9 | 120 | 300 | 31SL1 |
| Di-n-butylphthalate | 6470 | na | 0 | na | 1 | 6 | 430 | 430 | 31SL3-2 |
| Fluoranthene | 423 | na | 0 | na | 3 | 6 | 50 | 200 | 31SL1 |
| Fluorene | 77.4 | na | 1 | na | 1 | 6 | 90 | 90 | 31SL1 |
| Indeno(1,2,3-cd)pyrene | 17 | na | 1 | na | 1 | 3 | 31 | 31 | 31SE8A |
| Naphthalene | 176 | na | 3 | na | 4 | 6 | 90 | 1330 | 31SL3 |
| Phenanthrene | 204 | na | 3 | na | 4 | 6 | 80 | 1180 | 31SL3 |
| Pyrene | 195 | na | 0 | na | 1 | 3 | 69 | 69 | 31SE8A |

**Table 3-13**
**SWMU 31**
**BTAG Sediment Screening Summary**
**Page 2 of 2**

| Analyte | BTAG Sed | Background | # of BTAG Sed Exceedances | # of Background Exceedances | # of Detections | # of Samples | Minimum Concentration | Maximum Concentration | Location of Maximum |
|---|---|---|---|---|---|---|---|---|---|
| ***Explosives (mg/kg)*** | | | | | | | | | |
| 2,4,6-Trinitrotoluene | 0.092 | na | 1 | na | 1 | 3 | 0.21 | 0.21 | 31SE11A |
| Nitrobenzene | na | na | na | na | 1 | 3 | 0.15 | 0.15 | 31SE11A |
| ***Metals (mg/kg)*** | | | | | | | | | |
| Aluminum | na | 40041 | na | 5 | 9 | 9 | 8770 | 108000 | 31SL1-2 |
| Antimony | 2 | na | 1 | na | 1 | 6 | 3.5 | 3.5 | 31SE11A |
| Arsenic | 9.8 | 15.8 | 0 | 0 | 8 | 9 | 2.74 | 12.5 | 31SE13A |
| Barium | na | 209 | na | 0 | 9 | 9 | 80.8 | 150 | 31SE13A |
| Beryllium | na | 1.02 | na | 6 | 8 | 9 | 0.95 | 2.3 | 31SL1 |
| Cadmium | 0.99 | 0.69 | 0 | 0 | 1 | 6 | 0.19 | 0.19 | 31SE8A |
| Calcium | na | na | na | na | 9 | 9 | 1700 | 4120 | 31SE11A |
| Chromium | 43.4 | 65.3 | 0 | 0 | 9 | 9 | 11.1 | 56.6 | 31SE13A |
| Cobalt | 50 | 72.3 | 0 | 0 | 9 | 9 | 6.2 | 18 | 31SE13A |
| Copper | 31.6 | 53.5 | 3 | 3 | 9 | 9 | 26.4 | 96.6 | 31SL2-2 |
| Iron | 20000 | 50962 | 0 | 0 | 9 | 9 | 7380 | 33300 | 31SL2 |
| Lead | 35.8 | 26.8 | 5 | 5 | 7 | 9 | 14.2 | 98.2 | 31SE13A |
| Magnesium | na | na | na | na | 9 | 9 | 951 | 6620 | 31SL2 |
| Manganese | 460 | 2543 | 0 | 0 | 9 | 9 | 134 | 669 | 31SL3-2 |
| Mercury | 0.18 | 0.13 | 2 | 2 | 4 | 9 | 0.087 | 0.53 | 31SE11A |
| Nickel | 22.7 | 62.8 | 0 | 0 | 9 | 9 | 16.5 | 32.6 | 31SL3-2 |
| Potassium | na | na | na | na | 9 | 9 | 576 | 2650 | 31SL2 |
| Selenium | 2 | na | 1 | na | 2 | 9 | 0.9 | 2.3 | 31SE13A |
| Silver | 1 | na | 1 | na | 1 | 9 | 1.2 | 1.2 | 31SL2 |
| Sodium | na | na | na | na | 9 | 9 | 116 | 1010 | 31SL2-2 |
| Thallium | na | 2.11 | na | 1 | 4 | 9 | 0.28 | 14.5 | 31SL2 |
| Vanadium | na | 108 | na | 0 | 9 | 9 | 21.2 | 68 | 31SE13A |
| Zinc | 121 | 202 | 0 | 0 | 9 | 9 | 38.6 | 180 | 31SL2-2 |
| ***Misc.*** | | | | | | | | | |
| Total Organic Carbon (mg/kg) | na | na | na | na | 3 | 3 | 44100 | 74500 | 31SE11A |
| pH | na | na | na | na | 3 | 3 | 6.14 | 6.97 | 31SE8A |

### *Sediment*

Composite sediment samples were collected in 1992 and 1998 from the lagoons and discrete sediment samples were collected from sediment borings during the 2002 investigation for a total of 17 samples. In the combined data set from the three investigations, there was one industrial screening level exceedance of benzo(a)pyrene (31SE12B) and industrial screening level exceedance of thallium (31SL2).

Sample 31SE12B was collected from the secondary lagoon at a depth of 2-4 ft below the surface water/sediment interface. In addition to the industrial screening level exceedance of benzo(a)pyrene in 31SE12B, there were also residential screening level exceedances of benz(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Benzo(a)pyrene was also detected above residential screening levels in seven other samples (31SL2-2, 31SL3-2, 31SE8A, 31SE10B, 31SE11A, 31SE11B, and 31SE14B).

The thallium exceedance (14.5 mg/kg) was found in one of the three samples collected for the VI in 1992. Results from VI samples collected at SWMU 58 and SWMU 39 also contained elevated levels of thallium (Shaw, 2003, 2005a). These results were not reproducible and were thought to be the result of false laboratory positives. The thallium exceedance at SWMU 31 from VI sample 31SL2 is attributed to the same phenomenon because sediment samples from the 2002 RFI had significantly lower concentrations (0.16 mg/kg – 1.9 mg/kg).

There was also one isolated residential screening level exceedance of antimony in sample 31SE11A at a concentration 3.5 mg/kg. The residential screening level for antimony is 3.1 mg/kg.

### *Soil*

Soil samples were collected in 1996, 1998, and 2002 at depths ranging from 0-2 ft bgs to 33-35 ft bgs. VOCs, PAHs, SVOCs, pesticides/PCBs, explosives, and herbicides were below residential screening levels and below SSLs. Metals did not exceed background and the residential screening levels or SSLs. Individual congeners of dioxins/furans were below the residential screening level and the SSL. The TCDD TE for surface soil sample 31SB5A exceeded the residential screening level, but was below the industrial screening level and the SSL. This sample was collected from beneath the asphalt in a road. TCDD TEs are discussed in more detail in the HHRA (*Section 5.0*).

### *Groundwater*

With the exception of bis(2-ethylhexyl)phthalate, MCL exceedances in groundwater were limited to metals. Aluminum, beryllium, iron, lead, and manganese exceeded the MCL in the total metals fraction of the groundwater samples. Aluminum and antimony exceeded the MCL in the filtered metals fraction. Antimony exceeded the MCL once during the 1995 sampling event in the upgradient well (31MW1) and was detected twice (both “B” flagged) in the 2002 sampling event at significantly lower concentrations for a total of three detections out of 15 samples. Beryllium, iron, lead, and manganese did not exceed the MCL in the filtered metals fraction, suggesting that these metals exceedances were the result of suspended sediment in the total groundwater sample. Aluminum concentrations were relatively consistent between the upgradient well (31MW1) and the downgradient wells (31MW2, 31MW3, and 31MW4), suggesting that either aluminum is naturally occurring in groundwater at these concentrations or the source of the aluminum is upgradient of the site.

Metals exceeding the tap water RBC follow the same pattern. Arsenic, barium, chromium, iron, manganese, and vanadium exceeded the tap water RBC in the total metals fraction of the sample, and barium and antimony exceeded the tap water RBC in the filtered metals fraction. Barium exceeded the tap water RBC in one out of 15 samples in the dissolved metals fraction. This exceedance was found in the upgradient well.

Chloroform, benzo(a)pyrene, and benzo(b)fluoranthene exceeded their respective tap water RBCs in groundwater samples. These compounds did not exceed MCLs in groundwater. As mentioned in the surface water section, the presence of chloroform is likely related to the current use of the lagoons associated with the water treatment plant. Benzo(a)pyrene and benzo(b)fluoranthene exceeded tap water RBCs during the 1998 sampling event. These compounds were not detected in any of the samples collected from wells in 2002.

### 3.2.7 Nature and Extent Conclusions

As illustrated on **Figures 3-2 through 3-5**, environmental samples have been collected from site surface water, sediment, surface and subsurface soil, and groundwater for the following analytical parameters: VOCs, SVOCs/PAHs, pesticides/PCBs, explosives, herbicides, metals, perchlorate (surface water and groundwater), and dioxins/furans (sediment and soil). Sample locations where these parameter groups were analyzed during all SWMU 31 investigations are illustrated on **Figures 3-9 through 3-14**. The following discussion compares the exceedances in each group across the different media.

***VOCs.*** VOCs detected at the site in surface water and groundwater are water chlorination byproducts, and were detected at concentrations below MCLs. These compounds were not detected in soil or sediment. Acetone was detected in site soil and sediment, but results were below residential screening levels. VOCs do not appear to be a concern for the site.

***PAHs/SVOCs.*** PAHs detected in sediment exceeded residential screening levels [industrial screening level for benzo(a)pyrene] in seven out of 14 samples. Benzo(a)pyrene also exceeded the tap water RBC, but was below the MCL, in two of seven groundwater samples. The low frequency of exceendances in sediment and the lack of reproducibility in the groundwater samples suggest that PAHs are not a concern at this site. Non-PAH SVOCs were detected below screening levels in site media, with the exception of bis(2-ethylhexyl)phthalate. This compound is a common laboratory contaminant and was “B” flagged during data validation were it exceeded screening levels, indicating that it was also detected in associated laboratory blanks. Non-PAH SVOCs do not appear to be a major concern at the site.

***Pesticides/PCBs.*** These compounds did not exceed screening levels in site media and are not a concern at the site.

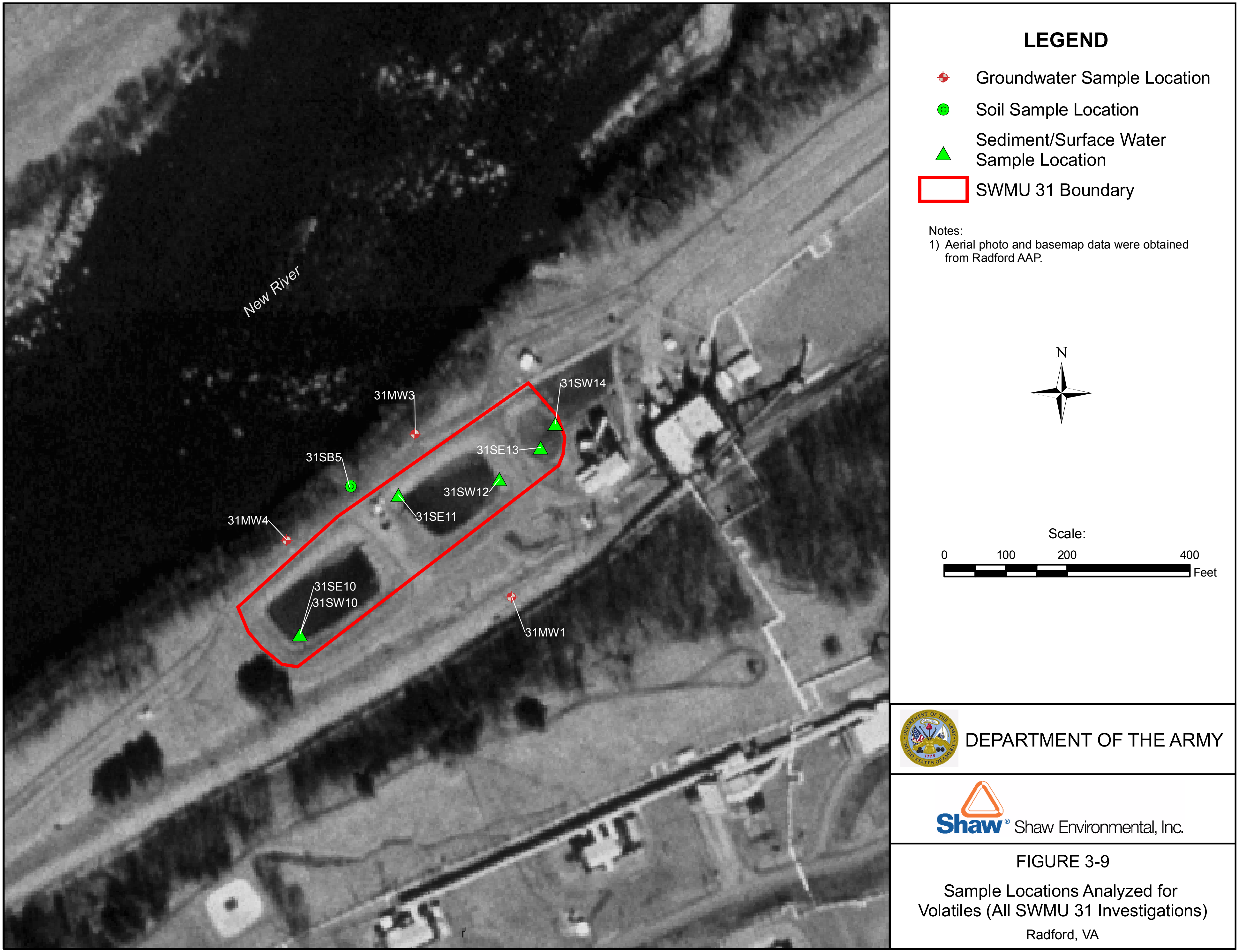
***Explosives.*** Explosives did not exceed screening levels in site media and are not a concern at the site.

***Herbicides.*** Herbicides did not exceed screening levels in site media and are not a concern at the site.

***Metals.*** Metals exceeding screening levels in surface water were aluminum, iron, and manganese. These metals are likely due to high background levels of these metals in surface water. Filtered groundwater samples show that aluminum was the only constituent to consistently exceed a screening level. As with the surface water, this is likely the result of high naturally-occurring levels of aluminum. Sediment also showed aluminum levels greater than its background screening level. In addition, there was a single industrial exceedance of thallium (likely a false positive) and a single residential exceedance of antimony in the sediment. Soil samples did not contain any metals at concentrations greater than background and residential or industrial screening levels.

***Perchlorate.*** Perchlorate was not detected in site surface water or groundwater and is not a concern at the site.

***Dioxins/Furans.*** The calculated TCDD TE for one sample exceeded the residential screening level for TCDD. Individual congeners of dioxins/furans were below screening levels. Deeper samples collected from the same soil boring indicate that dioxins/furans are not migrating vertically. This sample was collected immediately beneath an asphalt road, which limits exposure to human or ecological receptors. The sediments in the lagoons had TCDD TEs below residential screening levels.



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

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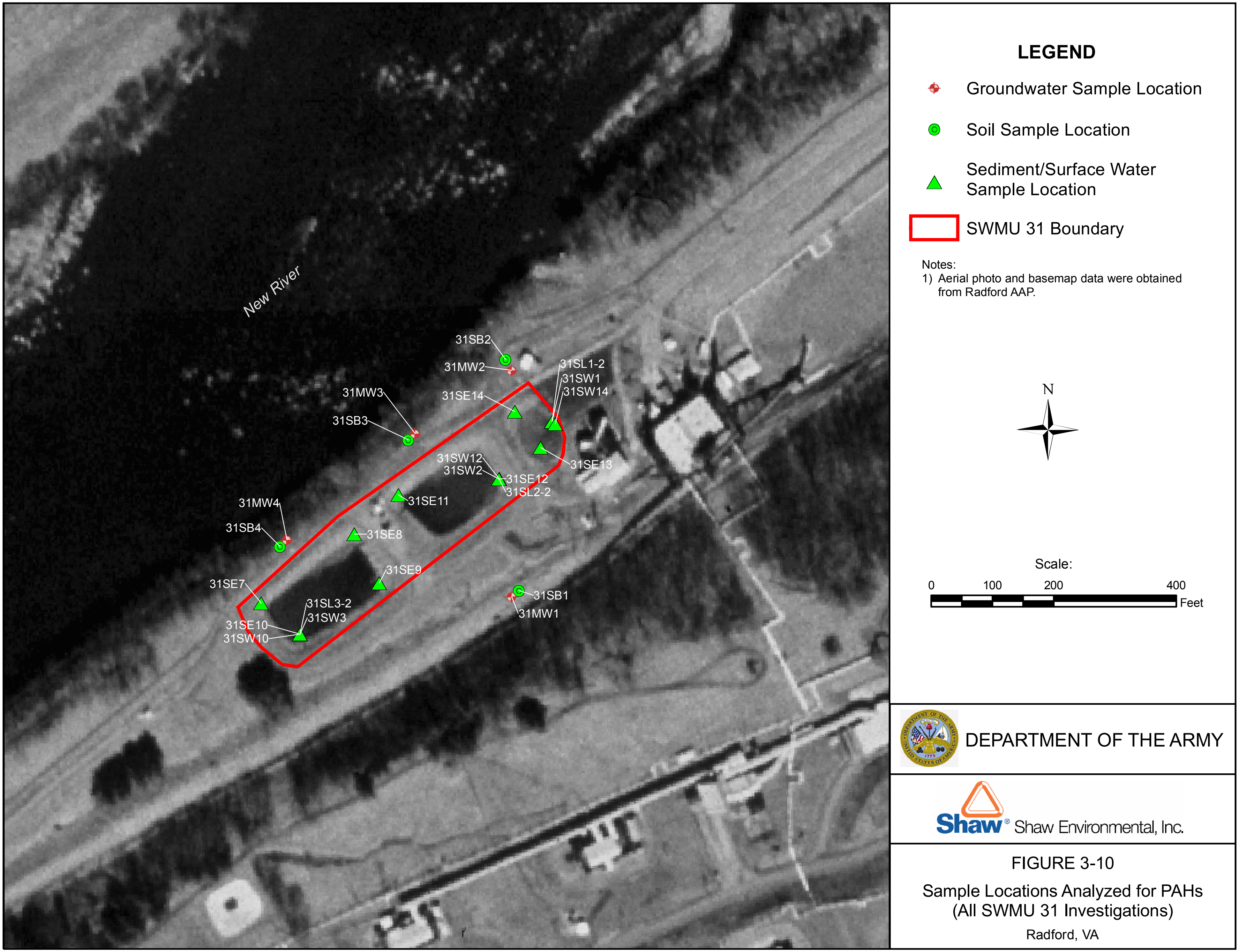
FIGURE 3-9

Sample Locations Analyzed for Volatiles (All SWMU 31 Investigations)

Radford, VA

Date: 11/8/06 GIS File: RFAAP_016_Fig3-9_SWMU31_V_Analyses.mxd



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

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FIGURE 3-10

Sample Locations Analyzed for PAHs
(All SWMU 31 Investigations)

Radford, VA

Date: 11/8/06 GIS File: RFAAP_012_Fig3-10_SWMU31_PAH_Analyses.mxd

## LEGEND

| | |
|---|---|
| ⌖ | Groundwater Sample Location |
| ◎ | Soil Sample Location |
| ▲ | Sediment/Surface Water Sample Location |
| ▭ | SWMU 31 Boundary |

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

N

Scale:

0 100 200 400 Feet

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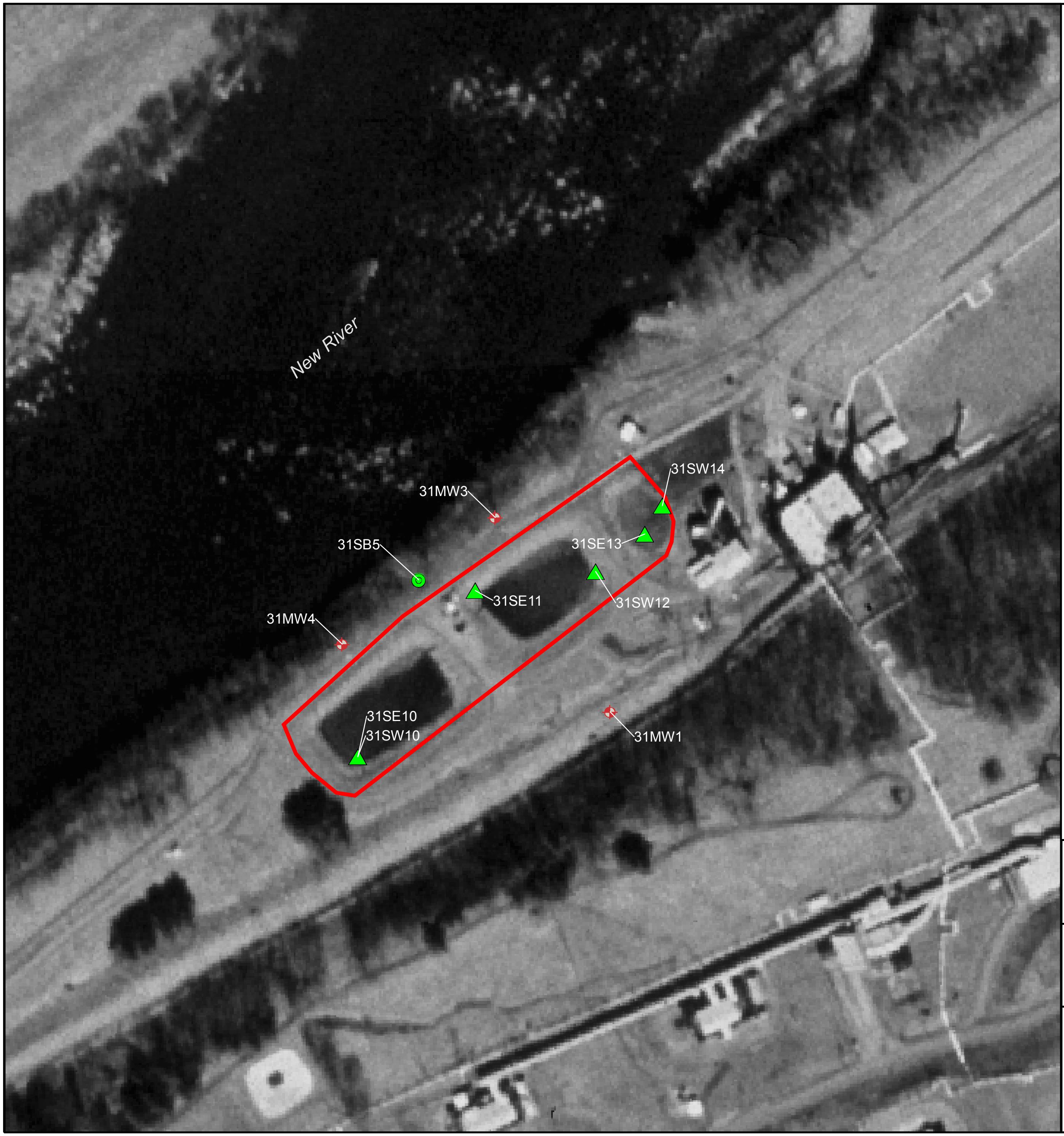
FIGURE 3-11

Sample Locations Analyzed for Semivolatiles (All SWMU 31 Investigations)

Radford, VA

GIS File: RFAAP_015_Fig3-11_SWMU31_SV_Analyses.mxd

Date: 11/8/06



## LEGEND

⊕ Groundwater Sample Location

● Soil Sample Location

▲ Sediment/Surface Water Sample Location

□ SWMU 31 Boundary

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

N

Scale:

0 100 200 400 Feet

DEPARTMENT OF THE ARMY

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### FIGURE 3-12
### Sample Locations Analyzed for PCBs, Pesticides, and Herbicides (All SWMU 31 Investigations)

Radford, VA

*Date: 11/8/06 GIS File: RFAAP_010_Fig3-12_SWMU31_PCB_Pest_Herb_Analyses.mxd*

## LEGEND

⊕ Groundwater Sample Location

◎ Soil Sample Location

▲ Sediment/Surface Water Sample Location

▭ SWMU 31 Boundary

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

N

Scale:
0 100 200 400
Feet

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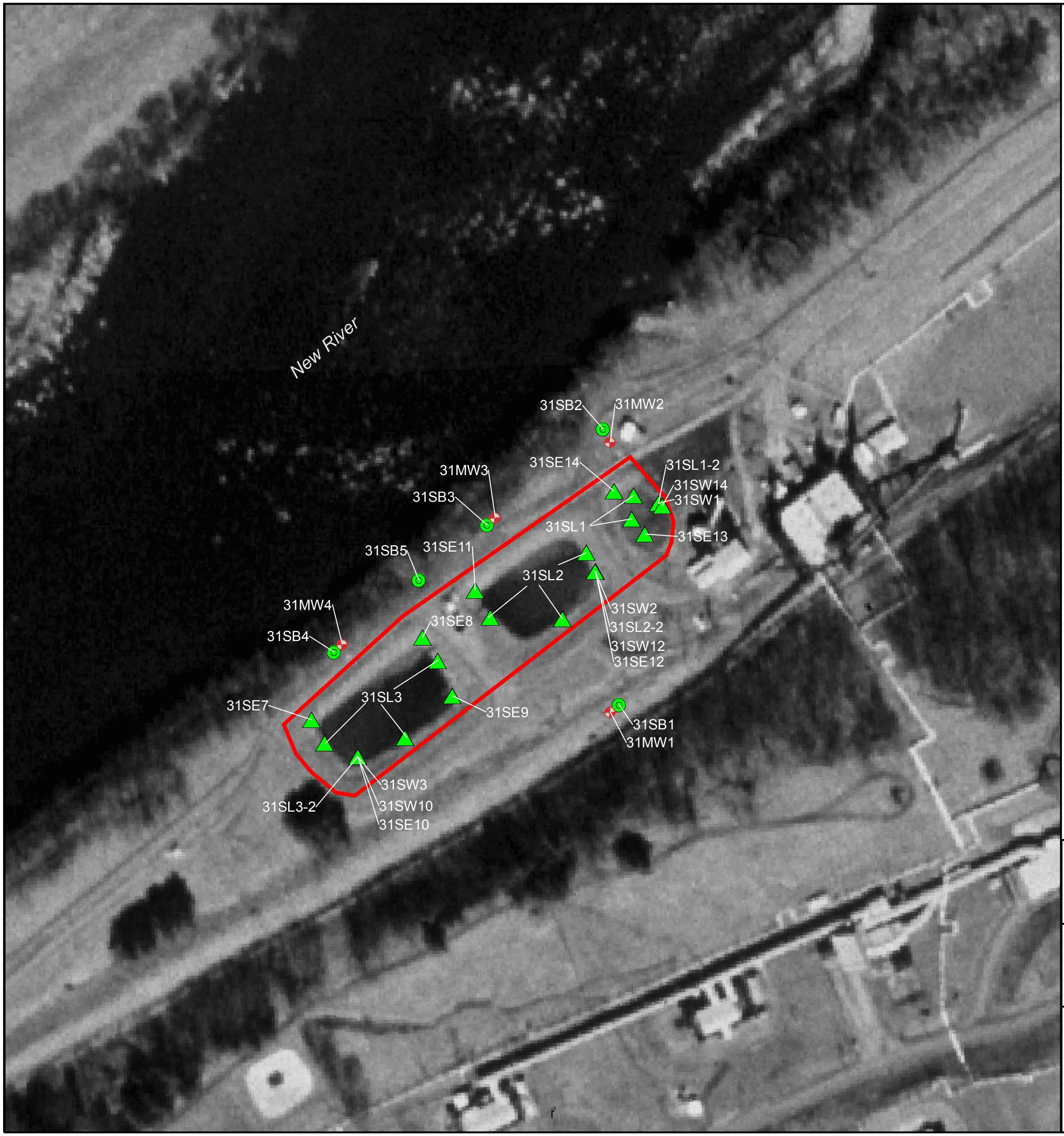
FIGURE 3-13

Sample Locations Analyzed for Explosives
(All SWMU 31 Investigations)

Radford, VA

Date: 11/8/06 GIS File: RFAAP_009_Fig3-13_SWMU31_Ex_Analyses.mxd



## LEGEND

⊕ Groundwater Sample Location

◎ Soil Sample Location

▲ Sediment/Surface Water Sample Location

□ SWMU 31 Boundary

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

N

Scale:
0 100 200 400 Feet

DEPARTMENT OF THE ARMY

Shaw® Shaw Environmental, Inc.

FIGURE 3-14

Sample Locations Analyzed for Metals
(All SWMU 31 Investigations)

Radford, VA

Date: 11/8/06 GIS File: RFAAP_011_Fig3-14_SWMU31_Met_Analyses.mxd

# 4.0 CONTAMINANT FATE AND TRANSPORT

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**.

This section presents a discussion of the fate and transport of the chemicals identified as chemicals of potential concern (COPCs) in *Section 5.1.4* of the HHRA. As presented in **Table 5-6**, one PAH [benzo(a)pyrene], two VOCs (bromodichloromethane and chloroform), one SVOC (dibenzofuran), the TCDD-Toxicity Equivalent, and seven metals (aluminum, arsenic, chromium, cobalt, iron, manganese, and vanadium) were identified as COPCs. The fate and transport of these constituents are presented in the following sections.

### 4.1.1 Organics

One PAH [benzo(a)pyrene], two VOCs (bromodichloromethane and chloroform), one SVOC (dibenzofuran), and the TCDD-Toxicity Equivalent were identified as COPCs in the HHRA. Only one PAH [benzo(a)pyrene] was identified as a COPC in sediment collected from depths down to 2 ft. Because SWMU 31 is currently an operating facility and the lagoons are covered by water, it is assumed that contact would occur only as a result of activities such as wading and swimming. These activities would result in contact within the first one or two feet of sediment only. Therefore, the remaining PAH detections below two feet are evaluated in total sediment and not a surface sediment scenario.

#### 4.1.1.1 Benzo(a)pyrene

Benzo(a)pyrene is a PAH, which is a group of more than a hundred organic compounds of two or more aromatic rings. As a general rule, when PAH compounds grow in molecular weight, their solubility in water decreases, solubility in fat tissues increases, and their melting and boiling points increase (Environment Canada, 1997). The solubility ranges of the PAHs detected at SWMU 31 indicate the PAHs present are not soluble in water. The vapor pressure ranges of the PAHs present indicate that these compounds do not readily volatilize into the atmosphere which is further supported by the Henry's Law Constant values. The organic carbon/water partition coefficient (Koc) is a measure of the tendency of a chemical to be sorbed to the organic fraction of soil. The logarithm (log10) of the Koc values for the PAHs detected indicate these PAHs have high sorption potentials and will not tend to leach into surface water runoff. This is further supported by the octanol/water partition coefficient, Kow, which is an indication of whether a compound will dissolve in a solvent (i.e., n-octanol) or water. The PAHs detected in SWMU 31 soil are nonpolar and hydrophobic and, as mentioned above, will tend to sorb to surface soil rather than partition into the polar water phase.

#### 4.1.1.2 Bromodichloromethane

Bromodichloromethane is a colorless, nonflammable liquid. Small amounts are formed naturally by algae in the oceans. Some of it will dissolve in water, but it readily evaporates into air. Only small quantities of bromodichloromethane are produced in the United States. The small quantities that are produced are used in laboratories or to make other chemicals. However, most bromodichloromethane is formed as a by-product when chlorine is added to drinking water to kill bacteria (ATSDR, 1999a).

Bromodichloromethane released to air is slowly broken down by reactions with other chemicals and sunlight or it can be removed by rain. In water, it will evaporate to the air and/or be broken down slowly by bacteria. When released to soil, most will evaporate to the air but some of it will be broken down by bacteria. Some bromodichloromethane may filter into the groundwater. Bromodichloromethane does not build up in the food chain (ATSDR, 1999a).

#### 4.1.1.3 Chloroform

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. Today, chloroform is used to make other chemicals and can also be formed in small amounts when chlorine is added to water.

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. Chloroform does not sorb 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. Chloroform does not appear to bioaccumulate in great amounts in plants and animals (ATSDR, 1997).

#### 4.1.1.4 Dibenzofuran

Dibenzofuran is released to the environment in atmospheric emissions involved with the combustion of coal, biomass, refuse, and diesel fuel. Wastewater emissions can occur from coal tar, coal gasification, and shale oil operations. If released to the atmosphere, dibenzofuran will exist primarily in the gas-phase where it will degrade relatively rapidly by reaction with photochemically produced hydroxyl radicals (estimated half-life of 11.3 hr in average air). A small percentage of the dibenzofuran released to air will exist in the particulate phase which may be relatively persistent to atmospheric degradation. Physical removal from air can occur by both wet and dry deposition. If released to water, dibenzofuran may partition significantly from the water column to sediments and suspended material. Volatilization from the water column may be important; however, sorption to sediment may diminish the potential importance of volatilization. If released to soil, dibenzofuran is not expected to leach significantly in most soil types. Biological screening studies have shown that dibenzofuran is biodegraded readily by adapted microbes in the presence of sufficient oxygen. However, in various groundwaters or aquatic sediments where oxygen is limited or lacking, biodegradation may occur very slowly resulting in long periods of persistence.

#### 4.1.1.5 Dioxins/Furans-Toxicity Equivalent

The concentration of dioxin/furan isomers detected at SWMU 31 were used to calculate the 2,3,7,8-TCDD TE, as described in *Section 5.1.1*. Dioxins/furans make up a family of chemicals with related properties and toxicity. There are 75 different forms of dioxins, while there are 135 different furans. Dioxins/furans are not manufactured or used. Instead, these groups of chemicals are formed unintentionally in two ways: (1) as a chemical contaminant of industrial processes involving chlorine or bromine, or (2) by burning organic matter in the presence of chlorine. The principal sources of dioxins/furans in the environment are combustion and incineration, chemical manufacturing, pulp and paper mills, and metal refining and smelting.

Several research studies have indicated that dioxins/furans act like a hormone, with effects that include neurotoxicity, immunotoxicity, and reproductive, developmental, and endocrine toxicity, including diabetes. Additional evidence exists that exposure to dioxins/furans at high levels for long periods of time causes cancer in humans (Gibbs, 1995).

Dioxins and furans share many physical properties, several of which influence how these compounds will behave in the environment. Dioxin and dioxin-like chemicals are not very water soluble. For example, the water solubility of TCDD, the most toxic dioxin, is $2.0\text{x}10^{-4}$ mg/L at 25°C. Dioxins/furans also have low vapor pressures [e.g., $1.0\text{x}10^{-6}$ millimeters mercury (mm Hg) for TCDD at 25°C], which means that these compounds do not readily volatilize to the atmosphere. Dioxins and furans have high $K_{oc}$ values (i.e., $3.30\text{x}10^{+6}$ for TCDD) indicating that dioxins and furans have high sorption potentials and will not tend to leach into groundwater or surface water runoff.

These groups of compounds also have high $K_{ow}$ values (i.e., log $K_{ow}$ of 6.72 for TCDD). The $K_{ow}$ value gives an indication of how a compound will preferentially distribute into a solvent (i.e., n-octanol) or water, and is basically a measure of hydrophobic characteristics. Chemicals with high $K_{ow}$ values, such as dioxins and furans, are relatively hydrophobic and will tend to sorb to soil rather than partitioning into the polar water phase.

Dioxins and furans with four or more chlorine atoms (i.e., OCDD and HpCDF) are extremely stable, with photolysis as the single significant degradation process. In the photodecomposition process, lower chlorinated congeners are formed (Crosby et al., 1971; Miller et al., 1989). Higher chlorinated congeners will have lower rates of decomposition. In addition, in or on solid phases, photochemical transformation results in a preferential loss of chlorine on the 1, 4, 6, and 9 positions leading to the formation of more toxic compounds (Lamparski et al., 1980; Nestrick et al., 1980). Since sunlight penetration becomes restricted in subsurface soil, photolysis of dioxins and furans will predominantly occur in the top layer of soil. For example, the dioxin concentration in the top one-eighth of inch of the contaminated soil at Times Beach, Missouri, was decreased 50 percent by photodegradation over a 16-month period, but the dioxin concentrations below this depth did not change.

In summary, dioxins and furans appear to be relatively immobile in soil due to their strong sorption behavior and limited water solubility. In soil systems, photolysis is the most significant degradation mechanism for dioxins/furans. However, degradation rates tend to be extremely slow and confined to the surface layer of the soil.

### 4.1.2 Metals

Seven metals (aluminum, arsenic, chromium, cobalt, iron, manganese, and vanadium) were identified as COPCs in the HHRA.

#### 4.1.2.1 Aluminum

Aluminum occurs naturally in soil, water, and air. It is redistributed or moved by natural and human activities. High levels in the environment can be caused by the mining and processing of its ores and by the production of aluminum metal, alloys, and compounds (ATSDR, 1999b). Small amounts of aluminum are released into the environment from coal-fired power plants and incinerators. Food, water, and air contain some aluminum, which nature is well adapted to handle (ATSDR, 1999b).

Aluminum cannot be destroyed in the environment. It can change its form or become attached or separated from particles. Aluminum particles released from power plants and other combustion processes are usually attached to very small particles. Aluminum contained in wind-borne soil is generally found in larger particles. These particles settle to the ground or are washed out of the air by rain. Aluminum that is attached to very small particles may stay in the air for many days. Most aluminum will ultimately end up in the soil or sediment. Aluminum in soil is taken up into plants, which are eaten by animals. Aluminum is not known to bioconcentrate up the food chain and therefore, vegetables, fruits, fish, and meat will not generally contain high concentrations of aluminum (ATSDR, 1999b). An exception is tea plants, which can accumulate aluminum. Because of the toxicity of dissolved aluminum to many aquatic organisms, including fish, these animals would die before the amount of aluminum in the animal became very high (ATSDR, 1999b).

Most aluminum-containing compounds do not dissolve much in water unless the water is acidic. However, when acid rain falls, aluminum compounds in the soil may dissolve and enter lakes and streams. Because the affected bodies of water are often acidic themselves from the acid rain, the dissolved aluminum does not combine with other elements in the water and settle out as it would under normal (i.e., non-acidic) conditions. In this situation, abnormally high concentrations of aluminum may occur.

#### 4.1.2.2 Arsenic

Arsenic (As) is a natural component of the earth's crust and can be released to the environment from natural sources (e.g., erosion of sulfide mineral deposits) as well as from human activities. Levels of arsenic are found in natural environmental media, ranging from 1 to 400 mg/kg in soil.

The most common forms of arsenic found in nature ($As^{+5}$ and $As^{+3}$) are found in aqueous solution as arsenate ($AsO_4^{-3}$) and arsenite ($AsO_2^{-1}$), respectively. However, the metallic (0 state) and –3 state may also occur. Both arsenate and arsenite are toxic; however, arsenite is the more toxic form, and arsenate is the most common form. Arsenate is relatively immobile in the environment due to its formation of insoluble complexes with iron, aluminum, and calcium. The presence of iron is most effective in controlling the mobility of arsenate. In contrast, arsenite compounds are 4 to 10 times more soluble than arsenate compounds. The adsorption of arsenite is also strongly pH dependent. One study found increased adsorption of arsenite by two clays over the pH range of 3 to 9, while another study found the maximum adsorption of arsenite by iron oxide occurred at pH 7 (USEPA, 1992d).

#### 4.1.2.3 Chromium

Chromium exists in two valence states in the environment: trivalent (Cr III) or hexavalent (Cr VI). Typically, Cr (III) in an aqueous environment would be associated with particles, while Cr (VI) would remain in solution. Cr (III), a positively charged particle, is the most thermodynamically stable form of chromium under common environmental conditions. Trivalent chromium has a strong tendency to sorb to negatively charged soil particles. As a result, Cr (III) is generally immobile and remains close to the origin of deposition. In addition, adsorption of Cr (III) will occur at slightly acidic soil pHs. Cr (VI) is also positively charged, however, it commonly occurs in the environment within negatively charged compounds: chromate ($CrO_4^{-2}$) and dichromate ($CrO_7^{-2}$). Negatively charged chromium compounds are less likely to sorb to soil because soil particles are negatively charged (USEPA, 1997d). As a result, Cr (VI) tends to be mobile in the environment. Cr (VI) that does sorb to soil will likely be reduced to Cr (III) by organic matter (USEPA, 1998). As previously stated, site surface soil ranges in pH from 5.03 to 7.4, with a mean pH of 6.2 (slightly acidic). Mobility of chromium is further inhibited and adsorption increased by soil with high clay content such as the soil found at the site.

#### 4.1.2.4 Cobalt

Cobalt (Co) occurs naturally in the earth's crust, and therefore, in soil. Low levels of cobalt also occur naturally in seawater and in some surface water and groundwater (Smith and Carson, 1981). However, elevated levels of cobalt in soil and water may result from anthropogenic activities such as the mining and processing of cobalt-bearing ores, the application of cobalt-containing sludge or phosphate fertilizers to soil, the disposal of cobalt-containing wastes, and atmospheric deposition from activities such as the burning of fossil fuels and smelting and refining of metals (Smith and Carson, 1981). Cobalt is released into the atmosphere from both anthropogenic and natural sources. However, emissions from natural sources are estimated to slightly exceed those from manufactured sources. Natural sources include windblown soil, seawater spray, volcanic eruptions, and forest fires. Primary anthropogenic sources include fossil fuel and waste combustion, vehicular and aircraft exhausts, processing of cobalt and cobalt-containing alloys, copper and nickel smelting and refining, and the manufacture and use of cobalt chemicals and fertilizers derived from phosphate rocks (Barceloux, 1999; Lantzy and Mackenzie, 1979; Nriagu, 1989; Smith and Carson, 1981). Co-60 and Co-58 may be released to the environment as a result of nuclear research and development, nuclear accidents, operation of nuclear power plants, and radioactive waste dumping in the sea or in radioactive waste landfills.

Cobalt is a by-product or coproduct of the refining of other mined metals such as copper and nickel. Some of the commercially mined ores are carrollite, smaltite, cobaltite, siegenite, and sphaerocobaltite. The amount of cobalt mined is relatively small in comparison with copper and nickel, and the cobalt supply depends to a large extent on the demand for the latter two metals. A major source of cobalt is food; as it concentrates in green, leafy vegetables and may be as great as 0.5 mg/kg dry weight. A few plant species accumulate cobalt above 100 mg/kg, the level that causes severe phytotoxicity. Hyperaccumulators of cobalt have been found which contain over 1 percent cobalt in dry leaves. Soil pH is very important in cobalt uptake and phytotoxicity. More acidic soil sorbs cobalt less strongly. In the process of weathering, cobalt may be taken into solution more readily than nickel. It is adsorbed to great extent by hydrolysate or oxidate sediments. Cobalt may be taken into solution in small amounts through bacteriological activity similar to that causing solution of manganese. The availability of cobalt is primarily regulated by pH and is usually found in soil as divalent cobalt. At a low pH, it is oxidized to trivalent cobalt and often found associated with iron. Adsorption of divalent cobalt on soil colloids is high between a pH 6 and 7, whereas leaching and plant uptake of cobalt are enhanced by a lower pH (Spectrum, 2003).

#### 4.1.2.5 Iron

Iron, like most metals, is not found in the Earth's crust in an elemental state. Iron can be found in the crust only in combination with oxygen or sulfur. Most iron is found in various iron oxides, such as the minerals hematite, magnetite, and taconite. Iron is a major component of steel. Since buried steel containers and other items are of concern at the site, the following discussion focuses on the degradation of iron in the environment.

Corrosion (chemical and biological) of iron is an electrochemical phenomenon in which ions go into solution (anodic reaction) and the electrons generated by the reaction diffuse through the metal to the cathode where they are consumed (cathodic reaction). Biologically induced corrosion occurs when microorganisms are able to initiate, facilitate, or accelerate the corrosion reaction without changing the electrochemical nature of the process.

The anodic reaction (also referred to as oxidation reaction) involves the production of electrons, an increase in the valence state of iron, or the conversion of the metal to its ion.

$$\mathrm{Fe(solid)} \rightarrow \mathrm{Fe^{2+}} + 2e^-$$

In the above equation, the iron atom has been transformed into an ion and two electrons are released.

At the cathode, electrons are consumed to complete the corrosion process. This is usually the rate-controlling step, and it can occur in a variety of ways. The most common cathodic (reduction) reactions are the following:

Oxygen reduction

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ (neutral or basic solutions)
$O_2 + 2H_2O + 2e^- \rightarrow 2OH^- + H_2O_2$ (neutral or basic solutions)
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ (acidic solutions)

Hydrogen evolution

$2H^+ + 2e^- \rightarrow H2$
$2H_3O^+ + 2e^- \rightarrow H_2 + 2H_2O$

Metal ion reduction

$$\mathrm{Fe^{3+}} + e^- \rightarrow \mathrm{Fe^{2+}}$$

Metal deposition

$$\mathrm{Fe^{2+}} + 2e^- \rightarrow \mathrm{Fe}$$

Hydrogen evolution and oxygen reduction are the more common cathodic reactions in the environment where an aqueous medium (acidic, basic or neutral) and air (oxygen) are often present.

The anodic and cathodic reactions occur simultaneously and at the same rate in terms of electron activity such that the iron metal does not become electrically charged. Thus, in the presence of oxygen and water molecules, iron would undergo an electrochemical reaction to produce ferrous hydroxide as follows:

$$2\mathrm{Fe} + 2H_2O + O_2 \rightarrow 2\mathrm{Fe^{2+}} + 4OH^- \rightarrow 2\mathrm{Fe(OH)_2}$$

Ferrous hydroxide would precipitate from solution at elevated pH; but in the presence of oxygen and water, ferrous hydroxide is unstable and would readily oxidize to the ferric salt (rust).

$$2\mathrm{Fe(OH)_2} + H_2O + \tfrac{1}{2}O_2 \rightarrow 2\mathrm{Fe(OH)_3}$$

The locations of anodes and cathodes on a metal surface area can be a grain size apart. The surface characteristics and oxygen availability vary slightly from one grain to another. At a given time, therefore, some of the grains would act as anodes while others would act as cathodes. This condition may be reversed a fraction of a second later. This changing anodic and cathodic sites explains the occurrence of uniform corrosion over an entire area. Thus, when a piece of iron encounters a low pH environment, the metal would tend to dissolve uniformly over its entire surface, the surface would become thinner, and would eventually fail.

On the other hand, when anodic and cathodic reaction sites are permanently separated either microscopically or macroscopically, localized corrosion is said to occur. Localized corrosion has been identified as a reliable signature for the occurrence of biocorrosion. Localized corrosion can be caused by a microbial colony that creates a differential in the oxygen availability. Pitting corrosion is an intense form of localized corrosion, which occurs when discrete sites on a surface undergo rapid attack, causing the formation of holes in the metal. The area under the microbial colony (area with the lowest oxygen availability) becomes the anode, while the area outside the deposit acts as the cathode. In general, biological activity that enhances or restricts either the anodic or cathodic reactions or permanently separates the reaction sites will promote corrosion.

#### 4.1.2.6 Manganese

Manganese is an essential element in trace amounts for plants and animals. It forms an essential part of the enzyme systems that metabolize proteins and energy in animals. It is also involved in the formation of mucopolysaccharides required for healthy joint membranes. In humans, manganese is involved in the digestion and absorption of food through peptidase activity, in the synthesis of cholesterol and fatty acids, in glucose metabolism and in the use of biotin, thiamine, vitamin C and chlorine. In the divalent state ($Mn^{++}$), it appears to provide protection against oxygen free radicals as part of the enzyme superoxide dismutase. Insufficient dietary manganese may result in abnormal carbohydrate metabolism and impaired insulin productions in humans, and a host of ailments in experimental animals.

The primary concerns due to manganese in drinking water are its objectionable taste and its capacity to stain plumbing and laundry. In aquatic environments, manganese toxicity is slight to moderate and is influenced by several factors such as water hardness, salinity, pH, and the presence of other contaminants. The effect of water hardness on manganese toxicity is by far the most studied factor.

Manganese comprises approximately 0.085 percent to 0.95 percent of the earth's crust at an average concentration of 950 mg/kg. Principal ores of manganese include: pyrolusite ($MnO_2$), manganite ($Mn_2O_3.H_2O$), hausmannite ($Mn_3O_4$) and rhodocrosite ($MnCO_3$). Ferromanganese minerals such as biotite mica [$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$] and amphibole [$(Mg,Fe)Si_8O_{22}(OH)_2$] also contain large amounts of manganese. Manganese in rocks and minerals is naturally released into the environment from weathering.

#### 4.1.2.7 Vanadium

The behavior of vanadium in soil is not yet fully understood (Mermut et al., 1996). The mobility of vanadium in soil is affected by the pH of the soil. Vanadium is fairly mobile in neutral or alkaline soil relative to other metals, but its mobility decreases in acidic soil. In the presence of humic acids, mobile metavanadate anions can be converted to the immobile vanadyl cations resulting in local accumulation of vanadium. Under oxidizing, unsaturated conditions some mobility is observed, but under reducing, saturated conditions vanadium is immobile (ATSDR, 1992). Vanadium may be important in soil with high iron oxides and soil experiencing redox reactions, as this element has four oxidation states. It occurs in iron oxides and is also adsorbed by silicate clay materials. Clay soil studied has more vanadium than other soil (Mermut et al., 1996). When mafic rocks weather in a humid climate, the vanadium remains in the trivalent state or is weakly oxidized to the relatively insoluble tetravalent state (Hilliard, 1992). In either case, the vanadium is captured along with aluminum in the residual clays. Subsequent leaching of the clays can produce bauxite and lateritic iron ores that contain 400 to 500 parts per million (ppm) vanadium (Hilliard, 1992). When mafic rocks are intensely oxidized in an arid climate, some of the vanadium is converted to the pentavalent state. The pentavalent cation is considerably more soluble than the trivalent cation, is readily dissolved by groundwater, and can be transported over long distances (Hilliard, 1992).

## 5.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA has been prepared to evaluate the probability and magnitude of potential adverse effects on human health associated with actual or potential exposure to site-related chemicals at SWMU 31.

The HHRA is consistent with Section 300.430(d)(4) of the National Contingency Plan (NCP) [40 CFR 300], which directs that an HHRA be conducted "to characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain." This section of the NCP was applied to the HHRA in which human health effects associated with site-related chemicals in surface soil, subsurface soil, sediment, surface water, and groundwater were evaluated. This HHRA is consistent with USEPA guidance and standards (USEPA, 1986a,b; 1989a; 1991a,b; 1992a,b,c; 1995a,b; 1997a,b; 2001a; 2002a; 2004b; 2005a,b; 2006a). In addition, site-specific guidance was applied, as appropriate. This guidance included the *RFAAP Final MWP* (URS, 2003) and the *RFAAP Site Screening Process* (USEPA, 2001b). The exposure media and exposure pathways that will be quantitatively evaluated in the HHRA are summarized in **Table 5-1** and depicted on **Figure 5-1**.

The HHRA is organized as follows:

- Data Summary and Selection of Chemicals of Potential Concern (COPCs) (*Section 5.1*). The chemicals detected in environmental media are identified and discussed. The data are summarized by presenting the frequency of detection and the range of detected concentrations in site-related samples, and the concentrations in background samples. In addition, COPCs are selected for quantitative evaluation in the HHRA based on a review of the data and a comparison to appropriate screening levels.
- Human Health Exposure Assessment (*Section 5.2*). The potential pathways by which individuals may be exposed to COPCs are discussed, and exposure pathways are selected for further evaluation. The chemical concentrations at the points of potential exposure are presented for each complete exposure pathway. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each pathway, and potential exposures (intakes) are then estimated.
- Human Health Toxicity Assessment (*Section 5.3*). The potential toxicity of chemicals to humans and the chemical-specific health effects criteria to be used in the quantitative assessment are presented.
- Human Health Risk Characterization (*Section 5.4*). Quantitative risk estimates are calculated for each complete exposure pathway by combining the toxicity criteria with estimated intakes of potentially exposed individuals.
- Uncertainties in the HHRA (*Section 5.5*). Major sources of uncertainty in the HHRA are discussed.
- HHRA Summary (*Section 5.6*). The HHRA is briefly summarized.

# Table 5-1
# Selection of Exposure Pathways

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Current | Surface Soil | Surface Soil | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | Quant | Maintenance workers could contact surface soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact surface soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | Quant | Industrial workers could contact surface soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact surface soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | Air | SWMU 31 | Maintenance Worker | Adult | Inhalation | On-site | Quant | Maintenance workers could be exposed to airborne volatiles or particulate matter released from surface soil at SWMU 31. |
| | | | | Industrial Worker (Outdoor) | Adult | Inhalation | On-site | Quant | Industrial workers could be exposed to airborne volatiles or particulate matter released from surface soil at SWMU 31. |
| | | | | Trespasser | Adolescent | Inhalation | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Total Soil (Surface and Subsurface) | Total Soil (Surface and Subsurface) | SWMU 31 | None | None | None | On-site | None | Current excavation or construction activities are not occurring at SWMU 31. |
| | Sediment | Sediment | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | Quant | Maintenance workers could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | Quant | Industrial workers could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Surface Water | Surface Water | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | None | Maintenance workers could contact surface water at SWMU 31 while wading. However, surface water ingestion is unlikely. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-Site | None | Industrial workers could contact surface water at SWMU 31 while wading. However, surface water ingestion is unlikely. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading. |

# Table 5-1
# Selection of Exposure Pathways

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Current (cont.) | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Groundwater | Groundwater | SWMU 31 | None | None | None | On-site | None | Groundwater is not currently being used at SWMU 31. Therefore, there is currently no direct exposure to groundwater. |
| | | Air | Volatile groundwater COPCs released to ambient air | Maintenance Worker | Adult | Inhalation | On-site | Quant | Volatiles could be released from groundwater into ambient air. Maintenance workers could be exposed via inhalation. |
| | | | | Industrial Worker (Outdoor) | Adult | Inhalation | On-site | Quant | Volatiles could be released from groundwater into ambient air. Industrial workers could be exposed via inhalation. |
| Future | Surface Soil | Surface Soil | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | Quant | Maintenance workers could contact surface soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact surface soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | Quant | Industrial workers could contact surface soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact surface soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | Air | SWMU 31 | Maintenance Worker | Adult | Inhalation | On-site | Quant | Maintenance workers could be exposed to airborne volatiles or particulate matter released from surface soil at SWMU 31. |
| | | | | Industrial Worker (Outdoor) | Adult | Inhalation | On-site | Quant | Industrial workers could be exposed to airborne volatiles or particulate matter released from surface soil at SWMU 31. |
| | | | | Trespasser | Adolescent | Inhalation | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Total Soil (Surface and Subsurface) | Total Soil (Surface and Subsurface) | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | Quant | Maintenance workers could contact soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | Quant | Industrial workers could contact soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact soil at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Excavation Worker | Adult | Ingestion | On-site | Quant | Excavation workers could contact soil at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Excavation workers could contact soil at SWMU 31 and be exposed to COPCs via dermal absorption. |

# Table 5-1
# Selection of Exposure Pathways

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Furure (cont.) | | | | Resident | Adult | Ingestion | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA. |
| | | | | | | Dermal | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via dermal absorption. |
| | | | | | Child | Ingestion | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA. |
| | | | | | | Dermal | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in total soil via dermal absorption. |
| | Total Soil (Surface and Subsurface) | Total Soil (Surface and Subsurface) | | Trespasser | Adolescent | Ingestion | On-site | None | Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | Air | SWMU 31 | Maintenance Worker | Adult | Inhalation | On-site | Quant | Maintenance workers could be exposed to airborne volatiles or particulate matter released from soils at SWMU 31. |
| | | | | Industrial Worker (Outdoor) | Adult | Inhalation | On-site | Quant | Industrial workers could be exposed to airborne volatiles or particulate matter released from soils at SWMU 31. |
| | | | | Excavation Worker | Adult | Inhalation | On-site | Quant | Excavation workers could be exposed to airborne volatiles or particulate matter released from soils at SWMU 31. |
| | | | | Resident | Adult | Inhalation | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to airborne volatiles or particulate matter released from total soil. |
| | | | | | Child | Inhalation | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to airborne volatiles or particulate matter released from total soil. |
| | | | | Trespasser | Adolescent | Inhalation | On-site | None | Given the industrial nature of the site, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Sediment | Sediment | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | Quant | Maintenance workers could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | Quant | Industrial workers could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption. |
| | | | | Excavation Worker | Adult | Ingestion | On-site | Quant | Excavation workers could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion. |
| | | | | | | Dermal | On-site | Quant | Excavation workers could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption. |

# Table 5-1
# Selection of Exposure Pathways

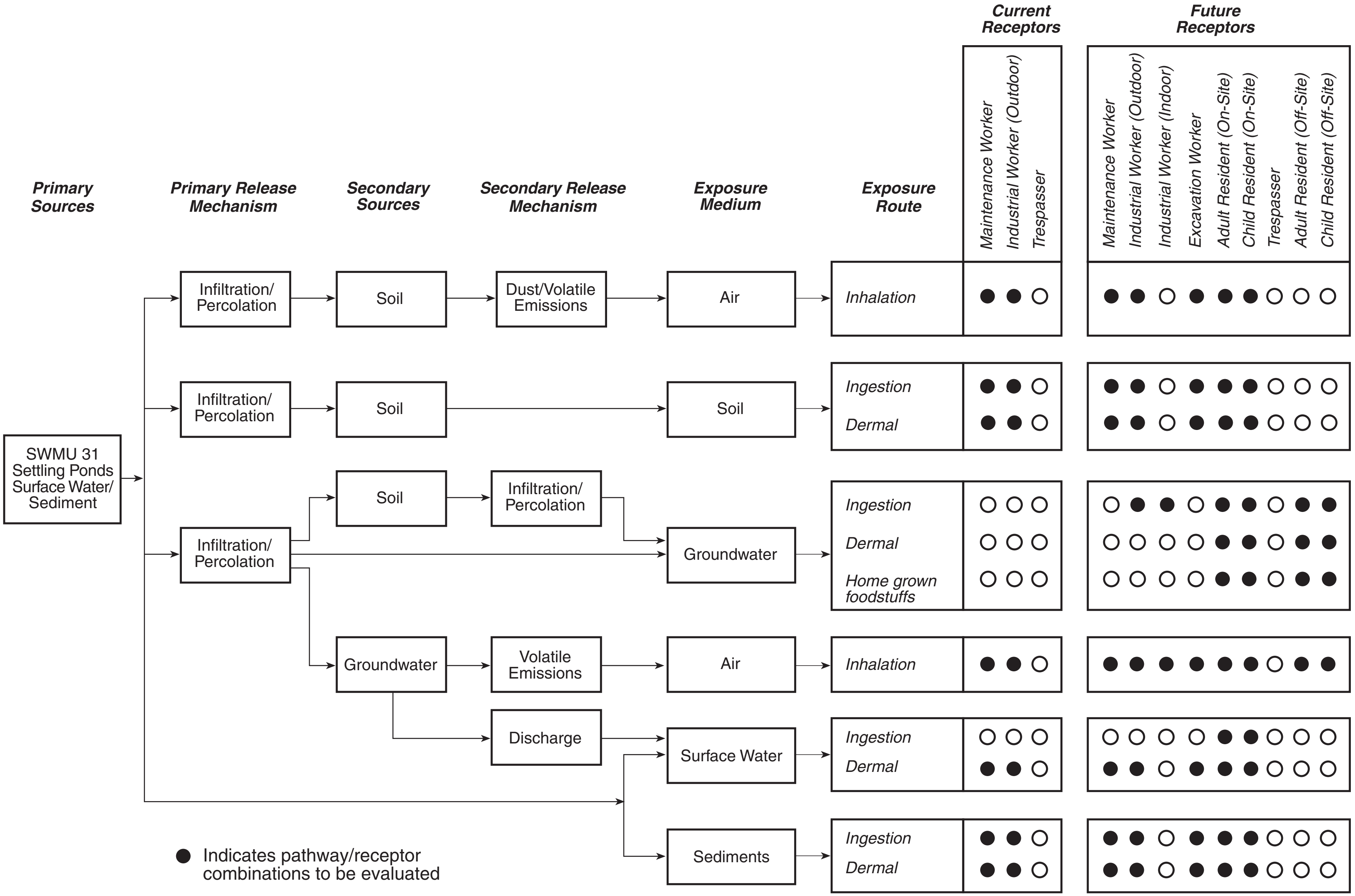
| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Future (cont.) | | | | Resident | Adult | Ingestion | On-site | Quant | Adult residents could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion during wading or swimming. |
| | | | | | | Dermal | On-site | Quant | Adult residents could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption during wading or swimming. |
| | | | | | Child | Ingestion | On-site | Quant | Child residents could contact sediment at SWMU 31 and be exposed to COPCs via incidental ingestion during wading or swimming. |
| | | | | | | Dermal | On-site | Quant | Child residents could contact sediment at SWMU 31 and be exposed to COPCs via dermal absorption during wading or swimming. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Surface Water | Surface Water | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | None | Maintenance workers could contact surface water at SWMU 31 while wading. However, surface water ingestion is unlikely. |
| | | | | | | Dermal | On-site | Quant | Maintenance workers could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading. |
| | | | | Industrial Worker (Outdoor) | Adult | Ingestion | On-site | None | Industrial workers could contact surface water at SWMU 31 while wading. However, surface water ingestion is unlikely. |
| | | | | | | Dermal | On-site | Quant | Industrial workers could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading. |
| | | | | Excavation Worker | Adult | Ingestion | On-site | None | Excavation workers could contact surface water at SWMU 31 while wading. However, surface water ingestion is unlikely. |
| | | | | | | Dermal | On-site | Quant | Excavation workers could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading. |
| | | | | Resident | Adult | Ingestion | On-site | Quant | Residents could contact surface water at SWMU 31 while wading or swimming. Surface water ingestion while wading is considered unlikely. |
| | | | | | | Dermal | On-site | Quant | Adult residents could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading or swimming. |
| | | | | | Child | Ingestion | On-site | Quant | Residents could contact surface water at SWMU 31 while wading or swimming. Surface water ingestion while wading is considered unlikely. Surface water ingestion while swimming is evaluated. |
| | | | | | | Dermal | On-site | Quant | Child residents could contact surface water at SWMU 31 and be exposed to COPCs via dermal absorption while wading or swimming. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |

# Table 5-1
# Selection of Exposure Pathways

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Future (cont.) | Groundwater | Groundwater | SWMU 31 | Maintenance Worker | Adult | Ingestion | On-site | None | Maintenance workers would not contact groundwater at SWMU 31. |
| | | | | | | Dermal | On-site | None | Maintenance workers would not contact groundwater at SWMU 31. |
| | | | | Industrial Worker (Outdoor and Indoor) | Adult | Ingestion | On-site | Quant | If SWMU 31 were to be further developed for industrial purposes and groundwater wells were installed at the site, site workers could be exposed to COPCs in groundwater via ingestion. |
| | | | | | | Dermal | On-site | None | Although site worker dermal exposures to groundwater could occur, the exposed body surface area of a worker (i.e., hands and arms) would be small and exposures would be infrequent. |
| | | | | Excavation Worker | Adult | Ingestion | On-site | None | Based on the depth to groundwater, excavation workers would not contact groundwater at SWMU 31. |
| | | | | | | Dermal | On-site | None | Based on the depth to groundwater, excavation workers would not contact groundwater at SWMU 31. |
| | | | | Resident | Adult | Ingestion | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in groundwater via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA. |
| | | | | | | Dermal | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in groundwater via dermal absorption. |
| | | | | | Child | Ingestion | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in groundwater via ingestion. The residential scenario is not considered to be a reasonably anticipated land use; however, it is being included in this evaluation to meet "clean closure" requirements under RCRA. |
| | | | | | | Dermal | On-site | Quant | If SWMU 31 were to be further developed for residential purposes, residents could be exposed to COPCs in groundwater via dermal absorption. |
| | | | | Trespasser | Adolescent | Ingestion | On-site | None | Due to security at the installation, trespasser exposures are unlikely. |
| | | | | | | Dermal | On-site | None | Due to security at the installation, trespasser exposures are unlikely. |
| | | Homegrown fruits and vegetables | SWMU 31 | Resident | Adult | Ingestion | On-site | Quant | Residents could ingest COPCs in groundwater that had been taken up by homegrown fruits and vegetables. |
| | | | | | Child | Ingestion | On-site | Quant | Residents could ingest COPCs in groundwater that had been taken up by homegrown fruits and vegetables. |
| | | Air | Volatile groundwater COPCs released to ambient air | Maintenance Worker | Adult | Inhalation | On-site | Quant | Volatiles could be released from groundwater into ambient air. Maintenance workers could be exposed via inhalation. |
| | | | | Industrial Worker (Outdoor) | Adult | Inhalation | On-site | Quant | Volatiles could be released from groundwater into ambient air. Industrial workers could be exposed via inhalation. |
| | | | Indoor Vapors | Industrial Worker (Indoor) | Adult | Inhalation | On-site | Quant | Volatiles in groundwater could potentially migrate into buildings via vapor intrusion. |
| | | | Trench Vapors | Excavation Worker | Adult | Inhalation | On-Site | Quant | Volatiles in groundwater could potentially migrate into a construction or utility trench via vapor intrusion. |

# Table 5-1
# Selection of Exposure Pathways

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | On-Site/ Off-Site | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|---|---|---|---|---|---|---|---|---|---|
| Future (cont.) | | | Volatiles at Showerhead | Resident | Adult | Inhalation | On-site | Quant | If groundwater wells were installed for residential purposes, adult residents could contact volatiles in groundwater via showering. |
| | | | | | Child | Inhalation | On-site | Quant | Children are assumed to bathe rather than shower. Therefore, inhalation exposure is assessed using only indoor air. |
| | | | Indoor Vapors | Resident | Adult | Inhalation | On-site | Quant | Volatiles in groundwater could potentially migrate into residences via vapor intrusion. |
| | | | | | Child | Inhalation | On-site | Quant | Volatiles in groundwater could potentially migrate into residences via vapor intrusion. |
| | | | Volatile groundwater COPCs released to ambient air | Trespasser | Adolescent | Inhalation | On-site | None | Due to security at the installation, trespasser exposures are unlikely. However, the maintenance worker scenario would be protective of the limited exposures that would be experienced by a trespasser. |
| | Groundwater | Groundwater | Off-site | Resident | Adult | Ingestion | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could be exposed to COPCs in groundwater via ingestion. |
| | | | | | | Dermal | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could be exposed to COPCs in groundwater via dermal absorption. |
| | | | | | Child | Ingestion | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could be exposed to COPCs in groundwater via ingestion. |
| | | | | | | Dermal | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could be exposed to COPCs in groundwater via dermal absorption. |
| | | Homegrown fruits and vegetables | Off-site | Resident | Adult | Ingestion | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could ingest COPCs in groundwater that had been taken up by homegrown fruits and vegetables. |
| | | | | | Child | Ingestion | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, off-site residents could ingest COPCs in groundwater that had been taken up by homegrown fruits and vegetables. |
| | | Air | Volatiles at Showerhead | Resident | Adult | Inhalation | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate to off-site wells in the future, adult residents could contact volatiles in groundwater via showering. |
| | | | | | Child | Inhalation | Off-site | Quant | Children are assumed to bathe rather than shower. Therefore, inhalation exposure is assessed using only indoor air. |
| | | | Indoor Vapors | Resident | Adult | Inhalation | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, volatiles in groundwater could potentially migrate into off-site residences via vapor intrusion. |
| | | | | | Child | Inhalation | Off-site | Quant | If COPCs from SWMU 31 groundwater were to migrate off-site in the future, volatiles in groundwater could potentially migrate into off-site residences via vapor intrusion. |



| Exposure Medium | Exposure Route | Current Receptors: Maintenance Worker | Current Receptors: Industrial Worker (Outdoor) | Current Receptors: Trespasser | Future Receptors: Maintenance Worker | Future Receptors: Industrial Worker (Outdoor) | Future Receptors: Industrial Worker (Indoor) | Future Receptors: Excavation Worker | Future Receptors: Adult Resident (On-Site) | Future Receptors: Child Resident (On-Site) | Future Receptors: Trespasser | Future Receptors: Adult Resident (Off-Site) | Future Receptors: Child Resident (Off-Site) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air | *Inhalation* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |
| Soil | *Ingestion* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |
| | *Dermal* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |
| Groundwater | *Ingestion* | ○ | ○ | ○ | ○ | ● | ● | ○ | ● | ● | ○ | ● | ● |
| | *Dermal* | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● | ○ | ● | ● |
| | *Home grown foodstuffs* | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● | ○ | ● | ● |
| Air | *Inhalation* | ● | ● | ○ | ● | ● | ● | ● | ● | ● | ○ | ● | ● |
| Surface Water | *Ingestion* | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ● | ● | ○ | ○ | ○ |
| | *Dermal* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |
| Sediments | *Ingestion* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |
| | *Dermal* | ● | ● | ○ | ● | ● | ○ | ● | ● | ● | ○ | ○ | ○ |

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or not evaluated

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Figure 5-1. Conceptual Site Model for SWMU 31.
Radford Army Ammunition Plant, Virginia

| | | | | | |
|---|---|---|---|---|---|
| DRAWING BY | *JIS, III*<br>*5/31/07* | CHECKED BY | *CH* | *5/31/07* | DRAWING NO. |
| | | APPROVED BY | *CH* | *5/31/07* | S-839197.06-5/07-w |

## 5.1 DATA SUMMARY AND SELECTION OF COPCs

This section of the HHRA discusses the methodologies used to summarize the data for the HHRA (*Section 5.1.1*) and to select COPCs for detailed evaluation in the HHRA (*Section 5.1.2*). The summarization of data and selection of human health COPCs are then presented for the sampled medium at SWMU 31 in *Section 5.1.3*. Finally, a summary of the COPCs selected in each medium is provided in *Section 5.1.4*.

### 5.1.1 Methodology for Data Summary

The first step of the HHRA process was to summarize the analytical data collected at SWMU 31. Complete details of the RFI quality assurance/quality control analysis and activities are presented in **Appendix C**. Chemical data validation reports and analytical data are provided on a CD located at the back of this report.

The following steps, which are in accordance with USEPA (1989a) guidance, were used to summarize the analytical data for this HHRA:

- Analytical data collected in 1992, 1996, 1998, and 2002 were summarized by environmental medium (i.e., surface soil, total soil, sediment, surface water, groundwater). In general, surface soil was defined as soil samples that were collected from 0 to 2 ft. Total soil consisted of surface soil and subsurface soil, assuming that soil would mix as a result of potential disturbance (e.g., excavation, construction) in the future. Subsurface soil samples were collected between 2 to 10 ft bgs. In addition, the samples were divided into groups that describe conditions relevant to potential exposure by receptors or were pertinent to site environmental factors.
- 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, 1995c, 2000a), 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.
- Data sets for this HHRA were evaluated for B-qualified data on an "analyte-by-analyte" basis. Because of the amount of B-qualified data reported for some analytes, one-half of the sample quantitation limit (SQL) was used as a proxy value for B-qualified data points to address potential uncertainty associated with eliminating these data. If the proportion of B-qualified results in the data set for SWMU 31 was greater than 50 percent, one-half of the SQL was used to represent the concentration. This approach was applied to all samples prior to averaging regular samples and duplicates. If the proportion of B-qualified results in the data set was less than 50 percent, the B-qualified data for the analyte were eliminated. The exception to this approach was the dioxin/furan results used to estimate a 2,3,7,8-TCDD TE concentration. For screening purposes, the B-qualified data were included in calculations of the dioxin toxicity equivalence (TCDD TE), as described in the sections below.
- Data that were considered estimated values (e.g., J-qualified) were used in the HHRA without modification.

- Arithmetic mean chemical concentrations were calculated by averaging the detected concentrations with one-half the SQL of non-detects. One-half of the SQL is typically used in assessments (USEPA, 1989a) when averaging non-detect concentrations, because the actual value can be between zero and a value just below the SQL. In accordance with USEPA Region III guidance (USEPA, 1995c), this procedure was used even when the non-detect SQL was two or more times higher than the maximum detected concentration (MDC) in that medium. The uncertainties associated with this methodology will be discussed in *Section 5.5*.
- Data from duplicate samples were averaged together and treated as one result. If a chemical was detected in one of two duplicate samples, one-half of the SQL was used for the non-detected value and averaged together with the detected result.
- Frequency of detection was calculated as the number of samples in which the chemical was detected over the total number of samples analyzed. The frequency of detection was assessed after the exclusion of B-qualified data, and after the treatment of duplicate sample data. Because samples were sometimes analyzed for different sets of analytes, the frequencies of detection varied by analyte. Frequency of detection, however, was not used as a selection criterion for COPCs in this HHRA.
- If a constituent was analyzed by two different methods, results from the most sensitive analytical method were generally used.

Dioxin-like compounds were treated according to procedures provided by USEPA and the World Health Organization (WHO) (USEPA, 1989b, 1994a; WHO, 1998). Dioxin-like compounds (PCDDs and PCDFs) 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. This procedure is described in the following steps:

- For each sample, the detected concentration of each congener was multiplied by a toxicity equivalency factor (TEF) to derive a 2,3,7,8-TCDD equivalent (TCDD TE) concentration (USEPA, 1989b). If the value for a particular congener was reported as a "non-detect" (ND), then the reported detection limit was used to represent a conservative concentration for the congener. If the result for a particular congener was B-qualified, then the result was conservatively retained for the calculation.
- To calculate the 2,3,7,8-TCDD TEQ for each sample, the TCDD TEs for individual congeners were summed. The TEF values for each congener are listed in **Table 5-2** (WHO, 1998).
- The total TCDD TE values for each medium were summarized by selecting the maximum and minimum TCDD TEs across each of the samples for that medium.

### 5.1.2 Methodology for Selection of COPCs for Human Health

Once the sampling data for SWMU 31 were grouped and summarized, COPCs for the HHRA were selected. The purpose of selecting COPCs is to identify those chemicals that are present as a result of past activities at the site and most likely to be of concern to human health. Therefore, the screening process eliminates from the HHRA:

## Table 5-2
## Toxicity Equivalency Factors (TEFs)

| Congener | TEF |
|---|---|
| **Dioxins** | |
| 2,3,7,8-TCDD or TCDD | 1.0 |
| HxCDD | 0.1 |
| 2,3,7,8-HpCDD or HpCDD | 0.01 |
| OCDD | 0.0001 |
| PeCDD | 1.0 |
| **Furans** | |
| TCDFs | 0.1 |
| HxCDF | 0.1 |
| 2,3,7,8-HpCDF or HpCDF | 0.01 |
| OCDF | 0.0001 |
| 1,2,3,7,8-PeCDF | 0.05 |
| 2,3,4,7,8-PeCDF | 0.5 |

- Those chemicals present in surface soil and total soil at concentrations below conservative health-based screening levels, represented by the USEPA Region III RBCs corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a).
- Those chemicals present in sediment at concentrations below conservative health-based screening levels, represented by the USEPA Region III RBCs for residential soil corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a), which have been increased by a factor of ten to represent sediment exposures.
- Those chemicals present in surface water at concentrations below conservative health-based screening levels, represented by the USEPA Region III RBCs for tap water corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a), which have been increased by a factor of ten to represent surface water exposures.
- Those chemicals present in groundwater at concentrations below relevant health-based screening levels, represented by the USEPA Region III RBCs for tap water corresponding to a carcinogenic risk of $1x10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a).
- Those chemicals that are essential human nutrients (i.e., calcium, magnesium, potassium, and sodium) and unlikely to pose risks to human health.

The following methodologies were used to eliminate chemicals detected at maximum concentrations below screening levels from quantitative evaluation in the HHRA, and to compare inorganic chemicals detected above screening levels to background concentrations. The RBCs used for this HHRA are presented in **Table 5-3**.

# Table 5-3
# USEPA Region III RBCs for Chemicals Detected at SWMU 31
### Page 1 of 2

| Chemical | USEPA Region III RBC (a) | USEPA Region III RBC (b) | USEPA Region III RBC (c) | USEPA Region III RBC (d) |
|---|---|---|---|---|
| | Residential Soil (organics - mg/kg; inorganics - mg/kg) | Sediment (organics - mg/kg; inorganics - mg/kg) | Tap Water (μg/L) | Surface Water (μg/L) |
| **Organics** | | | | |
| Acenaphthene | --- | 4.7E+03 | 3.7E+01 | 3.7E+02 |
| Acenaphthylene (e) | --- | 2.4E+03 | --- | 1.8E+02 |
| Anthracene | --- | 2.3E+04 | --- | 1.8E+03 |
| Aroclor 1254 | 3.2E-01 | 3.2E+00 | --- | --- |
| Benzo(a)anthracene | --- | 8.7E+00 | 9.2E-02 | --- |
| Benzo(a)pyrene | --- | 8.7E-01 | 9.2E-03 | --- |
| Benzo(b)fluoranthene | --- | 8.7E+00 | 9.2E-02 | --- |
| Benzo(g,h,i)perylene (e) | --- | 2.3E+03 | --- | --- |
| Benzo(k)fluoranthene | --- | 8.7E+01 | --- | --- |
| Benzoic acid | --- | --- | --- | 1.5E+05 |
| alpha-BHC | --- | --- | --- | 1.1E-01 |
| delta-BHC (f) | --- | --- | --- | 1.1E-01 |
| gamma-BHC (Lindane) | 4.9E-01 | 4.9E-01 | --- | 5.2E-01 |
| Bromodichloromethane | --- | --- | --- | 1.7E+00 |
| Butyl benzyl phthalate | --- | --- | --- | 7.3E+04 |
| Di-n-butyl phthalate | --- | --- | --- | 3.7E+03 |
| Carbazole | --- | 3.2E+02 | --- | --- |
| Chloroform | --- | --- | 1.5E-01 | 1.5E+00 |
| Chrysene | --- | 8.7E+02 | --- | --- |
| 4,4'-DDD | 2.7E+00 | 2.7E+01 | --- | --- |
| 4,4'-DDE | 1.9E+00 | 1.9E+01 | --- | --- |
| 4,4'-DDT | 1.9E+00 | --- | --- | 1.9E+00 |
| Dibenz(a,h)anthracene | --- | 8.7E-01 | --- | --- |
| Dibenzofuran | NRA | NRA | NRA | NRA |
| Dibromochloromethane | --- | --- | --- | 1.3E+00 |
| Dicamba | --- | --- | --- | 1.1E+03 |
| 1,2-Dichlorobenzene | --- | --- | --- | 2.7E+02 |
| 1,3-Dichlorobenzene | --- | --- | --- | 1.8E+01 |
| 1,4-Dichlorobenzene | --- | --- | --- | 4.7E+00 |
| Diethyl phthalate | --- | --- | --- | 2.9E+04 |
| 2,4-Dimethylphenol | --- | 1.6E+03 | --- | --- |
| Endosulfan II (g) | 4.7E+01 | --- | --- | 2.2E+02 |
| Endosulfan sulfate (g) | 4.7E+01 | --- | --- | 2.2E+02 |
| Endrin | 2.3E+00 | 2.3E+01 | --- | 1.1E+01 |
| Endrin aldehyde (h) | 2.3E+00 | 2.3E+01 | --- | 1.1E+01 |
| Fluoranthene | --- | 3.1E+03 | --- | --- |
| Fluorene | --- | 3.1E+03 | 2.4E+01 | 2.4E+02 |
| Hexachlorobutadiene | --- | --- | --- | 7.3E+00 |
| Hexachloroethane | --- | --- | --- | 3.7E+01 |
| Indeno(1,2,3-c,d)pyrene | --- | 8.7E+00 | --- | --- |
| Methoxychlor | 3.9E+01 | 3.9E+02 | --- | --- |
| 2-Methylnaphthalene | --- | 3.1E+02 | --- | 2.4E+01 |
| Naphthalene | --- | 1.6E+03 | --- | --- |
| Nitrobenzene | --- | 3.9E+01 | --- | 3.5E+00 |
| Nitroglycerin | 1.3E+02 | 1.3E+03 | --- | --- |
| n-Nitrosodiphenylamine | --- | 1.3E+03 | --- | --- |
| Phenanthrene (e) | --- | 2.3E+03 | --- | 1.8E+02 |
| Pyrene | --- | 2.3E+03 | --- | 1.8E+02 |
| TCDD Toxicity Equivalent | 4.3E-06 | 4.3E-05 | --- | --- |
| 2,4,5-TP | --- | --- | --- | 3.7E+02 |
| 2,4,6-Trinitrotoluene | --- | 3.9E+01 | --- | --- |
| **Inorganics** | | | | |
| Aluminum | NRA | NRA | NRA | NRA |
| Antimony | 3.1E+00 | 3.1E+01 | --- | --- |
| Arsenic | 4.3E-01 | 4.3E+00 | 4.5E-02 | --- |
| Barium | 1.6E+03 | 1.6E+04 | 7.3E+02 | 7.3E+03 |
| Beryllium | 1.6E+01 | 1.6E+02 | 7.3E+00 | --- |
| Cadmium (i) | 3.9E+00 | 3.9E+01 | --- | --- |
| Calcium (j) | 1.0E+06 | 1.0E+06 | 5.0E+05 | 5.0E+05 |
| Chromium (k) | 2.3E+01 | 2.3E+02 | 1.1E+01 | 1.1E+02 |
| Cobalt | NRA | NRA | NRA | --- |
| Copper | 3.1E+02 | 3.1E+03 | 1.5E+02 | --- |
| Iron | 2.3E+03 | 2.3E+04 | 1.1E+03 | 1.1E+04 |
| Lead (l) | 4.0E+02 | 4.0E+02 | 1.5E+01 | 1.5E+01 |
| Magnesium (j) | 1.0E+06 | 1.0E+06 | 1.8E+05 | 1.8E+05 |
| Manganese (m) | 1.6E+02 | 1.6E+03 | 7.3E+01 | 7.3E+02 |

## Table 5-3
## USEPA Region III RBCs for Chemicals Detected at SWMU 31
### Page 2 of 2

| Chemical | USEPA Region III RBC (a) | USEPA Region III RBC (b) | USEPA Region III RBC (c) | USEPA Region III RBC (d) |
|---|---|---|---|---|
| | Residential Soil (organics - mg/kg; inorganics - mg/kg) | Sediment (organics - mg/kg; inorganics - mg/kg) | Tap Water (µg/L) | Surface Water (µg/L) |
| Mercury (n) | 2.3E+00 | 7.8E+00 | --- | 1.1E+01 |
| Nickel | 1.6E+02 | 1.6E+03 | --- | 7.3E+02 |
| Potassium (j) | 1.0E+06 | 1.0E+06 | 1.0E+06 | 1.0E+06 |
| Sodium (j) | 1.0E+06 | 1.0E+06 | 2.0E+04 | 2.0E+04 |
| Thallium | 5.5E-01 | 5.5E+00 | --- | --- |
| Vanadium | 7.8E+00 | 7.8E+01 | 3.7E+00 | --- |
| Zinc | 2.3E+03 | 2.3E+04 | --- | 1.1E+04 |

(a) USEPA Region III residential soil RBCs are used as screening values for soil (USEPA, 2006a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1, following USEPA Region III guidance.

(b) USEPA Region III residential soil RBCs are used as screening values for sediment (USEPA, 2006a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1 and a carcinogenic risk of $1x10^{-6}$, following USEPA Region III guidance. The RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for sediment.

(c) USEPA Region III tap water RBCs are used as screening values for groundwater (USEPA, 2006a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1 and a carcinogenic risk of $1x10^{-6}$, following USEPA Region III guidance.

(d) USEPA Region III tap water RBCs are used as screening values for surface water (USEPA, 2006a). RBCs for noncarcinogenic chemicals are conservatively based on a hazard quotient of 0.1 and a carcinogenic risk of $1x10^{-6}$, following USEPA Region III guidance. The RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for surface water.

(e) The RBC for pyrene was used for non-carcinogenic polynuclear aromatic hydrocarbons (PAHs) lacking RBCs.

(f) The RBC for gamma-BHC was used.

(g) The RBC for endosulfan was used.

(h) The RBC for endrin was used.

(i) The soil RBC for water was used because it is a more conservative value.

(j) Value is a Recommended Daily Allowance (RDA) level for essential human nutrients.

(k) The RBC for chromium VI was used as the screening criterion, although not all of the chromium at the site will be in this form.

(l) Because lead does not have an RBC, the 400 mg/kg residential screening level (USEPA, 1994b) was used for soil. The drinking water action level (15 ug/L) was used as the screening criterion for water (USEPA, 2004a).

(m) The RBC for non-food was used.

(n) For soil, the RBC for mercury chloride was used. For sediment, the RBC for methylmercury was used.

NRA = No RBC Available. The PPRTV for the chemical has been retired by the National Center for Environmental Assessment (USEPA, 2006a).

--- = The chemical was either not tested for or not detected in this media.

#### 5.1.2.1 Comparison of Detected Chemicals to Relevant Health-Based Levels

The maximum concentrations of detected chemicals were compared to RBCs (USEPA, 2006a), in accordance with Region III guidance. The RBCs presented in the USEPA Region III RBC table are health-protective chemical concentrations that are back-calculated using conservative exposure parameters and either carcinogenic toxicity criteria and a $1 \times 10^{-6}$ target risk level, or noncarcinogenic toxicity criteria and an HI of 1.0 (whichever results in a lower RBC).

For the purposes of this HHRA, RBCs that were back-calculated using carcinogenic toxicity criteria were used directly as screening criteria, whereas RBCs that were back-calculated using noncarcinogenic toxicity criteria were adjusted downward by a factor of 10 in order to add a ten-fold measure of safety (i.e., to ensure that compounds that could combine to result in an HI greater than 1 for a specific target organ/critical effect were not eliminated from the assessment). If the maximum detected on-site chemical concentration was less than the RBC (or adjusted RBC for noncarcinogenic chemicals), the excess probability of developing cancer would be less than 1 in 1 million, and adverse noncarcinogenic effects would not be expected to occur. As a result, those chemicals detected at levels greater than RBCs (or adjusted RBCs) were retained for evaluation.

Because RBCs are not available for sediment, chemicals present in sediment were compared with USEPA Region III RBCs for residential soil corresponding to a carcinogenic risk of $1 \times 10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a). To be consistent with the *RFAAP Final MWP*, Section 6.2.2, Selection of COPCs for the HHRA (URS, 2003), the residential soil RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for this medium.

Because RBCs are not available for surface water, chemicals present in surface water were compared to USEPA Region III RBCs for tap water corresponding to a carcinogenic risk of $1 \times 10^{-6}$ or adjusted to reflect one-tenth (0.1) of the HI for noncarcinogenic effects (USEPA, 2006a). To be consistent with the *RFAAP Final MWP*, Section 6.2.2, Selection of COPCs for the HHRA (URS, 2003), the tap water RBCs were then increased by one order of magnitude to represent the types of exposures that are more likely to occur for this medium.

Although current and future land-uses at SWMU 31 are most likely to be industrial in nature (see *Section 5.2*), residential (rather than industrial) soil RBCs were used for comparisons to soil concentrations. Because the resident scenario was evaluated for this HHRA, residential soil RBCs were used to screen chemicals in soil as a conservative measure.

RBCs are not available for lead. For screening purposes, however, the maximum detected lead concentrations in soil were conservatively compared to USEPA's residential SSL of 400 mg/kg (USEPA, 1994b). Per 40 CFR 745, the lead concentration of 400 mg/kg applies to areas where children play. The maximum detected lead concentrations in groundwater were conservatively compared to USEPA's drinking water action level of 0.015 mg/L (USEPA, 2004a). Lead was selected for further evaluation in the HHRA where MDCs of lead exceed screening levels.

#### 5.1.2.2 Comparison of Essential Human Nutrients to Allowable Daily Intakes

The maximum concentrations of the four essential human nutrients that do not have RBCs (i.e., calcium, magnesium, potassium, and sodium) were compared to dietary Allowable Daily Intakes (ADIs). As recommended in both the *Site Screening Process* (USEPA, 2001b) and the *Final MWP* (URS, 2003), the essential nutrients calcium, magnesium, potassium, and sodium were eliminated as COPCs. Although iron is also an essential nutrient, there is an RBC available for iron. It is noted in the *Site Screening Process* (USEPA, 2001b), however, that if iron concentrations in soil or water result in a hazard quotient (HQ) of 0.5 or greater, then a "margin of exposure" evaluation would be performed. Risks from exposure to iron would be characterized by comparing estimated iron intake to the Recommended Daily Allowance (RDA) and concentrations known to cause effects in children (USEPA, 1996a).

### 5.1.2.3 Comparison of Inorganic Compounds to Background Levels

Comparisons between detected site concentrations and background concentrations were also conducted in the HHRA for information purposes only. Background data for SWMU 31 soils were obtained from the FWBSR (IT, 2001). There are no background data established for sediment, surface water, and groundwater. Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were noted as being within background levels, but were still carried through the risk calculation in the HHRA. In addition, COPCs that are present at concentrations within background range will be qualitatively addressed in the HHRAs.

For the HHRA, the evaluation of site concentrations to background concentrations was achieved using two methods of comparison. First, the MDC for each inorganic constituent was compared to the background UTL, as established in the FWBSR. Chemical concentrations are compared to RFAAP background concentrations (*Section 3.1.1*) as an indication of whether a chemical is present from site-related activity or as natural background. This comparison, performed as part of the risk characterization for each site, is generally valid for inorganic chemicals, but not for organic chemicals, because inorganic chemicals are naturally occurring and most organic chemicals are not. The 95 percent UTL, as provided in the FWBSR (IT, 2001) was used as one of the background comparison statistics (**Table 5-4**). A detailed discussion can be found in the FWBSR (IT, 2001).

**Table 5-4**
**Facility-Wide Background Soil Concentrations**

| Chemical | Minimum Concentration | Maximum Concentration | 95% UTL of the Mean |
|---|---|---|---|
| Aluminum | 3,620 | 47,900 | 40,041 |
| Arsenic | 1.2 | 35.9 | 15.8 |
| Barium | 23.4 | 174 | 209 |
| Beryllium | 0.61 | 5.4 | 1.02 |
| Cadmium | 0.62 | 2.5 | 0.69 |
| Chromium | 6.3 | 75.8 | 65.3 |
| Cobalt | 5.9 | 130 | 72.3 |
| Copper | 1.6 | 38.7 | 53.5 |
| Iron | 7,250 | 67,700 | 50,962 |
| Lead | 2.1 | 256 | 26.8 |
| Manganese | 16.7 | 2,040 | 2,543 |
| Mercury | 0.038 | 1.2 | 0.130 |
| Nickel | 4.6 | 94.2 | 62.8 |
| Thallium | 1.3 | 5 | 2.11 |
| Vanadium | 12.2 | 114 | 108 |
| Zinc | 4.7 | 598 | 202 |

Note: units in mg/kg

The second method involved the statistical comparison of site concentrations to background concentrations to evaluate whether the populations were similar. This approach paralleled the methodology applied to population comparisons for the FWBSR. The data sets were first evaluated to assess whether data were normally distributed. The site data sets and background data sets were tested individually.

The Shapiro-Wilk test or W test (Gilbert, 1987) was used for data sets with sample sizes equal to or less than 50 to assess whether or not a data set has been drawn from a population that is normally distributed. By conducting this test on the natural logarithm of each data value, the W test was used to assess whether or not the sample was drawn from an underlying lognormal distribution. The null hypothesis for this test is:

$H_o$: The population has a normal (lognormal when the data is transformed) distribution.

versus

$H_A$: The population does not have a normal (lognormal when the data is transformed) distribution.

If $H_o$ is rejected, then $H_A$ is accepted.

The Shapiro-Francia test was used for data sets with sample sizes greater than 50 to assess whether or not a data set has been drawn from a population that is normally distributed. Like the Shapiro-Wilk test, the Shapiro-Francia test statistic (W′) can be calculated using the natural logarithm of each data value. This approach is used to assess whether or not the sample was drawn from an underlying lognormal distribution. The null hypothesis for this test is:

$H_o$: The population has normal (lognormal when data is transformed) distribution.

versus

$H_A$: The population does not have a normal (lognormal when data is transformed) distribution.

If $H_o$ is rejected, then $H_A$ is accepted.

If these tests indicated that the data sets did not follow a normal distribution, data points were log-transformed and the tests were used to assess whether the data were lognormally distributed.

When data were found to follow a normal distribution, the F-test was applied to assess whether there was a statistical difference between the variances of the two groups. An alpha of 0.05 was selected for this test. The null hypothesis for this test is:

$H_o$: The populations have equivalent variances ($\sigma = \sigma$)

versus

$H_A$: The populations do not have equivalent variances ($\sigma \neq \sigma$)

Results from the F-test were used to identify the appropriate t-test. For example, when the variances were found to be similar, the t-test was calculated using equal variances. Conversely, t-tests were calculated using unequal variances when the F-test demonstrated that the variances between the data sets were not similar.

The t-test was used to assess whether the means of the data sets for the site concentrations were similar or greater than the background concentrations. If the t-test indicated that the means between the two data groups were similar, site concentrations were considered to be within or below background levels. If the t-test indicated that the mean for the site data set was greater than the mean for the background data set, then site concentrations were considered to be above background concentrations. An alpha of 0.05 was selected for this test. The null hypothesis for this test is:

$H_o$: The populations have equal means ($\mu_1 = \mu_2$)

versus

$H_A$: The mean of the site data set is greater than the mean of the background data set ($\mu_1 > \mu_2$)

When site and background data sets had different distributions or did not pass the normal distribution test, the Mann-Whitney U test was used to assess whether the medians of the data sets for the site concentrations were similar or greater than the background concentrations. The Mann-Whitney U test is a nonparametric test that involves ranking the data. This test is not dependent upon the distribution of the data. If the Mann-Whitney U test indicated that the medians between the two data groups were similar, site concentrations were considered to be within or below background levels. If the Mann-Whitney U indicated that the median for the site data set was greater than the mean for the background concentrations, then site concentrations were considered to be above background concentrations. The null hypothesis for this test is:

$H_o$: The populations have equal medians set ($U_1 = U_2$)

versus

$H_A$: The median of the site data set is greater than the median of the background data set ($U_1 > U_2$)

Based on these evaluations, chemicals were considered to be within the range of background concentrations if they met both of the following conditions:

- The MDC was below the UTL.
- Based on statistical comparisons, site concentrations are within or below background concentrations.

The results of these analyses are included in **Appendix E-2, Tables 1 and 2**. For total soil, arsenic, chromium, iron, manganese, and vanadium exceeded screening criteria but were shown to be within background concentrations. As stated previously, inorganic chemicals detected at concentrations exceeding RBCs or ADIs, but within background levels, were not eliminated from the quantitative evaluation in the HHRA. These inorganic chemicals were included in the risk calculations, in addition to being qualitatively addressed in the HHRA.

### 5.1.3 Data Summary and Selection of COPCs for Sampled Media

The following sections describe the environmental samples collected at SWMU 31, the sample groupings selected for the HHRA, and the COPCs selected within each of the sample groupings. In addition, the background data obtained from the FWBSR (IT, 2001) for each medium are discussed. Summary tables present chemical data by timeframe, medium, and data grouping and contain parameters such as the range of detected concentrations, location of the MDC, frequency of detection, screening criteria, and the 95 percent UTL of the background concentrations. The tables presenting the summarized data and selected COPCs are included in **Appendix E-1, Tables E-1, E-3, E-5, E-7, and E-9**.

### 5.1.3.1 Surface Soil

Surface soil samples (i.e., samples collected from the 0 to 2-ft soil interval) included in the HHRA for evaluation are shown in **Table 5-5**. A total of two surface soil samples collected in July 2002 at SWMU 31 were evaluated in the HHRA. Surface soil samples were analyzed for VOCs, pesticides, herbicides, PCBs, TAL metals, dioxins/furans, and explosives. It is noted that one sample was collected from 1 to 3 foot interval. This sample was included as surface soil in the HHRA to be consistent with the sample grouping for the SLERA.

**Table 5-5**
**SWMU 31 Sample Groupings**

| | | |
|---|---|---|
| **SURFACE SOIL** | | |
| 31SB05A | 31SB05B | |
| **SUBSURFACE SOIL** | | |
| 31SB05A | 31SB05B | |
| **SURFACE WATER** | | |
| 31SW1<br>31SW2 | 31SW3<br>31SW10 | 31SW12<br>31SW14 |
| **SEDIMENT** | | |
| 31SE8A<br>31SE11A<br>31SE11B | 31SE13A<br>31SL1-2 | 31SL2-2<br>31SL3-2 |
| **GROUNDWATER** | | |
| 31MW04<br>31MW3 | 31MW2-2[a]<br>31MW3-2 | 31MW4-2 |

[a] Sample 31MW2-2 was collected from well 31MW2 during the 1998 RFI and the results were used in the risk assessment. Well 31MW2 was dry during the 2002 sampling event, so only results for 1998 are included.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in the surface soil evaluated in the HHRA are presented in **Appendix E-1, Table E-1**. Surface soil COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs and by comparing maximum concentrations of essential human nutrients to ADIs. Comparisons between detected site concentrations and background concentrations were also conducted (**Appendix E-2, Tables 1 and 2**). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (*Section 5.4*).

As shown in **Appendix E-1, Table E-1**, 21 inorganics were detected in surface soil at SWMU 31. Five inorganics were detected at concentrations above residential soil RBCs, or other screening criteria, and were selected as COPCs. These inorganics include: arsenic, chromium, iron, manganese, and vanadium. Aluminum and cobalt were retained as COPCs because there were no RBCs available for comparison. Nine organic compounds were detected in surface soil. None were detected at concentrations above residential soil RBCs, and were selected as a COPC. Fifteen dioxin/furan congeners were detected. The TCDD TE exceeded the residential soil RBC and dioxins/furans were selected as COPCs for surface soil.

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 RBCs to ensure that the range of reporting limits was generally low enough to detect constituents that would exceed RBCs. The maximum reporting limits for these constituents were compared to RBCs. The results of the screening are included as **Appendix E-1, Table E-2**. Eighty organic compounds, two inorganic compounds, and one dioxin/furan were reported as non-detected. The maximum reporting limits for four compounds were above the RBCs: MCPA, MCPP, 2,4-dinitrotoluene, and 2,6-dinitrotoluene. Eight chemicals had no RBCs to be compared against. These included: 3-nitrotoluene, 4-nitrotoluene, 1,2,3,7,8,9-hexachlorodibenzofuran, PETN; dichloroprop; 4-methyl-2-pentanone, 2-hexanone, and chloromethane.

#### 5.1.3.2 Total Soil

Total soil samples (i.e., surface soil and subsurface soil samples collected from the 0 to 10-ft soil interval) included in the HHRA for evaluation are shown in **Table 5-5**. A total of two surface and two subsurface soil samples collected in July 2002 at SWMU 31 were evaluated in the HHRA. Surface and subsurface soil samples were analyzed for VOCs, pesticides, herbicides, PCBs, TAL metals, dioxins/furans, and explosives.

#### 5.1.3.3 Total Soil

Total soil samples (i.e., surface soil and subsurface soil samples collected from the 0 to 10-ft soil interval) included in the HHRA for evaluation are shown in **Table 5-5**. A total of two surface and two subsurface soil samples collected in July 2002 at SWMU 31 were evaluated in the HHRA. Surface and subsurface soil samples were analyzed for VOCs, pesticides, herbicides, PCBs, TAL metals, dioxins/furans, and explosives.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in total soil evaluated in the HHRA are presented in **Appendix E-1, Table E-3**. Total soil COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs and by comparing maximum concentrations of essential human nutrients to ADIs. Comparisons between detected site concentrations and background concentrations were also conducted (**Appendix E-2, Tables 1 and 2**). Inorganic chemicals detected at concentrations exceeding screening levels, but within background levels, were carried through the quantitative risk assessment and addressed in the risk characterization, if applicable (*Section 5.4*).

As shown in **Appendix E-1, Table E-3**, 21 inorganics were detected in total soil at SWMU 31. Five inorganics were detected at concentrations above residential soil RBCs, or other screening criteria, and were selected as COPCs. These inorganics include: arsenic, chromium, iron, manganese, and vanadium. Aluminum and cobalt were retained as COPCs because there were no RBCs available for comparison. All of these COPCs were determined to be within background concentrations. Ten organic compounds were detected in total soil. None were detected at concentrations above residential soil RBCs, and none were selected as COPCs. Sixteen dioxin/furan congeners were detected. The TCDD TE exceeded the residential soil RBC and dioxins/furans were selected as COPCs for total soil.

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 RBCs to ensure that the range of reporting limits was generally low enough to detect constituents that would exceed RBCs. The maximum reporting limits for these constituents were compared to RBCs. The results of the screening are included as **Appendix E-1, Table E-4**. Seventy-nine organic compounds, two inorganic compounds, and one dioxin/furan were reported as non-detected. The maximum reporting limits for four compounds were above the RBCs: MCPA, MCPP, 2,4-dinitrotoluene, and 2,6-dinitrotoluene. Eight chemicals had no RBCs to be compared against. These included: 3-nitrotoluene, 4-nitrotoluene, 1,2,3,7,8,9-hexachlorodibenzofuran, PETN, dichloroprop, 4-methyl-2-pentanone, 2-hexanone, and chloromethane.

#### 5.1.3.4 Sediment

Sediment samples included in the HHRA for evaluation are shown in **Table 5-5**. A total of seven sediment samples collected in July 2002 at SWMU 31 were evaluated in the HHRA. Sediment samples were analyzed for VOCs, SVOCs, PAHs, pesticides, herbicides, PCBs, TAL metals, dioxins/furans, and explosives.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in the sediment evaluated in the HHRA are presented in **Appendix E-1, Table E-5**. Sediment COPCs were selected by comparing maximum concentrations of detected chemicals to residential soil RBCs (adjusted by one order or magnitude) and by comparing maximum concentrations of essential human nutrients to RDAs.

As shown in **Appendix E-1, Table E-5**, 21 inorganic compounds were detected in sediment at SWMU 31. Two inorganics (arsenic and iron) were detected at concentrations above screening criteria, and were selected as COPCs. Twenty-six organic compounds were detected in sediment at SWMU 31. No organics were detected at concentrations above residential soil RBCs, or other screening criteria, where available. Fifteen dioxin/furan congeners were detected. The TCDD TE was below the residential soil RBC and dioxins/furans were not selected as COPCs for sediment. Aluminum, cobalt, and dibenzofuran were retained as COPCs because there were no RBCs available for comparison.

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 RBCs to ensure that the range of reporting limits was generally low enough to detect constituents that would exceed RBCs. The maximum reporting limits for these constituents were compared to RBCs. The results of the screening are included in **Appendix E-1, Table E-6**. Two inorganics and 130 organic compounds were reported as non-detected. The maximum reporting limit for nine compounds (2-nitrotoluene, MCPA, MCPP, 2,4-dinitrophenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 4,6-dinitro-o-cresol, hexachlorobenzene, and n-nitroso-di-n-propylamine) was above the RBC. Thirteen chemicals had no RBCs to be compared against. These included: 3-nitrotoluene, 4-nitrotoluene, 2-nitrophenol, 3&4 methyl phenol, PETN, dichloroprop, bis(2-chloroethoxy)methane, p-chloro-m-cresol, 2-hexanone, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, 4-methyl-2-pentanone, and chloromethane. The results of the screening are included in **Appendix E-1, Table E-6**.

#### 5.1.3.5 Surface Water

Surface water samples included in the HHRA for evaluation are shown in **Table 5-5**. A total of six surface water samples collected in July 2002 at SWMU 31 were evaluated in the HHRA. Surface water samples were analyzed for VOCs, SVOCs, PAHs, pesticides, herbicides, PCBs, TAL metals, and explosives.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in the surface water evaluated in the HHRA are presented in **Appendix E-1, Table E-7**. Surface water COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs (adjusted by one order of magnitude) and by comparing maximum concentrations of essential human nutrients to RDAs.

As shown in **Appendix E-1, Table E-7**, thirteen inorganic compounds were detected in surface water at SWMU 31. No inorganics were detected at concentrations above screening criteria. Aluminum was retained as a COPC, however, because there was no RBC available for comparison. Twenty-two organic compounds were detected in surface water at SWMU 31. Two VOCs (bromodichloromethane and chloroform) were detected at concentrations above screening criteria, and were selected as COPCs. As discussed in *Section 3.2.6*, the presence of these compounds in the lagoons is likely due to the current operations associated with the water treatment plant.

Ten inorganics and 133 organic compounds were reported as non-detected. The maximum reporting limits of 24 chemicals were above the RBCs: 1,2-diphenyl hydrazine, 2-nitrotoluene, arsenic, MCPA, MCPP, toxaphene, 1,2,4-trichlorobenzene, 3,3'-dichlorobenzidine,3-nitroaniline, 4,6-dinitro-o-cresol, 4-nitroaniline, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chrysene, dibenz(a,h)anthracene, hexachlorobenzene, n-nitroso-di-n-propylamine, p-chloroaniline, pentachlorophenol, 1,1,2,2-tetrachloroethane, trichloroethene, vinyl chloride, thallium, and vanadium. Thirteen chemicals had no RBCs to be compared against. These included: 3-nitrotoluene, 4-nitrotoluene, PETN, dichloroprop, 2-nitrophenol, 4-nitrophenol, bis(2-chloroethoxy)methane, p-chloro-m- cresol, 2-hexanone, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, cis-1,3-dichloro-1-propene, and trans-1,3-dichloropropene. The results of the screening are included in **Appendix E-1, Table E-8**.

#### 5.1.3.6 Groundwater

Groundwater samples included in the HHRA for evaluation are shown in **Table 5-5**. A total of five groundwater samples collected in 1998 and 2002 at SWMU 31 were evaluated in the HHRA. Groundwater samples were analyzed for VOCs, SVOCs, PAHs, pesticides, herbicides, PCBs, metals, explosives, and perchlorate.

Summaries of the ranges of detected concentrations, locations of the MDCs, and frequencies of detection of chemicals in groundwater evaluated in the HHRA are presented in **Appendix E-1, Table E-9**. Groundwater COPCs were selected by comparing maximum concentrations of detected chemicals to tap water RBCs and by comparing maximum concentrations of essential human nutrients to ADIs.

As shown in **Appendix E-1, Table E-9**, 15 inorganics were detected in groundwater at SWMU 31. Four inorganics were detected at concentrations above tap water RBCs, or other screening criteria, and were selected as COPCs. Aluminum and cobalt were retained as COPCs because there were no RBCs available for comparison. These inorganics include: arsenic, iron, manganese, and vanadium. Six organic compounds were detected in groundwater. One PAH [benzo(a)pyrene] and one VOC (chloroform) were detected at concentrations above tap water RBCs, and were selected as COPCs. As stated in *Section 3.2.6*, the presence of chloroform is likely related to the current use of the lagoons associated with the water treatment plant.

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 RBCs to ensure that the range of reporting limits was generally low enough to detect constituents that would exceed RBCs. The maximum reporting limits for these constituents were compared to RBCs. The results of the screening are included as **Appendix E-1, Table E-10**. One-hundred fifty organic compounds and eight inorganic compounds were reported as non-detected. The maximum reporting limits for 60 compounds were above the RBCs. Thirteen chemicals had no RBCs to be compared against. These included: 3-nitrotoluene, 4-nitrotoluene, PETN, dichloroprop, 2-nitrophenol, 4-nitrophenol, bis(2-chloroethoxy)methane, p-chloro-m-cresol, 2-hexanone, 4-bromophenyl phenylether, 4-chlorophenyl phenylether, cis-1,3-dichloro-1-propene, and trans-1,3-dichloropropene.

### 5.1.4 Summary of Chemicals Selected as COPCs

COPCs selected at SWMU 31 are summarized in **Table 5-6**. Contamination at this site is primarily due to inorganics and dioxins/furans in soil, inorganics in sediment, VOCs in surface water, and a VOC, a PAH, and inorganics in groundwater.

## 5.2 HUMAN HEALTH EXPOSURE ASSESSMENT

In this section, the potential pathways by which individuals may be exposed to the COPCs in each environmental medium are identified and exposures are quantified. A discussion of potential current and future exposure pathways through which populations could be exposed to chemicals at or originating from SWMU 31 is presented in *Section 5.2.1*.

For each pathway selected for quantitative evaluation, the chemical concentrations at the points of exposure are estimated (*Section 5.2.2*), and the methodology for calculating potential chemical intakes for each pathway selected for quantitative evaluation is discussed (*Section 5.2.3*).

### 5.2.1 Potential Human Exposure Pathways

An exposure pathway describes the course a chemical takes from the source to the exposed individual, and is defined by four elements:

- A source and mechanism of chemical release to the environment.
- An environmental transport medium (e.g., soil) for the released chemical.

## Table 5-6
## Summary of Chemicals of Potential Concern at SWMU 31

| Chemical (a) | Surface Soil | Total Soil | Sediment | Surface Water | Groundwater |
|---|---|---|---|---|---|
| **Organics** | | | | | |
| Acenaphthene | | | | | |
| Acenaphthylene | | | | | |
| Anthracene | | | | | |
| Aroclor 1254 | | | | | |
| Benzo(a)anthracene | | | | | |
| Benzo(a)pyrene | | | | | X |
| Benzo(b)fluoranthene | | | | | |
| Benzo(g,h,i)perylene | | | | | |
| Benzo(k)fluoranthene | | | | | |
| Benzoic acid | | | | | |
| alpha-BHC | | | | | |
| delta-BHC | | | | | |
| gamma-BHC | | | | | |
| Bromodichloromethane | | | | X | |
| Butyl benzyl phthalate | | | | | |
| Carbazole | | | | | |
| Chloroform | | | | X | X |
| Chrysene | | | | | |
| 4,4'-DDD | | | | | |
| 4,4'-DDE | | | | | |
| 4,4'-DDT | | | | | |
| Dibenz(a,h)anthracene | | | | | |
| Dibenzofuran | | | X | | |
| Dicamba | | | | | |
| 1,2-Dichlorobenzene | | | | | |
| 1,3-Dichlorobenzene | | | | | |
| 1,4-Dichlorobenzene | | | | | |
| Diethyl phthalate | | | | | |
| 2,4-Dimethylphenol | | | | | |
| Di-n-butyl phthalate | | | | | |
| Endosulfan II | | | | | |
| Endosulfan sulfate | | | | | |
| Endrin | | | | | |
| Endrin aldehyde | | | | | |
| Fluoranthene | | | | | |
| Fluorene | | | | | |
| Hexachlorobutadiene | | | | | |
| Hexachloroethane | | | | | |
| Indeno(1,2,3-c,d)pyrene | | | | | |
| Methoxychlor | | | | | |
| 2-Methylnaphthalene | | | | | |
| Naphthalene | | | | | |
| Nitrobenzene | | | | | |
| Nitroglycerin | | | | | |
| n-Nitrosodiphenylamine | | | | | |
| Phenanthrene | | | | | |
| Pyrene | | | | | |
| TCDD-Toxicity Equivalent | X | X | | | |
| 2,4,5-TP | | | | | |
| 2,4,6-Trinitrotoluene | | | | | |
| **Inorganics** | | | | | |
| Aluminum | X | X | X | X | X |
| Antimony | | | | | |
| Arsenic | X | X | X | | X |
| Barium | | | | | |
| Beryllium | | | | | |
| Cadmium | | | | | |
| Calcium | | | | | |
| Chromium | X | X | | | |
| Cobalt | X | X | X | | X |
| Copper | | | | | |
| Iron | X | X | X | | X |
| Lead | | | | | |
| Magnesium | | | | | |
| Manganese | X | X | | | X |
| Mercury | | | | | |
| Nickel | | | | | |
| Potassium | | | | | |
| Sodium | | | | | |
| Thallium | | | | | |
| Vanadium | X | X | | | X |
| Zinc | | | | | |

(a) Chemicals detected in all media at SWMU 31.
Shaded cells indicate that the chemical lacks toxicity criteria and cannot be quantitatively evaluated.
X = Selected as a COPC.

- A point of potential contact with the contaminated medium (referred to as the exposure point).
- An exposure route (e.g., ingestion) at the contact point.

An exposure pathway is considered complete when each of the four elements is present. In risk assessments, complete exposure pathways are quantitatively evaluated.

When conducting an exposure assessment, USEPA (1989a, 1991b) guidance requires that plausible exposures under both current and future land-use scenarios be evaluated in an HHRA. Accordingly, potential human exposure pathways are identified for current and potential future land-use conditions at SWMU 31 in the following sections. The current land-use scenario is based on conditions, as they currently exist, while the future land-use scenario evaluates potential risks that may be associated with possible changes in site use, assuming no remedial action occurs.

The potential exposure pathways through which humans could currently be exposed to contamination resulting from past activities at SWMU 31 are discussed below. **Table 5-1** presents an exposure pathway analysis for potential current/future land-use conditions, indicating the exposure media, exposure points, potential receptors, and exposure routes. This table also indicates whether a quantitative analysis was conducted for the pathway and the rationale for selection or exclusion of the pathway.

**Receptor Characterization.** SWMU 31 is located in the northwest section of the HSA. This area is not highly developed and land use in the vicinity of the facility is mostly rural, with less rugged areas having been primarily used for agriculture. Residential and recreational areas are located adjacent to the facility (IT, 2001). It is unlikely, however, that the uses of land within the HSA will change significantly in the future. The HSA contains numerous buildings and facilities, and it is likely that the area will remain industrial in nature.

SWMU 31 is currently in use, and it was conservatively assumed that maintenance workers and industrial workers are the most likely receptors at the site. If future development occurs, excavation workers could also be receptors. Therefore, maintenance worker, industrial worker, and excavation worker exposures at SWMU 31 were evaluated in the HHRA.

Although the water treatment plant at SWMU 31 is currently operational, typical industrial/ commercial workers on the Installation do not routinely work around the lagoons. As a conservative measure, however, outdoor industrial workers were included as receptors under the current exposure scenario. It is likely that SWMU 31 will remain industrial in nature, even if future development does occur, and industrial workers could be receptors. Therefore, current and future industrial worker exposures at SWMU 31 were evaluated in the HHRA.

Due to security at the Installation (e.g., strict security at entry gates, guard towers, barbed-wire fences), it is not likely that children would be able to trespass at the Installation. It would also be difficult for an adolescent to trespass at the site. Even if an older adolescent were able to evade security measures, it would be difficult to do so on a routine basis. Therefore, a trespasser scenario was not quantitatively evaluated. However, hypothetical future exposures to children were considered in the residential scenario described below. The exposure parameters for residents are more conservative than those for children trespassers. Also, the maintenance worker scenario that is being evaluated would be similar to the limited exposure that an adolescent trespasser could experience at the site and would be protective of the trespasser.

Since land use is expected to remain industrial, a residential scenario is not considered to be a reasonably anticipated land use. However, the residential scenario was evaluated to meet “clean closure” requirements under RCRA. Therefore, adult resident and child resident exposures at SWMU 31 were evaluated in the HHRA.

**Exposure Pathway Identification.** The exposure pathways associated with maintenance workers and industrial workers at SWMU 31 were identified based on consideration of the sources and releases of chemicals. The exposure pathways considered for evaluation under current land-use conditions are described below.

***Surface Soil.*** Human exposures to chemicals in surface soil could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. As a result, maintenance worker and industrial worker exposures to COPCs in surface soil via incidental ingestion and dermal absorption were evaluated under current land-use conditions for SWMU 31. Because current land-use of the site does not include residents, adult and child resident exposures to chemicals in surface soil would not occur. Therefore, residential exposures to chemicals in surface soil were not evaluated under current land-use conditions.

***Total Soil.*** Because ground-intrusive or construction/excavation activities are not currently taking place, potential excavation worker exposures to chemicals in surface and subsurface soil (i.e., total soil) would not occur. In addition, it is not likely that maintenance workers and industrial workers would have the opportunity to be exposed to total soil when on-site; thus, exposures to chemicals in total soil were not evaluated under current land-use conditions. Because current land-use of the site does not include residents, adult and child resident exposures to chemicals in surface and subsurface soil (i.e., total soil) would not occur. Therefore, residential exposures to chemicals in total soil were not evaluated under current land-use conditions.

***Air.*** Airborne releases of COPCs can occur via the wind entrainment of chemicals on dust particles. Maintenance workers and industrial workers could potentially be exposed to airborne chemicals released from soil at SWMU 31. Excavation worker and residential exposures were not evaluated under current land-use conditions.

***Sediment.*** Human exposures to chemicals in sediment could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. Sediment samples were collected from each of the three lagoons.

Maintenance worker and industrial worker exposures to COPCs in sediment via incidental ingestion and dermal absorption were evaluated under current land-use conditions for SWMU 31. Excavation worker and residential exposures were not evaluated under current land-use conditions.

***Surface Water.*** Human exposures to chemicals in surface water could occur by direct contact. Because workers could wade in surface water during maintenance or repair activities, exposure via dermal absorption was evaluated. It was assumed that workers would not swim in surface water at SWMU 31. Therefore, incidental ingestion of COPCs in surface water would likely be negligible. Maintenance worker and industrial worker exposures to COPCs in surface water via dermal absorption were evaluated under current land-use conditions for SWMU 31. Excavation worker and residential exposures were not evaluated under current land-use conditions.

***Groundwater.*** Groundwater at SWMU 31 flows toward the river and there are no wells in the flow path. Furthermore, the groundwater is not currently used as a source for drinking water or for other purposes. As a result, potential direct contact exposure pathways (i.e., ingestion and dermal contact) to chemicals in groundwater at SWMU 31 are not complete, and were not quantitatively evaluated. However, airborne releases of COPCs from groundwater can occur via volatilization of chemicals into ambient air. As a result, exposures to contaminants in groundwater via inhalation of VOCs in ambient air by maintenance workers and industrial workers were evaluated.

#### 5.2.1.1 Summary of Potential Exposure Pathways under Current Land-Use Conditions

In summary, the following exposure pathways were selected for quantitative evaluation under current land-use conditions:

- Incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 31 by maintenance and industrial (outdoor) workers.
- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by maintenance and industrial (outdoor) workers.
- Dermal absorption of chemicals in surface water at SWMU 31 by maintenance and industrial (outdoor) workers.
- Inhalation of VOCs in ambient air from on-site groundwater by maintenance and industrial (outdoor) workers.

The following exposure pathways are potentially complete for possible trespassers at SWMU 31:

- Incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 31 by trespassers.
- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by trespassers.
- Dermal absorption of chemicals in surface water at SWMU 31 by trespassers.
- Inhalation of VOCs in ambient air from groundwater by trespassers.

Because trespassing is unlikely to occur on a routine basis at SWMU 31, exposures to trespassers were not quantitatively evaluated. The maintenance worker and the future child resident scenarios were considered to be sufficiently protective of the trespasser.

#### 5.2.1.2 Potential Exposure Pathways under Future Land-Use Conditions

According to USEPA (1995a), a risk assessment evaluating potential future exposures should reflect the most reasonably anticipated future land uses. The potential future exposure pathways through which humans could be exposed to environmental media at SWMU 31 are discussed below. **Table 5-1** presents an exposure pathway analysis for potential future land-use conditions, indicating the exposure media, exposure points, potential receptors, and exposure routes. This table also indicates whether a quantitative analysis was conducted for the pathway and the rationale for selection or exclusion of the pathway.

As described in *Section 5.2.1*, future land use at SWMU 31 is expected to remain industrial. Maintenance workers are considered the most likely receptors to potential contamination at SWMU 31. Given the industrial nature of the site, the maintenance worker scenario would be protective of exposures to trespassers. If future development occurs, industrial workers and excavation workers could also be receptors. Assuming that future construction/excavation activities could occur, future maintenance worker, industrial worker, and excavation worker exposures to surface and subsurface soil at SWMU 31 were evaluated in the HHRA. It is assumed that surface and subsurface soil would mix as a result of these activities. Therefore, future exposures to these sites were evaluated as exposures to total soil.

Although it is unlikely, the site could potentially be used for residential land-use in the future; therefore, hypothetical residential exposures were evaluated.

***Surface Soil.*** Maintenance and industrial worker exposures to surface soil under future industrial land-use conditions will be the same as those described under current industrial land-use conditions. Excavation worker exposures to surface soil were not evaluated in the HHRA because excavation worker exposures would involve both surface and subsurface soil (i.e., total soil) that would be mixed during construction/excavation activities. Resident exposures to surface soil were not evaluated in the HHRA because it was assumed that both surface and subsurface soil (i.e., total soil) would have become mixed during construction/excavation activities for the future development area.

***Total Soil.*** Future development at SWMU 31 could result in exposures to individuals performing excavation activities via contact with chemicals in total soil. In addition, maintenance workers and industrial workers may contact soil after the site has been disturbed and soil has been dispersed after construction or excavation activities. Therefore, potential incidental ingestion and dermal absorption exposures to chemicals in total soil by maintenance workers, industrial workers, and excavation workers were evaluated. Although future residential development of this site is unlikely, the residential scenario was evaluated for total soil. Hypothetical future residents may contact soil after the site has been developed and soil has been dispersed after construction or excavation activities. Therefore, potential incidental ingestion and dermal absorption exposures to chemicals in total soil by residents were evaluated. (It is assumed that surface and subsurface soil would mix as a result of construction/excavation activities and future exposures to the site were evaluated as exposures to total soil.)

***Air.*** Airborne releases of COPCs can occur via wind entrainment of chemicals on dust particles. Maintenance, industrial and excavation workers, and residents could potentially be exposed to airborne chemicals released from soil at SWMU 31.

***Sediment.*** Human exposures to chemicals in sediment could occur by direct contact and subsequent dermal absorption and/or incidental ingestion of COPCs. Therefore, potential exposures to COPCs in sediment via incidental ingestion and dermal absorption by maintenance workers, industrial workers, and excavation workers were evaluated.

Although future development of SWMU 31 is unlikely, the residential scenario was evaluated for exposure to sediment. Hypothetical future residents may contact sediment after the site has been developed for use. Therefore, potential incidental ingestion and dermal absorption due to exposures to COPCs in sediment were evaluated for adult and child residents.

***Surface Water.*** Human exposures to chemicals in surface water could occur by direct contact. Because workers could wade in surface water during maintenance or repair activities, exposure via dermal absorption was evaluated. It was assumed that workers would not swim in surface water at SWMU 31. Therefore, incidental ingestion of COPCs in surface water would likely be negligible. Maintenance worker, industrial worker, and excavation worker exposures to COPCs in surface water via dermal absorption were evaluated.

Although future development of SWMU 31 is unlikely, the residential scenario was evaluated for exposure to surface water. Hypothetical future residents may contact surface water after the site has been developed for use. Because residents could wade in shallow surface water (e.g., lagoon edges), dermal absorption was evaluated in these areas. It was assumed that incidental ingestion of COPCs in surface water would likely be negligible. However, swimming could occur at sites with deeper surface water bodies (i.e., lagoons). For these exposures, adult and child residents were evaluated for incidental ingestion and dermal absorption.

***Groundwater.*** Under future land-use conditions, it is assumed that maintenance workers and industrial workers could be exposed to contaminants in groundwater via inhalation of VOCs in ambient air. Direct contact exposure pathways (i.e., ingestion and dermal contact) to chemicals in groundwater by maintenance workers at SWMU 31 are not complete. Potential future industrial workers were assumed to contact groundwater if wells were installed for drinking water. Therefore, potential ingestion exposures to COPCs in groundwater by industrial workers (outdoor and indoor) were evaluated. Airborne releases of COPCs could occur via volatilization of VOCs. Therefore, potential exposures to VOCs in groundwater via vapor intrusion into indoor air of an office building and releases into ambient air were evaluated for the industrial worker (indoor). In addition, exposures of excavation workers to VOCs in groundwater via vapors migrating into a trench or pit could occur. Due to the depth of the groundwater below ground surface (i.e., approximately 19.5 ft), dermal contact of groundwater in the trench was not considered likely.

As stated above, a residential scenario was evaluated to meet “clean closure” requirements under RCRA. Therefore, lifetime/adult and child residents were evaluated with respect to groundwater use. It was assumed that residents (adult and child) could be exposed to groundwater via household use, including ingestion, dermal contact, and inhalation during showering (adult only). It is possible that residents could be exposed to VOCs in groundwater via vapor intrusion into indoor air of a residence. Because it is possible that groundwater could move off the Installation in the future, potential off-site residents were also evaluated.

#### 5.2.1.3 Summary of Potential Exposure Pathways under Future Land-Use Conditions

In summary, the following exposure pathways were selected for quantitative evaluation under future land-use conditions:

- Incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 31 by a maintenance worker.
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 31 by a maintenance worker.
- Incidental ingestion, dermal absorption, and inhalation of chemicals in surface soil at SWMU 31 by an industrial worker (outdoor).
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 31 by an industrial worker (outdoor).
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 31 by an excavation worker.
- Incidental ingestion, dermal absorption, and inhalation of chemicals in total soil at SWMU 31 by a resident (adult and child).
- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by a maintenance worker.

- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by an industrial worker (outdoor).
- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by an excavation worker.
- Incidental ingestion and dermal absorption of chemicals in sediment at SWMU 31 by residents (adult and child).
- Dermal absorption of chemicals in surface water at SWMU 31 by a maintenance worker.
- Dermal absorption of chemicals in surface water at SWMU 31 by an industrial worker (outdoor).
- Dermal absorption of chemicals in surface water at SWMU 31 by an excavation worker.
- Dermal absorption of chemicals in surface water at SWMU 31 by residents (adult and child) during wading in the lagoon edges.
- Incidental ingestion and dermal absorption of chemicals in surface water at SWMU 31 by residents (adult and child) during swimming in the lagoon(s).
- Inhalation of VOCs in ambient air from groundwater by maintenance workers.
- Ingestion of chemicals from groundwater by industrial workers (outdoor and indoor).
- Inhalation of VOCs in ambient air from groundwater by industrial workers (outdoor).
- Inhalation of VOCs in indoor air from groundwater by industrial workers (indoor).
- Inhalation of VOCs in trench air from groundwater by excavation workers.
- Ingestion and dermal absorption of chemicals from groundwater by on-site and off-site residents (adult and child).
- Inhalation of VOCs in indoor air from groundwater by on-site and off-site residents (adult and child).
- Inhalation of VOCs from groundwater by on-site and off-site residents (adult only) while showering.

### 5.2.2 Determination of Exposure Point Concentrations

To evaluate the magnitude of exposures and risks that may be experienced by an individual, the concentration of the COPCs in the exposure medium must be known or estimated. This concentration is referred to as an exposure point concentration (EPC). The EPCs used in the HHRA are based on the data summarized in *Section 5.1.1*, and were assessed for each of the selected COPCs. EPCs for surface soil, total soil, sediment, surface water, and groundwater are shown in **Appendix E-1, Tables E-11 through E-19**.

The approach used to estimate EPCs in the media sampled at SWMU 31 follows that recommended by USEPA (1989a, 1992a, 2002b) guidance. According to this guidance, the most appropriate measurement of central tendency for exposure to environmental chemical concentrations is the arithmetic mean. To account for uncertainty associated with this value, USEPA guidance requires the use of the 95 percent upper confidence limit (UCL) on the arithmetic mean concentration for the estimation of the Reasonable Maximum Exposure (RME) risk. The term RME is defined as the maximum exposure that is reasonably expected to occur at a site (USEPA, 1989a). The RME concentration of each COPC in each medium was assumed to represent the concentration to which receptors could be exposed at these sites. The approach used to calculate UCLs for this HHRA is similar to that which is presented in USEPA's guidance *Calculating Upper Confidence Limits for Exposure Point Concentrations of Hazardous Waste Sites* (USEPA, 2002b). Although several statistical procedures are cited in the guidance, the specific methods used in this HHRA are described in the following section.

Because of the uncertainty associated with characterizing contamination in environmental media, the 95 percent UCL of the mean has been estimated for chemicals selected as COPCs. In general, outliers are included in the calculation of the UCL because high values in environmental data are seldom true statistical outliers. Inclusion of outliers increases the overall conservatism of the risk estimate, and the likelihood of rejecting the null hypothesis ($H_o$) (i.e., there are no chemical stressors at the site).

Data sets have been tested for normality and lognormality based on the Shapiro-Wilk test (USEPA, 1992a). Statistical analysis has been performed on chemicals selected as COPCs. If statistical tests support the assumption that the data set is normally distributed, the UCL for a normal distribution is calculated. If the statistical analysis shows the data to be lognormally distributed, the UCL is calculated for a lognormal distribution. It should be noted that the designation of normal or lognormal data distributions also included data sets that were "close" to their respective categorizations, i.e., within 5 percent of being categorized as normal or lognormal, using the Shapiro-Wilk test criterion. This is a conservative approach, especially for those data sets that are close to being lognormal, as the lognormal UCL equation (Gilbert, 1987) generally overestimates the UCL, compared with the alternative bootstrap method. If a data set passes both the normal and lognormal distribution tests, the distribution with the best fit (i.e., the distribution with the value that is closest to the critical value) is selected.

The UCL is calculated for a normal distribution as follows (USEPA, 1992a):

$$UCL = \bar{x} + t_{1-\alpha,n-1}\, x\, (s/\sqrt{n}\,)$$

where:

$\bar{x}$ = sample arithmetic mean
$t$ = critical value for student's t distribution
$1-\alpha$ = 0.05 (95 percent confidence limit for a one-tailed test)
$n$ = number of samples in the set
$s$ = sample standard deviation.

The UCL is calculated for a lognormal distribution as follows (Gilbert, 1987):

$$\mathrm{UCL} = e^{\left(\bar{y} + (0.5 \bullet s_y^2) + \left[H_{0.95} \bullet \frac{s_y}{(n-1)^{0.5}}\right]\right)}$$

where:

$\bar{y}$ = 3y/n=sample arithmetic mean of the log-transformed data, y = ln x
$s_y$ = sample standard deviation of the log-transformed data
$n$ = number of samples in the data set
$H_{0.95}$ = value for computing the one-sided 95 percent UCL on a lognormal mean from standard statistical tables (Land, 1975).

A nonparametric confidence limit is used when the data set fits neither a normal nor a lognormal distribution. Although there are several methods available for calculating UCLs for data sets that are nonparametric, the "bootstrap" method (Efron, 1981), a nonparametric method recommended by USEPA for censored data was used to calculate 95 percent UCLs on the arithmetic means for these COPC data. This method, which estimates the UCL by simulation, is a computer-based replacement method for assigning measures of accuracy to statistical estimates. This method does not require assumptions regarding the statistical distribution of the underlying population (Efron, 1981). Bootstrap 95 percent UCLs were calculated as follows (Efron, 1981; Efron and Tibshirani, 1993):

- The data set was randomly resampled with replacement.
- The arithmetic mean of the resampled data set was estimated.
- Based on guidance from USEPA (2002b), "thousands of iterations" are recommended for the bootstrap method. Therefore, Steps 1 and 2 were performed 5,000 times and a new data set of 5,000 resampled means was created.
- The 95th percentile of the resampled mean data set created during Step 3 was selected. Per Efron and Tibshirani (1993), the 95th percentile of the resampled mean data set is a good approximation to the 95 percent UCL on the mean of the original data set.

**EPCs Associated with Ambient Air (Groundwater).** For this scenario, the volatilization model outlined in ASTM Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. The model, outlined in ASTM (1995), is based on the *Superfund Exposure Assessment Manual* (USEPA, 1988). This model calculates a representative concentration in outdoor air based on the assumptions that there is a constant dissolved concentration in groundwater, a steady-state vapor and liquid phase, and no biodegradation. The model considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. The following equation is used to calculate the volatilization factor to ambient air:

$$VF_{wamb} = (H/(1+ (U_a d_{air} L_{GW}/WD_{effws})) \text{ X } 10^3 \text{ L/m}^3$$

where:

$VF_{wamb}$ = Volatilization factor (mg/m$^3$ air per mg/L water) – calculated
H = Henry's Law Constant (cm$^3$-water per cm$^3$-air) – chemical-specific
$U_a$ = Wind speed above ground surface (cm/sec) – 35 (USEPA, 1984)
$d_{air}$ = Ambient air mixing zone height (cm) – 200 (ASTM, 1995)
$L_{GW}$ = Depth to groundwater (cm) – 594.36 cm (site-specific)
W = Width of source area parallel to wind flow direction (cm) - 18,553 cm (site-specific)
$_{Deffws}$ = Effective diffusion coefficient between groundwater and soil surface (cm$^2$/sec; calculated)

The final volatilization factor is multiplied by the groundwater EPC concentration to obtain a final concentration in ambient air. A summary of the groundwater EPCs in ambient air for the current and future maintenance and industrial worker (outdoor) scenarios is presented in **Appendix E-1, Table E-16**.

**EPCs Associated with Volatilization in a Construction Trench.** In the event that excavation work is performed on-site, 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 Virginia Department of Environmental Quality (VDEQ) provides such a model on their Voluntary Remediation Program (VRP) web site (VDEQ, 2006). Given the average depth to groundwater is 19.5 ft, VDEQ's model intended for depths greater than 15 ft was used for this HHRA.

Airborne concentrations of a contaminant in a trench are estimated using the equation below (VDEQ, 2006):

$$C_{trench} = C_{GW} \text{ x } VF$$

where:

$C_{trench}$ = concentration of contaminant in the trench ($\mu g/m^3$)

$C_{GW}$ = concentration of contaminant in groundwater ($\mu g/L$)

$VF$ = volatilization factor ($L/m^3$)

The EPC for each COPC was used to represent the groundwater concentration beneath the trench. The VF is estimated using the equation below (VDEQ, 2006):

$$VF = (H_i \text{ x } D_{air} \text{ x } AC_{vad}^{3.33} \text{ x } A \text{ x } F \text{ x } 10^{-3} \text{ x } 10^{4} \text{ x } 3600) / (R \text{ x } T \text{ x } L_d \text{ x } ACH \text{ x } V \text{ x } Por_{vad}^{2})$$

where:

$H_i$ = Henry's Law constant for contaminant (atm-$m^3$/mol)
$D_{air}$ = diffusion coefficient in air ($cm^2/s$)
$AC_{vad}$ = volumetric air content in vadose zone soil ($cm^3/cm^3$)
$A$ = area of trench ($m^2$)
$F$ = fraction of floor through which contaminant can enter (unitless)
$R$ = ideal gas constant (atm-$m^3$/mole-°K)
$T$ = average system absolute temperature (°K)
$L_d$ = distance between trench bottom and groundwater (cm)
$ACH$ = air changes per hour ($h^{-1}$)
$V$ = volume of trench ($m^3$)
$Por_{vad}$ = total soil porosity in vadose zone ($cm^3/cm^3$)
$10^{-3}$ = conversion factor ($L/cm^3$)
$10^{-4}$ = conversion factor ($cm^2/m^2$)
3600 = conversion factor (s/hr)

The value for R is $8.2\text{x}10^{-5}$ atm-$m^3$/mole-°K. A value of 286°K, which was based on the average temperature for shallow groundwater (USEPA, 2004d), was used for the average system absolute temperature.

Studies of urban canyons suggest that if the ratio of trench width – relative to wind direction – to trench depth or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of air exchange with atmosphere. In consultation with USEPA Region III, VDEQ has assumed an ACH in this case of 2/hr – based upon ventilation rates of buildings.

The trench model input values and the trench air concentrations (i.e., EPCs) for the construction/utility worker scenario are presented in **Appendix E-1, Table E-17**.

**EPCs Associated with Vapor Intrusion.** The Johnson and Ettinger model (1991; USEPA, 2004d) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the soil and into a structure. Spreadsheets for this model are provided by USEPA (USEPA, 2004d); these spreadsheets were used to estimate air concentrations of VOCs in office buildings and residences for this HHRA.

Site-specific values were used in the model in lieu of model defaults (USEPA, 2004d), where appropriate. It was conservatively assumed that buildings would be constructed with a basement. The EPCs for groundwater were used in the model (see **Appendix E-1, Table E-15**).

The values used in the model to estimate indoor air concentrations of volatiles for the future on-site and off-site residential scenario are described below:

- Average soil/groundwater temperature ($T_S$) is set at 55.7°F or 13.7°C, based on the average temperature of shallow groundwater for the vicinity of SWMU 31.
- Depth below grade to bottom of enclosed space floor ($L_F$) is set at the default value of 200 cm because building construction is likely to include a basement.
- Depth below grade to water table ($L_{wt}$) is set at 594.36 cm (19.5 ft), conservatively based on the depth of groundwater measured in the monitoring wells.
- The soil type in the vadose zone was modeled as sandy loam (SL). This is based on soil type found at SWMU 31 (i.e., Wheeling Sandy Loam).
- The thickness and properties of the capillary zone are calculated by the model based on the SL soil type.
- The vadose zone soil total porosity is set at 0.387, based on the “lookup” soil parameter in the model for sandy loam (USEPA, 2004d).
- The vadose zone soil water-filled porosity is set at 0.103 $cm^3/cm^3$, based on the “lookup” soil parameter in the model for sandy loam (USEPA, 2004d).
- The vadose zone soil dry bulk density (pb) is set at the ”lookup” soil parameter of 1.62 $g/cm^3$ for sandy loam in the model (USEPA, 2004d).
- The calculated concentration of each COPC in building air ($C_{building}$) served as the EPC in the intake calculations for inhalation.

The Johnson and Ettinger model input values and model results for the groundwater COPC (chloroform) are presented in **Appendix E-3**. A summary of the groundwater EPCs in indoor air for the future residential scenario and industrial worker (indoor) scenario is presented in **Appendix E-1, Table E-18**.

**EPCs in Shower Room Air.** EPCs of VOCs in air due to volatilization from groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987) shower room model. Although VOCs may gain access to ambient air from most typical household uses of groundwater, showering likely represents the upper–bound for exposure, because the warm water temperature of a shower facilitates volatilization, and the VOCs released and the receptor are confined together in a relatively small space. In addition, showering and the characteristics of a typical shower room have been studied sufficiently to permit estimating shower room air concentrations of the VOCs.

The Foster-Chrostowski model estimates the liquid-film and gas-film mass transfer coefficients as follows:

$$k_l = 20 \cdot (44 / MW)^{0.5}$$

where:

$k_l$ = liquid-film mass transfer coefficient (centimeters per hour [cm/hour])
20 = liquid-film mass transfer coefficient for carbon dioxide (cm/hour)
44 = conversion factor
MW = molecular weight (chemical-specific)

and

$$k_g = 3000 \cdot (18 / MW)^{0.5}$$

where:

$k_g$ = gas-film mass transfer coefficient (cm/hour)
3000 = gas-film mass transfer coefficient for water(cm/hour)
18 = conversion factor
MW = molecular weight (chemical-specific)

The overall mass transfer coefficient is estimated as follows:

$$K_L = \left( \frac{1}{k_l} + \frac{R \cdot T}{H \cdot k_g} \right)^{-1}$$

where:

$K_L$ = overall mass transfer coefficient (cm/hour)
$k_l$ = liquid-film mass transfer coefficient (cm/hour)
R = gas constant (8.2E-5 atm-$m^3$/mole-°K)
T = room temperature (293 °K, Foster-Chrostowski, 1987)
H = Henry's Law constant (chemical-specific, atm-$m^3$/mole)
$k_g$ = gas-film mass transfer coefficient (cm/hour)

The overall mass transfer coefficient is adjusted to the shower water temperature as follows:

$$K_{aL} = K_L \cdot \left( \frac{T_1 \cdot \mu_s}{T_s \cdot \mu_l} \right)^{-0.5}$$

where:

$K_{aL}$ = adjusted overall mass transfer coefficient (cm/hour)
$K_L$ = overall mass transfer coefficient (cm/hour)
$T_1$ = calibration (room) temperature (293 °K, Foster-Chrostowski, 1987)
$\mu_s$ = water viscosity at temperature $T_s$ (0.596 centipoise [cp], Foster-Chrostowski, 1987)
$T_s$ = shower water temperature (318 °K, Foster-Chrostowski, 1987)
$\mu_l$ = water viscosity at temperature $T_1$ (1.002 cp, Foster-Chrostowski, 1987)

The contribution of VOCs to ambient air is estimated as the concentration leaving the shower droplet as described by:

$$C_{wd} = C_w \cdot \left( 1 - \exp\left[ \frac{-K_{aL} \cdot t_s}{60 \cdot d} \right] \right)$$

where:

$C_{wd}$ = concentration leaving shower droplet after time $t_s$ (µg/L)
$C_w$ = concentration in shower water (µg/L)
$K_{aL}$ = adjusted overall mass transfer coefficient (cm/hour)
$t_s$ = shower droplet drop time (0.5 seconds, Foster-Chrostowski, 2003)
60 = conversion factor
d = shower droplet diameter (1 millimeter, Foster-Chrostowski, 1987)

Applying the shower water flow rate and the shower room air volume to the concentration leaving the shower droplet allows estimating the VOCs in air generation rate as follows:

$$S = \frac{C_{wd} \cdot FR}{SV}$$

where:

S = VOCs in air generation rate (µg/$m^3$-min)
$C_{wd}$ = concentration leaving shower droplet after time $t_s$ (µg/L)
FR = shower water flow rate (10 L/minute, professional judgment adapted from flow rates reported in USEPA, 1997b)
SV = shower room air volume (12 $m^3$, Foster-Chrostowski, 2003)

For cases in which the shower duration is less than total time spent in the shower room, the concentration of VOCs in the shower room air is estimated as follows:

$$C_{wa} = \left(\frac{S}{R_a \cdot t \cdot CF}\right) \cdot [D_s + \frac{e^{(-Ra \cdot t)}}{R_a} - \frac{e^{Ra(Ds-t)}}{R_a}]$$

where:

$C_{wa}$ = VOC concentration in shower room air (mg/m$^3$)
S = VOCs in air generation rate (µg/m$^3$-minute)
$R_a$ = shower room air exchange rate (0.01667 per minute, Foster-Chrostowski, 1987)
$D_s$ = shower duration (30 minutes, USEPA, 2004b, USEPA, 1997b, PRA Guidance)
t = total time in shower room (60 minutes, USEPA, 1997b)
CF = conversion factor (1000 µg/mg).

The resulting EPC for the groundwater is shown in **Appendix E-1, Table E-19**. The chemical-specific Foster-Chrostowski shower model input values are shown in **Appendix E-1, Table E-20**.

### 5.2.3 Quantification of Dose Due to Chemical Exposures

This section describes the development of the exposure estimates (chemical doses) that serve as the basis of the risk estimates in *Section 5.4*. To estimate doses, EPCs for each COPC are combined with information describing the extent, frequency, and duration of exposure for each potential receptor of concern. This section presents an overview of the approaches and equations used in quantifying exposures and specific details relevant to each selected exposure pathway. The approaches used to quantify exposures are consistent with guidance provided by USEPA (1989a; 1991a; 1992a,b,c; 2002a; 2004b).

**Methodology for Deriving Dose Estimates.** For the exposure pathways that involve ingestion or dermal contact, quantification of exposure involves the estimation of an average daily dose (ADD), expressed in units of mg chemical/kg body weight per day (mg/kg-day). Dose can be defined as an exposure rate to a chemical assessed over an exposure period per unit body weight, and is calculated similarly for ingestion and dermal absorption pathways. There are, however, significant differences in the meaning and terms used to describe doses for the ingestion pathways as compared to the dermal absorption pathways. For the ingestion exposure pathways, the doses calculated in this assessment are referred to as "potential doses." The potential dose is the amount of chemical ingested and available for uptake in the body, and is analogous to the administered dose in a dose-response toxicity experiment. For the dermal absorption pathways, the estimated dose is referred to as an "internal dose," and reflects the amount of chemical that has been absorbed into the body and is available for interaction with biologically important tissues.

ADDs are estimated differently for chemicals exhibiting noncarcinogenic and carcinogenic effects, because different toxicity criteria are available for carcinogenic effects and noncarcinogenic effects of chemicals (see *Section 5.3*, Human Health Toxicity Assessment). ADDs for noncarcinogens are averaged over the duration of exposure and, following USEPA (2004b) guidance, are given the acronym ADD for average daily doses. ADDs for carcinogens are averaged over a lifetime, and are given the acronym LADD for lifetime average daily doses.

The ADDs and LADDs are estimated using EPCs of chemicals together with exposure parameters that specifically describe the exposure pathway. ADDs and LADDs for each pathway were derived by combining the selected EPC (based on the maximum or on the 95 percent UCL on the mean concentration) of each chemical with reasonable maximum values describing the extent, frequency, and duration of exposure (USEPA, 1989a, 1992c, 2002a, 2004b).

The following sections present the equations and exposure parameters used in the HHRA to estimate potential doses ($ADDs_{pot}$ and $LADDs_{pot}$) for ingestion exposures, internal doses ($ADDs_{int}$ and $LADDs_{int}$) for dermal absorption exposures, and ($ADDs_{pot}$ and $LADDs_{pot}$) for inhalation exposures. It was assumed that the chemical concentrations in the media evaluated would remain constant over the exposure period.

The particulate emission factor (PEF) for wind erosion used to calculate the particulate inhalation ADDs and LADDs was calculated based on an equation provided by USEPA (1996b), and is shown below. It should be noted that one of the inputs for calculating the PEF is the Q/C value, which represents both local climatic conditions and the size of the contaminated area. Q/C values are provided by USEPA (1996b) for 29 different cities in the United States and for contaminated areas ranging from 0.5 to 30 acres. For this HHRA, Q/C value representing climatic conditions for Zone VII, Huntington, WV was selected. A site-specific PEF value was calculated to account for the approximate size of SWMU 31 (1.25 acres excluding lagoons). Based on a 1-acre site, a Q/C value of 47.24 was selected to represent SWMU 31 study area.

The variable for vegetative cover used to calculate the PEF accounts for the percentage of ground cover (e.g., pavement, gravel, or vegetation) that potentially inhibits the release of VOCs and particulate matter from soil into ambient air. Although the majority of the site is currently covered, the fraction of the vegetative cover was conservatively assumed to be 50 percent to allow for potential changes to site conditions in the future. USEPA's default value was used to represent the mean annual wind speed [4.69 meters per second (m/s)].

Using the following equation and the assumptions described above, a PEF of $6.85 \times 10^8$ m$^3$/kg was calculated for SWMU 31.

$$\mathrm{PEF} = \frac{Q}{C} \cdot \frac{3{,}600 \frac{\mathrm{sec}}{\mathrm{hr}}}{0.036 \cdot (1 - V) \cdot \left( \frac{U_m}{U_t} \right)^3 \cdot F(x)}$$

where:

PEF = particulate emission factor (m$^3$/kg)

$\frac{Q}{C}$ = inverse of the mean concentration at the center of a 1-acre source (equal to 47.24 g/m$^2$·sec per kg/m$^3$) for Climatic Zone VII, Huntington, WV (USEPA, 1996b)

V = fraction of vegetative cover (assumed to be 50 percent, default)

$U_m$ = mean annual windspeed (4.69 m/s, default)

$U_t$ = equivalent threshold value of windspeed at 7 m (11.32 m/s, default)

F(x) = function dependent on Um/Ut derived using Cowherd et al. (as cited in USEPA, 1996b)

**Excavation Worker (Construction Worker) PEF.** Under a construction scenario, fugitive dusts may be generated from surface soil by wind erosion, construction vehicle traffic on temporary unpaved roads, and other construction activities. Due to the potential for increased dust exposure from truck traffic on unpaved roads during construction, USEPA recommends that fugitive dusts associated with the construction scenario be evaluated for semivolatile compounds (SVOCs) and for all metals (USEPA, 2002a).

The methodology for calculating a PEF for road emissions (PEFsc) is described in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002a). The equation for the $PEF_{sc}$ requires estimates of parameters that represent the movement of vehicular traffic across the site, such as number of days with at least 0.01 inch of rainfall, the mean vehicle weight, and the sum of fleet vehicle distance traveled during construction. Because future plans for construction at the RFAAP sites have not been defined, a range of conservative values was used in the sample calculations. The equations and exposure parameters are described in the following sections.

The subchronic dispersion factor for dust generated by unpaved road traffic ($Q/C_{sr}$) was first calculated for each site as follows (USEPA, 2002a):

$$Q/C_{sr} = A \; x \; \exp\left[\frac{(\ln A_s - B)^2}{C}\right]$$

where: $Q/C_{sr}$ = inverse of the ratio of 1-hour geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (g/m$^2$-s) per kg/m$^3$)
$A$ = constant (12.9351; unitless)
$A_s$ = area extent of site surface soil contamination (1.25 acres); site-specific
$B$ = constant (5.7383; unitless)
$C$ = constant (71.7711; unitless)

As noted in the guidance (USEPA, 2002a), the $Q/C_{sr}$ for the construction worker scenario can only be modified to reflect different site sizes; it cannot be modified for climatic zone like the Q/C values for other scenarios. It was assumed that the surface area of the site was 1.25 acres.

Using a combination of default and site-specific values, the $PEF_{sc}$ was calculated as follows (USEPA, 2002a):

$$PEF_{sc} = Q/C_{sr} \; x \; \frac{1}{F_D} \; x \left[\frac{T \; x \; A_R}{556 \; x \; (W/3)^{0.4} \; x \; \frac{365 \; day/yr - p)}{365 \; day/yr} \; x \sum VKT}\right]$$

where: $PEF_{sc}$ = subchronic road particulate emission factor (m$^3$/kg)
$Q/C_{sr}$ = inverse of the ratio of 1-hour geometric mean air concentration to the emission flux along a straight road segment bisecting a square site (calculated 19.76 g/m$^2$-s) per kg/m$^3$); site-specific

$F_D$ = dispersion correction factor (0.19; unitless; calculated following Appendix E, USEPA, 2002a) to estimate subchronic average air concentrations (e.g., 3-, 8- and 24-hour durations) instead of 1-hour concentrations
$T$ = total time over which construction occurs (7,488,000 sec); site-specific
$A_R$ = surface area of contaminated road segment (433.6 $m^2$); site-specific
$W$ = mean vehicle weight (8 tons)
$p$ = number of days with at least 0.01 inch of precipitation (days/year); site-specific
$\sum VKT$ = sum of fleet vehicle kilometers traveled during the exposure duration (554.8 km); site-specific

The number of days with at least 0.01 inch of rainfall was estimated using Exhibit 5-2 of the Supplemental SSL Guidance (USEPA, 2002a). Mean vehicle weight (W) was estimated by assuming the numbers and weights of different types of vehicles. For the worst-case scenario, following the example provided by USEPA (2002a), it was assumed that the daily unpaved road traffic consists of twenty 2-ton cars and ten 20-ton trucks. The calculated mean vehicle weight was:

$$W = [(20\ \text{cars x 2 tons/car}) + (10\ \text{trucks x 20 tons/truck})]/30\ \text{vehicles} = 8\ \text{tons}$$

The sum of the fleet vehicle km traveled during construction ($\sum VKT$) was estimated based on the size of the area of the site, assuming the configuration of the unpaved road and the amount of vehicle traffic on the road. For example, the area of soil contamination in acres or square meters ($m^2$) was assumed to be configured as a square, with the unpaved road segment dividing the square evenly. The road length is equal to the square root of $m^2$ in units of meters (m) or km. Assuming that each vehicle travels the length of the road once per day, 5 days per week, for a total of 12 months (consistent with the construction worker's exposure duration of 1 year), the total fleet vehicle km traveled for SWMU 31 would be:

$$\sum VKT = 30\ \text{vehicles x 0.045 km/day x (52 weeks) x 5 days/week} = 351\ \text{km}$$

**Current and Future Maintenance Worker Dose Equations and Exposure Parameters for Soil.** The potential chemical doses for current and future maintenance worker exposures to surface soil and total soil at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**<u>Incidental Ingestion of Soil by Maintenance Workers</u>.** The exposure for incidental ingestion of COPCs in soil by workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-21 and E-22**. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Workers were assumed to be exposed to soil 50 days/year, based on the assumption that maintenance/inspection activities are conducted 1 day/week based on a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to adults in the workplace. It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most maintenance workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

**Dermal Absorption of Chemicals in Soil by Maintenance Workers.** The internal dose due to dermal absorption of COPCs in soil by workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-21 and E-22**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a worker's head, hands, and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997b), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.2 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. For a chemical to be absorbed through the skin from soil, it must be released from the soil matrix, pass through the layers of the skin, and enter into the systemic circulation. This series of events is dependent on a number of factors including the characteristics of the chemical, the concentration in the applied dose, the site of exposure, inter-individual variability, and characteristics of soil (e.g., particle size and organic carbon content). Data regarding the amount of specific chemicals that may be absorbed through the skin under conditions normally encountered in the environment (and assumed to occur for this assessment) are lacking. While a number of approaches have been developed to estimate absorption of compounds from the soil matrix, the resulting dose estimates are highly uncertain (USEPA, 1992c, 2004b). Chemical-specific dermal absorption factors were used to estimate absorption of COPCs from soil (USEPA, 2004b). If chemical-specific information was not available, class-specific dermal absorption values were applied (USEPA, 1995b, 2003a). The dermal absorption factors include arsenic (3 percent), cadmium (0.1 percent), other inorganics (1 percent), SVOCs (10 percent), PCBs (14 percent), and dioxins (3 percent).

**Inhalation of Particulates from Soil by Maintenance Workers.** The exposure for inhalation of COPCs in soil by maintenance workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-23 and E-24**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 $m^3$ per hour for maintenance workers was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 2002a) by an 8-hour workday. The exposure time is 8 hours per day. It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas; however, it is unlikely that a worker would spend the entire day at just one location on the Installation every day.

**Current and Future Industrial Worker (Outdoor) Dose Equations and Exposure Parameters for Soil.** The potential chemical doses for future industrial worker exposures to surface and total soil at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the Risk Characterization section (*Section 5.4*).

**Incidental Ingestion of Soil by Industrial Workers (Outdoor).** The exposure for incidental ingestion of COPCs in soil by workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-25**. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (> 18 years of age).

Workers were assumed to be exposed to soil 225 days/year, a value which represents the average number of days worked per year by male and female workers engaged in activities likely to be similar to those of the outdoor worker receptor (USEPA, 2002a). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for workers was assumed to be 100 mg/day (USEPA, 2002a). It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most industrial workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

**Dermal Absorption of Chemicals in Soil by Industrial Workers (Outdoor).** The internal dose due to dermal absorption of COPCs in soil by workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-25**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and amount of chemical absorbed through the skin from soil. It was assumed that a worker's head, hands, and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997b, 2002a), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.2 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

**Inhalation of Particulates from Soil by Industrial Workers (Outdoor).** The exposure for inhalation of COPCs in soil by site workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-26**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a site worker.

The inhalation rate of 2.5 $m^3$ per hour for site workers was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 2002a) by an 8-hour workday. The exposure time is 8 hours per day. It was conservatively assumed that all soil inhaled during the visit would originate in the sampled areas.

**Future Excavation Worker Dose Equations and Exposure Parameters for Soil.** The potential chemical doses for future excavation worker exposures to total soil at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables in the Risk Characterization section (*Section 5.4*).

**Incidental Ingestion of Soil by Excavation Workers.** The exposure for incidental ingestion of COPCs in soil by excavation workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. Excavation workers were assumed to be exposed to soil 250 days/year, a standard USEPA (2002a) default assumption assuming a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for excavation workers was assumed to be 1 year, a standard USEPA default (2002a). The body weight value used for excavation workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 1 year was used for noncarcinogenic COPCs.

The daily soil ingestion rate for excavation workers was assumed to be 330 mg/day, a standard USEPA (2002a) default value for exposure to construction workers. It was conservatively assumed that soil ingested during the workday by workers would originate in the sampled areas; however, most excavation workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

**Dermal Absorption of Chemicals in Soil by Excavation Workers.** The internal dose due to dermal absorption of COPCs in total soil by excavation workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an excavation worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that an excavation worker's head, hands, and forearms would be exposed to soil, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (USEPA Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for excavation workers would be 3,300 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.3 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

**Inhalation of Particulates from Soil by Excavation Workers.** The exposure for inhalation of COPCs in total soil by excavation workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-24**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an excavation worker.

The inhalation rate of 2.5 $m^3$ per hour for excavation workers was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 2002a) by an 8-hour workday. The exposure time is 8 hours per day. It was conservatively assumed that soil inhaled during the visit would originate in the sampled areas.

**Future Adult Resident Dose Equations and Exposure Parameters for Soil.** The potential chemical doses for future hypothetical adult resident exposures to total soil at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in the Risk Characterization section (*Section 5.4*).

**Incidental Ingestion of Soil by Adult Residents.** The exposure for incidental ingestion of COPCs in total soil by adult residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. Standard parameters were used to characterize adult exposures (> 18 years of age).

Adult residents were assumed to be exposed to total soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for residents was assumed to be 30 years, a USEPA (1991a) upper-bound default estimate of the time spent residing in one location. The body weight value used for adult residents was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for adult residents was assumed to be 100 mg/day, a standard USEPA (1991a) default value for exposure to soil for the residential scenario. It was conservatively assumed that soil ingested during time at home by residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

**Dermal Absorption of Chemicals in Soil by Adult Residents.** The internal dose due to dermal absorption of COPCs in total soil by adult residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a resident's head, hands, arms, and lower legs would be exposed to soil. Using data from USEPA (Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for adult residents would be 5,700 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.07 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

**Inhalation of Particulates from Soil by Adult Residents.** The exposure for inhalation of COPCs in total soil by adult residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-24**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by an adult resident.

The inhalation rate of 0.83 $m^3$ per hour for adult residents was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 1991a) by 24 hours per day. The exposure time is 1 hour per day based on the average time an adult spends outside (1.5 hours/day; USEPA, 1997b) with the exception of the three coldest months of the year. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

**Future Child Resident Dose Equations and Exposure Parameters for Soil.** The potential chemical doses for future hypothetical child resident exposures to soil at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Soil by Child Residents.** The exposure for incidental ingestion of COPCs in total soil by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to total soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a). The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

The daily soil ingestion rate for child residents was assumed to be 200 mg/day, a standard USEPA (1991a) default value for exposure to soil for the children of 6 years of age and under. It was conservatively assumed that soil ingested during time at home by child residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the soil.

**Dermal Absorption of Chemicals in Soil by Child Residents.** The internal dose due to dermal absorption of COPCs in total soil by child residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-22**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of soil adhering to the skin, and the amount of chemical absorbed through the skin from soil. It was assumed that a child's head, hands, forearms, lower legs, and feet would be exposed to soil. Using data from USEPA (USEPA Tables 6-6, 6-7, 6-8; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for child residents would be 2,800 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.2 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 1997b, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from soil.

**Inhalation of Particulates from Soil by Child Residents.** The exposure for inhalation of COPCs in total soil by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-24**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a child resident.

The inhalation rate of 1.0 $m^3$ per hour for child residents was based the recommended value for light activities (USEPA Table 5-23; USEPA, 1997b). The exposure time is 1 hour per day. It was assumed that children under the age of 6 years old are likely to be accompanied or supervised by an adult during their time spent outdoors. Therefore, the exposure time was assumed to be equivalent to that of the adult resident. It was conservatively assumed that soil inhaled at the residence would originate in the sampled areas.

**Current and Future Maintenance Worker Dose Equations and Exposure Parameters for Sediment.** The potential chemical doses for current and future maintenance worker exposures to sediment at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Sediment by Maintenance Workers.** The exposure for incidental ingestion of COPCs in sediment by workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-27 and E-28**. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (>18 years of age).

Workers were assumed to be exposed to sediment 50 days/year, based on the assumption that maintenance/inspection activities are conducted 1 day/week based on a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation/holiday). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of

70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily sediment ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to soil by adults in the workplace. It was conservatively assumed that sediment ingested during the workday by workers would originate in the sampled areas; however, most maintenance workers would likely visit other portions of the Installation. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the sediment.

**Dermal Absorption of Chemicals in Sediment by Maintenance Workers.** The internal dose due to dermal absorption of COPCs in sediment by workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-27 and E-28**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and amount of chemical absorbed through the skin from sediment. It was assumed that a worker's head, hands, and forearms would be exposed to sediment, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997b), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 $cm^2$. The adherence factor was assumed to be 0.6 $mg/cm^2$-event, based on 50th percentile values for wet soil (pipe layers) (USEPA, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment.

**Current and Future Industrial Worker Dose Equations and Exposure Parameters for Sediment.** The potential chemical doses for current and future industrial worker exposures to sediment at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Sediment by Industrial Workers (Outdoor).** The exposure for incidental ingestion of COPCs in sediment by industrial workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-27 and E-28**. Where relevant, standard adult parameters were used to characterize worker exposures, since most workers are adults (>18 years of age).

Industrial workers were assumed to be exposed to sediment 225 days/year, a value which represents the average number of days worked per year by male and female workers engaged in activities likely to be similar to those of the outdoor worker receptor (USEPA, 2002a). Duration of exposure for industrial workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The body weight value used for workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

The daily sediment ingestion rate for workers was assumed to be 100 mg/day, a standard USEPA (2002a) default value for exposure to soil by adults in the workplace. It was assumed that the chemical would be totally available for intake into the body rather than bound to the sediment.

**Dermal Absorption of Chemicals in Sediment by Industrial Workers (Outdoor).** The internal dose due to dermal absorption of COPCs in sediment by workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-27 and E-28**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and amount of chemical absorbed through the skin from sediment. It was assumed that a worker's head, hands and forearms would be exposed to sediment, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (1997b), and averaging across gender and age, it was estimated that the exposed skin surface area for workers would be 3,300 $cm^2$. The adherence factor was assumed to be 0.6 $mg/cm^2$-event, based on 50th percentile values wet soil (pipe layers) (USEPA, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment

**Future Excavation Worker Dose Equations and Exposure Parameters for Sediment.** The potential chemical doses for future excavation worker exposures to sediment at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Sediment by Excavation Workers.** The exposure for incidental ingestion of COPCs in sediment by excavation workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. Excavation workers were assumed to be exposed to sediment 250 days/year, a standard USEPA (2002a) default assumption assuming a 5-day work week for 50 weeks/year (workers were assumed to spend 2 weeks a year on vacation). Duration of exposure for excavation workers was assumed to be 1 year, a standard USEPA default (2002a). The body weight value used for excavation workers was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 1 year was used for noncarcinogenic COPCs.

The daily sediment ingestion rate for excavation workers was assumed to be 330 mg/day, a standard USEPA (2002a) default value for soil exposure to construction workers. It was conservatively assumed that sediment ingested during the workday by workers would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the sediment.

**Dermal Absorption of Chemicals in Sediment by Excavation Workers.** The internal dose due to dermal absorption of COPCs in sediment by excavation workers was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of sediment by an excavation worker.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and the amount of chemical absorbed through the skin from sediment. It was assumed that an excavation worker's head, hands, and forearms would be exposed to sediment, based on the likelihood that workers at the site will wear long pants but may wear short sleeve shirts. Using data from USEPA (USEPA Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for excavation workers would be 3,300 $cm^2$. The adherence factor was assumed to be 0.6 $mg/cm^2$-event, based on 50th percentile values for wet soil activities (pipe layers) (USEPA, 2002a).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment.

**Future Adult Resident Dose Equations and Exposure Parameters for Sediment.** The potential chemical doses for future hypothetical adult resident exposures to sediment at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Sediment by Adult Residents.** The exposure for incidental ingestion of COPCs in sediment by adult residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. Standard parameters were used to characterize adult exposures (> 18 years of age).

Adult residents were assumed to be exposed to sediment for 40 days/year. This exposure frequency is based on best professional judgment that the time an adult would spend wading would be similar to time spent gardening or doing yard work (USEPA, 1997b). Duration of exposure for residents was assumed to be 30 years, a USEPA (1991a) upper-bound default estimate of the time spent residing in one location. The body weight value used for adult residents was 70 kg, the standard USEPA (1991a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

The daily sediment ingestion rate for adult residents was assumed to be 100 mg/day, a standard USEPA (1991a) default value for exposure to soil for the residential scenario. It was conservatively assumed that sediment ingested during time at home by residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the sediment.

**Dermal Absorption of Chemicals in Sediment by Adult Residents.** The internal dose due to dermal absorption of COPCs in sediment by adult residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of sediment by an adult resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and the amount of chemical absorbed through the skin from sediment. It was assumed that a resident's hands, arms, lower legs, and feet would be exposed to sediment. Using data from USEPA (Tables 6-2 and 6-3; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for adult residents would be 5,700 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.2 $mg/cm^2$-event, based on 50th percentile values for wet soil activities (USEPA, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment.

**Future Child Resident Dose Equations and Exposure Parameters for Sediment.** The potential chemical doses for future hypothetical child resident exposures to sediment at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Sediment by Child Residents.** The exposure for incidental ingestion of COPCs in sediment by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to sediment for 40 days/year, assuming that a child under 6 years of age would be accompanied by an adult while wading. Duration of exposure for children was assumed to be 6 years (USEPA, 1991a). The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

The daily sediment ingestion rate for child residents was assumed to be 200 mg/day, a standard USEPA (1991a) default value for exposure to soil for the children of 6 years of age and under. It was conservatively assumed that sediment ingested during time at home by child residents would originate in the sampled areas. Furthermore, it was assumed that the chemical would be totally available for intake into the body rather than bound to the sediment.

**Dermal Absorption of Chemicals in Sediment by Child Residents.** The internal dose due to dermal absorption of COPCs in sediment by child residents was estimated using the equation and the exposure parameters presented in **Appendix E-1, Table E-28**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of sediment by a child resident.

Parameters that are specific to the dermal absorption exposure scenario include the area of exposed skin, the amount of sediment adhering to the skin, and the amount of chemical absorbed through the skin from sediment. It was assumed that a child's head, face, hands, forearms, lower legs, and feet would be exposed to sediment. Using data from USEPA (USEPA Tables 6-6, 6-7, 6-8; USEPA, 1997b), and averaging 50th percentile values across gender and age, it was estimated that the exposed skin surface area for child residents would be 2,800 $cm^2$. The soil-to-skin adherence factor was assumed to be 0.2 $mg/cm^2$-event, based on 50th percentile values for similar activities (USEPA, 2004b).

The amount of chemical in soil absorbed through the skin must be estimated in order to calculate dermal absorption doses. The estimation of absorbed dose is described in the previous section for maintenance worker exposures to soil. Dermal absorption factors (USEPA, 1995b, 2003a, 2004b) were used to estimate absorption of COPCs from sediment.

**Current and Future Maintenance Worker Dose Equations and Exposure Parameters for Surface Water.** The potential chemical doses for worker exposures to surface water at SWMU 31 were estimated using the equations and exposure parameters presented below. Due to the type of activities in which maintenance workers would be expected to be involved, it was assumed that surface water contact would most likely occur via wading. Therefore, the water bodies at SWMU 31 were evaluated for surface water exposures associated with wading.

The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Surface Water by Maintenance Workers - Wading.** It was assumed that workers would not swim in surface water at SWMU 31. Therefore, incidental ingestion of COPCs in surface water would likely be negligible. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

**Dermal Absorption of Chemicals in Surface Water by Maintenance Workers - Wading.** The internal dose due to dermal absorption of COPCs in surface water by maintenance workers at SWMU 31 was estimated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-29 and E-30**. Where relevant, standard parameters were used to characterize adult exposures (>18 years of age).

Maintenance workers were assumed to be exposed to surface water 50 days/year, based on wading in the area for 1 day/week and assuming 2 weeks for vacation. Exposure duration was assumed to be 25 years (USEPA, 2002a). The body weight value used for adults was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

It was assumed that the maintenance worker would contact surface water once per day for a period of one hour. The skin surface area available for contact is 3,300 $cm^2$ (USEPA, 2002a) based on the assumption that the head, hands, and forearms are exposed to surface water while wading. It is also assumed that the lower legs and feet would be protected by boots. This value represents an average of the 50th percentile values for males and females (Tables 6-2 and 6-3; USEPA, 1997b).

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. DA is calculated differently depending on whether a steady-state or nonsteady-state approach is used. Following USEPA (2004b) guidance, a steady-state approach should be used to evaluate dermal absorption of inorganics from an aqueous matrix, while a nonsteady-state approach has been recommended to evaluate dermal absorption of organics in an aqueous matrix.

Receptor-specific ADDs and LADDs for dermal contact with surface water were calculated using the following equation (USEPA, 2004b):

$$\text{CDI} = \frac{\text{DA}_{\text{event}} \times \text{SA} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

where:

$\text{DA}_{\text{event}}$ = Absorbed dose per event (mg/cm2-event).
Each of the other variables have previously been described.

The SA parameter describes the amount of skin exposed to the contaminated media and is dependent on the exposure scenario. For the maintenance worker's dermal contact with surface water, it is assumed that the exposed body parts are head, hands and forearms, for a total surface area of 3,300 $\text{cm}^2$ (USEPA, 1997b, 2002a).

The $\text{DA}_{\text{event}}$ is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin ($K_p$), and exposure time (ET). $\text{DA}_{\text{event}}$ is calculated in the same manner for both carcinogenic and noncarcinogenic effects; however, it is calculated differently, depending on whether a steady-state (e.g., for inorganic chemicals) or a non-steady state (e.g., for organic chemicals) approach is used.

The assessment of dermal exposure to inorganic COPCs in surface water relies on the traditional steady-state assumption, since a non-steady state approach has not been developed for inorganic compounds (USEPA, 2004b). Under the steady-state approach, it is assumed that the concentration gradient across each of the skin layers is constant and the rate at which a chemical enters the skin was equal to that of water. The $\text{DA}_{\text{event}}$ is then estimated as (USEPA, 2004b):

$$\text{DA}_{\text{event}} = \text{C} \times \text{CF} \times \text{K}_{\text{p}} \times \text{ET}$$

where:

C = Concentration of chemical in water ($\text{mg/cm}^3$)
CF = Conversion factor - volume (1E-03 liters per cubic centimeter [$\text{L/cm}^3$]);
Kp = Chemical-specific dermal permeability coefficient (centimeters per hour [cm/hr]); and
ET = Exposure time (hours per event [hr/event]).

It is assumed that the duration of exposure to surface water for maintenance workers is short (1 hour) and that one exposure event per day occurs.

The non-steady state approach has been developed for organic compounds for which octanol-water partitioning data ($K_{ow}$) are available; this approach was applied to the organic COPCs. The non-steady state approach is recommended by the USEPA to account for the total amount of chemical crossing the exposed (outside) skin surface rather than the amount which has traversed the skin and entered the blood during the exposure period (e.g., under a steady-state condition). Therefore, the non-steady state approach more accurately reflects normal exposure conditions (under which a steady state often may not occur) and accounts for the dose that may enter the circulatory system after the exposure event due to the storage of chemicals in skin lipids (USEPA, 2004b).

The equations applied to derive the $DA_{event}$ values under the non-steady state assumption were dependent on the length of assumed $t_{event}$ in relation to the time required after initial contact of a chemical with the skin for steady-state to be achieved (t*). The term t* is dependent on chemical-specific properties, and the appropriate equation to derive t* for a chemical is dependent on a dimensionless constant reflecting the partitioning properties of that chemical (USEPA, 2004b). This constant, termed B, can be derived from the dermal permeability coefficient $K_p$ values, as follows:

$$B = K_p \frac{\sqrt{MW}}{2.6}$$

where:

B = Ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless)
Kp = Chemical-specific dermal permeability coefficient in water (cm/hr); compiled from USEPA (2004b)
MW = Chemical-specific molecular weight (g/mole)

Once B was derived, t* can be calculated using the appropriate equation below (USEPA, 2004b):

- For $B \leq 0.6$:

$$t^* = 2.4 \times \tau$$

where $\tau$ = lag time (hr).

- For $B > 0.6$:

$$t^* = 6(b - \sqrt{b^2 - c^2}) \times \tau$$

where:

$$b = \frac{2}{\pi}(1+B)^2 - c \qquad \text{and} \qquad c = \frac{1+3B+3B^2}{3(1+B)}$$

The lag time ($\tau$) is defined for the stratum corneum, the outermost layer of the skin, which is thought to provide the major resistance to the absorption into the circulatory system of chemicals deposited on the skin (USEPA, 2004b). The $\tau$ values can be derived from the following equation (USEPA, 2004b):

$$\tau = \frac{l_{sc}^2}{6D_{sc}} = 0.105 \times 10^{(0.0056 \times MW)}$$

where:

Lsc = Thickness of stratum corneum ($10^{-3}$ cm); and
Dsc = Diffusivity of a chemical within the stratum corneum ($cm^2$/hr).

The diffusivity of a chemical within the stratum corneum ($D_{sc}$) can be estimated from the thickness of the stratum corneum ($l_{sc}$) and the molecular weight (MW) of the chemical, using the following equation (USEPA, 2004b):

$$\text{Log}\frac{D_{sc}}{l_{sc}} = -2.80 - (0.0056 \times \text{MW})$$

Once the time until steady-state (t*) has been derived, it can be compared to the assumed exposure time ($t_{event}$) in order to select the appropriate equation to derive the $DA_{event}$. If the exposure time was less than or equal to the time until steady-state (i.e., if $t_{event} \leq t^*$), the following equation was used (USEPA, 2004b):

$$DA_{event} = 2FA \times K_p \times C\sqrt{\frac{6 \times \tau \times t_{event}}{\pi}}$$

where:

FA = Chemical-specific fraction absorbed (dimensionless); compiled from USEPA (2004b)

The other variables have been previously described.

If the exposure time was greater than the time until steady-state (i.e., if $t_{event} > t^*$), then the following equation was used (USEPA, 2004b):

$$DA_{event} = FA \times C \times K_p \times \left[\frac{t_{event}}{1+B} + (2 \times \tau \times \frac{1+3B+3B^2}{(1+B)^2})\right]$$

Each of the variables has been previously described. **Appendix E-1, Table E-31** presents the $DA_{event}$ values for organics.

**Current and Future Industrial Worker Dose Equations and Exposure Parameters for Surface Water.** The potential chemical doses for industrial worker exposures to surface water at SWMU 31 were estimated using the equations and exposure parameters presented below. Due to the type of activities in which industrial workers would be expected to be involved, it was assumed that surface water contact would most likely occur via wading. Therefore, the water bodies at SWMU 31 were evaluated for surface water exposures associated with wading.

The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Surface Water by Industrial Workers (Outdoor) - Wading.** It was assumed that industrial workers would not swim in surface water at SWMU 31. Therefore, incidental ingestion of COPCs in surface water would likely be negligible. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

**Dermal Absorption of Chemicals in Surface Water by Industrial Workers (Outdoor) - Wading.** Exposures for dermal absorption of chemicals in surface water by industrial workers wading at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1, Tables E-29 and E-30**. Where relevant, standard parameters were used to characterize adult exposures (>18 years of age).

Industrial workers were assumed to be exposed to surface water 225 days/year. Exposure duration was assumed to be 25 years (USEPA, 2002a). The body weight value used for adults was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

It was assumed that the industrial worker would contact surface water once per day for a period of one hour. The skin surface area available for contact is 3,300 $cm^2$ (USEPA, 2002a) based on the assumption that the head, hands, and forearms are exposed to surface water while wading. It is also assumed that the lower legs and feet would be protected by boots. This value represents an average of the 50th percentile values for males and females (Tables 6-2 and 6-3; USEPA, 1997b).

The absorbed dose was calculated using the method (USEPA, 2004b) described in the previous paragraphs for the maintenance worker exposure to surface water.

**Future Excavation Worker Dose Equations and Exposure Parameters for Surface Water.** The potential chemical doses for excavation worker exposures to surface water at SWMU 31 were estimated using the equations and exposure parameters presented below. Due to the type of activities in which excavation workers would be expected to be involved, it was assumed that surface water contact would most likely occur via wading. Therefore, the water bodies at SWMU 31 were evaluated for surface water exposures associated with wading.

The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Surface Water by Excavation Workers - Wading.** It was assumed that excavation workers would not swim in surface water at SWMU 31. Therefore, incidental ingestion of COPCs in surface water would likely be negligible. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

**Dermal Absorption of Chemicals in Surface Water by Excavation Workers - Wading.** Exposures for dermal absorption of chemicals in surface water by excavation workers wading at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1, Table E-30**. Where relevant, standard parameters were used to characterize adult exposures (>18 years of age).

Excavation workers were assumed to be exposed to surface water 250 days/year. Exposure duration was assumed to be 25 years (USEPA, 2002a). The body weight value used for adults was 70 kg, the standard USEPA (2002a) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 25 years was used for noncarcinogenic COPCs.

It was assumed that the excavation worker would contact surface water once per day for a period of one hour. The skin surface area available for contact is 3,300 $cm^2$ (USEPA, 2002a) based on the assumption that the head, hands, and forearms are exposed to surface water while wading. It is also assumed that the lower legs and feet would be protected by boots. This value represents an average of the 50th percentile values for males and females (Tables 6-2 and 6-3; USEPA, 1997b).

The absorbed dose was calculated using the method (USEPA, 2004b) described in the previous paragraphs for the maintenance worker exposure to surface water.

**Future Lifetime (Adult) Resident Dose Equations and Exposure Parameters for Surface Water.** A lifetime resident is calculated as the sum of the exposures of 6 yrs as a child and 24 years as an adult. The potential chemical doses for residential exposures to surface water at SWMU 31 were estimated using the equations and exposure parameters presented below. These exposures were dependent upon the water bodies associated the area of concern. Because lagoons were present at SWMU 31, it was assumed that these water bodies were deep enough for swimming. Therefore, surface water exposures associated with swimming were evaluated for SWMU 31. Surface water exposures associated with wading at the edges of the lagoons were also evaluated.

The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Surface Water by Lifetime Residents - Swimming.** Exposures for incidental ingestion of chemicals in surface water by lifetime residents swimming in the lagoons at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1, Table E-30**.

Lifetime residents were assumed to be exposed to surface water 5 days/year, based on swimming in the area for 1 day/month during the warmer months (i.e., May through September) (USEPA, 1997b). Exposure duration was assumed to be 24 years (USEPA, 1991a) with a body weight value used for adult residents was 70 kg, the standard USEPA (1991a) default value for adult body weight, plus another 6 years at a body weight of 15 kg. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs. In addition, incidental intake of surface water used for adult swimmers will be assumed to be 0.05 L/hr based on USEPA (1989a) and the exposure time is assumed to be 1 hour/day.

**Dermal Absorption of Chemicals in Surface Water by Lifetime Residents - Swimming.** Exposures for dermal absorption of chemicals in surface water by adult residents swimming in the lagoons at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1, Table E-30**.

It is assumed that the entire body will be exposed to surface water for the swimming scenario. Using data from USEPA (1997b), the skin surface area for the lifetime resident (18,000 $cm^2$) is estimated from USEPA (Tables 6-2 and 6-3, 1997b). The event frequency is assumed to be 1 event/day. The absorbed dose was calculated using the method (USEPA, 2004b) described in the previous paragraphs for the maintenance worker exposure to surface water.

**Incidental Ingestion of Surface Water by Lifetime Residents -Wading.** It was assumed that exposure to surface water in the lagoon edges via ingestion is expected to be negligible during wading. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

**Dermal Absorption of Chemicals in Surface Water by Lifetime Residents -Wading.** The internal dose due to dermal absorption of COPCs in surface water by adult residents at SWMU 31 was estimated using the equation and the exposure parameters presented in **Appendix E-1**, **Table E-30**. Where relevant, standard parameters were used to characterize adult exposures (> 18 years of age).

Adult residents were assumed to be exposed to surface water for 40 days/year, based on best professional judgment that the time an adult resident would spend wading would be similar to the time spent gardening or doing yard work (USEPA, 1997b). The body weight value used for adult residents was 70 kg (for 24 years) and 15 kg (for 6years), the standard USEPA (1991a) default value for body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

It was assumed that the adult resident would contact surface water once per day for a period of one hour. The skin surface area available for contact is 5,700 $cm^2$ (USEPA, 1997b) based on the assumption that the hands, forearms, lower legs, and feet are exposed to surface water while wading. This value represents an average of the 50th percentile values for males and females (Tables 6-2 and 6-3, USEPA, 1997b).

**Future Child Resident Dose Equations and Exposure Parameters for Surface Water.** The potential chemical doses for residential exposures to surface water at SWMU 31 were estimated using the equations and exposure parameters presented below. As described for adult residents, exposure scenarios associated with both swimming and wading were considered.

The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for residents in *Section 5.4*.

**Incidental Ingestion of Surface Water by Child Residents - Swimming.** Exposures for incidental ingestion of chemicals in surface water by child residents swimming in the lagoons at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1**, **Table E-30**.

Child residents were assumed to be exposed to surface water for 5 days/year, based on swimming in the area for 1 day/month during the warmer months (i.e., May through September) (USEPA, 1997b). These values correspond to those of the adult resident because it was assumed that children in this age group would be accompanied or supervised by an adult while swimming. Exposure duration was assumed to be 6 years. The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for the body weight of a child under 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs. In addition, incidental intake of surface water used for child swimmers will be assumed to be 0.05 L/hr based on USEPA (1989a) and the exposure time is assumed to be 1 hour/day.

**Dermal Absorption of Chemicals in Surface Water by Child Residents - Swimming.** Exposures for dermal absorption of chemicals in surface water by child residents swimming in the lagoons at SWMU 31 were calculated using the equation and exposure parameters presented in **Appendix E-1, Table E-30**.

It is assumed that the entire body would be exposed to surface water for the swimming scenario. Using data from USEPA (1997b), the skin surface area for the child resident (6,600 $cm^2$) is estimated from USEPA (Tables 6-6 and 6-7, 1997b). The event frequency is assumed to be 1 event/day. The absorbed dose was calculated using the method (USEPA, 2004b) described in the previous paragraphs for the maintenance worker exposure to surface water.

**Incidental Ingestion of Surface Water by Child Residents - Wading.** It was assumed that exposure to surface water in lagoon edges via ingestion is expected to be negligible while wading. Therefore, the ingestion pathway was not quantitatively evaluated for this receptor.

**Dermal Absorption of Chemicals in Surface Water by Child Residents -Wading.** The internal dose due to dermal absorption of COPCs in surface water by child residents at SWMU 31 was estimated using the equation and the exposure parameters presented in **Appendix E-1**, **Table E-30**. Where relevant, standard parameters were used to characterize child exposures (> 6 years of age).

Child residents were assumed to be exposed to surface water for 40 days/year, based on the assumption that the child under 6 years of age would be accompanied by an adult while wading and, therefore, would have an exposure frequency similar to an adult resident. These values correspond to those of the adult resident because it was assumed that children in this age group would be accompanied or supervised by an adult while wading. The body weight value used for child residents was 15 kg, the standard USEPA (1991a) default value for child body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

It was assumed that the child resident would contact surface water once per day for a period of one hour. The skin surface area available for contact with surface water is 1,900 $cm^2$ (USEPA, 1997b) based on the assumption that the hands, forearms, lower legs, and feet are exposed to surface water while wading. This value represents an average of the 50th percentile values for males and females (Tables 6-6 and 6-7, USEPA, 1997b).

**Current and Future Maintenance Worker Dose Equations and Exposure Parameters for Groundwater.** Under both current and future land-use conditions, maintenance workers could be exposed to COPCs in groundwater. Exposures to groundwater through direct contact are not likely. However, exposure to VOCs in groundwater released to ambient air is possible. The potential chemical doses for current and future maintenance worker exposures to groundwater at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**Inhalation of VOCs from Groundwater by Maintenance Workers.** The exposure for inhalation of COPCs in groundwater by maintenance workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-32**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

The inhalation rate of 2.5 $m^3$ per hour for maintenance workers was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a). It was conservatively assumed that VOCs inhaled during the visit would originate in the sampled areas; however, it is unlikely that a worker would spend the entire day at just one location on the Installation every day.

**Current and Future Industrial Worker Dose Equations and Exposure Parameters for Groundwater.** Under current and future land-use conditions, industrial workers could be exposed to COPCs in groundwater. Industrial workers are assumed to be exposed to COPCs in groundwater via ingestion, inhalation of ambient air and indoor air. The potential chemical doses for future industrial worker exposures to groundwater at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**Ingestion of COPCs in Groundwater by an Industrial Worker (Outdoor and Indoor).** The exposure for ingestion of COPCs in groundwater by industrial workers were calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-33**. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of soil by an industrial worker.

Workers were assumed to be exposed to soil 225 days/year, a value which represents the average number of days worked per year by male and female workers engaged in activities likely to be similar to those of the outdoor worker receptor (USEPA, 2002a). Duration of exposure for workers was assumed to be 25 years, a USEPA (2002a) upper-bound default estimate of the time spent working in one location. The water ingestion rate used for an industrial worker was 1 L/day (USEPA, 1991a).

**Inhalation of VOCs from Groundwater by Industrial Workers (Outdoor and Indoor).** The exposure for inhalation of COPCs in groundwater by industrial workers was calculated using the equation and the exposure parameters presented in **Appendix E-1, Tables E-32 and E-34**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of soil by a maintenance worker.

For outdoor workers, the EPC was based on the ambient air concentration of the volatile COPC (chloroform), as calculated in *Section 5.2.2* and provided in **Appendix E-1, Table E-16**. The EPC for indoor workers was based on the concentration of chloroform in building air, as calculated by the Johnson & Ettinger model described in *Section 5.2.2* and provided in **Appendix E-1, Table E-18**.

For both scenarios, the inhalation rate of 2.5 $m^3$ per hour for industrial workers was derived by dividing the adult daily rate of 20 $m^3$/day (USEPA, 1991a) by an 8-hour workday. The exposure time is 8 hours per day (USEPA, 2002a).

**Future Excavation Worker Dose Equations and Exposure Parameters for Groundwater.** Under future land-use conditions, excavation workers could be exposed to COPCs in groundwater. Exposures to groundwater through direct contact are not likely. However, exposure to VOCs in groundwater released to air while working in a trench is possible. The potential chemical doses for future excavation worker exposures to groundwater at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**Inhalation of COPCs in Groundwater by an Excavation Worker.** The exposure for inhalation of COPCs in groundwater by excavation workers due to vapors generated during work in a trench or a pit were calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-34**. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating the incidental ingestion of total soil by an excavation worker. It was assumed that the exposure time was 4 hours/day (VDEQ, 2006). The inhalation rate was estimated to be 2.5 $m^3$/hour, which was determined by dividing the adult daily inhalation rate of 20 $m^3$/day (USEPA, 1997b) by 8 hours/day.

**Future Lifetime Resident Dose Equations and Exposure Parameters for Groundwater.** Under future land-use conditions, lifetime residents could be exposed to COPCs in groundwater through household use or vapor intrusion. Adult residents are assumed to be exposed to COPCs in groundwater via ingestion, dermal contact, inhalation of indoor air and shower air, and ingestion of homegrown produce. The potential chemical doses for future lifetime resident exposures to groundwater at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**Ingestion of COPCs in Groundwater by a Lifetime Resident.** The exposure for ingestion of chemicals in groundwater during household use by residents was calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-33**. Residents were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for residents was assumed to be 30 years (USEPA, 1991a, 2003c). The body weight value used for adults was 70 kg, the standard USEPA (1991a, 2003c) default value for adult body weight. The water ingestion rate used for an adult resident was 2 L/day (USEPA, 2003c).

**Dermal Absorption of COPCs in Groundwater by a Lifetime Resident.** The exposure for dermal absorption of COPCs in groundwater by lifetime residents during showering were calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-33**. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by an adult resident. It was assumed that one shower would be taken per day (i.e., event frequency equals one) (USEPA, 2004b). The skin surface area available for contact is 18,000 $cm^2$, which is based on the assumption that the total body area is exposed to groundwater while bathing or showering. This value represents an average of the 50th percentile surface area values for adult males and females (USEPA, 2004b). The absorbed dose was calculated using the method presented earlier (USEPA, 2004b) to evaluate dermal absorption of COPCs in surface water by maintenance workers.

**Inhalation of COPCs in Groundwater during Shower by a Lifetime Resident.** Potential doses due to inhalation of chemicals in groundwater due to vapors generated during showering were calculated for adult residents. The dose equation and exposure parameters are presented in **Appendix E-1, Table E-34**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by a lifetime resident. The inhalation rate was estimated to be 0.83 $m^3$/hour, which was determined by dividing the adult daily inhalation rate of 20 $m^3$/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 65 minutes/day (1.08 hours/day), which assumes 35 minutes (based on the 95th percentile value for overall showering time) being spent showering and an additional 30 minutes spent in the shower room (USEPA, 2004b).

**Inhalation of COPCs in Groundwater via Vapor Intrusion by a Lifetime Resident.** The exposure for inhalation of VOC COPCs in groundwater that could migrate into hypothetical future residences were calculated for lifetime residents (aged 18 through 70) using the equations and exposure parameters presented in **Appendix E-1, Table E-34**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater by an adult resident. The inhalation rate was estimated to be 0.83 $m^3$/hour, which was determined by dividing the adult daily inhalation rate of 20 $m^3$/day (USEPA, 1991a) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

**Ingestion of Home Grown Vegetables and Fruit by Lifetime Residents.** The exposure for ingestion of COPCs in home grown produce (vegetables and fruit) by lifetime residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-35**. Standard parameters were used to characterize exposures by adults (> 18 years of age).

Lifetime residents were assumed to consume vegetables and/or fruits 350 days/year, a standard USEPA (1991a, 2003c) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for residents was assumed to be 30 years, a USEPA (1991a, 2003c) upper-bound default estimate of the time spent residing in one location. The body weight value used for adult residents was 70 kg, the standard USEPA (1991a, 2003c) default value for adult body weight. An averaging time of 70 years was used for carcinogenic COPCs, while 30 years was used for noncarcinogenic COPCs.

The daily produce ingestion rate for lifetime residents was assumed to be 7.5 g/day of vegetables and 11.1 g/day of fruit. Ingestion rate is based on the 95th percentile values for home grown food intake (Table 1-2; USEPA, 1997b).

The transfer of COPCs in groundwater to vegetables by watering a garden was calculated using two equations based on “exposed produce” developed by Baes et al. (1984):

$$CV_W = WR \cdot R \cdot \frac{1 - e^{-kt}}{Y \cdot K \cdot CF}$$

where:

$CV_W$ = constituent concentration in the vegetables/fruits (mg/kg)
WR = watering rate (μg/$m^2$-year)
R = interception fraction for exposed vegetables/fruits (0.0319)
K = plant surface degradation rate constant for COPC wash-off (18 $yr^{-1}$)
t = length of growing season (0.50 year, based on 184 frost-free days)
Y = vegetation yield (1.5 kg/$m^2$)
CF = conversion factor (1,000 μg/mg)

$$WR = C_W \cdot I \cdot F$$

where:

WR = watering rate ($\mu g/m^2$-year)
$C_W$ = constituent concentration in “deep” groundwater (mg/L)
I = watering intensity (0.5 L/event)
F = watering frequency (184 events/year, once each day assumed for a 6-month growing season from May through October)

It should be noted that USEPA has determined that sufficient data exists for only arsenic, cadmium, mercury, nickel, selenium, and zinc (USEPA, 1996b). Arsenic was found to be a COPC in the groundwater associated with the site, and estimates of exposure for it were calculated and included in the total estimate of exposure.

**Future Child Resident Dose Equations and Exposure Parameters for Groundwater.** Under future land-use conditions, child residents could be exposed to COPCs in groundwater through household use or vapor intrusion. Child residents are assumed to be exposed to COPCs in groundwater via ingestion, dermal contact, inhalation of indoor air, and ingestion of homegrown produce. The potential chemical doses for future child resident exposures to groundwater at SWMU 31 were estimated using the equations and exposure parameters presented below. The EPCs used to estimate potential chemical doses for each evaluated medium and data grouping were presented in *Section 5.2.2*, while the calculated LADDs for carcinogenic effects and ADDs for noncarcinogenic effects are presented in the corresponding tables for workers in the *Section 5.4*.

**Ingestion of COPCs in Groundwater by a Child Resident.** The exposure for ingestion of chemicals in groundwater during household use by children were calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-33**. Children were assumed to be exposed to groundwater 350 days/year, assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation away from home). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a, 2003c), representing the age period of concern (6 years total). The body weight value used for children was 15 kg, the standard USEPA (1991a, 2003c) default value for a child’s body weight averaged over ages 0 to 6. The water ingestion rate used for a child resident was 1 L/day, as recommended by USEPA (2003c).

**Dermal Absorption of COPCs in Groundwater by a Child Resident.** The exposure for dermal absorption of COPCs in groundwater by child residents during bathing were calculated using the equations and exposure parameters presented in **Appendix E-1, Table E-33**. The parameters describing the frequency of exposure, duration of exposure, and body weight are identical to those used for estimating incidental ingestion of groundwater by a child resident. It was assumed that one bath would be taken per day (i.e., event frequency equals one) (USEPA, 2004b) for an exposure time of 60 minutes (1 hour) (USEPA, 2004b). The skin surface area available for contact is 6,600 $cm^2$ based on the assumption that the total body area is exposed to groundwater while bathing. This value represents an average of the 50th percentile surface area values for males and females up to 6 years of age (USEPA, 2004b). The absorbed dose was calculated using the method presented earlier (USEPA, 2004b) to evaluate dermal absorption of COPCs in surface water by maintenance workers.

**Inhalation of COPCs in Groundwater via Vapor Intrusion by a Child Resident.** The exposure for inhalation of VOC COPCs in groundwater that could migrate into hypothetical future residences were calculated for child residents (aged 0 through 6 years) using the equations and exposure parameters presented in **Appendix E-1, Table E-34**. The parameters describing the frequency of exposure, duration of exposure, body weight, and averaging time are identical to those used for estimating the ingestion of groundwater for a child resident. The inhalation rate was estimated to be 1 $m^3$/hour, which was based on light activities (USEPA, 1997b) by 24 hours/day. It was assumed that the ET was 24 hours/day (Johnson and Ettinger, 1991).

**Ingestion of Home Grown Vegetables and Fruit by Child Residents.** The exposure for ingestion of COPCs in home grown produce (vegetables and fruit) by child residents was calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E-35**. Standard parameters were used to characterize exposures by children of 6 years of age or less.

Child residents were assumed to be exposed to soil 350 days/year, a standard USEPA (1991a) default assumption assuming a 7-day week for 50 weeks/year (residents were assumed to spend 2 weeks a year on vacation). Duration of exposure for children was assumed to be 6 years (USEPA, 1991a, 2003c). The body weight value used for child residents was 15 kg, the standard USEPA (1991a, 2003c) default value for a child's body weight averaged over 0 to 6 years of age. An averaging time of 70 years was used for carcinogenic COPCs, while 6 years was used for noncarcinogenic COPCs.

The daily produce ingestion rate for child residents was assumed to be 7.5 g/day of vegetables and 11.1 g/day of fruit. Ingestion rate is based on the 95th percentile values for home grown food intake (Table 1-2; USEPA, 1997b). Concentrations in produce were calculated using the method presented above for the adult resident.

## 5.3 HUMAN HEALTH TOXICITY ASSESSMENT

The general methodology for the classification of health effects and the development of health effects criteria is described in *Section 5.3.1* to provide the analytical framework for the characterization of human health risks. In *Section 5.3.2*, the health effects criteria, or toxicity values, used to derive estimates of risk are presented. These values are combined with dose information for each complete exposure pathway quantitatively evaluated to predict potential risks associated with exposures to COPCs in environmental media at SWMU 31 (*Section 5.4*).

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (1986a,b; 1989a; 1997a; 2005c). The health effects analysis considers chronic (long-term) exposures. Using the following hierarchy (USEPA, 2003b), the chronic toxicity criteria were obtained from:

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2005c).
- 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 (NCEA)/Superfund Health Risk Technical Support Center (USEPA, 2003b.) Because access to PPRTV is limited (USEPA, 2004c), these values were obtained directly from USEPA Region III's RBC table (USEPA, 2006a).
- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information. This tier includes the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a).

### 5.3.1 Health Effects Classification and Criteria Development

According to USEPA's science policy, there are two primary approaches to developing toxicity values or health criteria. The non-threshold approach is based on USEPA's scientific policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells. This is described as a non-threshold initiator mechanism, because there is essentially no level of exposure (i.e., a threshold) to a constituent that will not result in some finite possibility of causing an adverse effect. Another assumption stemming from USEPA's science policy is that the dose-response curve is linear at low doses. For most carcinogens, toxicity values are based on the non-threshold approach.

The threshold approach is based on the assumption that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the adverse effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is realized. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects. Toxicity values for noncarcinogenic effects are based on the threshold approach. Furthermore, as additional information regarding the mechanisms of toxicity becomes available, the threshold approach does apply to some carcinogens (e.g., chloroform).

**Health Effects Criteria for Potential Carcinogens.** For carcinogens, USEPA estimates the excess lifetime cancer risks associated with various levels of exposure by developing cancer slope factors (CSFs) and unit risks. CSFs are expressed in terms of reciprocal dose, as units of (mg chemical/kg body weight-day)$^{-1}$, which describes the upper-bound increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure. Unit risks are expressed either as a reciprocal air concentration, in units of ($\mu$g/m$^3$)$^{-1}$, or as a reciprocal drinking water concentration, in units of ($\mu$g/L)$^{-1}$. Similarly, they are defined as the excess probability of an individual developing cancer over a 70-year lifetime as a result of exposure to one unit of concentration in air or water. Because regulatory efforts are geared to be protective of public health, including even the most sensitive members of the population, the CSFs are derived using conservative assumptions.

CSFs and unit risks are derived from the results of human epidemiological studies or chronic animal bioassays. The animal studies usually must be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed to doses lower than those used in the animal studies, the potential cancer risks at lower doses are estimated by using mathematical models. The data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response relationship. In general, after the data are fit to the dose-response model, the 95 percent UCL of the slope of the resulting dose-response relationship at low doses is calculated. This upper-bound limit is subjected to various adjustments, and an interspecies scaling factor is applied to derive the slope factor or unit risk for humans. Thus, the actual risks associated with a given intake of a potential carcinogen quantitatively evaluated based on animal data are generally regarded as not likely to exceed the risks estimated using these CSFs or unit risks, and they may be as low as zero (USEPA, 1986a). Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. CSFs and unit risks based on human epidemiological data are derived using conservative assumptions and, as such, they too are unlikely to underestimate risks for a given level of exposure.

Weight-of-evidence categories represent an assessment of the amount and quality of the data, which support the finding that specific chemicals and elements can cause cancer in humans. Although USEPA's guidelines for carcinogen risk assessment (USEPA, 1996c, 1999a, 2005b) propose a weight-of-evidence narrative, IRIS currently uses the original alphanumeric classification. Under the existing guidelines (USEPA, 1986a), chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A includes those substances for which high-quality studies have demonstrated a relationship between the exposure to the substance in question and the development of cancer in human populations. Groups B1, B2, and C represent chemicals with limited (B1) or insufficient (B2) human evidence of carcinogenicity, and sufficient (B1, B2) or insufficient (C) animal data. Group D substances are those for which there is insufficient or no evidence of carcinogenicity in humans or animals, while Group E substances are those for which no evidence of carcinogenicity is available in adequate human or animal studies.

**Health Effects Criteria for Noncarcinogens.** Health effects criteria for chemicals exhibiting noncarcinogenic effects are generally developed using verified risk reference doses (RfDs) and reference concentrations (RfCs). These are developed by USEPA and listed in IRIS (USEPA, 2005c), or can be obtained from HEAST (USEPA, 1997a) and supplements. The RfD is expressed in units of dose (mg chemical/kg body weight-day) and is usually derived either from human studies involving workplace exposures or from animal studies. The RfDs are estimates (with uncertainty spanning perhaps several orders of magnitude) of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is used as a reference point for gauging the potential effects of exposures. Usually, exposures (as chemical intakes or doses) that are less than the RfD are not likely to be associated with adverse health effects. As the frequency and/or magnitude of the exposures exceeding the RfD increase, the probability of adverse effects in a human population increases.

RfDs are developed for both chronic and subchronic exposures. Chronic RfDs are presented in IRIS or HEAST and are intended for use in evaluating exposures of durations greater than seven years. Subchronic RfDs are developed by USEPA's NCEA and are used to characterize the potential for the occurrence of noncarcinogenic effects associated with short-term exposures [two weeks to seven years as defined by USEPA (1989a)]. The subchronic RfDs are developed similarly to chronic RfDs, and are typically equal to chronic RfDs or are one order of magnitude greater (less stringent). The subchronic RfDs are presented in HEAST, but they are no longer being reviewed and updated in the same manner as IRIS. Because there is greater uncertainty associated with the subchronic RfDs, chronic RfDs have been used in this HHRA.

The RfDs are derived using uncertainty factors that reflect scientific judgment regarding the various types of data used to estimate the RfD. RfDs are typically estimated from no observable adverse effect levels (NOAELs) or lowest observable adverse effect levels (LOAELs) in human or animal studies. Uncertainty factors, generally 10-fold factors, are intended to account for:

- The variation in sensitivity among members of the human population.
- The uncertainty in extrapolating animal data to the case of humans.
- The uncertainty in extrapolating from data obtained in a study that is less-than-lifetime exposure.
- The uncertainty in using LOAEL data, when necessary, rather than NOAEL data.

- The inability of a single study to adequately address every possible adverse outcome in humans.

To derive RfDs, NOAELs or LOAELs are divided by one or more uncertainty factors, as appropriate. When taken together, these uncertainty factors may confer an extra margin of safety of up to a factor of 10,000 below a LOAEL. In some cases, modifying factors are also applied to RfDs to take into account other uncertainties in the toxicity database and reflect the professional judgment of those reviewing the database. The net result is that RfDs are generally considered to provide a conservative estimate of the likelihood of adverse noncarcinogenic effects.

### 5.3.2 Health Effects Criteria for COPCs

Health effects criteria for chronic exposures to COPCs via the oral route of exposure are presented in **Appendix E-1, Tables E-36 and E-37**. Health effects criteria for chronic exposures to the COPCs in soil via the inhalation of particulate matter and volatiles are presented in **Appendix E-1, Tables E-38 and E-39**. The following chemical-specific guidance was also used.

***Chromium.*** The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998). Two common forms of chromium are trivalent chromium (chromium III) and hexavalent chromium (chromium VI). Chromium III is the predominant form of chromium in nature and is the less toxic of the two forms. Hexavalent chromium is the more toxic form of chromium and is considered to be a Class A carcinogen via the route of inhalation. The speciation of hexavalent chromium (Cr VI) is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with hexavalent chromium (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that hexavalent chromium may be present at a site (such as its use for control of scale in non-contact cooling water piping for a power plant or a chromium plating operation), it is generally not included in an analytical program. For SWMU 31, hexavalent chromium analyses were not performed for the environmental media samples.

It was assumed that the majority of the chromium that was detected at the site would be in the trivalent form. Hexavalent chromium is relatively unstable in the environment and is typically converted to trivalent chromium. As stated in *Water-Related Environmental Fate of 129 Priority Pollutants* (USEPA, 1979), hexavalent chromium or Cr(VI) is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent chromium or Cr(III). Chemical speciation is an important fate process for chromium and in aquatic environments. Cr(VI), if present, would be expected to remain in a soluble form, while trivalent chromium would be expected to hydrolyze and precipitate as $Cr(OH)_3$. Cr(III) the most stable form under reducing conditions normally found in natural waters and sediments, and when in solution at pH greater than 5, quickly precipitates due to formation of the insoluble hydroxide or oxide.

Cr (III) is the stable form of chromium in soil (FRTR, 2002). Cr (III) hydroxy compounds precipitate at pH 4.5 and complete precipitation of the hydroxy species occurs at pH 5.5. In contrast to Cr (VI), Cr (III) is relatively immobile in soil. Three soil samples from one location were analyzed for pH at SWMU 31. The pH values for soil at SWMU 31 were 7.37 (31SB05A), 7.13 (31SB05B), and 6.96 (31SB05C). Because the pH data indicate that the soil is not acidic, the precipitation of total chromium as Cr (III) is not expected. The corresponding chromium concentrations for these samples (15.8 mg/kg, 28.2 mg/kg, and 29.7 mg/kg), however, were within background concentrations.

Because of its anionic nature, Cr (VI) associates with soil surfaces at positively charged exchange sites (FRTR, 2002). This association decreases with increasing soil pH. Regardless of pH and redox potential, most Cr(VI) in soil is reduced to Cr(III). Soil organic matter and iron (Fe II) minerals donate electrons in this reaction. The reduction reaction in the presence of organic matter proceeds at a slow rate under normal environmental pH and temperatures, but the rate of reaction increases with decreasing soil pH.

A number of studies have been conducted with respect to the fate and transport of chromium in soil. For example, the objectives of a study conducted by the Oak Ridge National Laboratory (ORNL) (Jardine et al., 1999), were to investigate the impact of coupled hydrologic and geochemical processes on the fate and transport of Cr(VI) in undisturbed soil cores. The reduction of Cr(VI) to Cr(III) was dramatically more significant on soil with higher levels of surface-bound natural organic matter. This indicated that natural organic matter was serving as a suitable reductant during Cr(VI) transport even in the presence of potentially competing geochemical oxidation reactions involving chromium. In another example, seven organic amendments (e.g., composts, manures) were investigated for their effects on the reduction of Cr(VI) in a mineral soil low in organic matter contact (Bolan et al., 2003). Addition of organic amendments enhanced the rate of reduction of Cr(VI) to Cr(III) in the soil. Finally, it was found that the distribution of metal contaminants such as chromium in soil can be strongly localized by transport limitations and redox gradients within soil aggregates (Tokunaga et al., 2001). Shifts in characteristic redox potential and the extent of Cr(VI) reduction to Cr(III) were related to organic matter availability.

Three samples from one location were analyzed for TOC at SWMU 31. The TOC values were 53,300 mg/kg (31SB05A) and 5,910 mg/kg (31SB05C) for total soil. The third sample was below the reporting limit of 1,150 mg/kg (31SB05B). The corresponding chromium concentrations were 15.8, 29.7, and 28.2 mg/kg. Due to the limited data, there is no trend between chromium concentrations versus TOC.

Even if trace amounts of Cr(VI) were present at the site, the environmental conditions at RFAAP, including typical precipitation events over the years, would tend to favor the conversion of this form of chromium to the more stable (less toxic) trivalent state. For these reasons, it was assumed that toxicity associated with chromium would be most accurately represented by the use of chromium III toxicity data.

***Iron.*** In accordance with the SSP for RFAAP (USEPA, 2001b), a "margin of exposure" evaluation was performed in cases where iron concentrations in soil or water resulted in an HQ greater than 0.5. Hazards associated with exposures to iron were characterized by comparing the estimated iron intake with the RDA and concentrations known to cause adverse effects in children (USEPA, 1996a).

***Dioxins/Furans.*** The procedure for calculating the 2,3,7,8-TCDD TEQ was described in *Section 5.1.1*. To evaluate the risk associated with dioxin-like compounds, an EPC was calculated by using the sample-specific 2,3,7,8-TCDD TEQs. To obtain an EPC that represented an RME, non-detected values were treated as one-half the SQL and B-qualified data were eliminated from the calculations. The toxicity slope factors for 2,3,7,8-TCDD (USEPA, 1997a) were applied in the risk assessment calculations.

### 5.3.3 Adjustment for Dermal Absorption

Toxicity criteria have not been developed by USEPA specifically for the dermal absorption route of exposure; instead, oral health effects criteria are adjusted to assess this pathway. In order to have a meaningful comparison between the dermal absorption dose estimates, which represent internal (or absorbed) doses, and oral toxicity criteria, which typically represent potential (or administered) doses, toxicity criteria are modified to represent absorbed doses. The method for modifying toxicity criteria involves determination of an absolute oral absorption factor for each chemical and use of this value to increase the chemical's CSF or to decrease the chemical's RfD, as shown in the following equations:

$$\text{(CSF) / (Absolute oral absorption factor) = Adjusted Dermal CSF}$$
$$\text{(RfD) x (Absolute oral absorption factor) = Adjusted Dermal RfD}$$

The absolute oral absorption factors that are applied should reflect the specific conditions under which the toxicological study was conducted (e.g., method of administration such as gavage, water or diet, and vehicle of administration such as solvent or solution). The absolute oral absorption factors and adjusted toxicity criteria for the COPCs used when evaluating dermal absorption are also presented in **Appendix E-1, Tables E-36 and E-37**. The adjusted CSFs and RfDs presented in these tables were used to evaluate potential risks associated with dermal absorption exposures.

## 5.4 HUMAN HEALTH RISK CHARACTERIZATION

In this section, the potential human health cancer risks and non-cancer hazards associated with selected human exposure pathways are calculated and detailed results are provided in **Appendix E-1, Tables E-40 through E-61**. To quantitatively assess risks at SWMU 31, the average daily doses (LADDs and ADDs) calculated in the exposure section are combined with the health effects criteria presented in the toxicity section. USEPA has developed guidance for assessing the potential risks to individuals from exposure to carcinogenic and noncarcinogenic chemicals, and uses separate methodologies for estimating the risks from these two different classes of compounds.

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated LADD by the upper-bound CSF. Upper-bound is a term used by USEPA to describe CSFs, meaning that actual risks are unlikely to be higher than the risks predicted using the upper-bound CSFs. Using this approach, a risk level of $1 \times 10^{-6}$, for example, represents an upper-bound increase in the lifetime probability of 1 in 1,000,000 that an individual could develop cancer as a result of exposure.

The approach of calculating carcinogenic risks by multiplying the LADD by the CSF assumes that the increased risk of cancer resulting from exposure to a constituent is linearly proportional to the amount of chemical intake averaged over a lifetime. According to USEPA (1989a) risk assessment guidance, this approach is appropriate when the estimated carcinogenic risks calculated are less than $10^{-2}$ (i.e., one excess cancer case per 100 people exposed). If the estimated risks are above $10^{-2}$, the assumption of linearity is not valid. In such cases, the carcinogenic risks should be calculated using the following equation, per USEPA risk assessment guidance (USEPA, 1989a):

$$\text{Risk} = 1 - e^{(-\text{LADD} * \text{CSF})}$$

It is important to note that although the upper-bound cancer risk estimates provide plausible estimates of the upper limits of risk, the actual risk could be considerably lower.

In order to assess the upper-bound individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals were summed within each exposure pathway. This approach is consistent with the USEPA's guidelines for evaluating the toxic effects of chemical mixtures (USEPA, 1986b, 1989a).

Potential adverse health effects for noncarcinogens were calculated by means of an HI technique as recommended by USEPA (1989a). The ratio of the ADD to the reference dose (ADD:RfD) was derived for each chemical. Values of these ratios, called HQs, which are greater than 1 are indicative of the potential for adverse health effects. The effects from simultaneous exposures to COPCs were computed by summing the individual ratios (HQs) within each exposure pathway. This sum, known as the HI, serves the same function for the mixture as the HQ does for the individual compound. In general, HIs that are less than 1 are not likely to be associated with health risks and are, therefore, less likely to be of regulatory concern than HIs greater than 1. If an HI is greater than 1, the COPCs are subdivided into categories based on target organ affected by exposure (e.g., liver, kidney) in accordance with USEPA (1989a) guidance. HIs are then recalculated for these categories to better identify whether noncarcinogenic effects to specific target organs or endpoints might occur.

The upper-bound excess lifetime cancer risks derived in this report can be compared to USEPA's target risk range for health protectiveness at Superfund sites of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ (USEPA, 1990). In addition, USEPA's Office of Solid Waste and Emergency Response (USEPA, 1991b) has issued a directive clarifying the role of HHRA in the Superfund process. The directive states that, where the cumulative carcinogenic site risk to an individual based on RME for both current and future land use is less than $1 \times 10^{-4}$, and the noncarcinogenic HI is less than 1, action generally is not warranted unless there could be adverse environmental effects (see *Section 6.0* for a discussion of potential ecological hazards).

### 5.4.1 Risk Estimates for Maintenance Workers under Current Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with maintenance worker exposures to surface soil, sediment, surface water, and groundwater at SWMU 31 under current land-use conditions are provided in **Appendix E-1, Table E-62**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1 \times 10^{-6}$ or HIs above 1 are identified in the text below. Since maintenance workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-62** and discussed below.

***Surface Soil.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in surface soil were $8.5 \times 10^{-7}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by a maintenance worker (HI = 0.072) was less than 1.

***Sediment.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment was $1.3 \times 10^{-6}$ for ingestion, primarily due to arsenic. This value was within the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The risk estimate for dermal absorption ($7.6 \times 10^{-7}$) was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by a maintenance worker (HI = 0.032) was less than 1.

***Surface Water.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface water was $6.1 \times 10^{-9}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface water by a maintenance worker (HI = 0.00027) was less than 1.

***Groundwater.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater was $1.8 \times 10^{-8}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by a maintenance worker (HI = 0.000046) was less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for maintenance workers exposed to surface soil, sediment, surface water, and groundwater at SWMU 31 under current land-use conditions was $2.9 \times 10^{-6}$, which is within the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for maintenance workers (HI = 0.10) was less than 1.

### 5.4.2 Risk Estimates for Maintenance Workers under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with maintenance worker exposures to surface soil, total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions are provided in **Appendix E-1, Table E-63**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1 \times 10^{-6}$ or HIs above 1 are identified in the text below. Since maintenance workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-63** and discussed below.

***Surface Soil.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in surface soil are assumed to be the same as those under current land-use conditions.

***Sediment.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in sediment are assumed to be the same as those under current land-use conditions.

***Surface Water.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in surface water are assumed to be the same as those under current land-use conditions.

***Total Soil.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil was $8.5 \times 10^{-7}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by a maintenance worker (HI= 0.073) was less than 1.

***Groundwater.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in groundwater are assumed to be the same as those under current land-use conditions.

***Cumulative Risk and Hazard.*** Since total soil represents the more highly contaminated portion of soil (based on hazard), cumulative risk and hazard estimates are conservatively based on this soil data grouping. The potential cumulative risk for maintenance workers exposed to total soil, sediment, surface water, and groundwater ($2.9 \times 10^{-6}$) at SWMU 31 under future land-use conditions was within the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for maintenance workers (HI = 0.11) was less than 1.

### 5.4.3 Risk Estimates for Industrial Workers (Outdoor) under Current Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with industrial worker exposures to surface soil, sediment, surface water, and groundwater at SWMU 31 under current land-use conditions are provided in **Appendix E-1, Table E-64**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since industrial workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-64** and discussed below.

***Surface Soil.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in surface soil were $3.2x10^{-6}$ for ingestion, primarily due to arsenic. This value was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for dermal absorption ($6.3x10^{-7}$) and inhalation ($8.3x10^{-9}$) were below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface soil by an industrial worker (HI = 0.32) was less than 1.

***Sediment.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment was $5.8x10^{-6}$ for ingestion, primarily due to arsenic. This value was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for dermal absorption ($3.4x10^{-6}$) was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by an industrial worker (HI = 0.15) was less than 1.

***Surface Water.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface water was $2.7x10^{-8}$, which was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface water by an industrial worker (HI = 0.0012) was less than 1.

***Groundwater.*** The risk estimate for inhalation of ambient air ($8.3x10^{-8}$) was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to non-carcinogenic COPCs in groundwater by an industrial worker (HI = 0.00021) was less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for industrial workers exposed to surface soil, sediment, surface water, and groundwater at SWMU 31 under current land-use conditions was $1.3x10^{-5}$, which is within the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for an industrial worker (HI = 0.47) was below 1.

### 5.4.4 Risk Estimates for Industrial Workers (Outdoor) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with industrial worker exposures to surface soil, total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions are provided in **Appendix E-1, Table E-65**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since industrial workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-65** and discussed below.

***Surface Soil.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in surface soil are assumed to be the same as those under current land-use conditions.

***Total Soil.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in total soil was $3.2 \times 10^{-6}$ for ingestion, primarily due arsenic. As described in *Section 5.1.2.3*, arsenic has been shown to be within background concentrations. This value was within the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The risk estimate for dermal absorption ($6.3 \times 10^{-7}$) and inhalation ($8.3 \times 10^{-9}$) were below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by an industrial worker (HI= 0.33) was less than 1.

***Sediment.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in sediment are assumed to be the same as those under current land-use conditions.

***Surface Water.*** The total upper-bound excess lifetime cancer risks and HIs associated with COPCs in surface water are assumed to be the same as those under current land-use conditions.

***Groundwater.*** The total upper-bound excess lifetime cancer risk associated with exposure to COPCs in groundwater via ingestion was $4.6 \times 10^{-5}$. The primary contributors were benzo(a)pyrene and arsenic. These values were within the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The risk estimate for inhalation of ambient air ($8.3 \times 10^{-8}$) was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to non-carcinogenic COPCs in groundwater by an industrial worker (HI = 0.73) was less than 1.

***Cumulative Risk and Hazard.*** Since total soil represents the more highly contaminated portion of soil (based on hazard), cumulative risk and hazard estimates are conservatively based on this soil data grouping. The potential cumulative risk for industrial workers exposed to total soil, sediment, surface water, and groundwater ($5.9 \times 10^{-5}$) at SWMU 31 under future land-use conditions was within the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for industrial workers (HI = 1.2) was above 1. However, no individual chemical or target organ HI was equal to or exceeded 1.

### 5.4.5 Risk Estimates for Industrial Workers (Indoor) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with indoor industrial worker exposures to groundwater at SWMU 31 under future land-use conditions are provided in **Appendix E-1, Table E-66**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1 \times 10^{-6}$ or HIs above 1 are identified in the text below. Since indoor industrial workers may be exposed at one time by a combination of pathways (e.g., ingestion and inhalation), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-66** and discussed below.

***Groundwater.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in groundwater were $4.6 \times 10^{-5}$ for ingestion and $1.2 \times 10^{-6}$ for inhalation (indoor air). The primary contributors were benzo(a)pyrene, arsenic, and chloroform. These values were within the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to non-carcinogenic COPCs in groundwater by an indoor industrial worker (HI = 0.73) was less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for indoor industrial workers exposed to groundwater at SWMU 31 under future land-use conditions was $4.7 \times 10^{-5}$, which is within the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for an indoor industrial worker (HI = 0.73) was below 1.

### 5.4.6 Risk Estimates for Excavation Worker under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with excavation worker exposures to total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions is provided in **Appendix E-1, Table E-67**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1 \times 10^{-6}$ or HIs above 1 are identified in the text below. Since excavation workers may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-67** and discussed below.

***Total Soil.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in total soil was $5.1 \times 10^{-7}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by an excavation worker (HI = 5.1) exceeded 1, primarily due to manganese. As described in *Section 5.1.2.3*, manganese has been shown to be within background concentrations.

***Sediment.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment was $1.0 \times 10^{-6}$ for ingestion and dermal absorption combined. The primary contributor was arsenic. This value was within the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by an excavation worker (HI = 0.44) was less than 1.

***Surface Water.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in surface water was $1.2 \times 10^{-9}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in surface water by an excavation worker (HI = 0.0013) was less than 1.

***Groundwater.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in groundwater was $1.3 \times 10^{-7}$, which was below the target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater by an excavation worker (HI = 0.0082) was less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for excavation workers exposed to total soil, sediment, surface water, and groundwater ($1.8 \times 10^{-6}$) at SWMU 31 under future land-use conditions was within the USEPA's target risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The potential cumulative HI for excavation workers was equal to 6.4, primarily due to manganese. When re-calculated by target organ, the HI for manganese (5.2) exceeded 1. As described in *Section 5.1.2.3*, manganese has been shown to be within background concentrations.

### 5.4.7 Risk Estimates for Lifetime/Adult Residents (On-Site) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with lifetime resident exposures to total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions is provided in **Appendix E-1, Table E-68**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above 1x10$^{-6}$ or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-68** and discussed below.

***Total Soil.*** The total upper-bound excess lifetime cancer risks associated with lifetime exposures to COPCs in total soil were estimated to be 1.6x10$^{-5}$ for incidental ingestion and 1.5x10$^{-6}$ for dermal absorption, primarily due to arsenic. As described in *Section 5.1.2.3*, arsenic has been shown to be within background concentrations. These values were within the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The risk estimate for inhalation (1.2x10$^{-9}$) was below the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The HI associated with lifetime/adult resident exposures to noncarcinogenic COPCs in total soil (HI = 0.40) was less than 1.

***Sediment.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment was 3.3x10$^{-6}$ for ingestion, due to arsenic. This value was within the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The risk estimate for dermal absorption (5.3x10$^{-7}$) was below the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by an adult resident (HI = 0.023) was less than 1.

***Surface Water.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in surface water while wading (1.1x10$^{-8}$) and swimming (6.2x10$^{-9}$) were below the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The HIs associated with exposures to noncarcinogenic COPCs in surface water by an adult resident while wading (HI = 0.00037) and swimming (HI = 0.00018) were less than 1.

***Groundwater.*** The total upper-bound excess lifetime cancer risks associated with lifetime exposures to COPCs in groundwater were 2.2x10$^{-4}$ for ingestion, 1.4x10$^{-4}$ for dermal absorption, 4.5x10$^{-6}$ for inhalation (indoor air), and 5.9x10$^{-5}$ for inhalation (shower room air). The primary contributors were benzo(a)pyrene, arsenic, and chloroform. The value for ingestion and dermal absorption were above the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The value for inhalation was within the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The risk estimate for ingestion of home grown produce (3.2x10$^{-7}$) was below the target risk range of 1x10$^{-6}$ to 1x10$^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater was greater than 1 for ingestion (HI = 2.3). No individual chemical or target organ HI was equal to or greater than 1. The HIs for dermal absorption (HI = 0.14), inhalation of indoor air (HI = 0.0048), inhalation of shower room air (HI = 0.15), and ingestion of home grown produce (HI = 0.00087) were less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for lifetime exposures to total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions was 3.9x10$^{-4}$, which is above the USEPA's target risk range of 1x10$^{-6}$ to 1x10$^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The primary contributors were benzo(a)pyrene, arsenic, and chloroform from exposure to groundwater. The potential cumulative HI for adult residents (HI = 2.9) was greater than 1. No individual chemical or target organ HI was equal to or greater than 1.

### 5.4.8 Risk Estimates for Child Resident (On-Site) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with child resident (on-site) exposures to total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions is provided in **Appendix E-1, Table E-69**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-69** and discussed below.

***Total Soil.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in total soil were estimated to be $1.1x10^{-5}$ for incidental ingestion. The primary contributors were dioxins/furans and arsenic. As described in *Section 5.1.2.3*, arsenic has been shown to be within background concentrations. This value was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for dermal absorption ($9.3x10^{-7}$) and inhalation ($7.2x10^{-10}$) were below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in total soil by a child resident exceeded 1 for the ingestion pathway (HI = 2.4), primarily due to iron and vanadium. The HIs for dermal absorption (HI = 0.95) and inhalation (HI = 0.0032) were less than 1.

As described in *Section 5.1.2.3*, vanadium concentrations were within the range of background concentrations. As described in *Section 5.1.2.2*, a margin of exposure evaluation was performed because the HI for iron (1.2) exceeded a value of 0.5. The calculated intake of iron was 0.36 mg/kg-day via the route of ingestion. This value was compared to 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 intake calculated for total soil at SWMU 31 is within the allowable range.

***Sediment.*** The total upper-bound excess lifetime cancer risk associated with exposures to COPCs in sediment was $2.3x10^{-6}$ for ingestion, due to arsenic. This value was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for dermal absorption ($1.9x10^{-7}$) was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in sediment by a child resident (HI = 0.19) was less than 1.

***Surface Water.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in surface water while wading ($3.1x10^{-9}$) and swimming ($2.2x10^{-9}$) were below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HIs associated with exposures to noncarcinogenic COPCs in surface water by a child resident while wading (HI = 0.00058) and swimming (HI = 0.0004) were less than 1.

***Groundwater.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in groundwater were $8.0x10^{-5}$ for ingestion, $5.2x10^{-5}$ for dermal absorption, and $2.6x10^{-6}$ for inhalation (indoor air). The primary contributors were benzo(a)pyrene, arsenic, and chloroform. These values were within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for ingestion of home grown produce ($1.6x10^{-7}$) was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater was greater than 1 for ingestion (HI = 5.3), primarily due to arsenic, iron, and vanadium. The HIs for dermal absorption (HI = 0.41), inhalation of indoor air (HI = 0.027), and ingestion of home grown produce (HI = 0.0040) were less than 1.

As described in *Section 5.1.2.2*, a margin of exposure evaluation was performed because the HI for iron (1.5) exceeded a value of 0.5. The calculated intake of iron was 0.45 mg/kg-day via the route of ingestion. This value was compared to 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 intake calculated for groundwater at SWMU 31 is within the recommended range.

***Cumulative Risk and Hazard.*** The potential cumulative risk for child residents exposed to total soil, sediment, surface water, and groundwater at SWMU 31 under future land-use conditions was $1.5x10^{-4}$, which is above the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The primary contributors were benzo(a)pyrene, arsenic, and chloroform from exposure to groundwater. The potential cumulative HI for child residents was equal to 9.3, primarily due to arsenic, iron, manganese, and vanadium. When recalculated by target organ, the following target organs exceeded 1: skin (2.4), vascular effects (2.4), blood (2.9), liver (3.0), GI irritation (2.9), CNS (1.2), and kidney (2.7).

### 5.4.9 Risk Estimates for Lifetime/Adult Residents (Off-Site) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with adult resident exposures to groundwater at SWMU 31 under future land-use conditions is provided in **Appendix E-1, Table E708**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-70** and discussed below.

***Groundwater.*** The total upper-bound excess lifetime cancer risks associated with lifetime exposures to COPCs in groundwater were $2.2x10^{-4}$ for ingestion, $1.4x10^{-4}$ for dermal absorption, $4.5x10^{-6}$ for inhalation (indoor air), and $5.9x10^{-5}$ for inhalation (shower room air). The primary contributors were benzo(a)pyrene, arsenic, and chloroform. The value for ingestion and dermal absorption were above the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The value for inhalation was within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for ingestion of home grown produce ($3.2x10^{-7}$) was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater was greater than 1 for ingestion (HI = 2.3). No individual chemical or target organ HI was equal to or greater than 1. The HIs for dermal absorption (HI = 0.14), inhalation of indoor air (HI = 0.0048), inhalation of shower room air (HI = 0.015), and ingestion of home grown produce (HI = 0.00087) were less than 1.

***Cumulative Risk and Hazard.*** The potential cumulative risk for lifetime exposures to groundwater at SWMU 31 under future land-use conditions was $3.7x10^{-4}$, which is above the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The primary contributors were benzo(a)pyrene, arsenic, and chloroform from exposure to groundwater. The potential cumulative HI for adult residents (HI = 2.4) was greater than 1. No individual chemical or target organ HI was equal to or greater than 1.

### 5.4.10 Risk Estimates for Child Resident (Off-Site) under Future Land-Use Conditions at SWMU 31

A summary of the upper-bound excess lifetime cancer risks and HIs associated with child resident exposures (off-site) to groundwater at SWMU 31 under future land-use conditions is provided in **Appendix E-1, Table E-71**. For each exposure pathway evaluated, the predominant chemicals contributing to total upper-bound excess lifetime cancer risks above $1x10^{-6}$ or HIs above 1 are identified in the text below. Since residents may be exposed at one time by a combination of pathways (e.g., incidental ingestion and dermal absorption), the cumulative pathway risks for plausible multiple pathway exposures are also provided in **Appendix E-1, Table E-71** and discussed below.

***Groundwater.*** The total upper-bound excess lifetime cancer risks associated with exposures to COPCs in groundwater were $8.0x10^{-5}$ for ingestion, $5.2x10^{-5}$ for dermal absorption, and $2.6x10^{-6}$ for inhalation (indoor air). The primary contributors were benzo(a)pyrene, arsenic, and chloroform. These values were within the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The risk estimate for ingestion of home grown produce ($1.6x10^{-7}$) was below the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The HI associated with exposures to noncarcinogenic COPCs in groundwater was greater than 1 for ingestion (HI = 5.3), primarily due to arsenic, iron, and vanadium. The HIs for dermal absorption (HI = 0.41), inhalation of indoor air (HI = 0.027), and ingestion of home grown produce (HI = 0.0040) were less than 1.

As described in *Section 5.1.2.2*, a margin of exposure evaluation was performed because the HI for iron (1.5) exceeded a value of 0.5. The calculated intake of iron was 0.45 mg/kg-day via the route of ingestion. This value was compared to 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 intake calculated for groundwater at SWMU 31 is within the recommended range.

***Cumulative Risk and Hazard.*** The potential cumulative risk for child residents off-site exposed to groundwater at SWMU 31 under future land-use conditions was $1.3x10^{-4}$, which is above the USEPA's target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at Superfund sites (USEPA, 1990). The primary contributors were benzo(a)pyrene, arsenic, and chloroform from exposure to groundwater. The potential cumulative HI for child residents was equal to 5.7, primarily due to arsenic, iron, manganese, and vanadium. When recalculated by target organ, the following target organs exceeded 1: skin (2.0), vascular effects (2.0), blood (1.5), liver (1.6), GI irritation (1.5), and kidney (1.4).

### 5.4.11 Summary of Predominant COPCs at SWMU 31

This section summarizes the predominant COPCs associated with potential risks and hazards at SWMU 31. For the purposes of the HHRA, predominant COPCs are defined as chemicals contributing to exposure route total cancer risks (i.e., based on the sum of every route evaluated) greater than or equal to $1x10^{-6}$ or exposure route total HIs greater than or equal to one. The predominant COPCs are summarized by receptor, media, and exposure route, in **Appendix E-1, Tables E-72 through E-81**. The predominant COPCs are discussed according to exposure medium in the text below.

***Surface Soil.*** As shown in **Appendix E-1, Tables E-72 through E-75,** the predominant COPC representing cancer risk for current and future exposures to surface soil at SWMU 31 is arsenic. The total cancer risk estimates for surface soil exposures for maintenance workers were below the USEPA target risk range for health protectiveness, while the total cancer risk estimates for the industrial workers (outdoor) were within the USEPA target risk range. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for maintenance worker and industrial worker (outdoor) exposures to surface soil were less than 1.

***Total Soil.*** As shown in **Appendix E-1, Tables E-73, E-75**, **E-77, E-78, and E-79**, the predominant COPCs representing cancer risk for total soil are dioxins/furans and arsenic. The total cancer risk estimates for total soil exposures for maintenance workers and excavation workers were below the USEPA target risk range. The total cancer risk estimates for total soil exposures for industrial workers (outdoor) and lifetime and child residents were within the USEPA target risk range. The predominant COPCs representing non-carcinogenic hazard for total soil are iron, manganese, and vanadium. Based on a "margin-of-exposure" evaluation, however, the intake of iron was within the allowable range. Manganese and vanadium concentrations were within the range of background concentrations. The HIs for total soil were less than 1 for the maintenance worker, industrial worker (outdoor), and adult resident and greater than 1 for the excavation worker and child resident.

***Sediment.*** As shown in **Appendix E-1, Tables E-72 through E-75 and E-77 through E-79,** the predominant COPC representing cancer risk for current and future exposures to sediment at SWMU 31 is arsenic. The total cancer risk estimates for sediment exposures for maintenance workers, industrial workers (outdoor), and lifetime and child residents were within the USEPA target risk range for health protectiveness. The total cancer risk for the excavation workers was equal to the lower bound ($1.0 \times 10^{-6}$) of the target risk range. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for sediment were less than 1 for maintenance workers, industrial workers (outdoor), excavation workers, and adult and child residents.

***Surface Water.*** As shown in **Appendix E-1, Tables E-72 through E-75 and E-77 through E-79,** there are no predominant COPCs representing cancer risk for current and future exposures to surface water at SWMU 31. The total cancer risk estimates for surface water exposures for maintenance workers, industrial workers (outdoor), excavation workers, and lifetime and child residents were below the USEPA target risk range for health protectiveness. There are no predominant COPCs representing non-carcinogenic hazard. The HIs for surface water were less than 1 for maintenance workers, industrial workers (outdoor), excavation workers, and lifetime and child residents.

***Groundwater.*** As shown in **Appendix E-1, Tables E-72 through E-81**, the predominant COPCs representing cancer risk for groundwater are benzo(a)pyrene, chloroform, and arsenic. The total cancer risk estimates for groundwater exposures for maintenance workers, current industrial workers (outdoors), and excavation workers were below the USEPA target risk range. The total cancer risk estimates for groundwater exposures for future industrial workers (outdoor and indoor) were within the USEPA target risk range. The total cancer risk estimates for groundwater exposures for lifetime residents and child residents (on-site and off-site) were above the USEPA target risk range. The predominant COPCs representing non-carcinogenic hazard for groundwater are arsenic, iron, and vanadium. Based on a "margin-of-exposure" evaluation, however, the intake of iron was within the recommended range. The HIs for groundwater were less than 1 for the maintenance worker, industrial worker (outdoor and indoor), and excavation worker and greater than 1 for the adult resident and child resident (on-site and off-site).

## 5.5 UNCERTAINTIES IN THE HHRA

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 chemicals at SWMU 31.

Consideration of the uncertainty attached to various aspects of the risk assessment process allows one to better interpret the risk assessment results and understand 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.

**Environmental Sampling and Analysis.** 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 reported detection limit, but still included in data analysis, and with those chemicals qualified with the letter J, indicating that the concentrations are estimated. Another issue involves the amount of blank-related (i.e., B-qualified) data in the data set. These data were eliminated from the HHRA. The effects of using data with these uncertainties may over- or underestimate risks.

The data set for each medium represented a compilation of several subsets. These subsets consisted of samples that were collected at various times under different investigations and analyzed by different laboratories. Combining these data involves some uncertainty in the risk assessment. The degree of potential overestimation or underestimation is not known. However, several measures were taken to minimize this uncertainty, which included using validated data, ensuring that chemical names in the file were comparable, and reviewing data qualifiers.

If the 95 percent UCL exceeded the maximum detected value or if fewer than five samples were available for a data grouping, the maximum value was used as a default value for the EPC. In particular, maximum values were used as EPCs for surface soil and total soil because the data sets consisted of two samples and four samples, respectively. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment.

The reporting limits for chemicals that were not detected were compared with RBCs in **Appendix E-1, Tables E-2, E-4, E-6, E-8, and E-10**. Chemicals with reporting limits that exceeded RBCs are listed for each medium in *Section 5.1.3*. The percentage of compounds with reporting limits that exceeded RBCs were: surface soil (4 of 83 or 4.8 percent), total soil (4 of 82 or 4.9 percent), sediment (9 of 131 or 6.9 percent), surface water (24 of 143 or 17 percent), and groundwater (60 of 158 or 38 percent).

The surface water and groundwater data sets had the highest percentage of exceedances. Reporting limits in surface water exceeded RBCs for 24 constituents: 1,2-diphenyl hydrazine, 2-nitrotoluene, arsenic, MCPA, MCPP, toxaphene, 1,2,4-trichlorobenzene, 3,3’-dichlorobenzidine, 3-nitroaniline, 4,6-dinitro-o-cresol, 4-nitroaniline, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chrysene, dibenz(a,h)anthracene, hexachlorobenzene, n-nitroso-di-n-propylamine, p-chloroaniline, pentachlorophenol, 1,1,2,2-tetrachloroethane, trichloroethene, vinyl chloride, thallium, and vanadium. The majority of these chemicals, however, have neither been used at SWMU 31 nor detected at other sites at RFAAP. Those constituents that have been detected in other media at SWMU 31 include: arsenic, chrysene, dibenz(a,h)anthracene, thallium, and vanadium. Of these, arsenic and vanadium were selected as COPCs. In addition, surface water exposures at SWMU 31 involve limited exposure frequency and exposure duration (e.g., through maintenance activities, wading, or swimming). Although these chemicals, if present, could contribute additional risk and hazard, they would not be expected to change the overall conclusions of the risk assessment.

Reporting limits in groundwater exceeded RBCs for 60 constituents: 1,2-diphenyl hydrazine, 2-nitrotoluene, pyridine, antimony, cadmium, thallium, aldrin, alpha-BHC, delta-BHC, dieldrin, heptachlor, heptachlor epoxide, MCPA, MCPP, toxaphene, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, 1,2,4-trichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,4,6-trichlorophenol, 2,4-dinitrophenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-chlorophenol, 2-methylnaphthalene, 2-nitroaniline, 3,3’-dichlorobenzidine, 3-nitroaniline, 4,6-dinitro-o-cresol, 4-nitroaniline, bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, bis(2-ethylhexyl)phthalate, carbazole, dibenz(a,h)anthracene, dibenzofuran, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, n-nitroso-di-n-propylamine, nitrobenzene, p-chloroaniline, pentachlorophenol, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,3-dichoropropane, benzene, bromodichloromethane, bromomethane, carbon tetrachloride, dibromochloromethane, tetrachloroethene, trichloroethene, and vinyl chloride. The majority of these chemicals, however, have neither been used at SWMU 31 nor detected at other sites at RFAAP. Sixteen constituents have been detected in other media at SWMU 31: antimony, cadmium, thallium, alpha-BHC, delta-BHC, Aroclor 1254, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2-methylnaphthalene, carbazole, dibenz(a,h)anthracene, dibenzofuran, hexachlorobutadiene, hexachloroethane, bromodichloromethane, and dibromochloromethane. Of these, only bromodichloromethane was selected as a COPC. It is assumed that groundwater exposures at SWMU 31 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 SWMU 31 groundwater will be used for residential purposes in the future. Although these chemicals, if present, could contribute additional risk and hazard, they would not be expected to change the overall conclusions of the risk assessment.

**Selection of Chemicals for Evaluation.** A comparison of maximum detected chemical concentrations to USEPA Region III RBCs or other screening criteria (e.g., ADI, TCDD TE) was conducted for each medium. Chemicals whose maximum concentrations were below their respective RBCs were not carried through the assessment. It is unlikely that this risk-based screening would have excluded chemicals that would be of concern, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the RBCs. 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 RBCs), and the overall cumulative risk estimates would not be expected to be significantly (if at all) greater.

Screening criteria (e.g., RBCs, ADIs, TCDD TEs) were available for all detected chemicals. For those chemicals that were not detected, the reporting limits were also compared with screening criteria. Chemicals without screening criteria were listed for each medium in *Section 5.1.3*. Because there were no screening criteria for these chemicals, it is not known whether the reporting limits were sufficiently low to have detected these chemicals at risk-based levels. The impact of this uncertainty is not known.

Because there were only two surface soil samples collected at the SWMU 31, it was not possible to perform a comparison between site concentrations and background concentrations. Background comparisons were performed for total soil, which consisted of two surface soil and two subsurface soil samples. Although the small sample size for total soil (n = 4) is a source of uncertainty, risk and hazard calculations were performed for all COPCs because chemicals were not eliminated from quantitative evaluation in the HHRA on the basis of these comparisons.

Chloroform was selected as a COPC for SWMU 31 surface water and groundwater because the maximum concentration exceeded the screening criterion. Although it is likely that the presence of chloroform is associated with the operation of the water treatment plant (*Section 3.2.6*), chloroform was carried through the HHRA. In the unlikely event that SWMU 31 is developed for residential use in the future, the water treatment plant would be dismantled. Therefore, potential future residents' exposures to chloroform in surface water and groundwater are likely over-estimated in the HHRA.

**Toxicological Data.** The assessment of risks relied 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, 1986a): "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 percent UCLs for CSFs for carcinogens, and safety factors for RfDs for noncarcinogens. 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 percent UCL) would be expected to substantially lower the final risk.

Because chromium was analyzed and reported as total chromium, there is uncertainty regarding the species of chromium that exists at SWMU 31. As discussed in *Section 5.3.2*, the toxicity values for chromium III were used in this HHRA because chromium III is the predominant form of chromium in nature. Based on past processes at SWMU 31, chromium VI would not be expected to be present at the site. In addition, chromium VI is more unstable in nature. To be consistent with HHRAs performed for other sites at the Installation (e.g., Building 4343, SWMU 39, SWMU 58), chromium concentrations were evaluated with respect to soil pH and TOC values. Because three samples from different depths at one location were analyzed for these parameters, however, there is no clear indication as to the effect of pH and TOC on the form of chromium at SWMU 31. However, the concentrations of total chromium at SWMU 31 are relatively low. For example, the range of concentrations of chromium for the total soil data set was 15.8 mg/kg to 29.7 mg/kg. The EPCs for surface soil (28.2 mg/kg) and total soil (29.7 mg/kg) were based on maximum values. As part of this uncertainty analysis, cancer risk and noncancer hazard for potential receptors at SWMU 31 were calculated using the toxicity criteria for chromium VI. Even if the toxicity criteria for chromium VI had been applied in this HHRA, cancer risk for chromium would have been below $1.0\text{x}10^{-6}$ and the noncancer HI would have been below 1.0. Therefore, the use of the chromium III toxicity criteria versus the use of chromium VI toxicity criteria does not impact the conclusions for this HHRA.

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitated the use of oral toxicity data. In order to calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses were combined with oral toxicity values. As described in *Section 5.3*, 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 chemicals for which sufficient information is lacking (i.e., iron), a default oral absorption factor of 1.0 was used, as recommended by USEPA. The risk estimates for the dermal absorption pathways may be over- or underestimated depending on how closely the values used in the HHRA reflect the difference between the oral and dermal routes.

For exposures to COPCs in groundwater via dermal absorption, the USEPA's dermal guidance (2004b) 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. For example, the risk estimates for dermal absorption of benzo(a)pyrene are greater than the risk estimates for exposure via ingestion. In addition, the guidance (USEPA, 2004b) notes that particulate-bound chemicals in aqueous medium (e.g., suspended soil particles) would be considered much less bioavailable for dermal absorption due to inefficient adsorption of suspended particles onto the skin surface and a slower rate of absorption into the skin. Because benzo(a)pyrene adsorbs to soil, the detection of benzo(a)pyrene in SWMU 31 groundwater samples is possibly attributable to the presence of particulates. Therefore, risks due to dermal absorption could potentially be overestimated.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria, i.e., PPRTVs, were used if available (**Appendix E-1, Tables E-36 through E-39**). For example, the oral RfDs for iron and vanadium are PPRTVs. The PPRTVs present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. Furthermore, it is not currently possible to obtain PPRTVs directly. The PPRTVs for this HHRA were obtained from the USEPA Region III RBC table (USEPA, 2006a). For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because the toxicity criteria have not been formally accepted by USEPA, there is uncertainty with these values and, therefore, with the risks calculated using these toxicity criteria. Another source of uncertainty is values obtained from HEAST. These values have not been updated since 1997.

There are no verified toxicity criteria available for aluminum, cobalt, and dibenzofuran (**Appendix E-1, Tables E-36 through E-39**) because these values were retired by NCEA (USEPA, 2005f, 2006a). Although lack of published toxicity data would result in an underestimation of risk, 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, 2002a) recommends that toxicity values for subchronic exposures be used to calculate the HQs for this pathway. Although subchronic values for some chemicals are included in USEPA's database of Provisional Peer-Reviewed Toxicity Values (USEPA, 2003b, 2005d), this web site cannot be accessed without authorization. However, the VDEQ compiles subchronic toxicity values. Although the web site for the VDEQ Voluntary Remediation Program was consulted for subchronic values (VDEQ, 2006), subchronic reference concentrations (RfC) and inhalation reference doses (RfD) were not available for dioxins/furans, aluminum, arsenic, chromium, cobalt, iron, manganese, and vanadium. Because there were no subchronic values available for the COPCs at SWMU 31, chronic toxicity values were used in the calculations. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of the cancer risk estimates and the HIs. Because chronic toxicity values were used for all COPCs, the calculated risks and hazards are likely to be overestimated. Typically, subchronic toxicity values are 10-fold greater than chronic toxicity values.

Finally, the lifetime cancer risk for benzo(a)pyrene has been re-calculated in accordance with recent guidance from USEPA Region III concerning carcinogens that act via a mutagenic mode of action (USEPA, 2006a). For chemicals that USEPA has determined to be carcinogenic via a mutagenic mode of action, special adjustments are now applied to estimating cancer risks. These adjustments are age-dependent adjustment factors (ADAFs). Because a chemical-specific ADAF has not yet been developed for benzo(a)pyrene, the following default ADAFs were used: 10 for age 0-2, 3 for age 2-6, and no adjustment for years 16 and older.

The following examples of the calculation is presented for ingestion of benzo(a)pyrene in groundwater:

*Age 0-2*

$$\frac{0.061\,\mu g/L \times 1\,L/day \times 350\,days/yr \times 2\,yr \times 1 \times 10^{-3}\,mg/\mu g}{365\,days/yr \times 70\,yr \times 15\,kg} \times \frac{7.3}{mg/kg/day} \times 10 = 8.1 \times 10^{-6}$$

*Age 2-6*

$$\frac{0.061\,\mu g/L \times 1\,L/day \times 350\,days/yr \times 4\,yr \times 1 \times 10^{-3}\,mg/\mu g}{365\,days/yr \times 70\,yr \times 15\,kg} \times \frac{7.3}{mg/kg/day} \times 3 = 4.9 \times 10^{-6}$$

*Age 6-16*

$$\frac{0.061\,\mu g/L \times 2\,L/day \times 350\,days/yr \times 10\,yr \times 1 \times 10^{-3}\,mg/\mu g}{365\,days/yr \times 70\,yr \times 70\,kg} \times \frac{7.3}{mg/kg/day} \times 3 = 5.2 \times 10^{-6}$$

*Age 16-30*

$$\frac{0.061\,\mu g/L \times 2\,L/day \times 350\,days/yr \times 14\,yr \times 1 \times 10^{-3}\,mg/\mu g}{365\,days/yr \times 70\,yr \times 70\,kg} \times \frac{7.3}{mg/kg/day} \times 1 = 2.4 \times 10^{-6}$$

*Total Ingestion Risk*

$(8.1\text{x}10^{-6}) + (4.9\text{x}10^{-6}) + (5.2\text{x}10^{-6}) + (2.4\text{x}10^{-6}) = 2.1\text{x}10^{-5}$

The cancer risk calculated using ADAFs ($2.1\text{x}10^{-5}$) is higher than that calculated for the lifetime resident ($6.6\text{x}10^{-6}$) and the child resident ($2.4\text{x}10^{-6}$). While the new calculations result in a greater cumulative risk, the conclusions regarding the cancer risk associated with groundwater do not change.

**Exposure Assessment.** The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the parameters used to estimate chemical doses. The uncertainties associated with these various sources are discussed below.

As discussed in *Section 5.2.1*, exposure scenarios were selected based on the current and anticipated land use. Although some exposure scenarios were not explicitly evaluated (e.g., trespasser), these receptors were assumed to be adequately addressed by the selected exposure pathways. As stated in *Section 5.2.1,* hypothetical future exposures to children were considered in the residential scenario. The exposure parameters for child residents are more conservative than those for children trespassers. For the child resident, the risk characterization results showed total cancer risk associated with total soil, sediment, surface water, and groundwater ($1.5x10^{-4}$) was within the target risk range. The total HI (HI = 9.7) was greater than 1. However, the maintenance worker scenario that is being evaluated would be similar to the limited exposure that an adolescent trespasser could experience at the site and would be protective of the trespasser. For the maintenance worker, the risk characterization results showed total cancer risks associated with total soil, sediment, and surface water ($2.9x10^{-6}$) was within the target risk range. The total HI for total soil, sediment, surface water, and groundwater (HI = 0.15) was less than 1. Given that risks and hazards for exposure to surface soil and total soil by the maintenance worker are within the target risk range and below the target HI, it is likely that risk and hazards would also be within the acceptable limits for the trespasser.

An underlying assumption in the HHRA is that individuals at the site would engage in certain activities that would result in exposures via each selected pathway. For example, it was assumed that receptors would engage in regular activities under current and future land-use conditions that would result in exposures to COPCs. This assumption is conservative, in that it is more likely that the activity patterns assumed to occur in this analysis would likely occur occasionally.

With respect to calculating EPCs, one assumption was that the concentrations of chemicals in the media evaluated would remain constant over time. Depending on the properties of the chemical and the media in which it was detected, this assumption could over- or underestimate risks to a low or high degree, depending on the degree of chemical degradation or transport to other media, although for the site in question, it is likely an overestimation, as further degradation is likely.

When calculating EPCs from sampling data, one-half of the reported quantitation limit was used for non-detect samples in the calculation of the 95 percent UCL on the mean. An approach dealing with non-detected chemical concentrations is associated with some uncertainty, because chemicals that were not detected at the specified SQL may be absent from the medium or may be present at a concentration below the SQL. The uncertainty of the EPC will increase as the number of non-detects in a data set increases, and the uncertainty could result in either the over- or underestimation of EPCs.

The 95 percent UCL was used preferably as the EPC for each medium if at least five samples were available for a data grouping. If the 95 percent UCL exceeded the maximum detected value or if fewer than five samples were available for a data grouping, the maximum was conservatively used as a default for the EPC. Using a value that is based on one sampling location (i.e., the maximum) is associated with some uncertainty, and adds a great deal of conservatism to the assessment.

The parameter values used to describe the extent, frequency, and duration of exposure are associated with some uncertainty. Actual risks for certain individuals within an exposed population may vary from those predicted depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weights. The 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 (1991a, 2002a) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. An example is soil ingestion rates. 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 were assumed to be 100 percent bioavailable; this assumes that ingested chemicals present in a soil matrix are completely absorbed through the gastrointestinal tract, which is unlikely due to their affinity to the 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 exposure parameters specific to dermal contact. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly over- or underestimate risks. More significant uncertainties are associated with the selection and use of dermal absorption factors. There were no specific dermal absorption factors for aluminum, chromium, iron, and vanadium. Although chromium III and chromium VI can penetrate the skin to some extent, studies were based on direct contact with chromium compounds (ATSDR, 2000) rather than chromium in soil. No reliable studies were located regarding absorption in humans or animals for dermal exposure to aluminum and vanadium (ATSDR, 1992, 1999b).

For this HHRA, the dermal absorption factors were based on USEPA Region III's technical guidance, *Assessing Dermal Exposure from Soil* (USEPA, 1995b) and *Updated Dermal Exposure Assessment Guidance* (USEPA, 2003a). The latter of these documents clarifies USEPA Region III's implementation of USEPA's interim draft document, *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E: Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004b). When comparing the USEPA Region III dermal absorption factors to values in the USEPA's RAGS, Part E, the values for the majority of the COPCs differed (**Table 5-7**). For example, the default dermal absorption factor for inorganics is 1 percent (USEPA, 1995b, 2003a). However, USEPA's *RAGS, Part E* (USEPA 2004b), states that the speciation of the compound is critical to the dermal absorption of inorganics and there are too little data to extrapolate a reasonable default value. Therefore, the impact of using the dermal absorption factors to evaluate dermal absorption exposures is not known.

As discussed in *Section 5.2.3*, the PEF is used to calculate the particulate inhalation ADDs and LADDs. One of the inputs for calculating the PEF is the Q/C value, which represents both local climatic conditions and the size of the contaminated area. The sampling and analysis program for SWMU 31 was designed to characterize the 1.25-acre site. The Q/C values from the SSL guidance (USEPA, 1996b) are presented by source area, city, and climatic zone. Thus, the 1.25-acre area was considered to be the source area for purposes of the PEF calculation. Based on a 1-acre site, a Q/C value of 47.24 was selected to represent the SWMU 31 study area. A PEF of $6.85 \times 10^8$ $m^3$/kg was calculated using the Q/C value for a 1-acre site.

## Table 5-7
## Dermal Absorption Factors

| COPC | USEPA Region III Dermal Absorption Factor[a,b] | USEPA RAGS Part E Dermal Absorption Factor[c] |
|---|---|---|
| TCDD | 0.03 | 0.03[d] |
| Aluminum | 0.01 | e |
| Arsenic | 0.032 | 0.03 |
| Chromium III | 0.01 | e |
| Iron | 0.01 | e |
| Manganese | 0.01 | e |
| Vanadium | 0.01 | e |

a) Assessing Dermal Exposure from Soil. Hazardous Waste Management Division. Office of Superfund Programs. USEPA Region III, Philadelphia, PA. (USEPA, 1995b)

b) Updated Dermal Exposure Assessment Guidance. Mid-Atlantic Hazardous Site Cleanup. Office of Superfund Programs. USEPA Region III, Philadelphia, PA. June. (USEPA, 2003a)

c) Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. (USEPA, 2004b)

d) The dermal absorption factor is 0.001 if soil organic content >10 percent.

e) No default value is given.

Because the source area (i.e., SWMU 31) is larger than 0.5 acres used to represent residential lot and there were no plans for residential development, the sampling program was not designed to address 0.5-acre subareas or to define exposures areas for residential lots (as described in Section 4.1.4 of the SSL guidance). To address this uncertainty, it was assumed that the sampling performed in the 1.25-acre area at the SWMU 31 is representative of concentrations in any one subarea of the site and the Q/C term associated with a 0.5 acre area was used to calculate the PEF. Based on a 0.5-acre site, a Q/C value of 53.89 was selected and a PEF of $7.81 \times 10^8$ $m^3$/kg was calculated using this value. A comparison was then made of inhalation risks and hazards estimated based on the PEF calculated for a 1.25-acre site versus those estimated based on the PEF calculated for a 0.5-acre site. Results are presented in the table below. The results indicate that inhalation risk and hazard estimates are lower when using a PEF based on a 0.5-acre subarea versus estimates using a PEF calculated for a larger area. For SWMU 31, however, the difference in the PEF would not have changed the conclusions of the HHRA.

| Receptor | PEF based on 1 acre (QC = 47.24; PEF = $6.85 \times 10^8$ $m^3$/kg) | | PEF based on 0.5 acres (QC = 53.89; PEF = $7.81 \times 10^8$ $m^3$/kg) | |
|---|---|---|---|---|
| | Cancer Risk | Non-Cancer Hazard | Cancer Risk | Non-Cancer Hazard |
| **Lifetime/Adult Resident** | 1.2E-09 | 5.7E-04 | 1.2E-9 | 5.0E-04 |
| **Child Resident** | 7.2E-10 | 3.2E-03 | 6.3E-10 | 2.8E-03 |

Similarly, a comparison was made of inhalation risks and hazards estimated based on the construction scenario (excavation worker) PEF calculated for a 1.25-acre site versus those estimated based on the construction scenario PEF calculated for a 0.5-acre site. Results are presented in the table below. The results indicate that inhalation risk and hazard estimates are lower when using a PEF calculated based on a 0.5-acre subarea versus estimates using a PEF calculated for a larger area. For SWMU 31, however, the difference in the construction scenario PEF would not have changed the conclusions of the HHRA.

| Receptor | PEF based on 1.25 acre (QC = 19.76; PEF =$1.33 \times 10^6$ $m^3$/kg) | | PEF based on 0.5 acres (QC = 23.02; PEF = $1.55 \times 10^6$ $m^3$/kg) | |
|---|---|---|---|---|
| | **Cancer Risk** | **Non-Cancer Hazard** | **Cancer Risk** | **Non-Cancer Hazard** |
| **Excavation Worker** | 1.9E-07 | 5.1E+00 | 1.6E-07 | 4.4E+00 |

The development of exposure assumptions for the excavation worker PEF calculations are highly uncertain because the potential for and the nature of future construction at RFAAP sites are not known. The default value from the Supplemental SSL Guidance (1 year or 12 months) was conservatively used for the exposure duration. This exposure duration was selected because it is consistent with the value used for other excavation worker exposure pathways at RFAAP. Conservative assumptions regarding exposure duration, the configuration of the construction area, and the amount of vehicle traffic are likely to result in an overestimation of risk and hazard at SWMU 31. For example, it is assumed that fugitive dust emissions are generated, in part, by construction vehicle traffic on unpaved roads. Because much of the surface area of SWMU 31 is comprised of lagoons, it is unlikely that the straight road segment described in the assumptions could be constructed at SWMU 31. If the land were to revert to commercial or residential development, it is likely that the lagoons would be backfilled prior to constructing temporary roads. As a result, dust emissions from contaminated soil would likely be diluted by dust emissions from clean fill. In this case, the risk and hazard calculated for the construction scenario would be overestimated.

In order to estimate the potential magnitude of overestimation, modeled particulate concentrations were compared with actual particulate levels measured at construction sites. Using the PEFs derived from the Supplemental SSL Guidance equations for the 1.25-acre site and a hypothetical 0.5-acre residential lot, total particulate concentrations in air may be estimated. As the concentration of soil particulates in soil is 100 percent or $1.0 \times 10^{-6}$ mg/kg, this concentration may be divided by the PEF to obtain an estimate of soil particulates in air, as shown below:

| Scenario | Particulates in Soil (mg/kg) | PEF ($m^3$/kg) | Estimated Particulate Concentration in Air (mg/$m^3$) |
|---|---|---|---|
| SWMU 31<br>1.25 acres | $1.0 \times 10^6$ | $1.33 \times 10^6$ | 0.75 |
| SWMU 31<br>0.5 acres | $1.0 \times 10^6$ | $1.55 \times 10^6$ | 0.65 |

Empirical particulate (dust) data are published by the Massachusetts Department of Environmental Protection (MADEP) collected proximate to construction sites, and may be used instead of modeled dust emissions from vehicle traffic or other site operations. An airborne particulate concentration of 0.060 mg/$m^3$ (for PM10) near construction activity is recommended by MADEP (2002). This empirical concentration is approximately 12-fold lower than the particulate concentrations predicted using the Supplemental SSL Guidance (USEPA, 2002a) equations for construction activities at the 1.25-acre site, and approximately 11-fold lower than the particulate concentrations predicted for construction activities at a 0.5-acre residential lot. These findings suggest that the estimated inhalation hazards are overestimated by at least 10-

fold. As stated in the previous section, the overall lack of subchronic toxicity values for the COPCs at these sites also contributes to the uncertainty of the cancer risk estimates and the HIs. Therefore, actual inhalation hazards are likely less than 1 for all of the evaluated scenarios.

The EPCs for both the vapor intrusion model and the trench model were based on a variety of parameters. The parameters for chemical/physical properties and environmental conditions were provided by VDEQ for the trench model (VDEQ, 2006). Site-specific information was applied, if possible.

The Johnson and Ettinger model was developed for use as a screening level model and is based on a number of simplifying assumptions. Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs have to be estimated or inferred from available data and other non-site-specific sources of information. Limitations and assumptions associated with the Johnson and Ettinger model are described in the user's guide (USEPA, 2004d). These include:

- Contaminant vapors enter the structure primarily through cracks and openings in the walls and foundation.
- Convective transport occurs primarily within the building zone of influence and vapor velocities decrease rapidly with increasing distance from the structure.
- Diffusion dominates vapor transport between the source of contamination and the building zone of influence.
- All vapors originating from below the building will enter the building unless the floors and walls are perfect vapor barriers.
- All soil properties in any horizontal plane are homogeneous.
- The contaminant is homogeneously distributed within the zone of contamination.
- The areal extent of the contamination is greater than that of the building floor in contact with the soil.
- Vapor transport occurs in the absence of convective water movement within the soil column (i.e., evaporation or infiltration), and in the absence of mechanical dispersion.
- The model does not account for transformation processes (e.g., biodegradation, hydrolysis).
- The soil layer is in contact with the structure floor and walls are isotropic with respect to permeability.
- Both the building ventilation rate and the difference in dynamic pressure between the interior of the structure and the soil surface are constant values.

It is also noted in the Johnson and Ettinger model user's guide (USEPA, 2004d) that use of measured soil gas concentrations directly beneath a building floor instead of calculated concentrations would reduce uncertainty in the estimation of indoor air concentrations.

Finally, there is uncertainty with respect to potential risks and hazards associated with exposure to the New River. No samples have been collected from the river in the vicinity of SWMU 31. Because the impact of potential discharge of contaminated groundwater from SWMU 31 is unknown, hypothetical exposure to the New River was evaluated by conservatively applying the groundwater EPCs to the wading and swimming scenarios that could occur in the New River.

For the wading scenario, estimated cancer risks for the lifetime resident/adult ($9.3 \times 10^{-8}$) and child resident ($2.3 \times 10^{-8}$) were below the target risk range of $1.0 \times 10^{-6}$ to $1.0 \times 10^{-4}$. The non-cancer HIs for the adult resident (0.0086) and the child resident (0.013) were below an HI = 1. For the swimming scenario, estimated cancer risks for the lifetime/adult resident ($2.6 \times 10^{-7}$) and resident child ($6.0 \times 10^{-8}$) were also within the target risk range. The HIs for the lifetime/adult resident (0.013) and child resident (0.057) were below 1. These calculations are extremely conservative because they do not account for decreasing concentrations due to transport from SWMU 31 to the river or reflect the dilution of COPCs by the river.

## 5.6 HHRA SUMMARY

This HHRA was performed to evaluate the potential human health effects associated with chemical contamination from past operations at SWMU 31. For the purposes of the HHRA, surface soil, total soil, sediment, surface water, and groundwater were evaluated.

The HHRA was performed for both current and future land-use conditions. Under current land-use conditions, maintenance and industrial worker (outdoor) exposures to surface soil, sediment, surface water, and groundwater were evaluated. Although exposures to trespassers were considered, it is unlikely that a trespasser would have access to SWMU 31 due to security at the Installation. However, the maintenance worker scenario would be similar to the limited exposure that a trespasser could experience at the site and would be protective of the trespasser.

Under future conditions, maintenance worker and industrial worker (outdoor) exposures to surface soil and maintenance worker, industrial worker (outdoor), and excavation worker exposures to total soil, sediment, surface water, and groundwater were evaluated. Exposures to surface soil, sediment, surface water, and groundwater by a maintenance worker and industrial worker (outdoor) were assumed to be the same under future land-use conditions as those under current land-use conditions. Industrial workers (indoor) were evaluated for exposures to groundwater only. In addition, lifetime resident and child resident exposures to total soil, sediment, surface water, and groundwater were evaluated under future conditions.

Upper-bound excess lifetime cancer risks and non-cancer HIs were estimated for the exposure pathways and data groupings described above. Estimations of non-cancer HIs and excess lifetime cancer risks and non-cancer HIs for maintenance worker, industrial worker, excavation worker, resident adult, and resident child exposures evaluated in the HHRA are presented in **Appendix E-1, Tables E-40 through E-61**. Summaries of upper-bound excess lifetime cancer risks and non-cancer HIs for exposures evaluated in the HHRA are presented in **Appendix E-1, Tables E-62 through E-71**; the predominant exposure pathways and COPCs are shown in **Appendix E-1, Tables E-72 through E-81**. These results are summarized for each receptor group.

**Maintenance Worker.** For the current and future maintenance worker exposures to surface soil at SWMU 31, the risk characterization results showed total cancer risk associated with surface soil ($8.5 \times 10^{-7}$) was below the target risk range. The total HI (HI = 0.072) was less than 1.

For the future maintenance worker exposures at SWMU 31, the risk characterization results showed total cancer risk associated with total soil ($8.5 \times 10^{-7}$) was below the target risk range. The total HI (HI = 0.073) was below 1.

For the current and future maintenance worker exposures to sediment at SWMU 31, the risk characterization results showed the total cancer risk estimate was within the target risk range ($2.0 \times 10^{-6}$, major risk driver – arsenic). The total HI (HI = 0.032) was less than 1.

For the current and future maintenance worker exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with surface water ($6.1x10^{-9}$) was below the target risk range. The total HI (0.00027) was less than 1.

For the current and future maintenance worker exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with groundwater ($1.8x10^{-8}$) was below the target risk range. The total HI (0.000046) was less than 1.

**Industrial Worker (Outdoor).** For the current and future industrial worker (outdoor) exposures to surface soil at SWMU 31, the risk characterization results showed total cancer risk associated with surface soil ($3.8x10^{-6}$, major risk driver – arsenic) was within the target risk range. Arsenic concentrations are within the range of background concentrations. The total HI (HI = 0.32) was less than 1.

For the current and future industrial worker (outdoor) exposures to total soil, the risk characterization results showed total cancer risk ($3.8x10^{-6}$, major risk driver – arsenic) was within the target risk range. Arsenic concentrations are within the range of background concentrations. The total HI (HI = 0.33) was less than 1.

For the current and future industrial worker (outdoor) exposures to sediment at SWMU 31, the risk characterization results showed the total cancer risk estimate was within the target risk range ($9.2x10^{-6}$, major risk driver – arsenic). The total HI (HI = 0.15) was less than 1.

For the current and future industrial worker (outdoor) exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with surface water ($2.7x10^{-8}$) was below the target risk range. The total HI (0.0012) was less than 1.

For the current industrial worker (outdoor) exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with groundwater ($8.3x10^{-8}$) was below the target risk range. The total HI (0.00021) was less than 1.

For the future industrial worker (outdoor) exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with groundwater [$4.6x10^{-5}$, major risk drivers – benzo(a)pyrene and arsenic] was within the target risk range. The total HI (0.73) was less than 1.

**Industrial Worker (Indoor).** For the future industrial worker exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with groundwater [$4.7x10^{-5}$, major risk drivers – benzo(a)pyrene, arsenic, and chloroform] was within the target risk range. The total HI (0.73) was less than 1.

**Excavation Worker.** For the future excavation worker, the risk characterization results showed total cancer risk associated with total soil ($7.0x10^{-7}$) was below the target risk range. The total HI (HI = 5.96; major driver-manganese) was above 1. Manganese concentrations are within the range of background concentrations.

For the future excavation worker exposures to sediment at SWMU 31, the risk characterization results showed the total cancer risk estimate was within the target risk range ($1.0x10^{-6}$, major risk driver – arsenic). The total HI (HI = 0.44) was less than 1.

For the future excavation worker exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with surface water ($1.2x10^{-9}$) was below the target risk range. The total HI (0.0013) was less than 1.

For the future excavation worker exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with groundwater ($1.3x10^{-7}$) was below the target risk range. The total HI (0.0082) was less than 1.

**Lifetime/Adult Resident (On-Site).** For the future lifetime/adult resident (on-site), the risk characterization results showed total cancer risk associated with total soil ($1.7x10^{-5}$, major risk driver – arsenic) was within the target risk range. Arsenic concentrations are within the range of background concentrations. The total HI (HI = 0.40) was less than 1.

For the future lifetime/adult resident exposures to sediment at SWMU 31, the risk characterization results showed the total cancer risk estimate was within the target risk range ($3.8x10^{-6}$, major risk driver – arsenic). The total HI (HI = 0.023) was less than 1.

For the future lifetime/adult resident exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with surface water ($1.7x10^{-8}$) was below the target risk range. The total HI (0.0005) was less than 1.

For the future lifetime/adult resident, the risk characterization results showed total cancer risk associated with groundwater [$3.7x10^{-4}$, major risk drivers – benzo(a)pyrene, arsenic, and chloroform] was above the target risk range. The total HI (HI = 2.4) was greater than 1. No individual chemical HI was equal to or greater than 1.

**Lifetime/Adult Resident (Off-Site).** For the future lifetime/adult resident (off-site), the risk characterization results showed total cancer risk associated with groundwater [$3.7x10^{-4}$, major risk drivers – benzo(a)pyrene, arsenic, and chloroform] was above the target risk range. The total HI (HI = 2.4) was greater than 1. No individual chemical HI was equal to or greater than 1.

**Child Resident (On-Site).** For the future child resident (on-site), the risk characterization results showed total cancer risk associated with total soil ($1.2x10^{-5}$, major risk drivers – dioxins/furans and arsenic) was within the target risk range. Arsenic was determined to be within background concentrations. The total HI (HI = 3.4) was greater than 1, primarily due to iron and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the allowable range. Vanadium concentrations are determined to be within the range of background concentrations.

For the future child resident exposures to sediment at SWMU 31, the risk characterization results showed the total cancer risk estimate was within the target risk range ($2.5\ x10^{-6}$, major risk driver – arsenic). The total HI (HI = 0.19) was less than 1.

For the future child resident exposures at SWMU 31, the risk characterization results showed the total cancer risk associated with surface water ($5.4x10^{-9}$) was below the target risk range. The total HI (0.0010) was less than 1.

For the future child resident, the risk characterization results showed total cancer risk associated with groundwater [$1.3x10^{-4}$, major risk drivers – benzo(a)pyrene and arsenic] was above the target risk range. The total HI (HI = 5.7) was greater than 1, primarily due to arsenic, iron, and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the recommended range. Although the individual HQs for manganese do not exceed 1, the target organ HI for the central nervous system was greater than 1, primarily due to manganese. Arsenic, iron, manganese, and vanadium concentrations are within the range of background concentrations.

**Child Resident (Off-Site).** For the future child resident (off-site), the risk characterization results showed total cancer risk associated with groundwater [$1.3 \times 10^{-4}$, major risk drivers – benzo(a)pyrene and arsenic] was above the target risk range. The total HI (HI = 5.7) was greater than 1, primarily due to arsenic, iron, and vanadium. The margin-of-exposure evaluation indicated that the intake of iron was within the recommended range. Although the individual HQs for manganese do not exceed 1, the target organ HI for the central nervous system was greater than 1, primarily due to manganese. Arsenic, iron, manganese, and vanadium concentrations are within the range of background concentrations.

## 6.0 ECOLOGICAL RISK ASSESSMENT

A SLERA was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 31 (Coal Ash Settling Lagoons). The results of the SLERA contribute to the overall characterization of the site and the scientific/management decision point reached from 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; or,
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERA was performed following the *RFAAP Final MWP* (URS, 2002), the *RFAAP Site Screening Process* (USEPA, 2001b), 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: 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 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 SWMU 31, 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 SWMU 31.

Concentrations of chemicals were measured in relevant environmental media including soil, sediment and surface water. Using available concentration data, a 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 a screening level preliminary exposure estimate and risk calculation (both referred to as a Tier 1 evaluation in this SLERA). Step 3a includes more realistic exposure assumptions (referred to as a Tier 2 evaluation in this SLERA). The SLERA is organized as follows: Site Characterization (*Section 6.1*); Identification of Chemicals of Potential Ecological Concern (COPECs) and Concentration Statistics (*Section 6.2*); Identification of Exposure Pathways and Potential Receptors for Analysis (*Section 6.3*); Identification of Assessment and Measurement Endpoints (*Section 6.4*); Exposure Estimation (*Section 6.5*); Effects Assessment *(Section 6.6)*; Risk Characterization (*Section 6.7*); Groundwater Evaluation (*Section 6.8*); Amphibian Evaluation (*Section 6.9*); Uncertainty Analysis (*Section 6.10*); and, Results and Conclusions (*Section 6.11*).

## 6.1 SITE CHARACTERIZATION

This section includes a general discussion of SWMU 31, vegetative communities, a species inventory, and a discussion on threatened and endangered species.

SWMU 31 is located in the northwest section of the HSA on a nearly level terrace adjacent to the New River at an approximate elevation of 1,700 ft msl. The New River flows from northeast to southwest along the northern boundary of SWMU 31 at an approximate elevation of 1,675 ft msl. SWMU 31 consists of three connected unlined settling lagoons that were constructed and first used in the 1950s and designed to receive effluent from both Power House No. 2 and the water treatment plant. The Power House stopped discharging to the settling lagoons in the late 1980s. The water treatment plant is still currently discharging to the lagoons. The primary settling lagoon (approximately 100 ft long by 50 ft wide) received water carrying fly ash and bottom ash from Power House No. 2 (which burned low sulfur coal to generate steam for HSA buildings) and filter backwash from the water treatment plant. The secondary lagoon (approximately 150 ft wide by 200 ft long) and the tertiary lagoon (approximately 150 ft wide by 250 ft long) were designed to receive the primary lagoon discharge if necessary. The ponds have not been used for any other activities. Facility representatives indicate that the water currently flowing into the primary settling lagoon consists of either overflow from the drinking water settling tanks or backwash from the cleaning of the filters at the drinking water settling tanks at Water Plant 4330. On average, 20,000 gallons of overflow water per day is released to the primary lagoon at a relatively constant flow rate. At a minimum, the filters require cleaning once every three days. This process involves passing 2,800 gallons of water per minute through the filters for 20 minutes to remove accumulated river sludge. The 56,000 gallons of turbid sludge-rich water yielded by this process is discharged to the primary settling lagoon.

The effluent from the secondary and tertiary settling lagoons is designed to discharge to the New River through Outfall 024 following pH adjustment with sulfuric acid. The outfall is regulated under a VPDES permit, which was issued in 1986. Facility representatives indicate that there have only been two discharges through Outfall 024. The first discharge occurred on July 18, 1992, flow = 0.0169 mgd, pH = 7.4. The second discharge from the outfall occurred in December 2005 from a pipe break that allowed water (surface/subsurface) to flow into the pipe and through the outfall. The pipe has been repaired.

Subsurface soil investigations have shown that the bedrock surface is variable and consists of weathered limestone and dolostone. Unconsolidated soil above the bedrock consists of alluvial sediment that is generally 25 to 28 ft thick along the New River.

### 6.1.1 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 SWMU 31 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 & 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, 2002).

Many of the reptiles, mammals, and birds listed in the assessment (USATHAMA, 1976) are believed to breed on the Installation. However, indications are that some species, including ruffed grouse and upland plovers, have decreased in number or have disappeared from RFAAP. Foxes, which were once trapped to prevent rabies outbreaks (the last trapping program for foxes was conducted in 1966), were reintroduced to RFAAP as a control for groundhogs. Deer are common at RFAAP and bow hunting has been allowed at the facility since 1991. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. Federally protected black vultures are present at RFAAP during certain times of the year. Between 1,500 and 3,000 of these migratory birds nest in thickets on the facility (Washington Post, 1995). 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.

According to the RFAAP Installation Assessment (USATHAMA, 1976), timber harvesting occurred at RFAAP in the past. The most recent harvest was conducted in 1987. 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, 2002). In 1964, 922 acres of the HSA were reforested. No reforestation has occurred in the MMA.

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 6-1**.

**Table 6-1**
**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**). A Shaw ecologist performed site reconnaissance activities in June 2002. 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 SWMUs and areas of concern. 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 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.

### 6.1.2 Surface Water

There are two potential surface water sources at SWMU 31, the New River, and settling lagoons located at the site. New River flows from northeast to southwest along the border of SWMU 31. The SWMU contains three connected pond-like lagoons. The primary, secondary, tertiary lagoons have surface areas of approximately 5,000, 30,000, and 37,500 square feet, respectively. The inflow initiates in the primary pond from overflow and filter flushing water from Water Plant 4330 and leaves the secondary and tertiary ponds via evaporation and/or percolation into the surrounding soils.

### 6.1.3 Wetlands

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey there are no designated wetlands at SWMU 31. It should be noted, however, that emergent aquatic vegetation is present in the primary settling lagoon (**Appendix F-1**), and the lagoons may be functioning as wetlands, even though they have not been formally designated as such.

### 6.1.4 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 during the reconnaissance and documented in photographs in **Appendix F-1**. Photos **F-1 through F-3** show the area surrounding SWMU 31 is primarily maintained grass along the banks of the settling lagoons.

#### 6.1.4.1 Grassland Community

The grass area is mowed on an infrequent basis to eliminate woody plants. No signs of vegetative stress were observed during the site reconnaissance.

This habitat type can be expected to support different wildlife species assemblages. Many species would be expected to spend some amount of within the area 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. Trees or shrubs may be present individually or in small groups, but a canopy is lacking. 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].

#### 6.1.4.2 Wet Meadow/Marsh and Pond Community

Small areas of saturated soil conditions bordering the settling ponds have a potential to support a wetland flora distinct from the upland vegetation. Also, as noted in *Section 6.1.3*, the primary settling lagoon has emergent aquatic vegetation (**Appendix F-1**).

Typical species of the wet meadow/marsh community type are *Typha latifolia, Sparganium americanum, Glyceria striata, Leersia oryzoides, Carex frankii, C. lurida, C. vulpinoidea, Schoenoplectus validus, Scripus atrovirens, S. pendulus, Acorus calamus, Juncus dudleyi, Boehmeria cylindrical, Impatiens capensis, Epilobium coloratum, Lycopus uniflorus, Mimulus rigens, Veronica anagalis-aquatica, Eupatorium perfoliatum,* and *Helenium autumnale*. Several artificial ponds provide habitat for submerged aquatic plants and certain animal species. The emergent flora of this habitat is essentially identical to that of the wet meadow community, but include submerged species such as *Potamogeton crispus, P. foliosus,* and *Callitriche heterophylla*.

During the site reconnaissance, the site was examined for vegetative stress, including looking for plants displaying stunted growth, poor foliage growth, tissue discoloration, and a loss of leaf coverage. Vegetative stress attributable to chemicals was not observed.

### 6.1.5 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. **Tables 6-2 and 6-3** presents the numbers of species recorded at RFAAP associated with the grassland and wet meadow/marsh/pond community types.

**Table 6-2**
**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 |

**Table 6-3**
**Species Inventory within RFAAP's Wet Meadow/Marsh and Pond Community Type**

| Taxa | Number of Species | Typical Examples |
|---|---|---|
| Plants | 28 | jewel weed, boneset, sedge, bulrush, cattail, pondweed |
| Invertebrates | 0 | - |
| Reptiles and amphibians | 0 | - |
| Fish | 0 | - |
| Birds | 0 | - |
| Mammals | 0 | - |

### 6.1.6 Threatened, Rare and Endangered Species Information

Threatened, rare, or endangered species found within the grassland and wetland/pond community types at RFAAP include those presented in **Tables 6-4 and 6-5** [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey]. Given the community composition at the site, it is possible these species could also occur at the site, however, as mentioned in *Section 6.1.1*, no threatened, rare, or endangered species have been documented at SWMU 31.

**Table 6-4**
**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 SWMU 31.

**Table 6-5**
**Rare, Threatened, and Endangered Species within RFAAP's Wet Meadow/Marsh and Pond Community Type**

| Common Name | Scientific Name | Federal Status | State Status |
|---|---|---|---|
| Prairie straw sedge | Carex suberecta | not available | Watchlist |
| Small-headed rush | *Juncus brachycephalus* | not available | Rare List |
| Bog Twayblade | *Liparis loeselii* | not available | Rare List |
| Shining ladies'-tresses | Spiranthes lucida | not available | Rare List |
| Tall dropseed | *Sporobolus asper* | not available | Rare List |

## 6.2 IDENTIFICATION OF COPECS AND CONCENTRATION STATISTICS

A list of samples used in the SLERA is presented in **Table 6-6**. COPECs are selected in **Table 6-7 through Table 6-12**, and the COPEC selection process is described in more detail in the following subsections. A discussion of nondetected constituent concentrations compared with ecotoxicity screening values is presented in the Uncertainty Analysis section (*Section 6.10*).

**Table 6-6**
**Sample Number and Medium for Samples Used in SWMU 31 SLERA**

| | | |
|---|---|---|
| 31SB05A (surface soil) | 31SW10 (surface water) | 31SE13A (sediment) |
| 31SB05B (surface soil) | 31SW12 (surface water) | 31SE8A (sediment) |
| 31SW1 (surface water) | 31SW14 (surface water) | 31SL1-2 (sediment) |
| 31SW2 (surface water) | 31SE11A (sediment) | 31SL2-2 (sediment) |
| 31SW3 (surface water) | 31SE11B (sediment) | 31SL3-2 (sediment) |
| --- | --- | 31SL3-2D (sediment; duplicate) |

# TABLE 6-7

# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31

Scenario Timeframe: Current
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 | N/A | 2,3,7,8-TCDD-TE (MAX) | 3.18E-07 | 8.38E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ-RME |
| | N/A | 2,3,7,8-TCDD-TE (RME) | 2.66E-07 | 8.37E-06 | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 7.73E-06 | 1.91E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 9.65E-07J | 3.76E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 55673-89-7 | 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 2.50E-06 | 2.50E-06 | mg/kg | 31SB05A | 1/2 | 3.20E-08 - 3.20E-08 | No | TEQ |
| | 39227-28-6 | 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 4.05E-06 | 4.05E-06 | mg/kg | 31SB05A | 1/2 | 4.70E-08 - 4.70E-08 | No | TEQ |
| | 70648-26-9 | 1,2,3,4,7,8-Hexachlorodibenzofuran | 2.21E-07J | 8.60E-06J | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 57653-85-7 | 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | 1.35E-07 | 6.71E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 57117-44-9 | 1,2,3,6,7,8-Hexachlorodibenzofuran | 1.24E-06 | 1.24E-06 | mg/kg | 31SB05A | 1/2 | 2.00E-08 - 2.00E-08 | No | TEQ |
| | 19408-74-3 | 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 3.84E-07 | 8.48E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 40321-76-4 | 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 1.63E-06 | 1.63E-06 | mg/kg | 31SB05A | 1/2 | 3.70E-08 - 3.70E-08 | No | TEQ |
| | 57117-41-6 | 1,2,3,7,8-Pentachlorodibenzofuran | 5.59E-07 | 5.59E-07 | mg/kg | 31SB05A | 1/2 | 2.00E-08 - 2.00E-08 | No | TEQ |
| | 51207-31-9 | 2,3,7,8-Tetrachlorodibenzofuran | 7.40E-07J | 7.40E-07J | mg/kg | 31SB05A | 1/2 | 2.70E-08 - 2.70E-08 | No | TEQ |
| | 37871-00-4 | Total Heptachlorodibenzo-p-dioxin | 1.40E-05 | 4.54E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 38998-75-3 | Total Heptachlorodibenzofuran | 4.01E-05 | 4.01E-05 | mg/kg | 31SB05A | 1/2 | 2.10E-08 - 2.10E-08 | No | TEQ |
| | 34465-46-8 | Total Hexachlorodibenzo-p-dioxin | 1.46E-06 | 7.93E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 55684-94-1 | Total Hexachlorodibenzofuran | 9.76E-07 | 5.34E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 36088-22-9 | Total Pentachlorodibenzo-p-dioxin | 1.94E-06 | 1.94E-06 | mg/kg | 31SB05A | 1/2 | 3.70E-08 - 3.70E-08 | No | TEQ |
| | 30402-15-4 | Total Pentachlorodibenzofuran | 9.20E-08 | 1.30E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 41903-57-5 | Total Tetrachlorodibenzo-p-dioxin | 2.08E-06 | 2.08E-06 | mg/kg | 31SB05A | 1/2 | 3.80E-08 - 3.80E-08 | No | TEQ |
| | 30402-14-3 | Total Tetrachlorodibenzofuran | 8.50E-08 | 5.14E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 60851-34-5 | 2,3,4,6,7,8-Hexachlorodibenzofuran | 1.57E-06 | 1.57E-06 | mg/kg | 31SB05A | 1/2 | 2.60E-08 - 2.60E-08 | No | TEQ |
| | 57117-31-4 | 2,3,4,7,8-Pentachlorodibenzofuran | 6.78E-07 | 6.78E-07 | mg/kg | 31SB05A | 1/2 | 2.20E-08 - 2.20E-08 | No | TEQ |
| | 1746-01-6 | 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 7.13E-07J | 7.13E-07J | mg/kg | 31SB05A | 1/2 | 3.80E-08 - 3.80E-08 | No | TEQ |
| | 3268-87-9 | Octachlorodibenzodioxin | 5.39E-04 | 1.85E-03 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 39001-02-0 | Octachlorodibenzofuran | 3.45E-06 | 1.28E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 7429-90-5 | Aluminum | 7.21E+03 | 1.55E+04 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-36-0 | Antimony | 5.86E-01L | 5.86E-01L | mg/kg | 31SB05B | 1/1 | N/A | Yes | DET |
| | 7440-38-2 | Arsenic | 1.07E+00 | 5.90E+00 | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-39-3 | Barium | 9.04E+01 | 9.64E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-41-7 | Beryllium | 6.34E-01 | 7.35E-01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-43-9 | Cadmium | 8.30E-02J | 4.62E-01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-70-2 | Calcium | 1.96E+03 | 5.67E+04 | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-47-3 | Chromium | 1.58E+01 | 2.82E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-48-4 | Cobalt | 7.69E+00 | 1.78E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-50-8 | Copper | 1.71E+01 | 1.77E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |

# TABLE 6-7
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31

| 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 | 7439-89-6 | Iron | 9.58E+03J | 2.78E+04J | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7439-92-1 | Lead | 1.46E+01J | 2.80E+01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7439-95-4 | Magnesium | 4.65E+03 | 2.50E+04 | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7439-96-5 | Manganese | 2.03E+02J | 4.95E+02J | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7439-97-6 | Mercury (Inorganic) | 3.50E-02L | 1.21E-01L | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-02-0 | Nickel | 1.15E+01 | 1.48E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-09-7 | Potassium | 9.38E+02 | 2.12E+03 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-23-5 | Sodium | 2.98E+01 | 7.75E+01 | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-28-0 | Thallium | 2.30E-01J | 3.40E-01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-62-2 | Vanadium | 2.20E+01 | 4.75E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | DET |
| | 7440-66-6 | Zinc | 6.02E+01J | 9.85E+01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | DET |
| | 7440-44-0 | Total Organic Carbon | 5.33E+04 | 5.33E+04 | mg/kg | 31SB05A | 1/2 | 1.15E+03 - 1.15E+03 | No | PHYS |
| | 72-54-8 | 4,4'-DDD | 6.98E-04J | 6.98E-04J | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 72-55-9 | 4,4'-DDE | 2.26E-03 | 2.26E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 50-29-3 | 4,4'-DDT | 1.33E-02 | 1.33E-02 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 11097-69-1 | Aroclor 1254 | 9.31E-02 | 9.31E-02 | mg/kg | 31SB05A | 1/2 | 3.83E-02 - 3.83E-02 | Yes | DET |
| | 33213-65-9 | Endosulfan II | 2.28E-03 | 2.28E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 1031-07-8 | Endosulfan sulfate | 8.93E-04 | 8.93E-04 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 7421-93-4 | Endrin aldehyde | 1.79E-03L | 1.79E-03L | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 72-43-5 | Methoxychlor | 7.65E-03 | 7.65E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | DET |
| | 55-63-0 | Nitroglycerin | 4.20E-01 | 4.20E-01 | mg/kg | 31SB05A | 1/2 | 3.45E-01 - 3.45E-01 | Yes | DET |

COPEC Selection Rationale Codes

Selection Reason: Detected constiuent (DET)

Deletion Reason: Dioxins and furans will be analyzed by the equivalent provided by the TCDD-TE (TEQ)
Physical/Chemical (PHYS)

Notes/Definitions:

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)
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 6-8
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31
## PAGE 1 of 2

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water

| 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 Water | N/A | Hardness | 5.54E+01 | 6.32E+01 | mg/l | 31SW14 | 3/3 | N/A | No | PHYS |
| | 7440-44-0 | Total Organic Carbon | 1.71E+00 | 5.08E+00 | mg/l | 31SW14 | 3/3 | N/A | No | PHYS |
| | 120-021 | Total Organic Halides | 1.10E-01J | 1.40E-01J | mg/l | 31SW12 | 3/3 | N/A | No | HAL |
| | 7429-90-5 | Aluminum | 2.97E-01J | 1.32E+01 | mg/l | 31SW14 | 6/6 | N/A | Yes | DET |
| | 7440-39-3 | Barium | 1.75E-02L | 3.56E-02 | mg/l | 31SW14 | 6/6 | N/A | Yes | DET |
| | 7440-70-2 | Calcium | 9.71E+00 | 1.58E+01 | mg/l | 31SW14 | 6/6 | N/A | Yes | DET |
| | 7440-47-3 | Chromium | 4.70E-03J | 4.70E-03J | mg/l | 31SW14 | 1/6 | 1.00E-03 - 1.00E-02 | Yes | DET |
| | 7439-89-6 | Iron | 5.04E-02 | 1.54E+00 | mg/l | 31SW14 | 3/3 | N/A | Yes | DET |
| | 7439-92-1 | Lead | 2.51E-03 | 6.01E-03 | mg/l | 31SW14 | 2/5 | 2.00E-03 - 2.00E-03 | Yes | DET |
| | 7439-95-4 | Magnesium | 3.67E+00J | 5.76E+00 | mg/l | 31SW14 | 6/6 | N/A | Yes | DET |
| | 7439-96-5 | Manganese | 7.60E-03J | 2.63E-01 | mg/l | 31SW14 | 4/4 | N/A | Yes | DET |
| | 7439-97-6 | Mercury (Inorganic) | 8.30E-05J | 1.86E-04 | mg/l | 31SW14 | 2/6 | 1.00E-04 - 2.00E-04 | Yes | DET |
| | 7440-02-0 | Nickel | 4.10E-03K | 4.10E-03K | mg/l | 31SW3 | 1/6 | 1.00E-03 - 4.00E-02 | Yes | DET |
| | 7440-09-7 | Potassium | 1.11E+00K | 1.90E+00 | mg/l | 31SW14 | 6/6 | N/A | Yes | DET |
| | 7440-23-5 | Sodium | 5.70E+00K | 1.19E+01 | mg/l | 31SW10 | 6/6 | N/A | Yes | DET |
| | 7440-66-6 | Zinc | 3.00E-03J | 1.60E-02J | mg/l | 31SW14 | 4/6 | 2.00E-02 - 2.00E-02 | Yes | DET |
| | 95-50-1 | 1,2-Dichlorobenzene | 2.50E-04J | 2.50E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 541-73-1 | 1,3-Dichlorobenzene | 2.60E-04J | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 106-46-7 | 1,4-Dichlorobenzene | 2.60E-04J | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 93-72-1 | 2,4,5-TP (Silvex) | 2.90E-05J | 2.90E-05J | mg/l | 31SW14 | 1/3 | 1.00E-04 - 1.00E-04 | Yes | DET |
| | 91-57-6 | 2-Methylnaphthalene | 3.10E-05 | 3.10E-05J | mg/l | 31SW10 | 1/6 | 5.00E-05 - 1.00E-02 | Yes | DET |
| | 65-85-0 | Benzoic Acid | 3.40E-03 | 1.20E-02J | mg/l | 31SW10 | 3/6 | 5.00E-02 - 5.00E-02 | Yes | DET |
| | 319-84-6 | alpha-BHC | 8.85E-06J | 9.15E-06J | mg/l | 31SW14 | 2/3 | 2.00E-05 - 2.00E-05 | Yes | DET |
| | 319-86-8 | delta-BHC | 1.42E-05J | 1.49E-05J | mg/l | 31SW12 | 2/3 | 2.00E-05 - 2.00E-05 | Yes | DET |
| | 58-89-9 | gamma-BHC (Lindane) | 7.19E-06J | 7.19E-06J | mg/l | 31SW14 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | DET |
| | 75-27-4 | Bromodichloromethane | 1.30E-03 | 3.60E-03 | mg/l | 31SW14 | 3/3 | N/A | Yes | DET |
| | 85-68-7 | Butyl benzyl phthalate | 5.00E-04 | 1.20E-03J | mg/l | 31SW10 | 2/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 84-74-2 | Di-n-butyl phthalate | 7.40E-04 | 1.00E-03J | mg/l | 31SW1 | 2/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 124-48-1 | Dibromochloromethane | 1.70E-04 | 2.00E-04J | mg/l | 31SW14 | 2/3 | 1.00E-03 - 1.00E-03 | Yes | DET |
| | 1918-00-9 | Dicamba | 1.54E-04L | 1.54E-04L | mg/l | 31SW14 | 1/3 | 5.00E-04 - 5.00E-04 | Yes | DET |
| | 84-66-2 | Diethyl phthalate | 2.00E-03 | 8.00E-03J | mg/l | 31SW3 | 3/6 | 5.00E-03 - 5.00E-03 | Yes | DET |
| | 33213-65-9 | Endosulfan II | 7.60E-05 | 7.60E-05 | mg/l | 31SW10 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | DET |
| | 72-20-8 | Endrin | 8.34E-05 | 8.34E-05 | mg/l | 31SW10 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | DET |

# TABLE 6-8
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31
## PAGE 2 of 2

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 87-68-3 | Hexachlorobutadiene | 2.60E-04 | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 67-72-1 | Hexachloroethane | 2.70E-04 | 2.70E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | DET |
| | 98-95-3 | Nitrobenzene | 1.00E-04 | 1.00E-04J | mg/l | 31SW10 | 1/6 | 2.60E-04 - 1.00E-02 | Yes | DET |
| | 129-00-0 | Pyrene | 2.60E-05 | 2.60E-05J | mg/l | 31SW14 | 1/6 | 5.00E-05 - 5.00E-05 | Yes | DET |
| | 67-66-3 | Trichloromethane | 1.60E-02 | 3.00E-02 | mg/l | 31SW14 | 3/3 | N/A | Yes | DET |

COPEC Selection Rationale Codes

Selection Reason: Detected constiuent (DET)

Deletion Reason: Physical/Chemical (PHYS)
Sum of all halides (HAL)

Notes/Definitions:

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

# TABLE 6-9
## OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31
PAGE 1 OF 2

Scenario Timeframe: Current
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 | N/A | TCDD-TEQ-RME | 3.83E-06 | 3.83E-06 | mg/kg | 31SE11B | 1/1 | N/A | Yes | DET |
| | N/A | TCDD-TEQ-MAX | 3.88E-06 | 3.88E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ-RME |
| | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 8.91E-05 | 8.91E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 1.47E-05 | 1.47E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 55673-89-7 | 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 1.21E-06 | 1.21E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 39227-28-6 | 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 1.96E-06 | 1.96E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 70648-26-9 | 1,2,3,4,7,8-Hexachlorodibenzofuran | 5.04E-06J | 5.04E-06J | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57653-85-7 | 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | 3.58E-06 | 3.58E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-44-9 | 1,2,3,6,7,8-Hexachlorodibenzofuran | 4.72E-07 | 4.72E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 19408-74-3 | 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 4.11E-06 | 4.11E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 40321-76-4 | 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 7.95E-07 | 7.95E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-41-6 | 1,2,3,7,8-Pentachlorodibenzofuran | 2.25E-07 | 2.25E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 51207-31-9 | 2,3,7,8-Tetrachlorodibenzofuran | 3.42E-07J | 3.42E-07J | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 37871-00-4 | Total Heptachlorodibenzo-p-dioxin | 1.53E-04 | 1.53E-04 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 38998-75-3 | Total Heptachlorodibenzofuran | 4.71E-05 | 4.71E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 34465-46-8 | Total Hexachlorodibenzo-p-dioxin | 2.43E-05 | 2.43E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 55684-94-1 | Total Hexachlorodibenzofuran | 2.44E-05 | 2.44E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 36088-22-9 | Total Pentachlorodibenzo-p-dioxin | 7.95E-07 | 7.95E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 30402-15-4 | Total Pentachlorodibenzofuran | 4.78E-06 | 4.78E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 41903-57-5 | Total Tetrachlorodibenzo-p-dioxin | 4.09E-07 | 4.09E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 30402-14-3 | Total Tetrachlorodibenzofuran | 3.83E-06 | 3.83E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 60851-34-5 | 2,3,4,6,7,8-Hexachlorodibenzofuran | 7.94E-07 | 7.94E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-31-4 | 2,3,4,7,8-Pentachlorodibenzofuran | 2.94E-07 | 2.94E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 3268-87-9 | Octachlorodibenzodioxin | 1.43E-03 | 1.43E-03 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 39001-02-0 | Octachlorodibenzofuran | 4.18E-05 | 4.18E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 7429-90-5 | Aluminum | 1.91E+04 | 1.08E+05 | mg/kg | 31SL1-2 | 7/7 | N/A | Yes | DET |
| | 7440-36-0 | Antimony | 5.63E+00J | 5.63E+00J | mg/kg | 31SL3-2 | 1/5 | 1.06E+00-6.60E+00 | Yes | DET |
| | 7440-38-2 | Arsenic | 2.74E+00J | 1.25E+01 | mg/kg | 31SE13A | 6/7 | 7.90E+00-7.90E+00 | Yes | DET |
| | 7440-39-3 | Barium | 9.11E+01L | 1.50E+02 | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7440-41-7 | Beryllium | 9.50E-01J | 1.80E+00J | mg/kg | 31SL2-2 | 6/7 | 1.30E+00-1.30E+00 | Yes | DET |
| | 7440-43-9 | Cadmium | 1.90E-01J | 9.65E-01K | mg/kg | 31SL3-2 | 2/6 | 6.62E-01-1.45E+00 | Yes | DET |
| | 7440-70-2 | Calcium | 1.70E+03 | 4.48E+03J | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | DET |
| | 7440-47-3 | Chromium | 2.32E+01J | 5.66E+01 | mg/kg | 31SE13A | 6/6 | N/A | Yes | DET |
| | 7440-48-4 | Cobalt | 6.20E+00L | 1.80E+01J | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7440-50-8 | Copper | 2.99E+01 | 5.00E+01 | mg/kg | 31SE13A | 4/4 | N/A | Yes | DET |
| | 7439-89-6 | Iron | 1.76E+04 | 2.83E+04 | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7439-92-1 | Lead | 1.42E+01 | 9.82E+01 | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7439-95-4 | Magnesium | 2.08E+03J | 3.59E+03 | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7439-96-5 | Manganese | 2.21E+02 | 8.11E+02 | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | DET |
| | 7439-97-6 | Mercury (Inorganic) | 8.70E-02J | 5.30E-01J | mg/kg | 31SE11A | 4/7 | 9.90E-01-1.30E+00 | Yes | DET |
| | 7440-02-0 | Nickel | 1.65E+01J | 3.27E+01J | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | DET |

# TABLE 6-9
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR DIRECT CONTACT EXPOSURE AT SWMU 31
## PAGE 2 OF 2

| 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 | 7440-09-7 | Potassium | 1.21E+03K | 1.80E+03J | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7440-23-5 | Sodium | 1.15E+02 | 1.80E+02 | mg/kg | 31SE13A | 3/3 | N/A | Yes | DET |
| | 7440-28-0 | Thallium | 2.80E-01J | 1.90E+00J | mg/kg | 31SE11A | 4/7 | 5.90E+00-7.90E+00 | Yes | DET |
| | 7440-62-2 | Vanadium | 3.38E+01 | 6.80E+01 | mg/kg | 31SE13A | 7/7 | N/A | Yes | DET |
| | 7440-66-6 | Zinc | 5.90E+01J | 1.95E+02J | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | DET |
| | 7440-44-0 | Total Organic Carbon | 4.41E+04 | 7.45E+04 | mg/kg | 31SE11A | 4/4 | N/A | No | PHYS |
| | 118-96-7 | 2,4,6-Trinitrotoluene | 2.10E-01J | 2.10E-01J | mg/kg | 31SE11A | 1/4 | 2.00E-01-2.00E-01 | Yes | DET |
| | 105-67-9 | 2,4-Dimethylphenol | 2.00E-01J | 2.00E-01J | mg/kg | 31SE11B | 1/7 | 3.50E-01-4.40E+00 | Yes | DET |
| | 91-57-6 | 2-Methylnaphthalene | 1.40E-01K | 1.30E+00 | mg/kg | 31SE8A | 3/6 | 3.30E+00-4.40E+00 | Yes | DET |
| | 72-54-8 | 4,4'-DDD | 7.00E-04J | 7.00E-04J | mg/kg | 31SE11B | 1/1 | N/A | Yes | DET |
| | 72-55-9 | 4,4'-DDE | 1.76E-03J | 1.76E-03J | mg/kg | 31SE11B | 1/1 | N/A | Yes | DET |
| | 83-32-9 | Acenaphthene | 2.80E-01 | 2.80E-01 | mg/kg | 31SL2-2 | 1/4 | 1.10E-02-2.15E-01 | Yes | DET |
| | 208-96-8 | Acenaphthylene | 1.90E-02 | 4.60E-02 | mg/kg | 31SE11A | 3/7 | 1.10E-02-5.50E-01 | Yes | DET |
| | 120-12-7 | Anthracene | 1.50E-02 | 5.90E-02 | mg/kg | 31SE8A | 3/7 | 1.10E-02-2.80E-02 | Yes | DET |
| | 56-55-3 | Benzo(a)anthracene | 1.40E-02 | 1.50E-01 | mg/kg | 31SE8A | 4/7 | 2.10E-02-2.80E-02 | Yes | DET |
| | 50-32-8 | Benzo(a)pyrene | 1.30E-02 | 8.60E-02 | mg/kg | 31SE8A | 6/7 | 2.10E-02-2.10E-02 | Yes | DET |
| | 205-99-2 | Benzo(b)fluoranthene | 2.70E-02 | 1.40E-01 | mg/kg | 31SE8A | 4/7 | 4.10E-02-5.50E-02 | Yes | DET |
| | 191-24-2 | Benzo(g,h,i)perylene | 9.50E-03J | 5.40E-02 | mg/kg | 31SE8A | 4/7 | 4.10E-02-5.50E-02 | Yes | DET |
| | 207-08-9 | Benzo(k)fluoranthene | 6.60E-03J | 4.50E-02 | mg/kg | 31SL2-2 | 5/7 | 2.10E-02-2.15E-02 | Yes | DET |
| | 86-74-8 | Carbazole | 2.00E-02J | 7.90E-02J | mg/kg | 31SE11B | 2/7 | 1.10E+00-4.40E+00 | Yes | DET |
| | 218-01-9 | Chrysene | 1.90E-02 | 2.10E-01 | mg/kg | 31SE8A | 5/7 | 2.10E-02-2.50E-02 | Yes | DET |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.20E-02J | 1.90E-02J | mg/kg | 31SE8A | 2/7 | 7.20E-04-5.50E-02 | Yes | DET |
| | 132-64-9 | Dibenzofuran | 1.20E-01J | 3.00E-01J | mg/kg | 31SE11B | 2/7 | 1.10E+00-4.40E+00 | Yes | DET |
| | 72-20-8 | Endrin | 9.78E-04J | 9.78E-04J | mg/kg | 31SE11B | 1/1 | N/A | Yes | DET |
| | 206-44-0 | Fluoranthene | 2.60E-02 | 9.75E-02 | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | DET |
| | 86-73-7 | Fluorene | 3.80E-02 | 8.70E-02 | mg/kg | 31SE8A | 3/7 | 1.10E-02-5.50E-02 | Yes | DET |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 1.10E-02 | 3.10E-02 | mg/kg | 31SE8A | 6/7 | 3.75E-02-3.75E-02 | Yes | DET |
| | 86-30-6 | n-Nitrosodiphenylamine | 2.30E-01J | 2.30E-01J | mg/kg | 31SE11B | 1/7 | 3.50E-01-4.40E+00 | Yes | DET |
| | 91-20-3 | Naphthalene | 1.30E-01 | 6.90E-01 | mg/kg | 31SE8A | 3/6 | 2.10E-01-2.80E-01 | Yes | DET |
| | 98-95-3 | Nitrobenzene | 1.50E-01J | 1.50E-01J | mg/kg | 31SE11A | 1/7 | 2.00E-01-4.40E+00 | Yes | DET |
| | 85-01-8 | Phenanthrene | 1.30E-02 | 7.10E-01 | mg/kg | 31SE8A | 6/7 | 2.10E-02-2.10E-02 | Yes | DET |
| | 129-00-0 | Pyrene | 3.00E-02 | 1.50E-01J | mg/kg | 31SE8A | 7/7 | N/A | Yes | DET |

COPEC Selection Rationale Codes

Selection Reason: Detected constiuent (DET)

Deletion Reason: Dioxins and furans will be analyzed by the equivalent provided by the TCDD-TE (TEQ)
Physical/Chemical (PHYS)

Notes/Definitions:

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)
N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
K = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

# TABLE 6-10
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31

Scenario Timeframe: Current
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 | N/A | 2,3,7,8-TCDD-TE (MAX) | 3.18E-07 | 8.38E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ-RME |
| | N/A | 2,3,7,8-TCDD-TE (RME) | 2.66E-07 | 8.37E-06 | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 7.73E-06 | 1.91E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 9.65E-07J | 3.76E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 55673-89-7 | 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 2.50E-06 | 2.50E-06 | mg/kg | 31SB05A | 1/2 | 3.20E-08 - 3.20E-08 | No | TEQ |
| | 39227-28-6 | 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 4.05E-06 | 4.05E-06 | mg/kg | 31SB05A | 1/2 | 4.70E-08 - 4.70E-08 | No | TEQ |
| | 70648-26-9 | 1,2,3,4,7,8-Hexachlorodibenzofuran | 2.21E-07J | 8.60E-06J | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 57653-85-7 | 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | 1.35E-07 | 6.71E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 57117-44-9 | 1,2,3,6,7,8-Hexachlorodibenzofuran | 1.24E-06 | 1.24E-06 | mg/kg | 31SB05A | 1/2 | 2.00E-08 - 2.00E-08 | No | TEQ |
| | 19408-74-3 | 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 3.84E-07 | 8.48E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 40321-76-4 | 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 1.63E-06 | 1.63E-06 | mg/kg | 31SB05A | 1/2 | 3.70E-08 - 3.70E-08 | No | TEQ |
| | 57117-41-6 | 1,2,3,7,8-Pentachlorodibenzofuran | 5.59E-07 | 5.59E-07 | mg/kg | 31SB05A | 1/2 | 2.00E-08 - 2.00E-08 | No | TEQ |
| | 51207-31-9 | 2,3,7,8-Tetrachlorodibenzofuran | 7.40E-07J | 7.40E-07J | mg/kg | 31SB05A | 1/2 | 2.70E-08 - 2.70E-08 | No | TEQ |
| | 37871-00-4 | Total Heptachlorodibenzo-p-dioxin | 1.40E-05 | 4.54E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 38998-75-3 | Total Heptachlorodibenzofuran | 4.01E-05 | 4.01E-05 | mg/kg | 31SB05A | 1/2 | 2.10E-08 - 2.10E-08 | No | TEQ |
| | 34465-46-8 | Total Hexachlorodibenzo-p-dioxin | 1.46E-06 | 7.93E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 55684-94-1 | Total Hexachlorodibenzofuran | 9.76E-07 | 5.34E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 36088-22-9 | Total Pentachlorodibenzo-p-dioxin | 1.94E-06 | 1.94E-06 | mg/kg | 31SB05A | 1/2 | 3.70E-08 - 3.70E-08 | No | TEQ |
| | 30402-15-4 | Total Pentachlorodibenzofuran | 9.20E-08 | 1.30E-05 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 41903-57-5 | Total Tetrachlorodibenzo-p-dioxin | 2.08E-06 | 2.08E-06 | mg/kg | 31SB05A | 1/2 | 3.80E-08 - 3.80E-08 | No | TEQ |
| | 30402-14-3 | Total Tetrachlorodibenzofuran | 8.50E-08 | 5.14E-06 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 60851-34-5 | 2,3,4,6,7,8-Hexachlorodibenzofuran | 1.57E-06 | 1.57E-06 | mg/kg | 31SB05A | 1/2 | 2.60E-08 - 2.60E-08 | No | TEQ |
| | 57117-31-4 | 2,3,4,7,8-Pentachlorodibenzofuran | 6.78E-07 | 6.78E-07 | mg/kg | 31SB05A | 1/2 | 2.20E-08 - 2.20E-08 | No | TEQ |
| | 1746-01-6 | 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 7.13E-07J | 7.13E-07J | mg/kg | 31SB05A | 1/2 | 3.80E-08 - 3.80E-08 | No | TEQ |
| | 3268-87-9 | Octachlorodibenzodioxin | 5.39E-04 | 1.85E-03 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 39001-02-0 | Octachlorodibenzofuran | 3.45E-06 | 1.28E-04 | mg/kg | 31SB05A | 2/2 | N/A | No | TEQ |
| | 7429-90-5 | Aluminum | 7.21E+03 | 1.55E+04 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-36-0 | Antimony | 5.86E-01L | 5.86E-01L | mg/kg | 31SB05B | 1/1 | N/A | No | NIBC |
| | 7440-38-2 | Arsenic | 1.07E+00 | 5.90E+00 | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 7440-39-3 | Barium | 9.04E+01 | 9.64E+01 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-41-7 | Beryllium | 6.34E-01 | 7.35E-01 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-43-9 | Cadmium | 8.30E-02J | 4.62E-01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 7440-70-2 | Calcium | 1.96E+03 | 5.67E+04 | mg/kg | 31SB05A | 2/2 | N/A | No | NIBC |
| | 7440-47-3 | Chromium | 1.58E+01 | 2.82E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | IBC |
| | 7440-48-4 | Cobalt | 7.69E+00 | 1.78E+01 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-50-8 | Copper | 1.71E+01 | 1.77E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | IBC |

# TABLE 6-10
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31

| 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 | 7439-89-6 | Iron | 9.58E+03J | 2.78E+04J | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7439-92-1 | Lead | 1.46E+01J | 2.80E+01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 7439-95-4 | Magnesium | 4.65E+03 | 2.50E+04 | mg/kg | 31SB05A | 2/2 | N/A | No | NIBC |
| | 7439-96-5 | Manganese | 2.03E+02J | 4.95E+02J | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7439-97-6 | Mercury (Inorganic) | 3.50E-02L | 1.21E-01L | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 7440-02-0 | Nickel | 1.15E+01 | 1.48E+01 | mg/kg | 31SB05B | 2/2 | N/A | Yes | IBC |
| | 7440-09-7 | Potassium | 9.38E+02 | 2.12E+03 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-23-5 | Sodium | 2.98E+01 | 7.75E+01 | mg/kg | 31SB05A | 2/2 | N/A | No | NIBC |
| | 7440-28-0 | Thallium | 2.30E-01J | 3.40E-01J | mg/kg | 31SB05A | 2/2 | N/A | No | NIBC |
| | 7440-62-2 | Vanadium | 2.20E+01 | 4.75E+01 | mg/kg | 31SB05B | 2/2 | N/A | No | NIBC |
| | 7440-66-6 | Zinc | 6.02E+01J | 9.85E+01J | mg/kg | 31SB05A | 2/2 | N/A | Yes | IBC |
| | 7440-44-0 | Total Organic Carbon | 5.33E+04 | 5.33E+04 | mg/kg | 31SB05A | 1/2 | 1.15E+03 - 1.15E+03 | No | NIBC |
| | 72-54-8 | 4,4'-DDD | 6.98E-04J | 6.98E-04J | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC |
| | 72-55-9 | 4,4'-DDE | 2.26E-03 | 2.26E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC |
| | 50-29-3 | 4,4'-DDT | 1.33E-02 | 1.33E-02 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC |
| | 11097-69-1 | Aroclor 1254 | 9.31E-02 | 9.31E-02 | mg/kg | 31SB05A | 1/2 | 3.83E-02 - 3.83E-02 | Yes | IBC |
| | 33213-65-9 | Endosulfan II | 2.28E-03 | 2.28E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC |
| | 1031-07-8 | Endosulfan sulfate | 8.93E-04 | 8.93E-04 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC-BDP |
| | 7421-93-4 | Endrin aldehyde | 1.79E-03L | 1.79E-03L | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC-BDP |
| | 72-43-5 | Methoxychlor | 7.65E-03 | 7.65E-03 | mg/kg | 31SB05A | 1/2 | 7.68E-04 - 7.68E-04 | Yes | IBC |
| | 55-63-0 | Nitroglycerin | 4.20E-01 | 4.20E-01 | mg/kg | 31SB05A | 1/2 | 3.45E-01 - 3.45E-01 | No | NIBC |

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]
Important Bioaccumulative Compounds - Break Down Product (IBC-BDP)

Deletion Reason: Not Important Bioaccumulative Compound (NIBC)
Dioxins and furans will be analyzed by the equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)
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 6-11
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31
## PAGE 1 of 2

Scenario Timeframe: Current
Medium: Surface Water
Exposure Medium: Surface Water

| 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 Water | N/A | Hardness | 5.54E+01 | 6.32E+01 | mg/l | 31SW14 | 3/3 | N/A | No | PHYS |
| | 7440-44-0 | Total Organic Carbon | 1.71E+00 | 5.08E+00 | mg/l | 31SW14 | 3/3 | N/A | No | PHYS |
| | 120-021 | Total Organic Halides | 1.10E-01J | 1.40E-01J | mg/l | 31SW12 | 3/3 | N/A | No | HAL |
| | 7429-90-5 | Aluminum | 2.97E-01J | 1.32E+01 | mg/l | 31SW14 | 6/6 | N/A | No | NIBC |
| | 7440-39-3 | Barium | 1.75E-02L | 3.56E-02 | mg/l | 31SW14 | 6/6 | N/A | No | NIBC |
| | 7440-70-2 | Calcium | 9.71E+00 | 1.58E+01 | mg/l | 31SW14 | 6/6 | N/A | No | NIBC |
| | 7440-47-3 | Chromium | 4.70E-03J | 4.70E-03J | mg/l | 31SW14 | 1/6 | 1.00E-03 - 1.00E-02 | Yes | IBC |
| | 7439-89-6 | Iron | 5.04E-02 | 1.54E+00 | mg/l | 31SW14 | 3/3 | N/A | No | NIBC |
| | 7439-92-1 | Lead | 2.51E-03 | 6.01E-03 | mg/l | 31SW14 | 2/5 | 2.00E-03 - 2.00E-03 | Yes | IBC |
| | 7439-95-4 | Magnesium | 3.67E+00J | 5.76E+00 | mg/l | 31SW14 | 6/6 | N/A | No | NIBC |
| | 7439-96-5 | Manganese | 7.60E-03J | 2.63E-01 | mg/l | 31SW14 | 4/4 | N/A | No | NIBC |
| | 7439-97-6 | Mercury (Inorganic) | 8.30E-05J | 1.86E-04 | mg/l | 31SW14 | 2/6 | 1.00E-04 - 2.00E-04 | Yes | IBC |
| | 7440-02-0 | Nickel | 4.10E-03K | 4.10E-03K | mg/l | 31SW3 | 1/6 | 1.00E-03 - 4.00E-02 | Yes | IBC |
| | 7440-09-7 | Potassium | 1.11E+00K | 1.90E+00 | mg/l | 31SW14 | 6/6 | N/A | No | NIBC |
| | 7440-23-5 | Sodium | 5.70E+00K | 1.19E+01 | mg/l | 31SW10 | 6/6 | N/A | No | NIBC |
| | 7440-66-6 | Zinc | 3.00E-03J | 1.60E-02J | mg/l | 31SW14 | 4/6 | 2.00E-02 - 2.00E-02 | Yes | IBC |
| | 95-50-1 | 1,2-Dichlorobenzene | 2.50E-04J | 2.50E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | IBC |
| | 541-73-1 | 1,3-Dichlorobenzene | 2.60E-04J | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | IBC |
| | 106-46-7 | 1,4-Dichlorobenzene | 2.60E-04J | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | IBC |
| | 93-72-1 | 2,4,5-TP (Silvex) | 2.90E-05J | 2.90E-05J | mg/l | 31SW14 | 1/3 | 1.00E-04 - 1.00E-04 | No | NIBC |
| | 91-57-6 | 2-Methylnaphthalene | 3.10E-05 | 3.10E-05J | mg/l | 31SW10 | 1/6 | 5.00E-05 - 1.00E-02 | No | NIBC |
| | 65-85-0 | Benzoic Acid | 3.40E-03 | 1.20E-02J | mg/l | 31SW10 | 3/6 | 5.00E-02 - 5.00E-02 | No | NIBC |
| | 319-84-6 | alpha-BHC | 8.85E-06J | 9.15E-06J | mg/l | 31SW14 | 2/3 | 2.00E-05 - 2.00E-05 | Yes | IBC |
| | 319-86-8 | delta-BHC | 1.42E-05J | 1.49E-05J | mg/l | 31SW12 | 2/3 | 2.00E-05 - 2.00E-05 | Yes | IBC |
| | 58-89-9 | gamma-BHC (Lindane) | 7.19E-06J | 7.19E-06J | mg/l | 31SW14 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | IBC |
| | 75-27-4 | Bromodichloromethane | 1.30E-03 | 3.60E-03 | mg/l | 31SW14 | 3/3 | N/A | No | NIBC |
| | 85-68-7 | Butyl benzyl phthalate | 5.00E-04 | 1.20E-03J | mg/l | 31SW10 | 2/6 | 5.00E-03 - 1.00E-02 | No | NIBC |
| | 84-74-2 | Di-n-butyl phthalate | 7.40E-04 | 1.00E-03J | mg/l | 31SW1 | 2/6 | 5.00E-03 - 1.00E-02 | No | NIBC |
| | 124-48-1 | Dibromochloromethane | 1.70E-04 | 2.00E-04J | mg/l | 31SW14 | 2/3 | 1.00E-03 - 1.00E-03 | No | NIBC |
| | 1918-00-9 | Dicamba | 1.54E-04L | 1.54E-04L | mg/l | 31SW14 | 1/3 | 5.00E-04 - 5.00E-04 | No | NIBC |
| | 84-66-2 | Diethyl phthalate | 2.00E-03 | 8.00E-03J | mg/l | 31SW3 | 3/6 | 5.00E-03 - 5.00E-03 | No | NIBC |
| | 33213-65-9 | Endosulfan II | 7.60E-05 | 7.60E-05 | mg/l | 31SW10 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | IBC |
| | 72-20-8 | Endrin | 8.34E-05 | 8.34E-05 | mg/l | 31SW10 | 1/3 | 2.00E-05 - 2.00E-05 | Yes | IBC |

# TABLE 6-11
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31
## PAGE 2 of 2

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 87-68-3 | Hexachlorobutadiene | 2.60E-04 | 2.60E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | IBC |
| | 67-72-1 | Hexachloroethane | 2.70E-04 | 2.70E-04J | mg/l | 31SW10 | 1/6 | 5.00E-03 - 1.00E-02 | Yes | IBC |
| | 98-95-3 | Nitrobenzene | 1.00E-04 | 1.00E-04J | mg/l | 31SW10 | 1/6 | 2.60E-04 - 1.00E-02 | No | NIBC |
| | 129-00-0 | Pyrene | 2.60E-05 | 2.60E-05J | mg/l | 31SW14 | 1/6 | 5.00E-05 - 5.00E-05 | Yes | IBC |
| | 67-66-3 | Trichloromethane | 1.60E-02 | 3.00E-02 | mg/l | 31SW14 | 3/3 | N/A | No | NIBC |

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]

Deletion Reason: Physical/Chemical (PHYS)
Sum of all halides (HAL)

Notes/Definitions:

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

# TABLE 6-12
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31
## PAGE 1 of 2

Scenario Timeframe: Current
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 | N/A | TCDD-TEQ-MAX | 3.88E-06 | 3.88E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ-RME |
| | N/A | TCDD-TEQ-RME | 3.83E-06 | 3.83E-06 | mg/kg | 31SE11B | 1/1 | N/A | Yes | IBC |
| | 35822-46-9 | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 8.91E-05 | 8.91E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 67562-39-4 | 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 1.47E-05 | 1.47E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 55673-89-7 | 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 1.21E-06 | 1.21E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 39227-28-6 | 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 1.96E-06 | 1.96E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 70648-26-9 | 1,2,3,4,7,8-Hexachlorodibenzofuran | 5.04E-06J | 5.04E-06J | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57653-85-7 | 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | 3.58E-06 | 3.58E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-44-9 | 1,2,3,6,7,8-Hexachlorodibenzofuran | 4.72E-07 | 4.72E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 19408-74-3 | 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 4.11E-06 | 4.11E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 40321-76-4 | 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 7.95E-07 | 7.95E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-41-6 | 1,2,3,7,8-Pentachlorodibenzofuran | 2.25E-07 | 2.25E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 51207-31-9 | 2,3,7,8-Tetrachlorodibenzofuran | 3.42E-07J | 3.42E-07J | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 37871-00-4 | Total Heptachlorodibenzo-p-dioxin | 1.53E-04 | 1.53E-04 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 38998-75-3 | Total Heptachlorodibenzofuran | 4.71E-05 | 4.71E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 34465-46-8 | Total Hexachlorodibenzo-p-dioxin | 2.43E-05 | 2.43E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 55684-94-1 | Total Hexachlorodibenzofuran | 2.44E-05 | 2.44E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 36088-22-9 | Total Pentachlorodibenzo-p-dioxin | 7.95E-07 | 7.95E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 30402-15-4 | Total Pentachlorodibenzofuran | 4.78E-06 | 4.78E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 41903-57-5 | Total Tetrachlorodibenzo-p-dioxin | 4.09E-07 | 4.09E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 30402-14-3 | Total Tetrachlorodibenzofuran | 3.83E-06 | 3.83E-06 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 60851-34-5 | 2,3,4,6,7,8-Hexachlorodibenzofuran | 7.94E-07 | 7.94E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 57117-31-4 | 2,3,4,7,8-Pentachlorodibenzofuran | 2.94E-07 | 2.94E-07 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 3268-87-9 | Octachlorodibenzodioxin | 1.43E-03 | 1.43E-03 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 39001-02-0 | Octachlorodibenzofuran | 4.18E-05 | 4.18E-05 | mg/kg | 31SE11B | 1/1 | N/A | No | TEQ |
| | 7429-90-5 | Aluminum | 1.91E+04 | 1.08E+05 | mg/kg | 31SL1-2 | 7/7 | N/A | No | NIBC |
| | 7440-36-0 | Antimony | 5.63E+00J | 5.63E+00J | mg/kg | 31SL3-2 | 1/5 | 1.06E+00-6.60E+00 | No | NIBC |
| | 7440-38-2 | Arsenic | 2.74E+00J | 1.25E+01 | mg/kg | 31SE13A | 6/7 | 7.90E+00-7.90E+00 | Yes | IBC |
| | 7440-39-3 | Barium | 9.11E+01L | 1.50E+02 | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |
| | 7440-41-7 | Beryllium | 9.50E-01J | 1.80E+00J | mg/kg | 31SL2-2 | 6/7 | 1.30E+00-1.30E+00 | No | NIBC |
| | 7440-43-9 | Cadmium | 1.90E-01J | 9.65E-01K | mg/kg | 31SL3-2 | 2/6 | 6.62E-01-1.45E+00 | Yes | IBC |
| | 7440-70-2 | Calcium | 1.70E+03 | 4.48E+03J | mg/kg | 31SL3-2 | 7/7 | N/A | No | NIBC |
| | 7440-47-3 | Chromium | 2.32E+01J | 5.66E+01 | mg/kg | 31SE13A | 6/6 | N/A | Yes | IBC |
| | 7440-48-4 | Cobalt | 6.20E+00L | 1.80E+01J | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |
| | 7440-50-8 | Copper | 2.99E+01 | 5.00E+01 | mg/kg | 31SE13A | 4/4 | N/A | Yes | IBC |
| | 7439-89-6 | Iron | 1.76E+04 | 2.83E+04 | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |
| | 7439-92-1 | Lead | 1.42E+01 | 9.82E+01 | mg/kg | 31SE13A | 7/7 | N/A | Yes | IBC |
| | 7439-95-4 | Magnesium | 2.08E+03J | 3.59E+03 | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |
| | 7439-96-5 | Manganese | 2.21E+02 | 8.11E+02 | mg/kg | 31SL3-2 | 7/7 | N/A | No | NIBC |
| | 7439-97-6 | Mercury (Inorganic) | 8.70E-02J | 5.30E-01J | mg/kg | 31SE11A | 4/7 | 9.90E-01-1.30E+00 | Yes | IBC |
| | 7440-02-0 | Nickel | 1.65E+01J | 3.27E+01J | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | IBC |
| | 7440-09-7 | Potassium | 1.21E+03K | 1.80E+03J | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |

# TABLE 6-12
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR FOOD CHAIN EXPOSURE AT SWMU 31
## PAGE 2 of 2

| 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 | 7440-23-5 | Sodium | 1.15E+02 | 1.80E+02 | mg/kg | 31SE13A | 3/3 | N/A | No | NIBC |
| | 7440-28-0 | Thallium | 2.80E-01J | 1.90E+00J | mg/kg | 31SE11A | 4/7 | 5.90E+00-7.90E+00 | No | NIBC |
| | 7440-62-2 | Vanadium | 3.38E+01 | 6.80E+01 | mg/kg | 31SE13A | 7/7 | N/A | No | NIBC |
| | 7440-66-6 | Zinc | 5.90E+01J | 1.95E+02J | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | IBC |
| | 7440-44-0 | Total Organic Carbon | 4.41E+04 | 7.45E+04 | mg/kg | 31SE11A | 4/4 | N/A | No | NIBC |
| | 118-96-7 | 2,4,6-Trinitrotoluene | 2.10E-01J | 2.10E-01J | mg/kg | 31SE11A | 1/4 | 2.00E-01-2.00E-01 | No | NIBC |
| | 105-67-9 | 2,4-Dimethylphenol | 2.00E-01J | 2.00E-01J | mg/kg | 31SE11B | 1/7 | 3.50E-01-4.40E+00 | No | NIBC |
| | 91-57-6 | 2-Methylnaphthalene | 1.40E-01K | 1.30E+00 | mg/kg | 31SE8A | 3/6 | 3.30E+00-4.40E+00 | No | NIBC |
| | 72-54-8 | 4,4'-DDD | 7.00E-04J | 7.00E-04J | mg/kg | 31SE11B | 1/1 | N/A | Yes | IBC |
| | 72-55-9 | 4,4'-DDE | 1.76E-03J | 1.76E-03J | mg/kg | 31SE11B | 1/1 | N/A | Yes | IBC |
| | 83-32-9 | Acenaphthene | 2.80E-01 | 2.80E-01 | mg/kg | 31SL2-2 | 1/4 | 1.10E-02-2.15E-01 | Yes | IBC |
| | 208-96-8 | Acenaphthylene | 1.90E-02 | 4.60E-02 | mg/kg | 31SE11A | 3/7 | 1.10E-02-5.50E-01 | Yes | IBC |
| | 120-12-7 | Anthracene | 1.50E-02 | 5.90E-02 | mg/kg | 31SE8A | 3/7 | 1.10E-02-2.80E-02 | Yes | IBC |
| | 56-55-3 | Benzo(a)anthracene | 1.40E-02 | 1.50E-01 | mg/kg | 31SE8A | 4/7 | 2.10E-02-2.80E-02 | Yes | IBC |
| | 50-32-8 | Benzo(a)pyrene | 1.30E-02 | 8.60E-02 | mg/kg | 31SE8A | 6/7 | 2.10E-02-2.10E-02 | Yes | IBC |
| | 205-99-2 | Benzo(b)fluoranthene | 2.70E-02 | 1.40E-01 | mg/kg | 31SE8A | 4/7 | 4.10E-02-5.50E-02 | Yes | IBC |
| | 191-24-2 | Benzo(g,h,i)perylene | 9.50E-03J | 5.40E-02 | mg/kg | 31SE8A | 4/7 | 4.10E-02-5.50E-02 | Yes | IBC |
| | 207-08-9 | Benzo(k)fluoranthene | 6.60E-03J | 4.50E-02 | mg/kg | 31SL2-2 | 5/7 | 2.10E-02-2.15E-02 | Yes | IBC |
| | 86-74-8 | Carbazole | 2.00E-02J | 7.90E-02J | mg/kg | 31SE11B | 2/7 | 1.10E+00-4.40E+00 | No | NIBC |
| | 218-01-9 | Chrysene | 1.90E-02 | 2.10E-01 | mg/kg | 31SE8A | 5/7 | 2.10E-02-2.50E-02 | Yes | IBC |
| | 53-70-3 | Dibenz(a,h)anthracene | 1.20E-02J | 1.90E-02J | mg/kg | 31SE8A | 2/7 | 7.20E-04-5.50E-02 | Yes | IBC |
| | 132-64-9 | Dibenzofuran | 1.20E-01J | 3.00E-01J | mg/kg | 31SE11B | 2/7 | 1.10E+00-4.40E+00 | No | NIBC |
| | 72-20-8 | Endrin | 9.78E-04J | 9.78E-04J | mg/kg | 31SE11B | 1/1 | N/A | Yes | IBC |
| | 206-44-0 | Fluoranthene | 2.60E-02 | 9.75E-02 | mg/kg | 31SL3-2 | 7/7 | N/A | Yes | IBC |
| | 86-73-7 | Fluorene | 3.80E-02 | 8.70E-02 | mg/kg | 31SE8A | 3/7 | 1.10E-02-5.50E-02 | Yes | IBC |
| | 193-39-5 | Indeno(1,2,3-cd)pyrene | 1.10E-02 | 3.10E-02 | mg/kg | 31SE8A | 6/7 | 3.75E-02-3.75E-02 | Yes | IBC |
| | 86-30-6 | n-Nitrosodiphenylamine | 2.30E-01J | 2.30E-01J | mg/kg | 31SE11B | 1/7 | 3.50E-01-4.40E+00 | No | NIBC |
| | 91-20-3 | Naphthalene | 1.30E-01 | 6.90E-01 | mg/kg | 31SE8A | 3/6 | 2.10E-01-2.80E-01 | No | NIBC |
| | 98-95-3 | Nitrobenzene | 1.50E-01J | 1.50E-01J | mg/kg | 31SE11A | 1/7 | 2.00E-01-4.40E+00 | No | NIBC |
| | 85-01-8 | Phenanthrene | 1.30E-02 | 7.10E-01 | mg/kg | 31SE8A | 6/7 | 2.10E-02-2.10E-02 | Yes | IBC |
| | 129-00-0 | Pyrene | 3.00E-02 | 1.50E-01J | mg/kg | 31SE8A | 7/7 | 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]

Deletion Reason: Not Important Bioaccumulative Compound (NIBC)

Dioxins and furans will be analyzed by the equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions

For 2,3,7,8-TCDD-TE, two values were calculated, the MAX and the RME (see text for further discussion)

N/A = Not Applicable or Not Available

COPEC = Chemical of Potential Ecological Concern

J = Estimated Value

K = Estimated Value

L = Estimated Value

mg/kg = milligrams per kilogram

### 6.2.1 Data Organization

The data for each chemical have been sorted by medium. To assess potential ecological impacts, surface water, and soil and sediment from 0-2 ft bgs have been considered. The 0-2 ft depth interval was selected for three primary reasons: (1) to maintain consistency with other RFAAP ecological risk assessment documents that used 0-2 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 and sediment depth exposure interval, as depths below 2 ft would be infrequently contacted; and, (3) to focus on the soil depth interval expected to have the highest COPEC concentrations. 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 0-2 ft depth range.

Chemicals that were not detected at least once in a medium have not been included in the risk assessment, but are presented in **Appendix F-2, Tables F-23 through F-25**. The analytical data may have qualifiers from the analytical laboratory quality control process or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings are from USEPA (1989a). Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the HHRAs.

### 6.2.2 Descriptive Statistical Calculations

Because of the uncertainty associated with characterizing contamination in environmental media, the 95 percent UCL of the mean has been estimated for chemicals selected as COPECs (**Tables 6-13 through 6-15**). The calculation of EPCs follows the same procedure used for the HHRA (*Section 5.2.2*). Groundwater COPECs are assessed as a special case in *Section 6.8* because ecological receptors are not directly exposed to groundwater.

### 6.2.3 Frequency of Detection

Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity or disposal practices. These chemicals, however, have been included in the risk evaluation and a low frequency of detection was not used to deselect COPECs.

### 6.2.4 Natural Site Constituents (Essential Nutrients)

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

### 6.2.5 Selection of COPECs

COPECs were selected as shown in **Table 6-7 through Table 6-12**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Table 6-7 through Table 6-9**). For food chain exposure pathways, detected COPECs were selected unless they were not important bioaccumulative constituents (NIBC; USEPA, 2000c) (**Table 6-10 through Table 6-12**).

Dioxin-like compounds were treated according to procedures provided by USEPA and WHO (USEPA, 1989b, 1994b; WHO, 1998). Dioxin-like compounds (PCDDs and PCDFs) 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

# Table 6-13
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
## Page 1 of 2

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

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Surface Soil (0-2 feet) | TCDD-TEQ-RME | mg/kg | 4.00E-06 | N/A | 8.37E-06 | 8.37E-06 | mg/kg | Max | Test(3) |
| | 4,4-DDD | mg/kg | 5.41E-04 | N/A | 6.98E-04 | 6.98E-04 | mg/kg | Max | W-Test(3) |
| | 4,4-DDE | mg/kg | 1.32E-03 | N/A | 2.26E-03 | 2.26E-03 | mg/kg | Max | W-Test(3) |
| | 4,4-DDT | mg/kg | 6.84E-03 | N/A | 1.33E-02 | 1.33E-02 | mg/kg | Max | W-Test(3) |
| | Aluminum | mg/kg | 1.14E+04 | N/A | 1.55E+04 | 1.55E+04 | mg/kg | Max | W-Test(3) |
| | Antimony | mg/kg | 5.86E-01 | N/A | 5.86E-01 | 5.86E-01 | mg/kg | Max | Test(3) |
| | Arsenic | mg/kg | 3.49E+00 | N/A | 5.90E+00 | 5.90E+00 | mg/kg | Max | W-Test(3) |
| | Barium | mg/kg | 9.34E+01 | N/A | 9.64E+01 | 9.64E+01 | mg/kg | Max | W-Test(3) |
| | Beryllium | mg/kg | 6.85E-01 | N/A | 7.35E-01 | 7.35E-01 | mg/kg | Max | Test(3) |
| | Cadmium | mg/kg | 2.73E-01 | N/A | 4.62E-01 | 4.62E-01 | mg/kg | Max | Test(3) |
| | Calcium | mg/kg | 2.93E+04 | N/A | 5.67E+04 | 5.67E+04 | mg/kg | Max | W-Test(3) |
| | Chromium | mg/kg | 2.20E+01 | N/A | 2.82E+01 | 2.82E+01 | mg/kg | Max | Test(3) |
| | Cobalt | mg/kg | 1.27E+01 | N/A | 1.78E+01 | 1.78E+01 | mg/kg | Max | Test(3) |
| | Copper | mg/kg | 1.74E+01 | N/A | 1.77E+01 | 1.77E+01 | mg/kg | Max | Test(3) |
| | Endosulfan II | mg/kg | 1.33E-03 | N/A | 2.28E-03 | 2.28E-03 | mg/kg | Max | Test(3) |
| | Endosulfan sulfate | mg/kg | 6.39E-04 | N/A | 8.93E-04 | 8.93E-04 | mg/kg | Max | Test(3) |
| | Endrin aldehyde | mg/kg | 1.09E-03 | N/A | 1.79E-03 | 1.79E-03 | mg/kg | Max | Test(3) |
| | Iron | mg/kg | 1.87E+04 | N/A | 2.78E+04 | 2.78E+04 | mg/kg | Max | Test(3) |
| | Lead | mg/kg | 2.13E+01 | N/A | 2.80E+01 | 2.80E+01 | mg/kg | Max | Test(3) |
| | Magnesium | mg/kg | 1.48E+04 | N/A | 2.50E+04 | 2.50E+04 | mg/kg | Max | W-Test(3) |
| | Manganese | mg/kg | 3.49E+02 | N/A | 4.95E+02 | 4.95E+02 | mg/kg | Max | Test(3) |
| | Mercury | mg/kg | 7.80E-02 | N/A | 1.21E-01 | 1.21E-01 | mg/kg | Max | Test(3) |
| | Methoxychlor | mg/kg | 4.02E-03 | N/A | 7.65E-03 | 7.65E-03 | mg/kg | Max | W-Test(3) |

# Table 6-13
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
## Page 2 of 2

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Surface Soil (0-2 feet) | Nickel | mg/kg | 1.32E+01 | N/A | 1.48E+01 | 1.48E+01 | mg/kg | Max | Test(3) |
| | Nitroglycerine | mg/kg | 2.96E-01 | N/A | 4.20E-01 | 4.20E-01 | mg/kg | Max | W-Test(3) |
| | PCB-1254 | mg/kg | 5.61E-02 | N/A | 9.31E-02 | 9.31E-02 | mg/kg | Max | W-Test(3) |
| | Potassium | mg/kg | 1.53E+03 | N/A | 2.12E+03 | 2.12E+03 | mg/kg | Max | W-Test(3) |
| | Sodium | mg/kg | 5.37E+01 | N/A | 7.75E+01 | 7.75E+01 | mg/kg | Max | W-Test(3) |
| | Thallium | mg/kg | 2.85E-01 | N/A | 3.40E-01 | 3.40E-01 | mg/kg | Max | Test(3) |
| | Vanadium | mg/kg | 3.48E+01 | N/A | 4.75E+01 | 4.75E+01 | mg/kg | Max | Test(3) |
| | Zinc | mg/kg | 7.94E+01 | N/A | 9.85E+01 | 9.85E+01 | mg/kg | Max | Test(3) |

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst).

N/A - Not Applicable; Not Available.

Distributions: Determined using ProUCL - Non Parametric (NP); Normal (N); Gamma (G); Lognormal (T).

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50); Bootstrap Statistic used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC.

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC.

# Table 6-14
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
## Page 1 of 2

Scenario Timeframe: Current
Medium: Water
Exposure Medium: Surface Water

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Surface Water | 1,2-Dichlorobenzene | mg/l | 3.38E-03 | 4.99E-03 (N) | 2.50E-04 | 2.50E-04 | mg/l | Max | W-Test(5) |
| | 1,3-Dichlorobenzene | mg/l | 3.38E-03 | 4.99E-03 (N) | 2.60E-04 | 2.60E-04 | mg/l | Max | W-Test(5) |
| | 1,4-Dichlorobenzene | mg/l | 3.38E-03 | 4.99E-03 (N) | 2.60E-04 | 2.60E-04 | mg/l | Max | W-Test(5) |
| | 2,4,5-TP | mg/l | 4.30E-05 | N/A | 2.90E-05 | 2.90E-05 | mg/l | Max | W-Test(3) |
| | 2-Methylnaphthalene | mg/l | 2.51E-03 | 4.78E-03 (NP) | 3.10E-05 | 3.10E-05 | mg/l | Max | W-Test(5) |
| | alpha-BHC | mg/l | 9.00E-06 | N/A | 9.15E-06 | 9.15E-06 | mg/l | Max | W-Test(3) |
| | Aluminum | mg/l | 3.93E+00 | 5.91E+02 (T) | 1.32E+01 | 1.32E+01 | mg/l | Max | W-Test(5) |
| | Barium | mg/l | 2.29E-02 | 2.99E-02 (T) | 3.56E-02 | 2.99E-02 | mg/l | 95%UCL-T | W-Test(2) |
| | Benzoic acid | mg/l | 1.63E-02 | 6.71E-02 (T) | 1.20E-02 | 1.20E-02 | mg/l | Max | W-Test(5) |
| | Butylbenzylphthalate | mg/l | 3.20E-03 | 2.06E-02 (T) | 1.20E-03 | 1.20E-03 | mg/l | Max | W-Test(5) |
| | Bromodichloromethane | mg/l | 2.50E-03 | N/A | 3.60E-03 | 3.60E-03 | mg/l | Max | W-Test(3) |
| | Calcium | mg/l | 1.25E+01 | 1.50E+01 (T) | 1.58E+01 | 1.50E+01 | mg/l | 95%UCL-T | W-Test(2) |
| | Chromium | mg/l | 2.70E-03 | 4.64E-03 (NP) | 4.70E-03 | 4.64E-03 | mg/l | 95%UCL-Bst | W-Test(1) |
| | delta-BHC | mg/l | 1.30E-05 | N/A | 1.49E-05 | 1.49E-05 | mg/l | Max | W-Test(3) |
| | Dibromochloromethane | mg/l | 2.90E-04 | N/A | 2.00E-04 | 2.00E-04 | mg/l | Max | W-Test(3) |
| | Dicamba | mg/l | 2.18E-04 | N/A | 1.54E-04 | 1.54E-04 | mg/l | Max | W-Test(3) |
| | Diethylphthalate | mg/l | 3.42E-03 | 4.56E-03 (NP) | 8.00E-03 | 4.56E-03 | mg/l | 95%UCL-Bst | W-Test(1) |
| | Di-n-butylphthalate | mg/l | 2.79E-03 | 1.05E-02 (T) | 1.00E-03 | 1.00E-03 | mg/l | Max | W-Test(5) |
| | Endosulfan II | mg/l | 3.20E-05 | N/A | 7.60E-05 | 7.60E-05 | mg/l | Max | W-Test(3) |
| | Endrin | mg/l | 3.40E-05 | N/A | 8.34E-05 | 8.34E-05 | mg/l | Max | W-Test(3) |
| | Hexachlorobutadiene | mg/l | 3.38E-03 | 4.99E-03 (N) | 2.60E-04 | 2.60E-04 | mg/l | Max | W-Test(5) |
| | Hexachloroethane | mg/l | 3.38E-03 | 4.99E-03 (N) | 2.70E-04 | 2.70E-04 | mg/l | Max | W-Test(5) |
| | Iron | mg/l | 6.40E-01 | N/A | 1.54E+00 | 1.54E+00 | mg/l | Max | W-Test(3) |

# Table 6-14
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
## Page 2 of 2

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Surface Water | Lead | mg/l | 2.30E-03 | N/A | 6.01E-03 | 6.01E-03 | mg/l | Max | W-Test(3) |
| | Lindane | mg/l | 9.00E-06 | N/A | 7.19E-06 | 7.19E-06 | mg/l | Max | W-Test(3) |
| | Magnesium | mg/l | 4.72E+00 | 5.57E+00 (T) | 5.76E+00 | 5.57E+00 | mg/l | 95%UCL-T | W-Test(2) |
| | Manganese | mg/l | 9.47E-02 | N/A | 2.63E-01 | 2.63E-01 | mg/l | Max | W-Test(3) |
| | Mercury | mg/l | 1.03E-04 | 1.48E-04 (NP) | 1.86E-04 | 1.48E-04 | mg/l | 95%UCL-Bst | W-Test(1) |
| | Nickel | mg/l | 1.09E-02 | 6.47E+00 (T) | 4.10E-03 | 4.10E-03 | mg/l | Max | W-Test(5) |
| | Nitrobenzene | mg/l | 2.56E-03 | 4.79E-03 (NP) | 1.00E-04 | 1.00E-04 | mg/l | Max | W-Test(5) |
| | Potassium | mg/l | 1.43E+00 | 1.76E+00 (T) | 1.90E+00 | 1.76E+00 | mg/l | 95%UCL-T | W-Test(2) |
| | Pyrene | mg/l | 2.50E-05 | 2.60E-05 (N) | 2.60E-05 | 2.60E-05 | mg/l | 95%UCL-N | W-Test(4) |
| | Sodium | mg/l | 9.41E+00 | 1.12E+01 (N) | 1.19E+01 | 1.12E+01 | mg/l | 95%UCL-N | W-Test(4) |
| | Trichloromethane | mg/l | 2.27E-02 | N/A | 3.00E-02 | 3.00E-02 | mg/l | Max | W-Test(3) |
| | Zinc | mg/l | 7.88E-03 | 2.18E-02 (T) | 1.60E-02 | 1.60E-02 | mg/l | Max | W-Test(5) |

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst).

N/A - Not Applicable; Not Available.

Distributions: Determined using ProUCL - Non Parametric (NP); Normal (N); Gamma (G); Lognormal (T).

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50); Bootstrap Statistic used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC.

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50).

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC.

# Table 6-15
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
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Scenario Timeframe: Current
Medium: Sediment
Exposure Medium: Sediment

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Sediment | TCDD-TEQ-RME | mg/kg | 1.95E-06 | N/A | 3.83E-06 | 3.83E-06 | mg/kg | Max | W-Test(3) |
| | 2,4,6-Trinitrotoluene | mg/kg | 1.28E-01 | N/A | 2.10E-01 | 2.10E-01 | mg/kg | Max | W-Test(3) |
| | 2,4-Dimethylphenol | mg/kg | 1.11E+00 | 1.71E+00 (N) | 2.00E-01 | 2.00E-01 | mg/kg | Max | W-Test(5) |
| | 2-Methylnaphthalene | mg/kg | 1.31E+00 | 1.93E+00 (N) | 1.30E+00 | 1.30E+00 | mg/kg | Max | W-Test(5) |
| | 4,4-DDD | mg/kg | 7.00E-04 | N/A | 7.00E-04 | 7.00E-04 | mg/kg | Max | W-Test(3) |
| | 4,4-DDE | mg/kg | 1.76E-03 | N/A | 1.76E-03 | 1.76E-03 | mg/kg | Max | W-Test(3) |
| | Acenaphthene | mg/kg | 1.25E-01 | N/A | 2.80E-01 | 2.80E-01 | mg/kg | Max | W-Test(3) |
| | Acenaphthylene | mg/kg | 1.12E-01 | 3.77E+00 (T) | 4.60E-02 | 4.60E-02 | mg/kg | Max | W-Test(5) |
| | Aluminum | mg/kg | 7.77E+04 | 1.03E+05 (N) | 1.08E+05 | 1.03E+05 | mg/kg | 95%UCL-N | W-Test(4) |
| | Anthracene | mg/kg | 2.23E-02 | 6.81E-02 (T) | 5.90E-02 | 5.90E-02 | mg/kg | Max | W-Test(5) |
| | Antimony | mg/kg | 2.72E+00 | N/A | 5.63E+00 | 5.63E+00 | mg/kg | Max | W-Test(3) |
| | Arsenic | mg/kg | 6.97E+00 | 1.22E+01 (T) | 1.25E+01 | 1.22E+01 | mg/kg | 95%UCL-T | W-Test(2) |
| | Barium | mg/kg | 1.20E+02 | 1.35E+02 (N) | 1.50E+02 | 1.35E+02 | mg/kg | 95%UCL-N | W-Test(4) |
| | Benzo(a)anthracene | mg/kg | 4.19E-02 | 2.06E-01 (T) | 1.50E-01 | 1.50E-01 | mg/kg | Max | W-Test(5) |
| | Benzo(a)pyrene | mg/kg | 4.23E-02 | 6.28E-02 (N) | 8.60E-02 | 6.28E-02 | mg/kg | 95%UCL-N | W-Test(4) |
| | Benzo(b)fluoranthene | mg/kg | 5.83E-02 | 1.73E-01 (T) | 1.40E-01 | 1.40E-01 | mg/kg | Max | W-Test(5) |
| | Benzo(g,h,i)perylene | mg/kg | 2.74E-01 | 5.24E-02 (T) | 5.40E-02 | 5.24E-02 | mg/kg | 95%UCL-T | W-Test(2) |
| | Benzo(k)fluoranthene | mg/kg | 1.90E-02 | 4.02E-02 (T) | 4.50E-02 | 4.02E-02 | mg/kg | 95%UCL-T | W-Test(2) |
| | Beryllium | mg/kg | 1.19E+00 | 1.45E+00 (N) | 1.80E+00 | 1.45E+00 | mg/kg | 95%UCL-N | W-Test(4) |
| | Cadmium | mg/kg | 5.59E-01 | 7.90E-01 (N) | 9.65E-01 | 7.90E-01 | mg/kg | 95%UCL-N | W-Test(4) |
| | Calcium | mg/kg | 2.99E+03 | 3.80E+03 (N) | 4.48E+03 | 3.80E+03 | mg/kg | 95%UCL-N | W-Test(4) |
| | Carbazole | mg/kg | 1.07E+00 | 1.71E+00 (N) | 7.90E-02 | 7.90E-02 | mg/kg | Max | W-Test(5) |
| | Chromium | mg/kg | 3.59E+01 | 5.21E+01 (T) | 5.66E+01 | 5.21E+01 | mg/kg | 95%UCL-T | W-Test(2) |
| | Chrysene | mg/kg | 5.45E-02 | 2.82E-01 (T) | 2.10E-01 | 2.10E-01 | mg/kg | Max | W-Test(5) |
| | Cobalt | mg/kg | 1.35E+01 | 1.65E+01 (N) | 1.80E+01 | 1.65E+01 | mg/kg | 95%UCL-N | W-Test(4) |
| | Copper | mg/kg | 4.01E+01 | N/A | 5.00E+01 | 5.00E+01 | mg/kg | Max | W-Test(3) |
| | Dibenz(a,h)anthracene | mg/kg | 1.51E-02 | 2.22E-02 (N) | 1.90E-02 | 1.90E-02 | mg/kg | Max | W-Test(5) |
| | Dibenzofuran | mg/kg | 1.12E+00 | 1.71E+00 (N) | 3.00E-01 | 3.00E-01 | mg/kg | Max | W-Test(5) |

# Table 6-15
# Medium-Specific Exposure Point Concentration Summary for SWMU 31
## Page 2 of 2

| Exposure Point | Chemical of Potential Concern | Units | Arithmetic Mean | 95% UCL (Distribution) | Maximum Concentration (Qualifier) | Exposure Point Concentration | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Value | Units | Statistic | Rationale |
| Sediment | Endrin | mg/kg | 9.78E-04 | N/A | 9.78E-04 | 9.78E-04 | mg/kg | Max | W-Test(3) |
| | Fluoranthene | mg/kg | 6.44E-02 | 8.40E-02 (N) | 9.75E-02 | 8.40E-02 | mg/kg | 95%UCL-N | W-Test(4) |
| | Fluorene | mg/kg | 3.82E-02 | 1.55E-01 (T) | 8.70E-02 | 8.70E-02 | mg/kg | Max | W-Test(5) |
| | Indeno(1,2,3-cd)pyrene | mg/kg | 2.27E-02 | 2.73E-02 (N) | 3.10E-02 | 2.73E-02 | mg/kg | 95%UCL-N | W-Test(4) |
| | Iron | mg/kg | 2.19E+04 | 2.53E+04 (T) | 2.83E+04 | 2.53E+04 | mg/kg | 95%UCL-T | W-Test(2) |
| | Lead | mg/kg | 5.68E+01 | 7.73E+01 (N) | 9.82E+01 | 7.73E+01 | mg/kg | 95%UCL-N | W-Test(4) |
| | Magnesium | mg/kg | 2.93E+03 | 3.31E+03 (N) | 3.59E+03 | 3.31E+03 | mg/kg | 95%UCL-N | W-Test(4) |
| | Manganese | mg/kg | 4.81E+02 | 7.47E+02 (T) | 8.11E+02 | 7.47E+02 | mg/kg | 95%UCL-T | W-Test(2) |
| | Mercury | mg/kg | 3.90E-01 | 5.48E-01 (N) | 5.30E-01 | 5.30E-01 | mg/kg | Max | W-Test(5) |
| | Naphthalene | mg/kg | 2.74E-01 | 1.04E+00 (T) | 6.90E-01 | 6.90E-01 | mg/kg | Max | W-Test(5) |
| | Nickel | mg/kg | 2.44E+01 | 2.98E+01 (N) | 3.27E+01 | 2.98E+01 | mg/kg | 95%UCL-N | W-Test(4) |
| | Nitrobenzene | mg/kg | 8.71E-01 | 1.55E+00 (NP) | 1.50E-01 | 1.50E-01 | mg/kg | Max | W-Test(5) |
| | N-Nitrosodiphenylamine | mg/kg | 1.12E+00 | 1.71E+00 (N) | 2.30E-01 | 2.30E-01 | mg/kg | Max | W-Test(5) |
| | Phenanthrene | mg/kg | 1.94E-01 | 9.42E+00 (T) | 7.10E-01 | 7.10E-01 | mg/kg | Max | W-Test(5) |
| | Potassium | mg/kg | 1.59E+03 | 1.74E+03 (N) | 1.80E+03 | 1.74E+03 | mg/kg | 95%UCL-N | W-Test(4) |
| | Pyrene | mg/kg | 7.73E-02 | 1.44E-01 (T) | 1.50E-01 | 1.44E-01 | mg/kg | 95%UCL-T | W-Test(2) |
| | Sodium | mg/kg | 1.37E+02 | N/A | 1.80E+02 | 1.80E+02 | mg/kg | Max | W-Test(3) |
| | Thallium | mg/kg | 1.93E+00 | 3.01E+00 (N) | 1.90E+00 | 1.90E+00 | mg/kg | Max | W-Test(5) |
| | Vanadium | mg/kg | 4.69E+01 | 5.85E+01 (T) | 6.80E+01 | 5.85E+01 | mg/kg | 95%UCL-T | W-Test(2) |
| | Zinc | mg/kg | 1.45E+02 | 1.82E+02 (N) | 1.95E+02 | 1.82E+02 | mg/kg | 95%UCL-N | W-Test(5) |

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T
Mean of Normal Data (Mean-N), 95% UCL based on bootstrap statistic (95% UCL-Bst)

N/A - Not Applicable; Not Available

Distributions: Determined using ProUCL - Non Parametric (NP); Normal (N); Gamma (G); Lognormal (T

Test(1) The data were determined to be neither normally or lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50)
Bootstrap Statistic used.

Test(2) The data were determined to be lognormally distributed using Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50

Test(3) The 95% UCL was not calculated due to limited number of samples (n<=5); therefore, the maximum detect was used as the EPC

Test(4) The data were determined to be normally distributed using Shapiro-Wilks Shapiro-Wilks (sample size<=50) or the Shapiro-Francia Calculation (sample size > 50

Test(5) The 95% UCL exceeds the maximum detected concentration; therefore, the maximum detect was used as the EPC

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. This toxicity equivalent procedure is described in the HHRA (*Section 5.1.1*).

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, 2000b). The technical basis for this rationale is that soluble and toxic forms of aluminum are only present in soil with soil pH values less than 5.5. The two surface soil samples analyzed for pH at SWMU 31 had pH values of 7.17 and 7.37 (geometric mean of 7.27). However, aluminum was conservatively selected as a COPEC for direct contact exposure due to BTAG's preference to avoid the use of "prescreens" in a SLERA.

### 6.2.6 Summary of COPEC Selection

**Tables 6-7 through 6-12** have been prepared for detected constituents in surface soil, surface water, and sediment, 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.
- COPEC selection conclusion: YES or NO.
- Rationale for selection or rejection of the COPEC.

Footnotes in the tables provide the rationale for selecting or rejecting a chemical as a COPEC.

Thirty-one COPECs (21 inorganic and 10 organic COPECs) have been selected for surface soil for direct contact exposure (**Table 6-7**).

Seventeen COPECs (8 inorganic and 9 organic COPECs) have been selected for surface soil for food chain exposure (**Table 6-10**). Chemicals not eliminated using the screening procedures previously presented are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

Thirty-five COPECs (13 inorganic and 22 organic COPECs) have been selected for surface water direct contact exposure (**Table 6-8**).

Sixteen COPECs (5 inorganic and 11 organic COPECs) have been selected for surface water food chain exposure (**Table 6-11**). Chemicals not eliminated using the screening procedures previously presented are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

Forty-eight COPECs (21 inorganic and 27 organic COPECs) have been selected for sediment direct contact exposure (**Table 6-9**).

Twenty-seven COPECs (8 inorganic and 19 organic COPECs) have been selected for sediment food chain exposure (**Table 6-12**). Chemicals not eliminated using the screening procedures previously presented are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

EPCs based on the statistical procedures discussed in *HHRA Section 5.2.2* are presented in **Tables 6-13 through 6-15**. Arithmetic mean concentrations are presented for informational purposes.

## 6.3 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 a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are viable exposure pathways and were considered in the SLERAs, if relevant. 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 SLERAs. In order to narrow the exposure characterization portion of the SLERAs on species or components that are the most likely to be affected, given the toxicological and mobility characteristics of the COPECs, and on those COPECs that, if affected, are most likely to produce greater effects in the on-site ecosystem, the SLERAs have 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).

- The assessment receptor may be listed as Rare, Threatened, or Endangered (RTE) by a governmental organization; or the receptor will consist of critical habitat for RTE species. Based on the availability of species-specific data, an RTE surrogate species may be selected.

Additional criteria for selection of assessment receptors were used to identify species that offer the most favorable combination of characteristics for determining the implications of on-site contaminants. These criteria included: (1) limited home range; (2) role in local nonhuman food chains; (3) potential high abundance and wide distribution; (4) sufficient toxicological information available in the literature for comparative and interpretive purposes; (5) sensitivity to COPECs; (6) relatively high likelihood of occurrence on-site following remediation (if required); (7) suitability for long-term monitoring; (8) importance to the stability of the ecological food chain or biotic community of concern; and, (9) relatively high likelihood that they will be present or that habitats present could support the species.

It is important that sufficient toxicological information is available in the literature on the receptor species, or that a closely related species may be selected. While the ecological communities have species with many desirable characteristics for use as receptor species, not every species has been used extensively for toxicological testing.

### 6.3.1 Terrestrial Receptors

Five representative receptor species that are expected or possible in the area of SWMU 31 (*Section 6.1*) 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 (*Section 6.1.4*). 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 **Table 6-16** and **Appendix F-2, Tables F-1 through F-10**.

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 in **Figure 6-1**. 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. The selected terrestrial receptor species have a potential high abundance and wide distribution at the site; also, sufficient toxicological information (with the exception of some bird species) is available in the literature for comparative and interpretive purposes. These 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).

Larger mammal species were generally not selected as sensitive receptors due to their large home ranges; however, the far-ranging red-tailed hawk and red fox were retained due to their unique role as top predators in the food chain. Smaller birds, except for the robin, were generally not included because most are migratory. The potential risk to species with larger home ranges and migratory avian species are generally included within the predicted risks to the selected

## Table 6-16
## Data Used to Model Exposure[a] in the Indicator Wildlife Species

| Indicator Species | Body Weight Range (average) (kg) | Average Home Range (ha) [ac] | Maximum Dietary Intake[b] (kg[dw]/day) | Average Dietary Intake[c] (kg[dw]/day) | Soil/Sed. Intake[d] (%Diet) (Avg – Max) (kg[dw]/day) | Maximum Water Intake[b] (L/day) | Average Water Intake[c] (L/day) | Trophic Level | Dietary Composition |
|---|---|---|---|---|---|---|---|---|---|
| Meadow vole (*Microtus pennsylvanicus*) | 0.0170-0.0524<br>(0.037) | 0.036<br>[0.089] | 0.010 | 0.0080 | (2.4%)<br>0.00019-0.00024 | 0.0070 | 0.0051 | Herbivore | Plants: 100% |
| Short-tailed shrew *(Blarina brevicauda)* | 0.0125-0.0225<br>(0.015) | 0.39<br>[0.96] | 0.0030 | 0.0022 | (10.4%)<br>0.00023-0.00031 | 0.0033 | 0.0023 | Insectivore | Terr. Inverts: 100% |
| American robin *(Turdus migratorius)* | 0.0635-0.103<br>(0.0773) | 0.48<br>[1.2] | 0.020 | 0.016 | (4%)<br>0.00064-0.00080 | 0.013 | 0.011 | Omnivore | Plants: 62%<br>Terr Inverts: 38% |
| Red-tailed hawk (*Buteo jamaicensis*) | 0.957-1.235<br>(1.134) | 842<br>[2081] | 0.063 | 0.059 | (0%) | 0.068 | 0.064 | Carnivore | Mammals: 76%<br>Birds: 24% |
| Red fox *(Vulpes vulpes)* | 2.95-7.04<br>(4.53) | 892<br>[2204] | 0.34 | 0.24 | (2.8%)<br>0.0067-0.0095 | 0.57 | 0.39 | Carnivore | Mammals: 65%<br>Birds: 14%<br>Plants: 17%<br>Terr. Inverts: 4% |
| Great blue heron (*Ardea herodias*) | 2.20-2.58<br>(2.34) | 8.4<br>[21] | 0.11 | 0.10 | (2%)<br>0.0020-0.0022 | 0.11 | 0.10 | Piscivore | Fish: 96%<br>Aq. Inverts: 4% |
| Mink *(Mustela vison)* | 0.55-1.73<br>(1.02) | 14.1<br>[35] | 0.11 | 0.070 | (2%)<br>0.0014-0.0022 | 0.16 | 0.10 | Omnivore | Plants: 18%<br>Fish: 65%<br>Aq. Inverts: 12%<br>Birds: 2.5%<br>Mammals: 2.5% |

[a] From USEPA (1993), except as noted.

[b] Maximum dietary and water intake based on appropriate allometric equation using maximum body weight.

[c] Average dietary and water intake based on appropriate allometric equation using average body weight.

[d] Soil/sediment ingestion rate based on estimated percent soil in diet (dry weight), and maximum or average dietary intake.

Allometric equations for mammals and birds from USEPA (1993), as follows, where FI = food ingestion (dry weight [dw]), WI = water ingestion, Wt = body weight, kg = kilogram, L = liter, and g = gram:

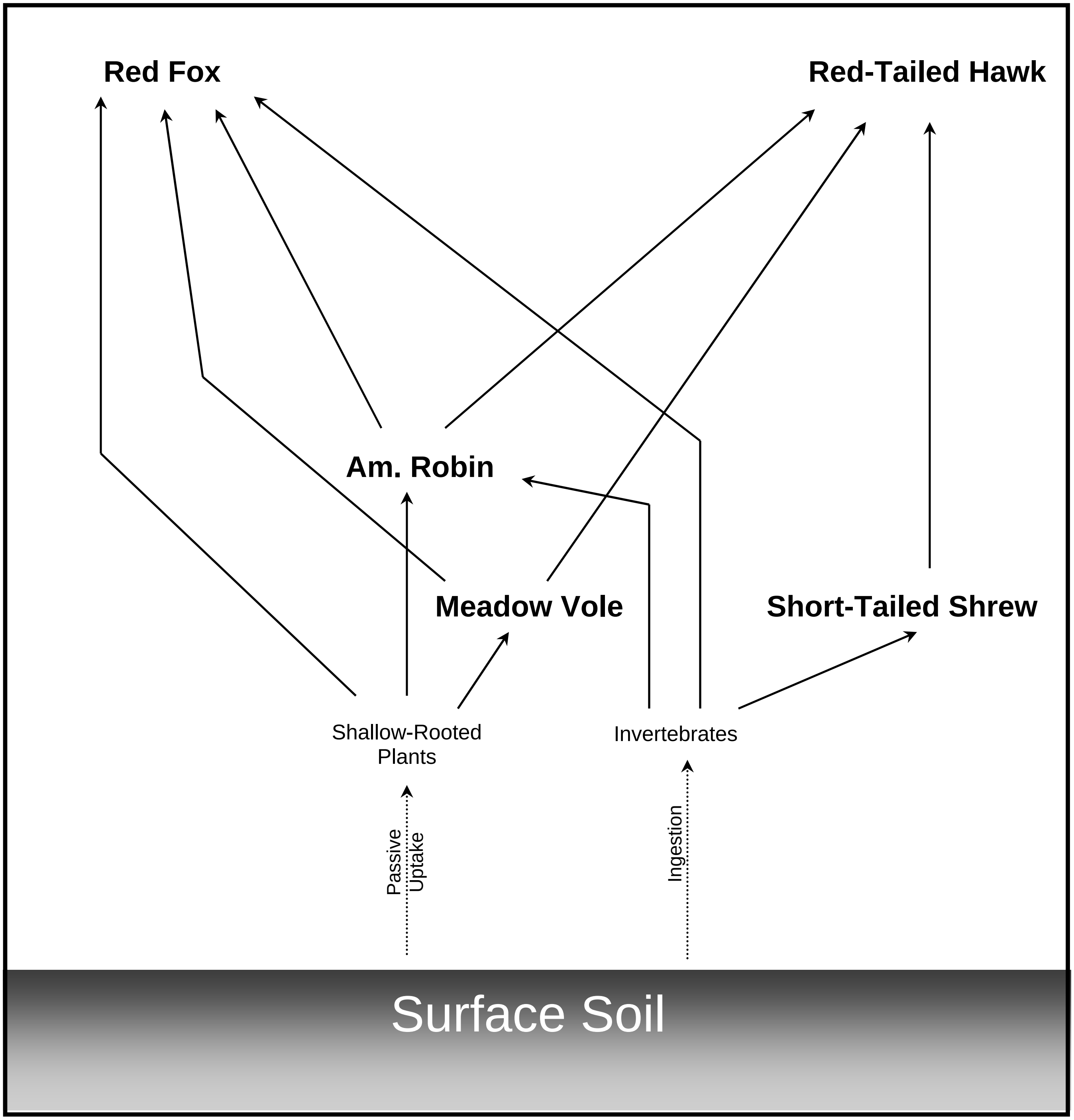
FI (kg/day) = 0.0687 $Wt^{0.822}$ for mammals (shrew, red fox, and mink),
FI (g/day) = 0.577 $Wt^{0.727}$ for herbivores (meadow vole),
FI (g/day) = 0.301 $Wt^{0.751}$ for non-passerine birds (red-tail hawk, great blue heron),
FI (g/day) = 0.398 $Wt^{0.850}$ for passerine birds (American robin).
WI (L/day) = 0.099 $Wt^{0.90}$ (Wt in kg) for mammals,
WI (L/day) = 0.059 $Wt^{0.67}$ (Wt in kg) for birds.
ha = hectare
ac = acre, and a hectare = 2.471 acres.

Notes:

The soil ingestion rate for the shrew set equal to the rate for the American woodcock (10.4% of diet), as both species feed predominantly on earthworms.

The soil ingestion rate for the American robin set equal to 48% of the American woodcock value (0.38 x 10.4% = 4%), based on a robin diet of 38% invertebrates (earthworms).

## Figure 6-1
## Simplified Terrestrial Food Web
## Conceptual Site Exposure Model (CSEM)



terrestrial indicator receptors. 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 in length, and weighs between 17 and 52 grams (USEPA, 1993). It is likely to have a relatively high rate of incidental soil ingestion given that it is sometimes coprophagous (consumes its own feces for secondary nutrient adsorption) and builds runways and burrows in the soil. 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 is the largest shrew found in North America. It is solid gray above and below, with a short tail, and 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 this SLERA (**Appendix F-2, Tables F-3 and F-4**). Longevity is typically around 20 months (USEPA, 1993), with 5 to 8 young born to each of 2 to 3 litters (Burt and Grossenheider, 1980).

**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 centimeters in size, have a body weight range of 63 to 103 grams, and an average home range of 1.2 acres (USEPA, 1993). The average longevity of a robin that survives to its first January is from 1.3 to 1.4 years (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 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 reports an average territory size of 2,081 acres (USEPA, 1993). 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 reports an average body weight of 1,134 grams (USEPA, 1993). More northerly populations are migratory, while the more southerly are year-round residents. They typically mate for life or until one of the pair dies, with pairs clinging to territories year after year (Austing, 1964).

**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 centimeters, with a 35 to 41 centimeter 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). Red fox incur high mortality rates as a result of shooting, trapping, disease, and accidents. Fecundity is higher in areas of high mortality and low population density.

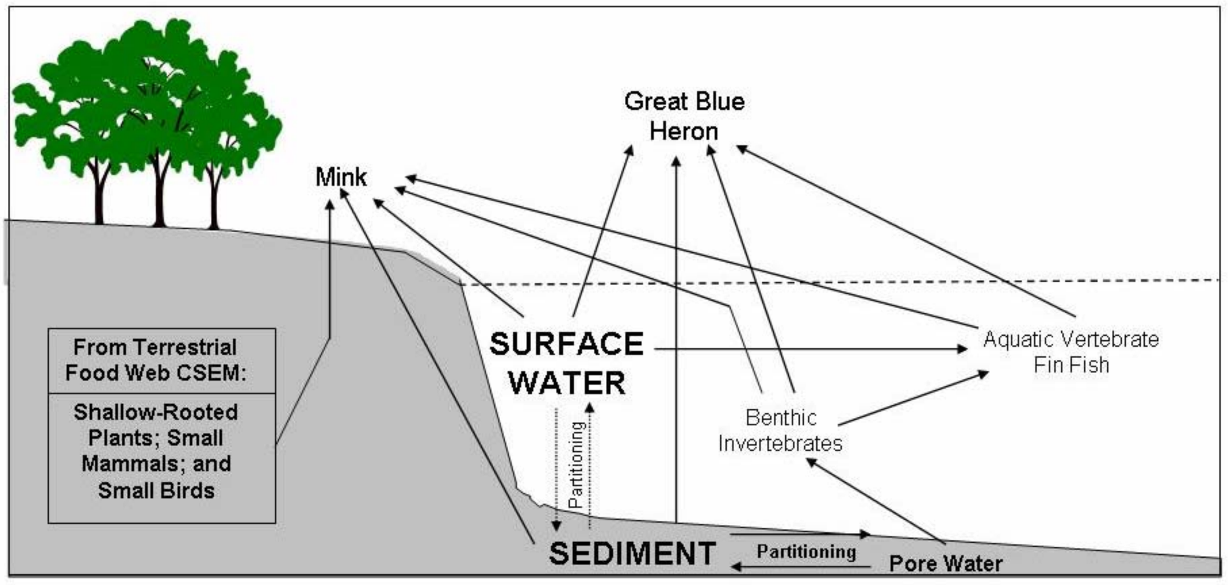
A pictorial representation of potential exposure has been prepared and is presented as **Figure 6-1**. This food web pictorial clarifies the conceptual site exposure model (CSEM). The CSEM traces the contaminant pathways through both abiotic components and biotic food web components of the environment. The CSEM presents potentially complete exposure pathways. The CSEM has been used as a tool for judging the appropriateness and usefulness of the selected measurement endpoints in evaluating the assessment endpoints, and for identifying sources of uncertainty in the exposure characterization.

### 6.3.2 Aquatic Receptors

Two representative aquatic receptor species that are expected or possible in the area of SWMU 31 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. 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 **Table 6-16** and **Appendix F-2**, **Tables F-11 through F-14.** It should be noted that potential impacts to aquatic plants and other aquatic biota are assessed by comparing measured surface water and sediment COPEC concentrations with available direct-contact criteria. Per a request from BTAG, an amphibian assessment is presented in *Section 6.9*).

An aquatic food web is presented on **Figure 6-2**. 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 the bird species) is available in the literature for comparative and interpretive purposes. In addition, the selected species are likely to occur after

## Figure 6-2
## Simplified Aquatic Food Web
## Conceptual Site Exposure Model (CSEM)



site remediation (if risk management decisions require it). 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.

**Great Blue Heron.** The great blue heron is the largest member of its group in North America (99 to 132 centimeters) (Bull and Farrand, 1995), with body weights ranging from 2.2 to 2.58 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).

## 6.4 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. Key aspects of ecological protection are presented as policy goals. These are general goals established by legislation or agency policy that are based on societal concern for the protection of certain environmental resources. For example, environmental protection is mandated by a variety of legislation and government agency policies (e.g., CERCLA, National Environmental Policy Act). Other legislation includes the Endangered Species Act 16 U.S.C. 1531-1544 (1993, as amended) and the Migratory Bird Treaty Act 16 U.S.C. 703-711 (1993, as amended). To assess whether these protection goals 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, the SLERA focuses on populations or groups of interbreeding nonhuman, nondomesticated receptors. In the SLERA process, the risks to individuals are generally assessed if they are protected under the Endangered Species Act.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Suggested criteria that may be considered in selecting assessment endpoints suitable for a specific ecological risk assessment are:

1. Ecological relevance.
2. Susceptibility to the contaminant(s).
3. Accessibility to prediction and/or measurement.
4. Definable in clear, operational terms (Suter, 1993).

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

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. Information gained during the site reconnaissance was used to assist in the selection of assessment and measurement endpoints. These endpoints, formal expressions of the environmental values to be protected (Suter, 1993), have been used to focus the goals of the SLERA.

Measurement endpoints for this SLERA 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. COPECs for those receptors and endpoints have been identified by drawing on the scientific literature to obtain information regarding potential toxic effects of site chemicals to site species. This process ensures that a conservative approach is taken in selecting endpoints and evaluating receptors that are likely to be adversely affected by the potentially most toxic chemicals measured at SWMU 31.

### 6.4.1 Assessment Endpoints

ERAGS (USEPA, 1997d) 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 SWMU 31 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 effect on the survival or reproductive capabilities of populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds.

Assessment receptor species were selected based on the likelihood of finding the species at SWMU 31. Historical information, the site reconnaissance, and the availability of toxicological data were used to select terrestrial and aquatic receptor species. These receptors species are depicted in the food web models (**Figures 6-1 and 6-2**). Food web models are simplified versions of the possible movement of contaminants through the food chain present or potentially present. Due to lack of data for every possible species, key species have been selected to represent broad classes, or guilds.

The food web CSEMs were developed to illustrate how the selected terrestrial and aquatic species are ecologically linked within food webs. One species was used to represent each of the major trophic levels and habitats. The decision was made not to complicate the food web models with detailed species selection at the base of the food web (i.e., specific terrestrial or aquatic invertebrates). Thus, generic terrestrial and aquatic invertebrates were used to represent the bottom of the food chain. 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 6.5.2*). These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary route of exposure. Brief life-history descriptions for the selected receptor species are provided in *Section 6.3*.

Trophic levels may be exposed to COPECs, either by direct exposure to contaminated abiotic media or through ingestion of lower trophic level food items. Primary producers (plants) absorb COPECs (as well as nutrients) from soil and/or water. In terrestrial and aquatic ecosystems, species bioconcentration occurs in plants and invertebrates, and higher food chain receptors bioaccumulate COPECs through the ingestion of food items.

### 6.4.2 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. Examples of typical measurement endpoints include mortality, growth or reproduction in toxicity tests; individual abundance; species diversity; and the presence or absence of indicator data in field surveys of existing impacts (USEPA, 1997c).

For assessments, measurable responses to stressors may include LOAELs, NOAELs, $LC_{50}$ (lethal concentration to 50 percent of the test population), or $LD_{50}$ (lethal dose to 50 percent of the test population), collectively termed toxicity endpoint values (see *Section 6.6.2* for further explanation). The most appropriate measurement endpoint(s) were chosen based on exposure pathways as well as ecotoxicity of the contaminant.

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.

## 6.5 EXPOSURE ESTIMATION

This section includes a discussion of how COPEC exposures were quantified, including intake (*Section 6.5.1*) and bioaccumulation (*Section 6.5.2*).

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site was developed, considering both current and reasonably plausible future use scenarios. Exposure characterization is critical in further evaluating the risk of compounds identified as COPECs during the selection process. The exposure assessment was conducted by linking the magnitude (concentration) and distribution (locations) of the constituents detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and identifying the points at which organisms found in the study area may contact contaminants.

An exposure analysis was performed, which combines the spatial and temporal distribution of the ecological receptors with those of the COPECs to evaluate exposure. The exposure analysis focuses on the chemical concentrations that are assumed to be bioavailable, and the means by which the ecological receptors are exposed (e.g., exposure pathways). The focus of the analysis is dependent on the assessment receptors being evaluated as well as the assessment and measurement endpoints.

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. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants. 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 6.3*, dermal contact and inhalation exposures are considered insignificant compared to other quantified routes of exposure.

Contamination of biota could result from exposure to one or more COPECs. Bioavailable compounds are those that a receptor can take in from the environment. Bioavailability of a chemical is a function of several physical and chemical factors such as grain size and organic carbon content.

Bioavailability of a chemical is an important contaminant characteristic that influences the degree of chemical-receptor interaction. It is a function of several physical and chemical factors such as soil moisture, soil/sediment pH, soil cation exchange capacity, sediment TOC, water hardness, and water total suspended solids (TSS). Bioavailability significantly influences whether potential soil, surface water, or sediment contaminants remain chemically bound (i.e., unavailable) in the matrix or whether they can be chemically mobilized (in a bioavailable form) and released for plant or biota absorption. Generally, neutral to alkaline soil (soil pH of 6.5 or greater) restrict the absorption of toxic metals, making pathway completion to plants difficult. As discussed in *Section 6.2.5*, the surface soil geometric mean of pH at SWMU 31 is 7.27. For purposes of the SLERAs, bioavailability is conservatively assumed to be 100 percent.

Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. These components have been addressed within this SLERA. If these components are not complete, then contaminants in those media do not constitute an environmental risk at that specific site. The major fate and transport properties associated with typical site contaminants directly affect a contaminant’s behavior in each of the exposure pathway components.

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 these SLERAs are based solely upon ingestion of contaminants from these media and from consumption of other organisms.

### 6.5.1 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 sediment, and are incorporated for the receptor species. This information is summarized in **Table 6-16** and **Appendix F-2**, **Tables F-1 through F-14**. For the SLERAs, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil or sediment 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 or sediment intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95 percent UCLs. The SWMU 31 site areas for water, soil and total area (water and soil combined) were estimated to be 0.74, 1.26, and 2.003 acres, respectively. 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 and aquatic vertebrates (excluding fish) that account for exposure via ingestion of contaminated water, incidental ingestion of contaminated soil or sediment, ingestion of plants grown in contaminated soil, and prey items.

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 k<sup>th</sup> food type (mg/kg dry weight)
$F_k$ = the fraction of the $k^{th}$ food type that is contaminated
$I_k$ = the ingestion rate of the $k^{th}$ 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 (**Appendix F-2**, **Tables F-1 through F-14**).

### 6.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERAs, bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for soil-to-plants, soil-to-earthworms, soil-to-small mammals and birds, sediment-to-aquatic invertebrate, and water-to-fish are presented in **Appendix F-2**, **Tables F-15, F-16, F-17, F-18, and F-19**, 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, 2001b) and the RFAAP Final MWP (URS, 2002). 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-15**) are based on information from Bechtel Jacobs (1998a), USEPA (2005e), Efroymson (2001), Baes et al. (1984), International Atomic Energy Agency (IAEA) (1994), and Travis and Arms (1988). Tier 2 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 (Note: the median is used for the Tier 2 because this is the reported BAF/BCF. It should be noted that as the Tier 2 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-15)

In order to estimate Tier 1 and Tier 2 BAF/BCF plant uptake values using the Travis and Arms (1988) regression equation, the lowest log $K_{ow}$ from the literature was used (as plant uptake is inversely related to $K_{ow}$). For the Tier 2 approach, a more accurate (average) log $K_{ow}$ value from the Syracuse Research Corporation (SRC) website (http://esc.syrres.com) was used. SRC's interactive website estimates log $K_{ow}$ values for organic chemicals using an atom/fragment contribution method, based on the method developed by Meylan and Howard (1995). BAF/BCF values estimated for organics using the Travis and Arms (1988) equation ranged from 0.011 for the Tier 1 approach (for 2,3,7,8-TCDD) to 0.004 for the Tier 2 approach (for 2,3,7,8-TCDD) (**Appendix F-2**, **Table F-15**).

Soil-to-earthworm BAF/BCF values (**Appendix F-2**, **Table F-16**) are based on information from Sample et al. (1998a), Sample et al. (1999), and USEPA (2005e). Earthworms are used as a surrogate species to represent terrestrial invertebrates including insects. Tier 2 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, 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-17**) are based on information from USEPA (2005e) and Sample et al. (1998b). Tier 2 values are based on regression equations (USEPA, 2005e) or upperbound BAF/BCF values if no regression equation is available.

Sediment-to-aquatic invertebrate BAF/BCF values (**Appendix F-2**, **Table F-18**) are based on information from Bechtel Jacobs (1998b). If no uptake value was available for a particular COPEC, a soil-to-terrestrial invertebrate BAF/BCF value was used (from **Appendix F-2**, **Table F-16**). However, for 2,3,7,8-TCDD, BAF/BCF values available for PCBs were used as a surrogate, as both PCBs and TCDD are known bioaccumulators with BAF/BCF values suspected to be greater than one. 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. For inorganic COPECs without an available BAF/BCF value, geometric means of the available inorganic uptake values from Bechtel Jacobs (1998b) were used: the geometric mean of the 90th percentile values was used for the Tier 1 BAF/BCF value and the geometric mean of the median values was used for the Tier 2 BAF/BCF value.

Water-to-fish BAF/BCF values (**Appendix F-2, Table F-19**) are based on information from IAEA (1994), Bintein and Devillers (1993), USEPA (1999b), 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 the surface water organic COPECs at SWMU 31 that did not have available literature uptake values, the following equation from Bintein and Devillers (1993) 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-19)

Fish BAF/BCF values estimated using the Bintein and Devillers (1993) equation ranged up to 10,546 (for endrin) (**Appendix F-2**, **Table F-19**). Due to the elevated BAF/BCF values produced by this equation (compared with BAF/BCF values estimated using $K_{ow}$ equations for soil-to-plant uptake), both Tier 1 and Tier 2 approaches used the more accurate log $K_{ow}$ value from the SRC website (http://esc.syrres.com) presented previously. SRC's interactive website estimates log $K_{ow}$ values for organic chemicals using an atom/fragment contribution method, based on the method developed by Meylan and Howard (1995).

These estimated tissue concentrations are used to predict wildlife intakes and are combined with COPEC toxicity values, discussed in the following section, to characterize potential ecological risk. The general uncertainties associated with the estimation of chemical intake and uptake are discussed in the uncertainty section.

For direct contact exposure for soil invertebrates to COPECs in surface soil, sediment invertebrates to COPECs in sediments, and aquatic biota to COPECs in surface water, measured COPEC concentrations in these media were simply compared with direct contact benchmarks appropriate for the soil and aquatic biota communities.

## 6.6 ECOLOGICAL EFFECTS CHARACTERIZATION

This ecological effects characterization section presents the selection of literature benchmark values and the development of reference toxicity values, and the approach for evaluating direct contact toxicity.

### 6.6.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values have been consulted, such as (1) Toxicological Benchmarks for Wildlife (Sample et al., 1996); Development of Toxicity Reference Values for Conducting Ecological Risk Assessments at Naval Facilities in California (Engineering Field Activity, West, 1998); Review of the Navy - USEPA Region IX BTAG Toxicity Reference Values for Wildlife (CH2M-Hill, 2000); and, (2) LD50 values from data bases such as the Registry of Toxic Effects Concentrations (RTEC) [extrapolated to chronic NOAEL or LOAEL values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors]. The level of effort has been limited to documents that summarize the available ecotoxicological information and does not consist of a review of the primary toxicological literature (i.e., details of toxicity test conditions were not reviewed to assess validity of the tests performed).

### 6.6.2 Development of Toxicity Reference Values

Toxicity reference values (TRVs) were selected from available data for use in the SWMU 31 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 in the following paragraphs.

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. As previously noted, where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical have been gathered for use in the SLERA.

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-20 and F-21** for NOAEL and LOAEL TRVs, respectively. 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 uncertainty factors are 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-22** for the receptors used in this SLERA. 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 6.7*.

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 (*Section 6.5*).

## 6.7 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.

### 6.7.1 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 (*Section 6.1.4*), and no obvious signs of vegetative stress were noted. The overall health of the grassland community at the site was comparable to the grasslands in the surrounding area. Plants were not quantitatively evaluated in this SLERA as the RFAAP Final MWP (URS, 2002) 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 site (i.e., mowing on an infrequent basis to eliminate woody plants), risks to plants are not quantitatively evaluated; however, plants (and invertebrates) are included in the SLERA as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

### 6.7.2 Predictive Risk Estimation for Terrestrial Wildlife and Aquatic Wildlife

The potential wildlife risks associated with SWMU 31 are estimated in this SLERA. 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 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 (Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. The criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that 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 1.0 to 815 (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 and aquatic receptors at SWMU 31 are presented in risk characterization tables (**Appendix F-2, Tables F-1 through F-14**) for the seven selected receptor species. The summed EEQs are presented in **Table 6-17** (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 6-17**, Tier 1 total EEQs ranged from approximately 2 to 800 for the seven receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew and mink were predicted to be the most impacted, followed by the American robin, the red-tailed hawk, the red fox, the meadow vole, and great blue heron, respectively. Inorganic and organic constituents including arsenic, copper, DDE, DDT, TCDD, and zinc were the COPECs contributing the most to the total EEQs for the receptors. Exposure pathways of most concern, based on the results of the food-chain modeling, were invertebrate, plant, small mammal, fish, and incidental sediment ingestion.

More realistic Tier 2 total EEQs were also elevated, especially values based on NOAEL TRVs, which ranged from less than one to approximately 100. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs. Both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk, great blue heron, mink, and red fox were equal to or less than one. Tier 2 total EEQs based on LOAEL values were approximately 14 for the American robin, nine for the short-tailed shrew, and one for the meadow vole, although no individual EEQ exceeded one for the meadow vole (**Table 6-17**). The hazard driver for the American robin was DDT based on invertebrate ingestion and TCDD was the hazard drivers for the short-tailed shrew based on invertebrate ingestion.

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

## Table 6-17
## SWMU 31 Wildlife EEQ Hazard Summary

| Receptor | Tier 1[a] |  | Tier 2[b] |  |
|---|---|---|---|---|
|  | NOAEL-Based EEQ | LOAEL-Based EEQ | NOAEL-Based EEQ | LOAEL-Based EEQ |
| Meadow vole | 14 | 3.6 | 4.9 | 1.3 |
| Hazard Driver(s)[c]: | As, Cu - soil and plant ingestion |  | As, Cu - soil and plant ingestion |  |
| Short-tailed shrew | 815 | 94 | 70 | 9.4 |
| Hazard Driver(s)[c]: | TCDD - terr. invertebrate ingestion |  | TCDD - terr. invertebrate ingestion |  |
| American robin | 208 | 30 | 97 | 14 |
| Hazard Driver(s)[c]: | DDT - terr. invertebrate ingestion |  | DDT - terr. invertebrate ingestion |  |
| Red-tailed hawk | 70 | 7.7 | 0.033 | 0.0037 |
| Hazard Driver(s)[c]: | DDE - mammal ingestion |  | --- |  |
| Red fox | 34 | 4.5 | 0.0053 | 0.00078 |
| Hazard Driver(s)[c]: | TCDD - terr. invertebrate and mammal ingestion |  | --- |  |
| Mink | 82 | 11 | 0.60 | 0.078 |
| Hazard Driver(s)[c]: | TCDD - aq. invertebrate ingestion |  | --- |  |
| Great blue heron | 9 | 1.8 | 0.085 | 0.023 |
| Hazard Driver(s)[c]: | Zn - fish ingestion |  | --- |  |

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.

[b] Tier 2 = EEQ using 95 percent EPC, non-max BAF/BCF, 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

**American Robin.** The total EEQs for both NOAEL and LOAEL TRVs exceeded one (97 and 14). Six COPECs had individual NOAEL-based EEQs that exceeded one (EEQ in parenthesis): DDT (46), zinc (22), chromium (3.2), lead (2.9), cadmium (2.3), and 2,3,7,8-TCDD-TE (1.6). Four COPECs had individual LOAEL-based EEQs that exceeded one (EEQ in parenthesis): DDT (4.6), chromium (3.1), zinc (2.4), and DDE (1.3). The primary exposure pathway was the ingestion of invertebrates. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-6**.

**Meadow Vole.** The total EEQs for both NOAEL and LOAEL TRVs exceeded one (4.9 and 1.3, respectively). One COPEC had an individual NOAEL-based EEQ that exceeded one (EEQ in parenthesis): arsenic (2.4). No COPECs had individual LOAEL-based EEQs that exceeded one. The results of the meadow vole Tier 2 risk evaluation is presented in **Appendix F-2, Table F-2**.

**Short-tailed Shrew.** The total EEQs for both NOAEL and LOAEL TRVs exceeded one (70 and 9.4, respectively). Seven COPECs had individual NOAEL-based EEQs that exceeded one (EEQ in parenthesis): 2,3,7,8-TCDD-TE (42), arsenic (14), cadmium (5.3), zinc (2.9), lead (2.2), Aroclor 1254 (1.4), and copper (1.1). Three COPECs had individual LOAEL-based EEQs that exceeded one (EEQ in parenthesis): 2,3,7,8-TCDD-TE (4.2), zinc (1.5), and arsenic (1.4). The primary exposure pathway was the ingestion of invertebrates. The results of the short-tailed shrew Tier 2 risk evaluation is presented in **Appendix F-2, Table F-4**.

### 6.7.3 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 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 media such as surface water, soil, or sediment. The results are summarized in **Tables 6-18 through 6-20**.

#### 6.7.3.1 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, 2005e), or if an EcoSSL was not available, with the lowest BTAG (USEPA, 1995c) soil screening value (**Table 6-18**). 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. Based on the results of this first step, 12 COPECs were selected (**Table 6-18**). In the second step, the MDC of these 12 COPECs was compared with five individual soil screening values that are referenced on the USEPA Region 3 BTAG website for direct contact toxicity, listed as follows (in additional to the BTAG screening value, if one was available):

- NOAA Screening Quick Reference Table (SQuiRT) values (Buckman, 1999).
- Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guideline values (CCME, 2003).
- EcoSSLs for invertebrate or plant toxicity (USEPA, 2005e).
- ORNL Benchmarks for Plants (ORNL, 1997a).
- ORNL Benchmarks for Soil Invertebrates (ORNL, 1997b).

The results of this second weight of evidence screening step are as follows:

- The chromium MDC exceeded two of the three available benchmarks; however, the EcoSSL guidance (USEPA, 2005e) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent.
- The cobalt MDC exceeded one of the three available benchmarks; however, this exceedance was for plant toxicity, and as discussed in *Section 6.7.4*, plant toxicity is not an overriding concern for the site.
- The magnesium MDC exceeded the one available benchmark from BTAG; however, no reference is available to determine the basis or appropriateness of the BTAG value.

# Table 6-18
# Direct Toxicity Evaluation for Surface Soil at SWMU 31

| Chemical (1) | Detection Frequency | Maximum Concentration (for informational purposes) | 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 | NOAA SQuiRT 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 | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,3,7,8-TCDD-TE (RME) | 2/2 | 8.37E-06 | 2.66E-07 | 1.00E-02 | No | | | | | | | | |
| Aluminum | 2/2 | 1.55E+04 | 7.21E+03 | pH < 5.5 | No | | | | | | | | |
| Antimony | 1/1 | 5.86E-01 | 5.86E-01 | 2.70E-01 | Yes | Mammal tox | NVA | 20 | 78 | 5.0 | NVA | 0/3 | No exceedences |
| Arsenic | 2/2 | 5.90E+00 | 1.07E+00 | 1.80E+01 | No | | | | | | | | |
| Barium | 2/2 | 9.64E+01 | 9.04E+01 | 3.30E+02 | No | | | | | | | | |
| Beryllium | 2/2 | 7.35E-01 | 6.34E-01 | 2.10E+01 | No | | | | | | | | |
| Cadmium | 2/2 | 4.62E-01 | 8.30E-02 | 3.60E-01 | Yes | Mammal tox | NVA | 1.4 | 32 | 4.0 | 20 | 0/4 | No exceedences |
| Calcium | 2/2 | 5.67E+04 | 1.96E+03 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Chromium (Cr III tox) | 2/2 | 2.82E+01 | 1.58E+01 | 2.60E+01 | Yes | Bird tox (Cr III) | NVA | 64 | NVA | 1.0 | 0.4 | 2/3 | EcoSSL says data insufficient to derive direct contact SSL |
| Chromium (Cr VI tox) | 2/2 | 2.82E+01 | 1.58E+01 | 8.10E+01 | No | | | | | | | | |
| Cobalt | 2/2 | 1.78E+01 | 7.69E+00 | 1.30E+01 | Yes | Plant tox | NVA | 40 | 13 | 20 | NVA | 1/3 | Plant tox |
| Copper | 2/2 | 1.77E+01 | 1.71E+01 | 2.80E+01 | No | | | | | | | | |
| Iron | 2/2 | 2.78E+04 | 9.58E+03 | pH < 5.0 | No | | | | | | | | |
| Lead | 2/2 | 2.80E+01 | 1.46E+01 | 1.10E+01 | Yes | Bird tox | NVA | 70 | 120 | 50 | 500 | 0/4 | No exceedences |
| Magnesium | 2/2 | 2.50E+04 | 4.65E+03 | 4.40E+03 | Yes | No reference | NVA | NVA | NVA | NVA | NVA | 1/1 | No reference |
| Manganese | 2/2 | 4.95E+02 | 2.03E+02 | 3.30E+02 | Yes | No reference | NVA | NVA | NVA | 500 | NVA | 1/2 | No reference |
| Mercury (Inorganic) | 2/2 | 1.21E-01 | 3.50E-02 | 5.80E-02 | Yes | No reference | NVA | 6.6 | NVA | 0.3 | 0.1 | 2/4 | EcoSSL says data insufficient to derive direct contact SSL |
| Nickel | 2/2 | 1.48E+01 | 1.15E+01 | 2.00E+00 | Yes | Plant tox (fungi) | NVA | 50 | NVA | 30 | 200 | 1/4 | Fungi not relevant |
| Potassium | 2/2 | 2.12E+03 | 9.38E+02 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Sodium | 2/2 | 7.75E+01 | 2.98E+01 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Thallium | 2/2 | 3.40E-01 | 2.30E-01 | 1.00E-03 | Yes | Plant tox (no ref) | NVA | 1.0 | NVA | 1.0 | NVA | 1/3 | No reference |
| Vanadium | 2/2 | 4.75E+01 | 2.20E+01 | 7.80E+00 | Yes | Bird tox | NVA | 130 | NVA | 2.0 | NVA | 1/2 | EcoSSL says data insufficient to derive direct contact SSL |
| Zinc | 2/2 | 9.85E+01 | 6.02E+01 | 1.00E+01 | Yes | Plant tox (OHMTADS) | NVA | 200 | NVA | 50 | 200 | 2/4 | Plant tox |
| 4,4'-DDD | 1/2 | 6.98E-04 | 6.98E-04 | 1.00E-01 | No | | | | | | | | |
| 4,4'-DDE | 1/2 | 2.26E-03 | 2.26E-03 | 1.00E-01 | No | | | | | | | | |
| 4,4'-DDT | 1/2 | 1.33E-02 | 1.33E-02 | 1.00E-01 | No | | | | | | | | |
| Aroclor 1254 | 1/2 | 9.31E-02 | 9.31E-02 | 1.00E-01 | No | | | | | | | | |
| Endosulfan II | 1/2 | 2.28E-03 | 2.28E-03 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Endosulfan sulfate | 1/2 | 8.93E-04 | 8.93E-04 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Endrin aldehyde | 1/2 | 1.79E-03 | 1.79E-03 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |
| Methoxychlor | 1/2 | 7.65E-03 | 7.65E-03 | 1.00E-01 | No | | | | | | | | |
| Nitroglycerin | 1/2 | 4.20E-01 | 4.20E-01 | NVA | NVA | | NVA | NVA | NVA | NVA | NVA | | |

All values presented in mg/kg.
NVA = No Value Available
Soil pH ranged from 7.13 to 7.37.

(1) COPECs from Table 6-7.
(2) Lowest screening toxicity values from BTAG (1995) or EcoSSL (USEPA, 2005). EcoSSLs given highest priority as they are more definitive.
(3) NOAA SQuiRT (Buckman, 1999).
(4) Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, 2003.
(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2005).
(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).

# Table 6-19
# Direct Contact Evaluation for Surface Water at SWMU 31
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| COPEC | MDC (ug/L) | EPC (ug/L) | USEPA Region 3 BTAG (ug/L) $^{A}$ | Retain COPECs as Max Conc > USEPA Region 3 BTAG Value? | NAWQC (ug/L) $^{B}$ | | Virginia Criteria (ug/L) $^{C}$ | | Tier II Secondary Values (ug/L) $^{D}$ | | Lowest Chronic Values (ug/L) $^{D}$ | | | | USEPA Region 4 Benchmark Screening Values (ug/L) $^{E}$ | COPEC Weight of Evidence Exceedence Summary | | Final COPEC? | Comment $^{F}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acute | Chronic | Acute | Chronic | Acute | Chronic | Fish | Daphnids | Non-Daphnids | Aquatic Plants | | Using MDC | Using EPC | | |
| 1,2-Dichlorobenzene | 2.50E-01 | 2.50E-01 | 7.00E-01 | No | | | | | | | | | | | | | | | |
| 1,3-Dichlorobenzene | 2.60E-01 | 2.60E-01 | 1.50E+02 | No | | | | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | 2.60E-01 | 2.60E-01 | 2.60E+01 | No | | | | | | | | | | | | | | | |
| 2,4,5-TP | 2.90E-02 | 2.90E-02 | 3.00E+01 | No | | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 3.10E-02 | 3.10E-02 | 4.70E+00 | No | | | | | | | | | | | | | | | |
| alpha-BHC | 9.15E-03 | 9.15E-03 | NVA | NVA | NVA | NVA | NVA | NVA | 39 | 2.2 | NVA | 95 | NVA | NVA | 5,000 | 0/4 | 0/4 | No | (3) |
| Aluminum | 1.32E+04 | 1.32E+04 | 8.70E+01 | **Yes** | 750 $^{G}$ | 87 $^{G}$ | NVA | NVA | NVA | NVA | 3,288 | 1,900 | NVA | 460 | 87 | 7/7 | 7/7 | Yes | (1,2) |
| Barium | 3.56E+01 | 2.99E+01 | 4.00E+00 | **Yes** | NVA | NVA | NVA | NVA | 110 | -- | NVA | NVA | NVA | NVA | NVA | 1/2 | 1/2 | Yes | (2) |
| Benzoic acid | 1.20E+01 | 1.20E+01 | 4.20E+01 | No | | | | | | | | | | | | | | | |
| Bromodichloromethane | 3.60E+00 | 3.60E+00 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | 11,000 | 0/1 | 0/1 | No | (3) |
| Butylbenzylphthalate | 1.20E+00 | 1.20E+00 | 1.90E+01 | No | | | | | | | | | | | | | | | |
| Calcium | 1.58E+04 | 1.50E+04 | 1.16E+05 | No | | | | | | | | | | | | | | | |
| Chromium (total) | 4.70E+00 | 4.64E+00 | 8.50E+01 | No | | | | | | | | | | | | | | | |
| delta-BHC | 1.49E-02 | 1.49E-02 | 1.41E+02 | No | | | | | | | | | | | | | | | |
| Dibromochloromethane | 2.00E-01 | 2.00E-01 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | 6,400 | 0/1 | 0/1 | No | (3) |
| Dicamba | 1.54E-01 | 1.54E-01 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (4) |
| Diethylphthalate | 8.00E+00 | 4.56E+00 | 2.10E+02 | No | | | | | | | | | | | | | | | |
| Di-n-butylphthalate | 1.00E+00 | 1.00E+00 | 1.90E+01 | No | | | | | | | | | | | | | | | |
| Endosulfan II | 7.60E-02 | 7.60E-02 | 5.10E-02 | **Yes** | 0.22 | 0.056 | 0.22 | 0.056 | NVA | 0.051 | NVA | NVA | NVA | NVA | 0.056 | 5/7 | 5/7 | Yes | (1,2) |
| Endrin | 8.34E-02 | 8.34E-02 | 3.60E-02 | **Yes** | 0.086 | 0.036 | 0.086 | 0.036 | NVA | NVA | NVA | NVA | NVA | NVA | 0.0023 | 4/6 | 4/6 | Yes | (1,2) |
| Hexachlorobutadiene | 2.60E-01 | 2.60E-01 | 1.30E+00 | No | | | | | | | | | | | | | | | |
| Hexachloroethane | 2.70E-01 | 2.70E-01 | 1.20E+01 | No | | | | | | | | | | | | | | | |
| Iron | 1.54E+03 | 1.54E+03 | 3.00E+02 | **Yes** | NVA | 1,000 | NVA | NVA | NVA | NVA | 1,300 | 158 | NVA | NVA | 1,000 | 5/5 | 5/5 | Yes | (1,2) |
| Lead | 6.01E+00 | 6.01E+00 | 2.50E+00 | **Yes** | 41.4 $^{H}$ | 1.6 $^{H}$ | 60.3 $^{H,I}$ | 6.8 $^{H,I}$ | NVA | NVA | 18.88 | 12.26 | 25.46 | 500 | 1.32 | 3/10 | 3/10 | Yes | (1) |
| Lindane | 7.19E-03 | 7.19E-03 | 1.00E-02 | No | | | | | | | | | | | | | | | |
| Magnesium | 5.76E+03 | 5.57E+03 | 8.20E+04 | No | | | | | | | | | | | | | | | |
| Manganese | 2.63E+02 | 2.63E+02 | 1.20E+02 | **Yes** | NVA | NVA | NVA | NVA | 2,300 | -- | 1,780 | 1,100 | NVA | NVA | NVA | 1/4 | 1/4 | No | (3) |
| Mercury (Inorganic) | 1.86E-01 | 1.48E-01 | 2.60E-02 | **Yes** | 1.70 | 0.90 | 1.4 $^{I}$ | 0.77 $^{I}$ | NVA | 1.3 | 0.23 | 0.96 | NVA | 5 | 0.012 | 2/10 | 2/10 | No | (3) |
| Nickel | 4.10E+00 | 4.10E+00 | 5.20E+01 | No | | | | | | | | | | | | | | | |
| Nitrobenzene | 1.00E-01 | 1.00E-01 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | 740 | 0/1 | 0/1 | No | (3) |
| Potassium | 1.90E+03 | 1.76E+03 | 5.30E+04 | No | | | | | | | | | | | | | | | |

# Table 6-19
# Direct Contact Evaluation for Surface Water at SWMU 31
## Page 2 of 2

| COPEC | MDC (ug/L) | EPC (ug/L) | USEPA Region 3 BTAG (ug/L) [A] | Retain COPECs as Max Conc > USEPA Region 3 BTAG Value? | NAWQC (ug/L) [B] | | Virginia Criteria (ug/L) [C] | | Tier II Secondary Values (ug/L) [D] | | Lowest Chronic Values (ug/L) [D] | | | | USEPA Region 4 Benchmark Screening Values (ug/L) [E] | COPEC Weight of Evidence Exceedence Summary | | Final COPEC? | Comment [F] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acute | Chronic | Acute | Chronic | Acute | Chronic | Fish | Daphnids | Non-Daphnids | Aquatic Plants | | Using MDC | Using EPC | | |
| Pyrene | 2.60E-02 | 2.60E-02 | 2.50E-02 | **Yes** | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | 0.30 | 1/2 | 1/2 | Yes | (2) |
| Sodium | 1.19E+04 | 1.12E+04 | 6.80E+05 | No | | | | | | | | | | | | | | | |
| Trichloromethane | 3.00E+01 | 3.00E+01 | 1.80E+00 | **Yes** | NVA | NVA | NVA | NVA | 490 | 28 | 1,240 | 4,483 | NVA | NVA | 289 | 2/6 | 2/6 | No | (3) |
| Zinc | 1.60E+01 | 1.60E+01 | 1.20E+02 | No | | | | | | | | | | | | | | | |

NVA = No Value Available
COPEC = Chemical of potential ecological concern
EPC = Exposure Point Concentration. The 95% UCL was selected as the EPC unless it exceeded the maximum detected concentration, in which case the MDC was chosen as the EPC
MDC = Maximum detected concentration
NAWQC = National Ambient Water Qualtiy Criteria
95% UCL = 95% upper confidence limit concentration
All concentrations are assumed to be total unless otherwise noted.

[A] Values from USEPA Region 3 BTAG Screening Levels (2006). Values are for freshwater.

[B] Unless otherwise noted, values from U.S. EPA. 2002. National Recommended Water Quality Criteria-2002 EPA 822-R-02-047.

[C] Values from Virginia Criteria for Surface Water, 9 VAC 25-260-140 (2004).

[D] Unless otherwise noted, values from Suter, G.W., and Tsao, C.L. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.ES/ER/TM-96/R2.
If value already used by BTAG, value is not repeated.

[E] Values from USEPA Region 4 Ecological Benchmark Screening Values for Surface Water (2000).

[F] Rationale for selection or non-selection of final COPEC:
(1) = Promulgated criterion exceeded.
(2) = Fifty percent or more of the available criteria and/or benchmarks exceeded.
(3) = Less than fifty percent of the available criteria and benchmarks exceeded, and no promulgated criteria exceeded.
(4) = No benchmarks or criteria available, constituent assumed to be non-toxic.

[G] Aluminum pH of 6.5-9.0. This value is for total metal concentrations.

[H] Average hardness for SWMU 31 = 58.63 mg/L as ($CaCO_3$).

[I] Value is a dissolved concentration.

# Table 6-20
## Direct Toxicity Evaluation for Sediment at SWMU 31
### Page 1 of 2

| COPEC | MDC (mg/kg) | EPC (mg/kg) | USEPA Region 3 BTAG (mg/kg)[A] | Retain COPEC as Max Conc > USEPA Region 3 BTAG Value? | USEPA Region 3 BTAG (mg/kg)[A] | ARCS[B] | | SQB (mg/kg)[B,C] | Canadian ISQG (mg/kg)[D] | NOAA[B] | SQuiRT (mg/kg) [E] | COPEC Weight of Evidence Exceedence Summary | | Final COPEC? | Comment [F] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TEC (mg/kg) | NEC (mg/kg) | | | ER-L (mg/kg) | | Using MDC | Using EPC | | |
| TCDD-TEQ-RME | 3.83E-06 | 3.83E-06 | 8.50E-07 | **Yes** | 8.50E-07 | NVA | NVA | NVA | 8.50E-07 | NVA | 8.80E-06 | 2/3 | 2/3 | **Yes** | (1) |
| 2,4,6-Trinitrotoluene | 2.10E-01 | 2.10E-01 | 9.20E-02 | **Yes** | 9.20E-02 | NVA | NVA | NVA | NVA | NVA | NVA | 1/1 | 1/1 | **Yes** | (1) |
| 2,4-Dimethylphenol | 2.00E-01 | 2.00E-01 | 2.90E-02 | **Yes** | 2.90E-02 | NVA | NVA | NVA | NVA | NVA | NVA | 1/1 | 1/1 | **Yes** | (1) |
| 2-Methylnaphthalene | 1.30E+00 | 1.30E+00 | 2.02E-02 | **Yes** | 2.02E-02 | NVA | NVA | 1.30E-01 | 2.02E-02 | 7.00E-02 | NVA | 4/4 | 4/4 | **Yes** | (1) |
| 4,4-DDD | 7.00E-04 | 7.00E-04 | 4.88E-03 | No | | | | | | | | | | | |
| 4,4-DDE | 1.76E-03 | 1.76E-03 | 3.16E-03 | No | | | | | | | | | | | |
| Acenaphthene | 2.80E-01 | 2.80E-01 | 6.70E-03 | **Yes** | 6.70E-03 | NVA | NVA | 1.30E+00 | 6.71E-03 | 1.60E-02 | 2.90E-01 | 3/5 | 3/5 | **Yes** | (1) |
| Acenaphthylene | 4.60E-02 | 4.60E-02 | 5.90E-03 | **Yes** | 5.90E-03 | NVA | NVA | NVA | 5.87E-03 | 4.40E-02 | 1.60E-01 | 3/4 | 3/4 | **Yes** | (1) |
| Aluminum | 1.08E+05 | 1.03E+05 | NVA | NVA | NVA | NVA | 7.32E+04 | NVA | NVA | NVA | 2.55E+04 | 2/2 | 2/2 | **Yes** | (1) |
| Anthracene | 5.90E-02 | 5.90E-02 | 5.72E-02 | **Yes** | 5.72E-02 | 31.62 | 1700 | 0.22 | 0.0469 | 0.0853 | 0.01 | 3/7 | 3/7 | No | (2) |
| Antimony | 5.63E+00 | 5.63E+00 | 2.00E+00 | **Yes** | 2.00E+00 | NVA | NVA | NVA | NVA | 2 | 3 | 3/3 | 3/3 | **Yes** | (1) |
| Arsenic | 1.25E+01 | 1.22E+01 | 9.80E+00 | **Yes** | 9.80E+00 | 1.21E+01 | 9.29E+01 | NVA | 5.90E+00 | 8.20E+00 | 5.90E+00 | 5/6 | 5/6 | **Yes** | (1) |
| Barium | 1.50E+02 | 1.35E+02 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Benzo(a)anthracene | 1.50E-01 | 1.50E-01 | 1.08E-01 | **Yes** | 1.08E-01 | 260 | 3500 | 0.11 | 0.0317 | 0.261 | 0.016 | 4/7 | 4/7 | **Yes** | (1) |
| Benzo(a)pyrene | 8.60E-02 | 6.28E-02 | 1.50E-01 | No | | | | | | | | | | | |
| Benzo(b)fluoranthene | 1.40E-01 | 1.40E-01 | 2.72E-02 | **Yes** | 2.72E-02 | 27.2 | 4000 | NVA | NVA | NVA | NVA | 1/3 | 1/3 | No | (2) |
| Benzo(g,h,i)perylene | 5.40E-02 | 5.24E-02 | 1.70E-01 | No | | | | | | | | | | | |
| Benzo(k)fluoranthene | 4.50E-02 | 4.02E-02 | 2.72E-02 | **Yes** | 2.72E-02 | 27.2 | 4000 | NVA | NVA | NVA | 0.027 | 2/4 | 2/4 | **Yes** | (1) |
| Beryllium | 1.80E+00 | 1.45E+00 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Cadmium | 9.65E-01 | 7.90E-01 | 9.90E-01 | No | | | | | | | | | | | |
| Calcium | 4.48E+03 | 3.80E+03 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Carbazole | 7.90E-02 | 7.90E-02 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Chromium | 5.66E+01 | 5.21E+01 | 4.34E+01 | **Yes** | 4.34E+01 | 5.60E+01 | 3.12E+02 | NVA | 3.73E+01 | 8.10E+01 | 3.63E+01 | 5/6 | 5/6 | **Yes** | (1) |
| Chrysene | 2.10E-01 | 2.10E-01 | 1.66E-01 | **Yes** | 1.66E-01 | 500 | 4000 | NVA | 0.0571 | 0.384 | 0.027 | 3/6 | 3/6 | **Yes** | (1) |
| Cobalt | 1.80E+01 | 1.65E+01 | 5.00E+01 | No | | | | | | | | | | | |
| Copper | 5.00E+01 | 5.00E+01 | 3.16E+01 | **Yes** | 3.16E+01 | 2.80E+01 | 5.48E+01 | NVA | 3.57E+01 | 3.40E+01 | 2.80E+01 | 5/6 | 5/6 | **Yes** | (1) |
| Dibenz(a,h)anthracene | 1.90E-02 | 1.90E-02 | 3.30E-02 | No | | | | | | | | | | | |
| Dibenzofuran | 3.00E-01 | 3.00E-01 | 4.15E-01 | No | | | | | | | | | | | |
| Endrin | 9.78E-04 | 9.78E-04 | 2.22E-03 | No | | | | | | | | | | | |
| Fluoranthene | 9.75E-02 | 8.40E-02 | 4.23E-01 | No | | | | | | | | | | | |
| Fluorene | 8.70E-02 | 8.70E-02 | 7.74E-02 | **Yes** | 7.74E-02 | 3.46E-02 | 1.80E+00 | 5.40E-01 | 2.12E-02 | 1.90E-02 | 1.00E-02 | 5/7 | 5/7 | **Yes** | (1) |
| Indeno(1,2,3-cd)pyrene | 3.10E-02 | 2.73E-02 | 1.70E-02 | **Yes** | 1.70E-02 | 7.80E-02 | 3.80E+00 | NVA | NVA | NVA | 1.70E-02 | 2/4 | 2/4 | **Yes** | (1) |
| Iron | 2.83E+04 | 2.53E+04 | 2.00E+04 | **Yes** | 2.00E+04 | NVA | NVA | NVA | NVA | NVA | 4.00E+04 | 1/2 | 1/2 | **Yes** | (1) |
| Lead | 9.82E+01 | 7.73E+01 | 3.58E+01 | **Yes** | 3.58E+01 | 3.42E+01 | 6.87E+01 | NVA | 3.50E+01 | 4.67E+01 | 3.50E+01 | 6/6 | 6/6 | **Yes** | (1) |
| Magnesium | 3.59E+03 | 3.31E+03 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Manganese | 8.11E+02 | 7.47E+02 | 4.60E+02 | **Yes** | 4.60E+02 | 1.67E+03 | 8.19E+02 | NVA | NVA | NVA | 6.30E+02 | 2/4 | 2/4 | **Yes** | (1) |
| Mercury | 5.30E-01 | 5.30E-01 | 1.80E-01 | **Yes** | 1.80E-01 | NVA | NVA | NVA | 1.70E-01 | 1.50E-01 | 1.74E-01 | 4/4 | 4/4 | **Yes** | (1) |
| Naphthalene | 6.90E-01 | 6.90E-01 | 1.76E-01 | **Yes** | 1.76E-01 | 3.28E-02 | 2.90E-01 | 2.40E-01 | 3.46E-02 | 1.60E-01 | 1.50E-02 | 7/7 | 7/7 | **Yes** | (1) |
| Nickel | 3.27E+01 | 2.98E+01 | 2.27E+01 | **Yes** | 2.27E+01 | 3.96E+01 | 3.79E+01 | NVA | NVA | 2.09E+01 | 1.80E+01 | 3/5 | 3/5 | **Yes** | (1) |
| Nitrobenzene | 1.50E-01 | 1.50E-01 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| N-Nitrosodiphenylamine | 2.30E-01 | 2.30E-01 | 2.68E+00 | No | | | | | | | | | | | |

# Table 6-20
# Direct Toxicity Evaluation for Sediment at SWMU 31
## Page 2 of 2

| COPEC | MDC (mg/kg) | EPC (mg/kg) | USEPA Region 3 BTAG (mg/kg)[A] | Retain COPEC as Max Conc > USEPA Region 3 BTAG Value? | USEPA Region 3 BTAG (mg/kg)[A] | ARCS[B] | | SQB (mg/kg)[B,C] | Canadian ISQG (mg/kg)[D] | NOAA[B] | SQuiRT (mg/kg) [E] | COPEC Weight of Evidence Exceedence Summary | | Final COPEC? | Comment [F] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TEC (mg/kg) | NEC (mg/kg) | | | ER-L (mg/kg) | | Using MDC | Using EPC | | |
| Phenanthrene | 7.10E-01 | 7.10E-01 | 2.04E-01 | **Yes** | 2.04E-01 | NVA | NVA | 1.80E+00 | 4.19E-02 | 2.40E-01 | 1.90E-02 | 4/5 | 4/5 | **Yes** | (1) |
| Potassium | 1.80E+03 | 1.74E+03 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Pyrene | 1.50E-01 | 1.44E-01 | 1.95E-01 | No | | | | | | | | | | | |
| Sodium | 1.80E+02 | 1.80E+02 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Thallium | 1.90E+00 | 1.90E+00 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Vanadium | 6.80E+01 | 5.85E+01 | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | NVA | --- | --- | No | (3) |
| Zinc | 1.95E+02 | 1.82E+02 | 1.21E+02 | **Yes** | 1.21E+02 | 1.59E+02 | 5.41E+02 | NVA | 1.23E+02 | 1.50E+02 | 9.80E+01 | 5/6 | 5/6 | **Yes** | (1) |

NVA = No Value Available
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
ISQG = Interim Sediment Quality Guideline

MDC = Maximum detected concentration.
NEC = High No Effect Concentration
NOAA = National Oceanic and Atmospheric Administration
SQB = Sediment Quality Benchmark
TEC = Threshold Effect Concentration

ARCS, SQB, and Canadian values for freshwater environments.
NOAA values for estuarine and marine environments, but may be used for screening purposes.

[A] Screening toxicity values from BTAG (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). 2003. Canadian Environmental Quality Guidelines. Summary Table Update 2003.

[E] NOAA QuiRT Values (Buchman, 1999)

[F] Selection Rationale:

(1) = 50 percent or more of available benchmarks exceeded.
(2) = Less than 50 percent of available benchmarks exceeded.
(3) = No benchmarks or criteria available, constituent assumed to be non-toxic.

- The manganese MDC exceeded the one available benchmark from BTAG; however, no reference is available to determine the basis or appropriateness of the BTAG value.
- The mercury MDC exceeded two of the four available benchmarks; however, the EcoSSL guidance (USEPA, 2005e) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent.
- The nickel MDC exceeded the one available benchmark from BTAG; however, this benchmark is for fungi toxicity and as discussed in *Section 6.7.4*, because plant toxicity is not an overriding concern for the site, fungi toxicity is also not an overriding concern.
- The thallium MDC exceeded the one available benchmark from BTAG; however, no reference is available to determine the basis or appropriateness of the BTAG value.
- The vanadium MDC exceeded one of the two available benchmarks; however, the EcoSSL guidance (USEPA, 2005e) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent.
- The zinc MDC exceeded two of the four available benchmarks; however, this exceedance was for plant toxicity, and as discussed in *Section 6.7.4*, plant toxicity is not an overriding concern for the site.
- None of other three COPECs selected in the first screening step had any benchmark exceedences.

These results suggest that direct contact toxicity for COPECs in soil are not a concern. 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.

#### 6.7.3.2 Surface Water

A two-step process was also used to assess direct contact surface water toxicity. First, the maximum detected surface water concentration was compared with the freshwater BTAG screening value [USEPA, 2005e (updated in 2006)] (**Table 6-19**). A chemical was only retained as a COPEC if the MDC exceeded the BTAG surface water screening value. Based on the results of this first step, 10 COPECs were selected (**Table 6-19**). In the second step, the MDC of these 10 COPECs was compared with eleven individual surface water screening values that are ether referenced on the USEPA Region 3 BTAG website for direct contact toxicity, or contained within one of the referenced website sources, listed as follows (in additional to the BTAG screening value, if one was available):

- National AWQC (acute and chronic values available) (USEPA, 2002d).
- Virginia Criteria for Water (acute and chronic values available) (VAC, 2004).
- Tier II Secondary Values(acute and chronic values available) (Suter and Tsao, 1996).
- Lowest Chronic Effect Values for Fish, Daphnids, Nondaphnids, and Aquatic Plants (Suter and Tsao, 1996).
- USEPA Region IV Screening Values (Suter and Tsao, 1996).

Some information on these screening criteria is presented in the following subsections.

USEPA's National AWQCs are ecotoxicologically-based benchmarks developed under the Clean Water Act Section 304 (USEPA, 1999c, 1996d, 1985). At least eight acute toxicity tests from eight different families and three chronic tests are required to develop a criterion for a chemical (USEPA, 1996d). To arrive at the chronic AWQC, the final acute value, which is the fifth percentile of the distribution of 48- to 96-hour acute toxicity test values, is divided by the final acute-chronic ratio. The final acute-chronic ratio is the geometric mean of quotients of at least three median lethal concentration ($LC_{50}$) tests divided by chronic value ratios from tests of different families of aquatic organisms. Standard chronic tests include measures of growth, reproduction, and lethality, as well as observations of deformities. Chronic AWQC are intended to prevent significant toxic effects in chronic exposures (Suter and Tsao, 1996). The National AWQC for some metals are hardness dependent, and the values presented for these COPECs have been adjusted using site-specific surface water hardness data. In addition, the hardness dependent inorganic criteria are for total concentrations in surface water, not dissolved concentrations, as the site surface water samples were not filtered during collection. The adjustment of these criteria has been performed using the appropriate coefficients presented in USEPA (2002d) to make the conversions.

Virginia Criteria for Water (VAC, 2004) are developed using a methodology similar to the National AWQC methodology, but take into account State-specific concerns related to the protection of aquatic biota. One important distinction is that the Virginia criteria are for dissolved inorganic constituents in surface water, whereas the National AWQC values use a coefficient to convert from dissolved inorganic constituent concentrations to total concentrations.

Tier II values (Suter and Tsao, 1996) are used as water quality benchmarks because AWQCs have only been developed for a limited number of constituents (USEPA, 1996d). Note: these Tier II values have no direct relation to the Tier 2 assessment approach utilized in the SWMU 31 SLERA. The methodology used for the Tier II values is from the Great Lakes Water Quality Initiative (USEPA, 1995d). It incorporates statistically derived “adjustment factors” for the effects threshold to be calculated with less toxicity data than is required for AWQC. The methodology is described in 40 CFR 132. Values for some of the chemicals were calculated by the EPA Office of Water (USEPA, 1995d) and others by Suter and Mabrey (1994). Differences between the USEPA (1995d) and Suter and Mabrey (1994) methodologies include an alternate calculation when no $LC_{50}$ value for a daphnid is available, and the use of nonstandard $LC_{50}$ and median effective concentration ($EC_{50}$) values in the Suter and Mabrey (1994) methods. These alterations allowed for Tier II values for screening purposes to be calculated for additional chemicals (Suter and Tsao, 1996).

Lowest chronic effect values for fish, daphnids (water fleas), nondaphnids (other aquatic invertebrates excluding water fleas), and aquatic plants (Suter and Tsao, 1996) represent the lowest available toxicity thresholds in the literature for adverse impacts to theses four general classes of aquatic biota. These thresholds are useful in estimating potential adverse impacts to these general types of freshwater aquatic receptors. However, as theses thresholds are not NOAELs they are nonconservative.

The USEPA Region IV Screening Values (Suter and Tsao, 1996) represent additional screening values available from USEPA Region IV.

***<u>Surface Water Direct Contact Summary</u>.***

It should be noted that because of the nature of various benchmark sources, promulgated water quality criteria (e.g., National AWQC and Virginia Criteria for Water) were determined to be more critical than non-promulgated benchmarks. Final COPEC selection was thus based on whether any exceedance of the promulgated criteria was noted and whether or not more than half of the available surface water benchmarks were exceeded. As some aquatic biota are relatively non-mobile, maximum detected surface water concentrations were used, in addition to a more realistic exposure concentration expressed as the 95 percent UCL.

Using the surface water benchmarks discussed previously, the results of the second screening step identified the following seven final COPECs (**Table 6-19**):

- Aluminum
- Barium
- Endosulfan II
- Endrin
- Iron
- Lead
- Pyrene

Based on these findings, it is possible that aquatic organisms inhabiting the surface water in the SWMU 31 lagoons may be adversely impacted by detected concentrations of these chemicals.

#### 6.7.3.3 Sediment

A two-step process was also used to assess direct contact sediment toxicity. First, the maximum detected sediment concentration was compared with the freshwater BTAG screening value [USEPA, 2005e (updated in 2006)] (**Table 6-20**). A chemical was only retained as a COPEC if the MDC exceeded the BTAG sediment screening value. Based on the results of this first step, 25 COPECs were selected (**Table 6-20**). In the second step, the MDC of these 25 COPECs was compared with six individual sediment screening values that are ether referenced on the USEPA Region 3 BTAG website for direct contact toxicity, or contained within one of the referenced sources, listed as follows (in additional to the BTAG screening value, if one was available):

- Threshold Effect Concentrations (TECs) from Assessment and Remediation of Contaminated Sediments (ARCS) program (Jones and Suter, 1997).
- No Effect Concentrations (NEC) from ARCS program (Jones and Suter, 1997).
- Sediment Quality Benchmarks (SQB) (Jones and Suter, 1997).
- Canadian Interim Sediment Quality Guidelines (ISQG) [Canadian Council of Ministers of the Environment (CCME), 2003].
- National Oceanic and Atmospheric Administration (NOAA) Effect Range – Low (ER-L) values (Jones and Suter, 1997).
- NOAA Screening Quick Reference Table (SQuiRT) values (Buckman, 1999).

Some information on these screening criteria is presented in the following subsections.

TECs and NECs (as reported in Jones and Suter, 1997), were developed for the ARCS program (Ingersoll et al., 1996). These values were based on sediment-effect concentrations, using laboratory data on the toxicity of constituents associated with field-collected sediment (predominantly freshwater) to the amphipod *Hyalella azteca* and the midge *Chironomus* *riparius*. Sediment-effect concentrations were calculated from the results of 14-day tests on *C. riparius*, and 14- and 28-day tests on *H. azteca*. The *H. azteca* endpoints were survival, growth (as length), or sexual maturation. The *C. riparius* endpoints were survival and growth.

SQBs from Jones and Suter (1997) are based on the sediment/water equilibrium partitioning (EqP) approach, where the prediction of a bulk sediment chemical concentration criterion is a function of the sediment organic carbon and an associated AWQC. Sediment TOC concentrations of one percent are assumed for these SQBs. The EqP approach applies specifically to non-ionic organic contaminants; while variations of the equation have been developed for use with polar and ionic organic chemicals.

ISQGs (CCME, 2003) represent Canadian Environmental Quality Guidelines initially published by CCME (1995), and include provisional lowest effect levels for some constituents (Persaud et al., 1993). These guidelines are numerical limits recommended to support and maintain aquatic life associated with bed sediments and were developed from the available scientific literature on the biological effects of sediment-associated chemicals. The methodology used in the development of these numerical limits included the modified National Status and Trends Program approach and the Spiked-Sediment Toxicity Test approach.

The methodology used by NOAA (Long et al., 1995; Long and Morgan, 1990) for their NOAA ER-M thresholds utilize data obtained from several approaches, including:

- Background Approach: use of reference background values from various geographic areas, against which site contaminant levels are screened.
- Sediment/Water EqP Approach: prediction of a bulk sediment chemical concentration criterion as a function of the sediment organic carbon and an associated AWQC.

The NOAA benchmarks are based primarily on estuarine and marine data, but may be used for screening purposes in freshwater environments (Jones and Suter, 1997). The NOAA ER-L is the lower 10th percentile of the screened data; as such, the ER-L represents the low end of the range for which effects were observed or predicted.

***<u>Sediment Direct Contact Summary</u>*.**

For aquatic organisms potentially exposed to COPECs in sediment collected from SWMU 31, a weight-of-evidence approach is used, where the more sediment benchmarks exceeded by the COPEC concentration, the greater the potential for adverse effects. The results are summarized in **Table 6-20**. 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 percent UCL.

Using the sediment benchmarks discussed previously, the results of the second weight of evidence screening step identified the following 24 final COPECs (**Table 6-20**):

| | |
|---|---|
| TCDD-TEQ | Chrysene |
| 2,4,6-Trinitrotoluene | Copper |
| 2,4-Dimethylphenol | Fluorene |
| 2-Methylnaphthalene | Indeno(1,2,3-cd)pyrene |
| Acenaphthene | Iron |

| | |
|---|---|
| Acenaphthylene | Lead |
| Aluminum | Manganese |
| Antimony | Mercury |
| Arsenic | Naphthalene |
| Benzo(a)anthracene | Nickel |
| Benzo(k)fluoranthene | Phenanthrene |
| Chromium | Zinc |

Based on these findings, it is possible that aquatic organisms inhabiting the sediment in the SWMU 31 lagoons may be adversely impacted by detected concentrations of these chemicals.

### 6.7.4 Background Metals Considerations

A background evaluation was conducted on the 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, inorganic COPEC drivers with EEQs greater than one for the food chain assessment are arsenic, chromium, copper, and zinc. COPEC hazard drivers for the direct contact Tier 2 assessment, although not considered significant, are chromium, cobalt, magnesium, manganese, mercury, nickel, thallium, vanadium, and zinc. Inorganics with MDCs less than the background UTL and shown not to be statistically different based on appropriate population statistical tests are considered background related (*Section 5.1.2.3*). For SWMU 31, all of the Tier 2 inorganic COPEC drivers for surface soil could be attributed to background, as summarized in **Table 6-21**.

**Table 6-21**
**Background Comparison for Surface Soil at SWMU 31**

| Soil COPEC Driver | Background UTL (mg/kg) | Maximum Concentration (mg/kg) | Results of Background Site Population Tests (for Total Soil) | Considered to be background (Y/N) |
|---|---|---|---|---|
| Arsenic | 15.8 | 5.9 | Bkg. Related | Yes |
| Chromium | 65.3 | 28.2 | Bkg. Related | Yes |
| Cobalt | 72.3 | 17.8 | Bkg. Related | Yes |
| Copper | 53.5 | 17.7 | Bkg. Related | Yes |
| Magnesium | Not Available | 2,500 | Bkg. Related | Yes |
| Manganese | 2,543 | 495 | Bkg. Related | Yes |
| Mercury | 0.13 | 0.12 | Bkg. Related | Yes |
| Nickel | 62.8 | 14.8 | Bkg. Related | Yes |
| Thallium | 2.11 | 0.34 | Bkg. Related | Yes |
| Vanadium | 108 | 47.5 | Bkg. Related | Yes |
| Zinc | 202 | 98.5 | Bkg. Related | Yes |

## 6.8 GROUNDWATER EVALUATION

Groundwater samples were collected from two rounds of sampling at four monitoring wells at and adjacent to SWMU 31 (three downgradient wells 31MW2, 31MW3, and 31MW4, and one upgradient well 31MW1). It should be noted that the first round of sampling could not be completed at monitoring well 31MW2 as it was dry. Given the proximity of SWMU 31 to the New River (approximately 120 to 135 ft), and the fact that groundwater flows directly north to the New River (**Figure 1-2**), it is possible groundwater chemicals originating from either surface water or sediment are migrating to the New River and possibly having an adverse impact on aquatic life or wildlife that use this resource. The remainder of the 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 6-22**). Filtered results for metals detected in groundwater samples are used, as these results are more indicative of concentrations available for possible transport to New River surface waters. Results from the upgradient well 31MW1 are not directly using in the screening table, as these results are not site-related, however, they are presented to indicate which chemicals may be moving onto the site from an upgradient source.

Based on the results of this screening assessment, nine groundwater COPECs were selected [acenaphthylene, aluminum, barium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chromium, fluorene, and trichloromethane (chloroform)]. As only five groundwater sample results (at most) are available for these COPECs, 95 percent UCLs were not calculated. These nine COPECs were evaluated in detail to determine the possible source. As shown in **Table 6-23**, concentrations of aluminum and barium in SWMU 31 surface water and sediment suggest that both of these media may be a possible source for these metals in groundwater; however, barium was also detected at an elevated concentration in the upgradient well (0.202 mg/L in the upgradient well compared with a MDC of 0.0253 mg/L in the site wells). The five PAHs and chromium were not detected in surface water, but were detected in sediment, suggesting the potential leaching of PAHs and chromium from sediments to underlying groundwater. Finally, trichloromethane was only detected in surface water, suggesting a possible source in surface water percolating to groundwater beneath the site.

Using the maximum and average groundwater concentrations of the six COPECs that had concentrations that exceeded the BTAG surface water screening criteria, HQs were estimated using the direct-contact surface water screening value (**Table 6-24**). Results of this initial assessment showed that if measured groundwater concentrations occur in New River surface water without any dilution, HQs would range from 1.2 to 6.3 using MDCs, and from 1.0 to 5.0 using average concentrations (**Table 6-24**).

Given the diffuse and expected slow discharge of site groundwater to the New River, and the relatively larger River flows, considerable dilution of these groundwater COPECs is expected. As shown in **Figure 6-3**, 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 6-3**). The flow in the New River near the site is controlled by discharges from

# TABLE 6-22
# OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL ECOLOGICAL CONCERN FOR EXPOSURE AT SWMU 31

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 | N/A | Hardness | 8.01E+01 | 1.06E+02 | mg/l | 31MW3 | 2/2 | N/A | 1.06E+02 | 4.14E+02 | N/A | No | No | PHYS |
| | 7429-90-5 | Aluminum | 7.80E-02 J | 2.15E-01 | mg/l | 31MW3 | 2/5 | 5.61E-02 - 1.11E-01 | 2.15E-01 | 7.80E-02 | 8.70E-02 | No | Yes | ASL |
| | 7440-39-3 | Barium | 1.44E-02 L | 2.53E-02 | mg/l | 31MW04 | 5/5 | N/A | 2.53E-02 | 2.02E-01 | 4.00E-03 | No | Yes | ASL, BKG |
| | 7440-70-2 | Calcium | 1.72E+01 J | 2.57E+01 | mg/l | 31MW3 | 5/5 | N/A | 2.57E+01 | 7.23E+01 | 1.16E+02 | No | No | BSL, BKG |
| | 7440-47-3 | Chromium | 5.90E-03 J | 7.30E-03 J | mg/l | 31MW3 | 2/5 | 1.10E-03 - 6.40E-03 | 7.30E-03 | 4.20E-03 | 6.98E-02 | Yes | Yes | IBC |
| | 7440-48-4 | Cobalt | 2.80E-03 J | 3.50E-03 L | mg/l | 31MW2-2 | 3/5 | 5.00E-02 - 5.00E-02 | 3.50E-03 | 3.20E-03 | 2.30E-02 | No | No | BSL |
| | 7439-89-6 | Iron | 7.94E-02 J | 1.62E-01 | mg/l | 31MW3 | 4/5 | 1.80E-02 - 1.80E-02 | 1.62E-01 | 8.99E-02 | 3.00E-01 | No | No | BSL |
| | 7439-95-4 | Magnesium | 6.27E+00 J | 9.57E+00 | mg/l | 31MW3 | 5/5 | N/A | 9.57E+00 | 5.30E+01 | 8.20E+01 | No | No | BSL, BKG |
| | 7439-96-5 | Manganese | 2.00E-03 J | 1.27E-02 J | mg/l | 31MW2-2 | 3/4 | 1.00E-02 - 1.00E-02 | 1.27E-02 | 1.10E-02 | 1.20E-01 | No | No | BSL |
| | 7440-09-7 | Potassium | 9.86E-01 J | 1.90E+00 J | mg/l | 31MW3 | 5/5 | N/A | 1.90E+00 | 3.00E+01 | 5.30E+01 | No | No | BSL, BKG |
| | 7440-23-5 | Sodium | 1.08E+01 K | 1.17E+01 J | mg/l | 31MW3-2 | 5/5 | N/A | 1.17E+01 | 1.67E+01 | 6.80E+02 | No | No | BSL, BKG |
| | 7440-44-0 | Total Organic Carbon | 7.00E-01 J | 1.00E+02 | mg/l | 31MW2-2 | 5/5 | N/A | 1.00E+02 | 1.00E+02 | NVA | No | No | PHYS |
| | 208-96-8 | Acenaphthylene | 2.70E-05 J | 2.70E-05 J | mg/l | 31MW3 | 1/5 | 5.00E-05 - 1.00E-03 | 2.70E-05 | ND | 5.80E-03 | Yes | Yes | IBC |
| | 56-55-3 | Benzo(a)anthracene | 2.20E-05 J | 2.20E-05 J | mg/l | 31MW2-2 | 1/5 | 5.00E-05 - 5.00E-05 | 2.20E-05 | ND | 1.80E-05 | Yes | Yes | ASL, IBC |
| | 50-32-8 | Benzo(a)pyrene | 2.20E-05 J | 6.10E-05 J | mg/l | 31MW3-2 | 2/5 | 5.00E-05 - 5.00E-05 | 6.10E-05 | ND | 1.50E-05 | Yes | Yes | ASL, IBC |
| | 205-99-2 | Benzo(b)fluoranthene | 2.70E-05 J | 6.60E-05 J | mg/l | 31MW3-2 | 2/5 | 5.00E-05 - 1.00E-04 | 6.60E-05 | ND | 1.50E-05 | Yes | Yes | ASL, IBC |
| | 86-73-7 | Fluorene | 2.40E-05 J | 2.40E-05 J | mg/l | 31MW3 | 1/5 | 5.00E-05 - 1.00E-04 | 2.40E-05 | ND | 3.00E-03 | Yes | Yes | IBC |
| | 67-66-3 | Trichloromethane | 6.30E-03 | 1.10E-02 | mg/l | 31MW04 | 2/2 | N/A | 1.10E-02 | ND | 1.80E-03 | No | Yes | ASL |

(1) Maximum concentration of filtered metal and unfiltered organic samples used for screening.
(2) Maximum detect from upgradient groundwater monitoring well (Samples: 31MW01, 31MW1-2, 31MW1-2D).
(3) Screening toxicity values from BTAG (2005).
Benzo(a)pyrene used as surrogate for benzo(b)fluoranthene.
Acenaphthene used as surrogate for acenaphthylene.
Average hardness of 93 mg/L (as CaCO3) used for hardness dependent criteria.
(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)

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
BKG = Below Upgradient (background) Concentration

## Table 6-23
## Source Evaluation of Groundwater COPECs at SWMU 31

| COPEC [a] | Groundwater MDC (mg/L) [b] | Groundwater Mean (mg/L) [b] | Surface Water MDC (mg/L) [c] | Surface Water Mean (mg/L) [c] | Sediment MDC (mg/kg) [d] | Presence in Groundwater Possible from Surface Water or Sediment? | Presence in Groundwater Likely from Upgradient Source? [e] |
|---|---|---|---|---|---|---|---|
| Aluminum | 0.215 | 0.0828 | 13.2 | 3.93 | 108,000 | Yes / Yes | No |
| Barium | 0.0253 | 0.0201 | 0.0356 | 0.0229 | 150 | Yes / Yes | Yes |
| Chromium | 7.30E-03 | 3.66E-03 | < 1.0E-02 | < 4.6E-03 | 56.6 | No / Yes | No |
| Acenaphthylene [f] | 2.70E-05 | 2.70E-05 | < 1.0E-04 | < 7.5E-05 | 0.046 | No / Yes | No |
| Benzo(a)anthracene [f] | 2.20E-05 | 2.20E-05 | < 5.0E-05 | < 5.0E-05 | 0.15 | No / Yes | No |
| Benzo(a)pyrene | 6.10E-05 | 3.20E-05 | < 5.0E-05 | < 5.0E-05 | 0.086 | No / Yes | No |
| Benzo(b)fluoranthene | 6.60E-05 | 3.90E-05 | < 1.0E-04 | < 7.5E-05 | 0.14 | No / Yes | No |
| Fluorene | 2.40E-05 | 4.00E-05 | < 1.0E-04 | < 7.5E-05 | 0.087 | No / Yes | No |
| Trichloromethane | 0.011 | 0.00865 | 0.0300 | 0.0227 | < 0.022 | Yes / No | No |

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from screening assessment (Table 6-24).

[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] Unfiltered results for both metals and organics presented for surface water, from Table 6-17 and F-24.

[d] Sediment results from Tables 6-9 and F-25.

[e] Upgradient groundwater source includes monitoring well 31MW1.

[f] Benzo(a)anthracene and acenaphthylene mean groundwater concentrations = MDC, to compensate for influence of elevated detection limit results.

**Notes:**
MDC = maximum detection concentration

## Table 6-24
## Impact Evaluation of Groundwater COPEC Concentrations in Surface Water Adjacent to SWMU 31

| **COPEC [a]** | **Ground-water MDC (mg/L) [b]** | **Ground-water Mean (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** | **Surface Water Concern From SWMU-31 Groundwater COPECs?** |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 0.215 | 0.0828 | 0.087 | 2.5 | 1.0 | 14 | 0.18 | 0.068 | No, HQs < 1 when DF used |
| Barium | 0.0253 | 0.0201 | 0.004 | 6.3 | 5.0 | 14 | 0.45 | 0.36 | No, HQs < 1 when DF used [g] |
| Benzo(a)anthracene [f] | 2.20E-05 | 2.20E-05 | 1.80E-05 | 1.2 | 1.2 | 14 | 0.087 | 0.087 | No, HQs < 1 when DF used |
| Benzo(a)pyrene | 6.10E-05 | 3.20E-05 | 1.40E-05 | 4.4 | 2.3 | 14 | 0.31 | 0.16 | No, HQs < 1 when DF used |
| Benzo(b)fluoranthene | 6.60E-05 | 3.90E-05 | 1.50E-05 | 4.4 | 2.6 | 14 | 0.31 | 0.19 | No, HQs < 1 when DF used |
| Trichloromethane | 0.011 | 0.00865 | 0.0018 | 6.1 | 4.8 | 14 | 0.44 | 0.34 | 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] Filtered metals results and unfiltered organics results. Filtered metals results are more indicative of concentrations available for transport in groundwater to surface water.

[c] Direct contact screening value (Table 6-24).

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

[e] Mixing zone dilution factor of 18.5 based on site-specific groundwater flow rate and New River low flow rate (see text for discussion).

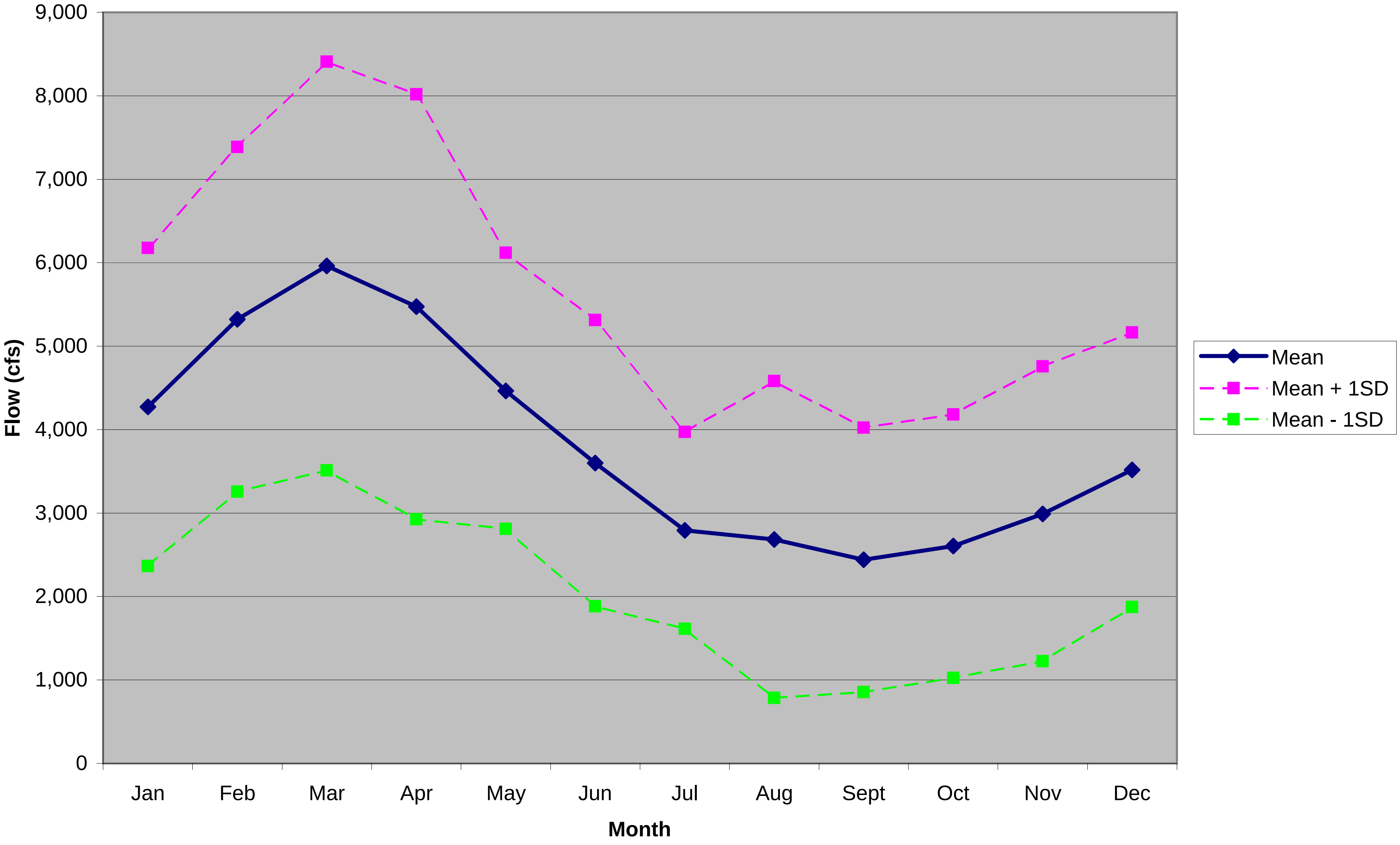
[f] Benzo(a)anthracene mean concentration = MDC, to compensate for influence of elevated detection limit results.

[g] Barium concentrations also likely related to upgradient source in groundwater.

**Notes:**

MDC = maximum detection concentration
DF = Dilution Factor

Figure 6-3 New River Mean Monthly Flow at Radford Virgina (1939-2003)



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 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 6-4**, 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 6-4**). 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 previous estimate of 50 cfs.

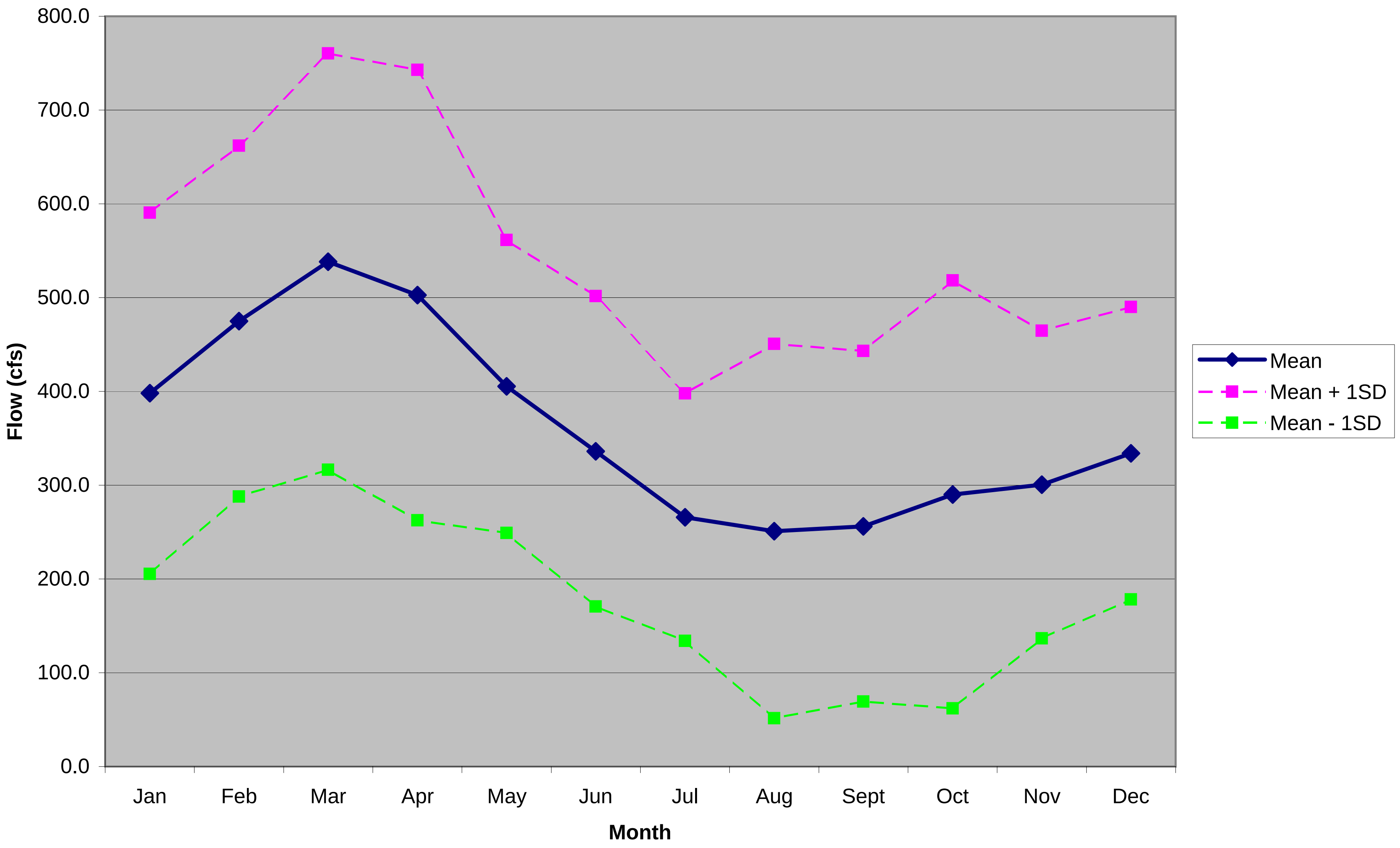
Adding the Little River estimated 7Q10 flow of 50 cfs to the minimum Claytor Reservoir discharge flow of 750 cfs results in an estimated total low flow of 800 cfs for the New River near the site.

The estimated groundwater transmissivity at monitoring well 31MW1 is 1.2E-3 cubic feet per minute, based on the results of a short-term pump test (Shaw, 2005b). As transmissivity is defined as the hydraulic conductivity times the saturated thickness of the aquifer, this value may be converted into a volumetric flow rate by multiplication with the expected width of the groundwater plume from the site. Given a width of 600 ft between the outside edges of the primary and tertiary Lagoons at SWMU 31, the estimated volumetric groundwater flow rate is 0.72 cubic feet per minute, or 43.2 cfs. Dividing this groundwater flow rate into the estimated New River low flow rate of 800 cfs results in a conservative dilution factor of 18.5 (e.g., 800/43.2 = 18.5). This dilution factor is used in **Table 6-24** to estimate the actual 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.

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. HQs are actually expected to be much lower, as the full saturated thickness of the aquifer is not expected to intercept the New River, and groundwater flows during the dry August-September period are expected to be lower than the yearly average.

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 (Kd) is multiplied by the water (solution) concentration to estimate the sorbed sediment concentration (USEPA, 2002a). Kd values for organics were estimated by multiplying the organic carbon partition coefficient (Koc) by the sediment fraction of organic carbon (foc).

Figure 6-4. Little River Mean Monthly Flow near Radford Virginia (1929-2005)



As no site-specific foc results are readily available for New River sediment adjacent to the site, a default value of 0.01 recommended in Appendix D of *The Incidence and Severity of Sediment Contamination in Surface Waters of the United States* (USEPA, 1997e) was used to estimate the Kd values for organic COPECs. Inorganic COPEC Kd values were obtained from the Risk Assessment Information System (RAIS) (ORNL, 2006) on-line data base.

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 an assumed dilution factor of 50 to yield the predicted concentrations in the New River. A long-term dilution factor of 50 is actually conservative, as the average New River flow is approximately 2,400 cfs in August-September (**Figure 6-3**), and 2,400/43.2 = 56. 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 6-25, 6-26, and 6-27**.

These predicted COPEC sediment concentrations were compared with BTAG (USEPA, 2005e) sediment screening values and HQs were calculated (**Tables 6-25 and 6-27**). If no BTAG sediment screening value was available, the lowest NOAA Screening Quick Reference Table (SQuiRT) (Buckman, 1999) value was used. As shown in the tables, two COPECs (benzo[a]pyrene and benzo[b]fluoranthene) had HQs that exceeded 1 when the conservative pore water method was used (**Table 6-25**), no COPEC exceedences were found when the dilution method was used (**Table 6-26**), and the same two COPECs had HQ exceedences when the recommended average of the pore water and dilution methods was used (**Table 6-27**), although the degree of HQ exceedences was reduced. For benzo(a)pyrene the estimated sediment HQ using the mean groundwater concentration was 1.1 and for benzo(b)fluoranthene the estimated sediment HQ was 9.

These sediment HQs are likely overestimated by several orders of magnitude because measured PAH concentrations in groundwater were assumed to be undiminished after groundwater transport to the sediments of the New River. For PAHs such as benzo(a)pyrene and benzo(b)fluoranthene, however, the elevated Koc values of 1.02E+06 and 1.23E+06, respectively (**Table 6-25**) would act to rapidly partition these organics to soils, with the result that their concentrations in groundwater would be significantly attenuated (reduced) along the groundwater flow path. This phenomenon is clearly demonstrated in TetraTech (2005) where estimated sediment concentrations for organics with elevated Koc values (e.g., DDT, DDD, DDE) range from 7.2E-241 to 1.2E-107 mg/kg, after execution of a groundwater transport model. Therefore, groundwater organic COPECs with elevated Koc values are not expected to even reach the New River.

# TABLE 6-25
# EVALUATION OF GROUNDWATER COPECs THAT MAY PARTITION TO SEDIMENT AT SWMU 31 - 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 2.15E-01 | 8.28E-02 | NA | 1.50E+03 | 2 | 3.23E+02 | 1.24E+02 | 1.80E+04 | 0.018 | 0.0069 |
| Barium | 2.53E-02 | 2.01E-02 | NA | 4.10E+01 | 2 | 1.04E+00 | 8.24E-01 | 4.80E+04 | 0.000022 | 0.000017 |
| Chromium | 7.30E-03 | 3.66E-03 | NA | 8.50E+02 | 2 | 6.21E+00 | 3.11E+00 | 4.34E+01 | 0.14 | 0.072 |
| Acenaphthylene [h] | 2.70E-05 | 2.70E-05 | 6.12E+03 | 6.12E+01 | 1, 2 | 1.65E-03 | 1.65E-03 | 5.90E-03 | 0.28 | 0.28 |
| Benzo(a)anthracene [h] | 2.20E-05 | 2.20E-05 | 3.98E+05 | 3.98E+03 | 1 | 8.76E-02 | 8.76E-02 | 1.08E-01 | 0.81 | 0.81 |
| Benzo(a)pyrene | 6.10E-05 | 3.20E-05 | 1.02E+06 | 1.02E+04 | 1 | 6.22E-01 | 3.26E-01 | 1.50E-01 | 4.1 | 2.2 |
| Benzo(b)fluoranthene | 6.60E-05 | 3.90E-05 | 1.23E+06 | 1.23E+04 | 1 | 8.12E-01 | 4.80E-01 | 2.72E-02 | 30 | 18 |
| Fluorene | 2.40E-05 | 4.00E-05 | 1.38E+04 | 1.38E+02 | 1 | 3.31E-03 | 5.52E-03 | 7.74E-02 | 0.043 | 0.071 |
| Trichloromethane | 1.10E-02 | 8.65E-03 | 3.98E+01 | 3.98E-01 | 1 | 4.38E-03 | 3.44E-03 | NA | NA | NA |

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 6-24.

[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] Organic $K_{oc}$ values from (1) *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002) and Inorganic $K_d$ values from The Risk Assessment Information System (RAIS) (ORNL, 2006 on-line data base).

[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). If no BTAG value available, lowest NOAA SQuiRT value was used (Buckman, 1999).

[g] HQ = hazard quotient (predicted sediment concentration divided by screening value)

[h] 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

# TABLE 6-26
# EVALUATION OF GROUNDWATER COPECs THAT MAY PARTITION TO SEDIMENT AT SWMU 31 - 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 2.15E-01 | 8.28E-02 | 4.30E-03 | 1.66E-03 | NA | 1.50E+03 | 2 | 6.45E+00 | 2.48E+00 | 1.80E+04 | 0.00036 | 0.00014 |
| Barium | 2.53E-02 | 2.01E-02 | 5.06E-04 | 4.02E-04 | NA | 4.10E+01 | 2 | 2.07E-02 | 1.65E-02 | 4.80E+04 | 0.00000043 | 0.00000034 |
| Chromium | 7.30E-03 | 3.66E-03 | 1.46E-04 | 7.32E-05 | NA | 8.50E+02 | 2 | 1.24E-01 | 6.22E-02 | 4.34E+01 | 0.0029 | 0.0014 |
| Acenaphthylene [i] | 2.70E-05 | 2.70E-05 | 5.40E-07 | 5.40E-07 | 6.12E+03 | 6.12E+01 | 1, 2 | 3.31E-05 | 3.31E-05 | 5.90E-03 | 0.0056 | 0.0056 |
| Benzo(a)anthracene [i] | 2.20E-05 | 2.20E-05 | 4.40E-07 | 4.40E-07 | 3.98E+05 | 3.98E+03 | 1 | 1.75E-03 | 1.75E-03 | 1.08E-01 | 0.016 | 0.016 |
| Benzo(a)pyrene | 6.10E-05 | 3.20E-05 | 1.22E-06 | 6.40E-07 | 1.02E+06 | 1.02E+04 | 1 | 1.24E-02 | 6.53E-03 | 1.50E-01 | 0.083 | 0.044 |
| Benzo(b)fluoranthene | 6.60E-05 | 3.90E-05 | 1.32E-06 | 7.80E-07 | 1.23E+06 | 1.23E+04 | 1 | 1.62E-02 | 9.59E-03 | 2.72E-02 | 0.60 | 0.35 |
| Fluorene | 2.40E-05 | 4.00E-05 | 4.80E-07 | 8.00E-07 | 1.38E+04 | 1.38E+02 | 1 | 6.62E-05 | 1.10E-04 | 7.74E-02 | 0.00086 | 0.0014 |
| Trichloromethane | 1.10E-02 | 8.65E-03 | 2.20E-04 | 1.73E-04 | 3.98E+01 | 3.98E-01 | 1 | 8.76E-05 | 6.89E-05 | NA | NA | NA |

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 6-24.

[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 50 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] Organic $K_{oc}$ values from (1) *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA, 2002) and Inorganic $K_d$ values from The Risk Assessment Information System (RAIS) (ORNL, 2006 on-line data base).

[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). If no BTAG value available, lowest NOAA SQuiRT value was used (Buckman, 1999).

[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

# TABLE 6-27
# EVALUATION OF GROUNDWATER COPECs THAT MAY PARTITION TO SEDIMENT AT SWMU 31-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 |
|---|---|---|---|---|---|---|
| Aluminum | 0.018 | 0.0069 | 0.00036 | 0.00014 | 0.0091 | 0.0035 |
| Barium | 0.000022 | 0.000017 | 0.00000043 | 0.00000034 | 0.000011 | 0.0000088 |
| Chromium | 0.14 | 0.072 | 0.0029 | 0.0014 | 0.073 | 0.037 |
| Acenaphthylene [d] | 0.28 | 0.28 | 0.0056 | 0.0056 | 0.14 | 0.14 |
| Benzo(a)anthracene [d] | 0.81 | 0.81 | 0.016 | 0.016 | 0.41 | 0.41 |
| Benzo(a)pyrene | 4.1 | 2.2 | 0.083 | 0.044 | 2.1 | 1.1 |
| Benzo(b)fluoranthene | 29.8 | 17.6 | 0.60 | 0.35 | 15.2 | 9.0 |
| Fluorene | 0.043 | 0.071 | 0.00086 | 0.0014 | 0.022 | 0.036 |
| Trichloromethane | NA | NA | NA | NA | NA | NA |

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 6-24.

[b] HQs from Table 6-27.

[c] HQs from Table 6-28.

[d] Benzo(a)anthracene and acenaphthylene mean concentrations = MDC, to compensate for influence of elevated detection limit results.

**Notes:**
MDC = maximum detection concentration in groundwater.
HQ = hazard quotient
NA = not 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 average sediment COPEC concentrations using the pore water method (**Table 6-25**) and using the dilution method (**Table 6-26**), 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. These estimated fish tissue concentrations (**Table 6-28**) 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 COPEC and for those COPECs that have available benchmark, they were all below 1 (**Table 6-28**). 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.

## 6.9 AMPHIBIAN EVALUATION

Surface water and sediment samples collected from SWMU 31 were used to assess potential impacts to sensitive amphibians that may live and reproduce at the site.

Two separate qualitative amphibian surveys were performed at SWMU 31 on April 12 and April 13, 2006. The first survey was conducted on April 12th between the hours of 1325 and 1405 and the second survey occurred on April 13th between 0730 and 0810. The surveys consisted of both visual and audible observances. Upon arrival at the site, an observer was positioned adjacent to the secondary lagoon (on the asphalt road between the lagoon and the New River) and listened for amphibian calls for three minutes. The purpose of this procedure was to identify and estimate the density of each amphibian species calling. The next procedure performed was to walk the perimeter of each lagoon at the water's edge to count the number and attempt to identify the species of amphibians observed either in the water or on the bank of the lagoon. Lastly, the entire site was traversed, looking for low areas or transition areas between the New River and the lagoons that might contain amphibians. These areas (shown on **Figure 6-5**) consisted of:

- A dry drainage ditch that paralleled the lagoons on the south side of the lagoons.
- Puddles in the road along and surrounding the lagoons.
- A dry low area approximately 50 yards west of the tertiary lagoon.
- Along the security fence line between SWMU 31 and the New River.

While walking along these areas, objects that could contain amphibians (i.e., rocks, logs, etc.) were overturned to look for evidence of amphibians. There were no breaks in the fence; therefore, a survey was not conducted along the shoreline of the New River bordering SWMU 31.

# TABLE 6-28
# EVALUATION OF GROUNDWATER COPECs THAT MAY PARTITION TO SEDIMENT AT SWMU 31 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 | 3.16 | 1.59 | 0.136 | 2 | 4.30E-01 | 2.16E-01 | 18.41 | 5.69 | 0.023 | 0.076 |
| Acenaphthylene | 0.00084 | 0.00084 | 0.29 | 1 | 2.45E-04 | 2.45E-04 | 3.04 | NA | 0.00008 | NA |
| Benzo(a)anthracene | 0.045 | 0.045 | 0.29 | 1 | 1.30E-02 | 1.30E-02 | 3.04 | NA | 0.0043 | NA |
| Benzo(a)pyrene | 0.32 | 0.17 | 0.29 | 1 | 9.20E-02 | 4.83E-02 | 3.04 | NA | 0.030 | NA |
| Benzo(b)fluoranthene | 0.41 | 0.24 | 0.29 | 1 | 1.20E-01 | 7.09E-02 | 3.04 | NA | 0.039 | NA |
| Fluorene | 0.0017 | 0.0028 | 0.29 | 1 | 4.90E-04 | 8.16E-04 | 3.04 | NA | 0.00016 | NA |

[a] Chemicals of potential ecological concern (COPEC) in groundwater, from Table 6-24, that are important bioaccumulative compounds.

[b] Sediment concentrations are means from MDC columns in Tables 6-27 and 6-28.

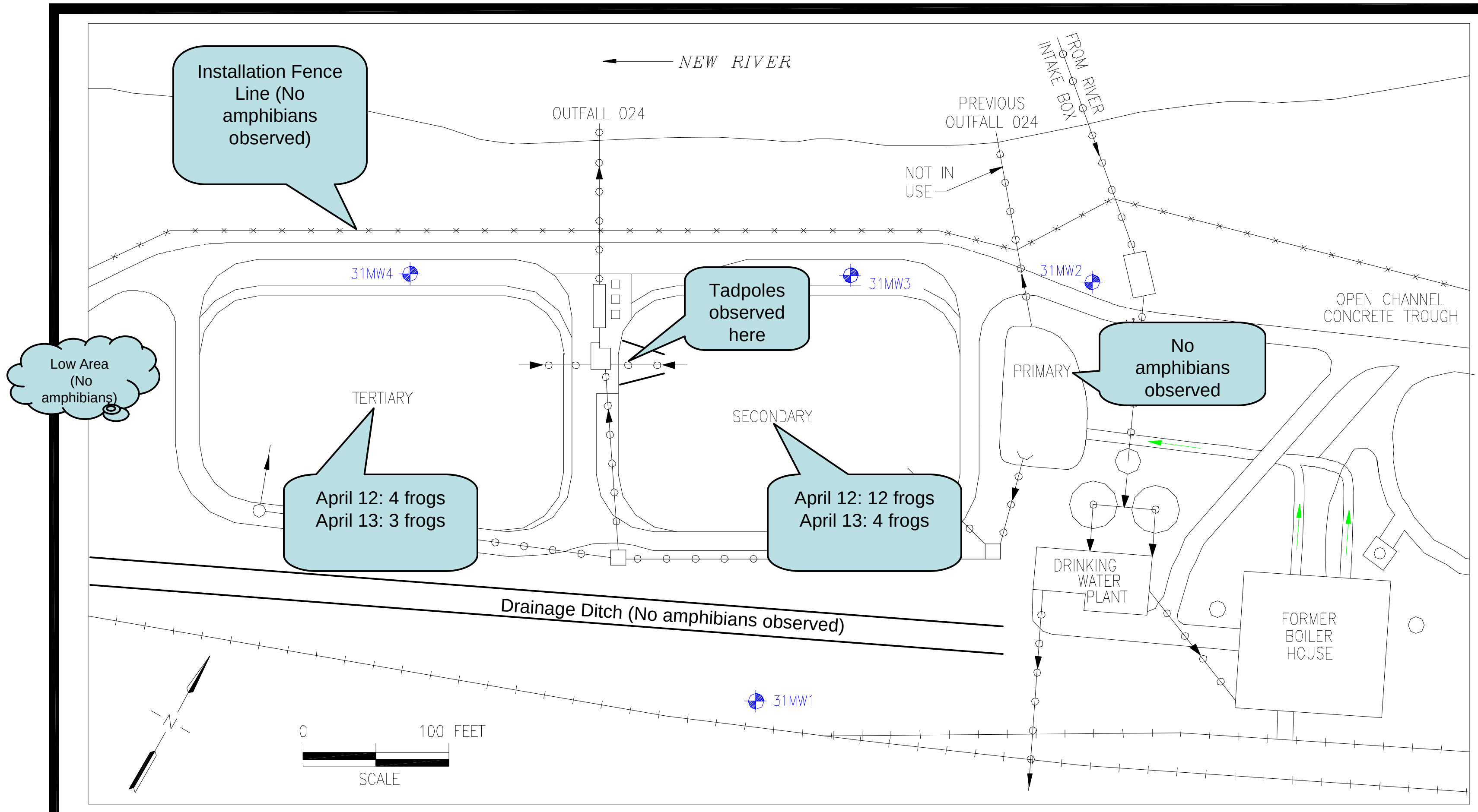
[c] Sediment concentrations are means from Mean columns in Tables 6-27 and 6-28.

[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
Benzo(a)pyrene used as a surrogate for all PAH NOAEL-based benchmarks



LEGEND

⊕ EXISTING MONITORING WELL LOCATION

GROUNDWATER CONTOUR

—o—o— UNDERGROUND PIPELINE

—×—×— FENCE

—+—+— RAILROAD TRACKS

→ SURFACE WATER FLOW

# RADFORD AAP

| | |
|---|---|
| PREPARED BY: SHAW | TASK NO: 82987002700000 |
| CHECKED BY: MT | IT DWG NO: FIGURE 6-5 |
| DATE: APRIL 2006 | |

FIGURE 6-5

SWMU 31
AMPHIBIAN SURVEY
OBSERVANCES

Results of the field survey did not document any amphibian calls (vocalizations) on either day. However, as the survey did not include the evening period, these results are not considered to be conclusive.

Results of the Lagoon Perimeter Survey and Low/Transition Area recorded the following:

- Primary Lagoon: No amphibians were observed in the primary lagoon on either day.
- Secondary Lagoon: This lagoon contained the most amphibians out of all three lagoons. On April 12th, there were 12 frogs observed jumping into the water. The majority were observed on the north shoreline. On April 13th, there were 4 frogs observed jumping into the water along the north shoreline. Also observed were approximately 10 tadpoles (approximately 2 inches long) swimming inside the concrete spillway in the northwest corner of the lagoon.
- Tertiary Lagoon: On April 12th, there were 4 frogs observed jumping into the water (2 on the north shoreline and 2 on the south shoreline). No tadpoles or other amphibians were observed. On April 13th, there were 3 frogs observed jumping into the water (1 on the north shoreline, 1 on the west shoreline, and 1 on the east shoreline). No tadpoles or other amphibians were observed.
- Low/Transition Area: No amphibians were observed on either day in this area.

Results of the amphibian survey demonstrate the presence of amphibians at the site.

To evaluate the potential significance of the 35 surface water COPECs (from **Table 6-8**) on amphibians, effect level concentrations were obtained from USEPA's ECOTOX on-line data base (USEPA, 2002c, 2006b). Effect endpoints of concern selected for the search included growth, reproduction, population, and survival. Target genera in the search included salamanders (Ambystoma), toads (Xenopus and Bufo), and frogs (Rana and Hyla). These five genera are expected to be representative of the typical amphibian test species utilized in standard laboratory toxicity tests, and these genera include 50 percent of the amphibian species listed as being present at RFAAP [Appendix B in Virginia Department of Game and Inland Fish (DGIF)]. **Table 6-29** presents a summary of the amphibian surface water concentrations of potential concern from the ECOTOX database search. The geometric average concentration of the available effect levels for each COPEC was determined following the approach used by USEPA (2005a) for developing NOAEL and LOAEL TRVs, as well as the lowest LOAEL for all five genera, as there may be significant differences among these genera (Thompson, 2006). As noted in **Table 6-29**, the concentrations of concern for iron may be biased low due to some of the compounds or elements considered in the individual studies for iron.

For SWMU 31, one COPEC (aluminum) had both maximum and mean concentrations that exceeded concentrations of potential concern for adverse amphibian effects (**Table 6-30**). Estimated HQs ranged from 6 to 264. There are many caveats associated with these hazard estimates, discussed as follows.

- The use of the detected concentrations in the screening assessment is overly conservative because total, not dissolved concentrations were collected in the field, and surface water samples collected may have been turbid. Dissolved concentrations of metals are actually the bioavailable fraction, and dissolved concentrations of COPECs are expected to be significantly lower than total concentrations.

## Table 6-29
## Concentrations of Concern for Potential Adverse Amphibian Effects From Exposure to Surface Water

| COPEC [a] | Concentration of Concern for Potential Adverse Amphibian Effects [b] (Geomean) (mg/L) | Concentration of Concern for Potential Adverse Amphibian Effects [c] (Lowest LOAEL) (mg/L) | Number of Effect Levels From ECOTOX Data Base Search [d] | Compounds Included in EcoTox Data Base Search Results | Comment |
|---|---|---|---|---|---|
| Aluminum | 0.64 | 0.05 | 25 | aluminum chloride | |
| Barium | 244 | 244 | 1 | barium chloride | |
| Calcium | NA | NA | NA | NA | |
| Chromium | 1.24 | 0.03 | 4 | Chromium | |
| Iron | 25 | 17.6 | 6 | iron methanoarsenate, iron salts | arsenic complexed with iron may be responsible for toxicity, not iron itself. |
| Lead | 2.4 | 0.04 | 16 | lead, lead nitrate, lead salts | |
| Magnesium | NA | NA | NA | NA | |
| Manganese | 9.8 | 1.42 | 10 | manganese, manganese sulfate, manganese chloride | |
| Mercury | 0.247 | 0.00016 | 52 | mercury, mercuric chloride, acetao-o-phenylmercury | |
| Nickel | 0.05 | 0.05 | 1 | Nickel | |
| Potassium | NA | NA | NA | NA | |
| Sodium | NA | NA | NA | NA | |
| Zinc | 9.57 | 0.01 | 5 | Zinc | |
| 1,2-Dichlorobenzene | NA | NA | NA | NA | |
| 1,3-Dichlorobenzene | NA | NA | NA | NA | |
| 1,4-Dichlorobenzene | NA | NA | NA | NA | |
| 2,4,5-TP (Silvex) | 29 | 10 | 12 | 2,4,5-TP (Silvex) | |
| 2-Methylnaphthalene | NA | NA | NA | NA | |
| Benzoic Acid | 748 | 433 | 2 | Benzoic Acid | |
| alpha-BHC | 13.2 | 7.27 | 2 | alpha-BHC | |
| delta-BHC | NA | NA | NA | NA | |
| gamma-BHC (Lindane) | 5.46 | 0.94 | 17 | gamma-BHC (Lindane) | |
| Butyl benzyl phthalate | NA | NA | NA | NA | |
| Di-n-butyl phthalate | NA | NA | NA | NA | |
| Diethyl phthalate | NA | NA | NA | NA | |
| Hexachlorobutadiene | NA | NA | NA | NA | |
| Hexachloroethane | 2.79 | 2.44 | 2 | Hexachloroethane | |
| Nitrobenzene | NA | NA | NA | NA | |
| Dicamba | NA | NA | NA | NA | |
| Endosulfan II | NA | NA | NA | NA | |
| Endrin | NA | NA | NA | NA | |
| Pyrene | 11.3 | 8.7 | 5 | benzo(a)pyrene used as surrogate (pyrene data NA). | |
| Bromodichloromethane | 1.0 | 1.0 | 4 | bromodichloromethane | |
| Dibromochloromethane | 1.0 | 1.0 | 4 | dibromochloromethane | |
| Trichloromethane | 3.5 | 0.27 | 9 | trichloromethane | |

NA = not available.

LOAEL = lowest observed adverse effect level.

[a] From Table 6-8.

[b] Geometric average of effect concentrations available from the USEPA ECOTOX data base (http://www.epa.gov/ecotox) for typical amphibian test species, including the following genera: *Ambystoma* (salamanders); *Xenopus* and *Bufo* (toads); and *Rana* and *Hyla* (frogs). Effect endpoints included growth, reproduction, population, and survival.

[c] Lowest effect concentrations available from the USEPA ECOTOX data base (http://www.epa.gov/ecotox) for typical amphibian test species, including the following genera: *Ambystoma* (salamanders); *Xenopus* and *Bufo* (toads); and *Rana* and *Hyla* (frogs). Effect endpoints included growth, reproduction, population, and survival.

[d] This represents the number of effect concentrations used in developing the potential effect concentrations, based on search criteria in footnotes "b" and "c."

## Table 6-30
## Surface Water COPECs and Potential Effects on Amphibians at SWMU 31

| COPEC [1] | Samples Results Summary (mg/L) | | | | | | Effect Levels (mg/L) | | Screening Assessment Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Detects | FOD | Min Detect | Mean Concentration [2] | Max Detect | Concentration of Potential Concern for Adverse Amphibian Effects (Geomean) [3] | Concentration of Potential Concern for Adverse Amphibian Effects (Lowest LOAEL) [3] | Maximum Concentration Greater than Geomean Concentration of Concern? | Mean Concentration Greater than Geomean Concentration of Concern? | Maximum Concentration Greater than Lowest LOAEL Concentration of Concern? | Mean Concentration Greater than Lowest LOAEL Concentration of Concern? |
| Aluminum | 6 | 6 | 100% | 2.97E-01 | 3.93E+00 | 1.32E+01 | 6.4E-01 | 5.0E-02 | **Yes** | **Yes** | **Yes** | **Yes** |
| Barium | 6 | 6 | 100% | 1.75E-02 | 2.29E-02 | 3.56E-02 | 2.4E+02 | 2.4E+02 | No | No | No | No |
| Calcium | 6 | 6 | 100% | 9.71E+00 | 1.25E+01 | 1.58E+01 | NA | NA | NA | NA | NA | NA |
| Chromium | 6 | 1 | 17% | 4.70E-03 | 2.70E-03 | 4.70E-03 | 1.2E+00 | 3.0E-02 | No | No | No | No |
| Iron | 3 | 3 | 100% | 5.04E-02 | 6.40E-01 | 1.54E+00 | 2.5E+01 | 1.8E+01 | No | No | No | No |
| Lead | 5 | 2 | 40% | 2.51E-03 | 2.30E-03 | 6.01E-03 | 2.4E+00 | 4.0E-02 | No | No | No | No |
| Magnesium | 6 | 6 | 100% | 3.67E+00 | 4.72E+00 | 5.76E+00 | NA | NA | NA | NA | NA | NA |
| Manganese | 4 | 4 | 100% | 7.60E-03 | 9.47E-02 | 2.63E-01 | 9.8E+00 | 1.4E+00 | No | No | No | No |
| Mercury | 6 | 2 | 33% | 8.30E-05 | 1.30E-04 | 1.86E-04 | 2.5E-01 | 1.6E-04 | No | No | **Yes** | No |
| Nickel | 6 | 1 | 17% | 4.10E-03 | 4.10E-03 | 4.10E-03 | 5.0E-02 | 5.0E-02 | No | No | No | No |
| Potassium | 6 | 6 | 100% | 1.11E+00 | 1.43E+00 | 1.90E+00 | NA | NA | NA | NA | NA | NA |
| Sodium | 6 | 6 | 100% | 5.70E+00 | 9.41E+00 | 1.19E+01 | NA | NA | NA | NA | NA | NA |
| Zinc | 6 | 4 | 67% | 3.00E-03 | 7.88E-03 | 1.60E-02 | 9.6E+00 | 1.0E-02 | No | No | **Yes** | No |
| 1,2-Dichlorobenzene | 6 | 1 | 17% | 2.50E-04 | 2.50E-04 | 2.50E-04 | NA | NA | NA | NA | NA | NA |
| 1,3-Dichlorobenzene | 6 | 1 | 17% | 2.60E-04 | 2.60E-04 | 2.60E-04 | NA | NA | NA | NA | NA | NA |
| 1,4-Dichlorobenzene | 6 | 1 | 17% | 2.60E-04 | 2.60E-04 | 2.60E-04 | NA | NA | NA | NA | NA | NA |
| 2,4,5-TP (Silvex) | 3 | 1 | 33% | 2.90E-05 | 2.90E-05 | 2.90E-05 | 2.9E+01 | 1.0E+01 | No | No | No | No |
| 2-Methylnaphthalene | 6 | 1 | 17% | 3.10E-05 | 3.10E-05 | 3.10E-05 | NA | NA | NA | NA | NA | NA |
| Benzoic Acid | 6 | 3 | 50% | 3.40E-03 | 1.20E-02 | 1.20E-02 | 7.5E+02 | 4.3E+02 | No | No | No | No |
| alpha-BHC | 3 | 2 | 67% | 8.85E-06 | 9.00E-06 | 9.15E-06 | 1.3E+01 | 7.3E+00 | No | No | No | No |
| delta-BHC | 3 | 2 | 67% | 1.42E-05 | 1.30E-05 | 1.49E-05 | NA | NA | NA | NA | NA | NA |
| gamma-BHC (Lindane) | 3 | 1 | 33% | 7.19E-06 | 7.19E-06 | 7.19E-06 | 5.5E+00 | 9.4E-01 | No | No | No | No |
| Butyl benzyl phthalate | 6 | 2 | 33% | 5.00E-04 | 1.20E-03 | 1.20E-03 | NA | NA | NA | NA | NA | NA |
| Di-n-butyl phthalate | 6 | 2 | 33% | 7.40E-04 | 1.00E-03 | 1.00E-03 | NA | NA | NA | NA | NA | NA |
| Diethyl phthalate | 6 | 3 | 50% | 2.00E-03 | 3.42E-03 | 8.00E-03 | NA | NA | NA | NA | NA | NA |
| Hexachlorobutadiene | 6 | 1 | 17% | 2.60E-04 | 2.60E-04 | 2.60E-04 | NA | NA | NA | NA | NA | NA |
| Hexachloroethane | 6 | 1 | 17% | 2.70E-04 | 2.70E-04 | 2.70E-04 | 2.8E+00 | 2.4E+00 | No | No | No | No |
| Nitrobenzene | 6 | 1 | 17% | 1.00E-04 | 1.00E-04 | 1.00E-04 | NA | NA | NA | NA | NA | NA |
| Dicamba | 3 | 1 | 33% | 1.54E-04 | 1.54E-04 | 1.54E-04 | NA | NA | NA | NA | NA | NA |
| Endosulfan II | 3 | 1 | 33% | 7.60E-05 | 3.20E-05 | 7.60E-05 | NA | NA | NA | NA | NA | NA |
| Endrin | 3 | 1 | 33% | 8.34E-05 | 3.40E-05 | 8.34E-05 | NA | NA | NA | NA | NA | NA |
| Pyrene | 6 | 1 | 17% | 2.60E-05 | 2.50E-05 | 2.60E-05 | 1.13E+01 | 8.70E+00 | No | No | No | No |
| Bromodichloromethane | 3 | 3 | 100% | 1.30E-03 | 2.50E-03 | 3.60E-03 | 1.00E+00 | 1.00E+00 | No | No | No | No |
| Dibromochloromethane | 3 | 2 | 67% | 1.70E-04 | 2.00E-04 | 2.00E-04 | 1.00E+00 | 1.00E+00 | No | No | No | No |
| Trichloromethane | 3 | 3 | 100% | 1.60E-02 | 2.27E-02 | 3.00E-02 | 3.50E+00 | 2.70E-01 | No | No | No | No |

**Notes:**

NA = not available.

LOAEL - lowest observed adverse effect level.

[1] See Table 6-8 for COPEC determination.

[2] Mean concentration calculated using one-half of the detection limit for non-detect results. If calculated mean > MDC, then MDC used.

[3] From USEPA EcoTox data base, see Table 6-31 and text for discussion.

- Background concentration of aluminum are likely greater than the ECOTOX effect concentrations of 0.64 and 0.05 mg/L. This suggests that some conditions of the aluminum toxicity tests, such as low pH for a number of the tests, may have artificially enhanced toxicity, which would overestimate toxicity if the 0.64 and 0.05 mg/L concentrations were used to assess potential toxicity in the field.
- Almost all of the literature toxicity tests used aluminum chloride, not aluminum; therefore, chloride could have contributed to the measured toxicity, and not aluminum.
- Many of the toxicity tests were run using amphibian eggs, which appear to be more sensitive to aluminum compared with tadpoles or adults. Thus, while lagoon surface water may inhibit egg development, adult amphibians may not be adversely affected.
- As tadpoles were observed in the lagoons, ambient concentrations of aluminum in surface water do not appear to be significantly impacting amphibian development in the field.

Two COPECs (mercury and zinc) had maximum concentrations that exceeded the lowest LOAEL for adverse amphibian effects (**Table 6-30**). Estimated HQs were relatively low, at 1.2 and 1.6, respectively. In addition, the use of mean concentrations or the use of the geometric mean effect thresholds, would have resulted in no exceedences for these two metals.

Concentrations of COPECs in sediment may be having an adverse effect on existing populations of amphibians in the lagoons. However, there are no readily available sediment screening concentrations for amphibians or searchable data bases for the adverse effects of sediment constituents on amphibians. Both direct exposure to sediments, and ingestion of contaminated food items that have bioaccumulated COPECs from sediment (and surface water) may be significant exposure pathways for amphibians. An indication of potential sediment toxicity to amphibians may be implied from the results of the direct sediment screen (**Table 6-20**). As shown in this table, 24 COPECs exceed conservative sediment screening values, suggesting some adverse effects to sensitive organisms such as amphibians. However, as the field survey recorded both juvenile and adult amphibians in the lagoons, ambient COPEC conditions in the sediments do not appear to be having acute adverse effects on local populations of amphibians.

In conclusion, the results of this amphibian evaluation suggest that local populations of amphibians are not expected to be significantly impacted by surface water or sediment COPECs.

## 6.10 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. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, toxicity information derived from toxicity testing, field studies, or observation will have uncertainties associated with them. Laboratory studies conducted to obtain site-specific, measured information often suffer from poor relevance to the actual exposure and uptake conditions on site (i.e., bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions). 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. Finally, habitat- or site-specific species may be misidentified if, for example, the observational assessment results are based on one brief site reconnaissance.

There were 83, 143, and 132 chemical constituents not detected in surface soil, surface water, and sediment analytical samples, respectively. **Appendix F-2, Tables F-23 through F-25** evaluates 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. Ecological screening values were compiled as discussed in **Appendix F-3**, and final screening values are presented in **Appendix F-2, Tables F-26 through F-28**.

For surface soil, 8 of the 83 non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

For surface water, 48 of the 143 non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

For sediment, 64 of the 132 non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

The uncertainty analysis is presented in **Table 6-31** 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, 1997b).

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 this 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 6-31
## Uncertainty Analysis

| Component | Bias | Magnitude | Ways to Minimize Uncertainty | Additional Comments |
|---|---|---|---|---|
| Use of 95 percent UCL as source-term concentration | Overestimates Risk | Medium | Use central tendency | Easy to implement, but may not be acceptable to Agency. |
| Assumption that soil depth interval of 0-2 ft is representative of surface soil | Overestimates Risk | Low to Medium | Resample to obtain additional samples 0-0.5 ft. for surface soil characterization | Moderately costly to implement. |
| 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 percent) for some species | Overestimates Risk | Medium | Use more site-specific foraging factors, i.e., less than 100 percent | May be difficult to obtain site-specific foraging factors. |
| Assumption that COPECs are 100 percent 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.<br>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. |

## 6.11 SLERA RESULTS AND CONCLUSIONS

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 31. 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 6-17**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife, and for other direct contact exposures in surface water and sediment, are summarized in **Tables 6-18 through 6-20**.

Although four metals were initially identified as risk drivers in soil for the food chain pathway, all of these metals were subsequently determined to be related to background.

The Tier 2 food chain assessment results suggest potential adverse impacts to terrestrial wildlife, such as the shrew and American robin, for modeled contact with 2,3,7,8-TCDD and DDT, respectively, in soil via terrestrial invertebrate ingestion.

The direct contact assessment results for soil invertebrates suggest that a reduction in wildlife food supply, due to COPECs in surface soil, is unlikely. The direct contact results for surface water and sediment, however, indicate that aluminum, barium, iron, lead, endosulfan II, endrin, and pyrene in surface water, and 24 COPECs in sediment, may potentially affect aquatic biota.

Potential adverse impacts to amphibians in the lagoons are a not expected to be a significant concern, as the results of the amphibian evaluation suggest that local populations of amphibians are not being significantly impacted by surface water or sediment COPECs. However, several screening COPEC concentrations were exceeded.

Migration of COPECs in groundwater to surface waters and sediment of the New River was determined not to be a significant ecological concern.

The assessment results may serve as the foci of discussions with risk managers and regulatory agencies. 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.

# 7.0 SUMMARY AND CONCLUSIONS

SWMU 31 consists of three connected unlined settling lagoons that were constructed and first used in the 1950s. The primary settling lagoon received water carrying fly ash and bottom ash from Power House No. 2 from the 1950s until the late 1980s. The secondary and tertiary lagoons were designed to receive the primary lagoon discharge.

Facility representatives indicate that the water currently flowing into the primary settling lagoon consists of either overflow from the drinking water settling tanks or backwash from the cleaning of the filters at the drinking water settling tanks at Water Plant 4330. The water treatment plant has also been active since the 1950s and is the only currently active discharge to the lagoons.

Data from three previous investigations was combined with data from the current (2002) investigation to evaluate the nature and extent of contamination (*Section 3.0*) and to assess potential impacts to human health (*Section 5.0*) and/or ecological receptors (*Section 6.0*).

### *Contamination Assessment*

The contamination assessment indicated that pesticides, herbicides, PCBs, explosives and perchlorate are not a concern at the site since they did not exceed screening levels in site media. The assessment also indicated that VOCs detected at the site in surface water and groundwater are water chlorination byproducts, and were detected at concentrations below MCLs. These compounds were not detected in soil or sediment, indicating that VOCs are not migrating via those pathways.

PAHs detected in sediment exceeded residential screening levels [industrial screening level for benzo(a)pyrene] in seven out of 14 samples. Benzo(a)pyrene also exceeded the tap water RBC, but was below the MCL, in two of seven groundwater samples. Although these results indicate that there is some migration of PAHs from sediment to groundwater, the low frequency of exceedances in sediment and the lack of reproducibility in the groundwater samples suggest that PAHs are not a major concern at this site. Non-PAH SVOCs were detected below screening levels in site media, with the exception of bis(2-ethylhexyl)phthalate. This compound is a common laboratory contaminant and was “B” flagged during data validation were it exceeded screening levels, indicating that it was also detected in associated laboratory blanks. Therefore, non-PAH SVOCs are also not considered to be a major concern at the site.

Metals exceeding screening levels in surface water were aluminum, iron, and manganese. Filtered groundwater samples show that aluminum was the only constituent to consistently exceed a screening level. Sediment also showed aluminum levels greater than background. Soil samples did not contain any metals at concentrations greater than background and residential or industrial screening levels.

The calculated TCDD TE for one soil sample exceeded the residential screening level for TCDD. Individual congeners of dioxins/furans were below screening levels. Deeper samples collected from the same soil boring indicate that dioxins/furans are not migrating vertically. This sample was collected immediately beneath an asphalt road, which limits exposure to human or ecological receptors. The sediments in the lagoons had TCDD TEs below residential screening levels. The lack of an exposure pathway to the sole exceedance of dioxins/furans suggests that dioxins/furans are not a major concern at the site.

### *Human Health Risk Assessment*

An HHRA (*Section 5.0*) was performed to evaluate the potential human health effects associated with past activities at SWMU 31. Using the results of the human exposure assessment and toxicity information, potential human health risks for each COPC and selected exposure pathway were evaluated.

The potential cumulative risks for maintenance workers (current and future) for exposure to surface soil were below the target risk range and HIs were less than 1. The risk range for exposure to sediment was slightly elevated at $2.0\text{x}10^{-6}$; however, the major risk driver was arsenic, which is below background at the site. The total HI was less than 1. Current and future maintenance exposure risks associated with surface water were also below the target risk range with an HI less than 1. Current and future maintenance exposure risks associated with groundwater were below the target risk range with an HI less than 1.

The cumulative risk for exposure to soil, sediment, surface water and groundwater is $2.9\text{x}10^{-6}$, with an HI of less than 1. These results indicate potentially slightly elevated risk to current workers, with the major COPC being arsenic, which was determined to be within background.

For the current and future industrial worker (outdoor), total cancer risk from exposure to total soil and surface soil was slightly elevated at $3.8\text{x}10^{-6}$, but again the major risk driver was arsenic, which is below background at the site. The total HIs were less than 1. Future exposure risks associated with sediment were also slightly elevated due to arsenic at $9.2\text{x}10^{-6}$, with an HI of less than 1. Risks from exposure to surface water were below the target risk range with an HI of less than 1. For the current industrial worker (outdoor) exposures, the risk characterization results showed the total cancer risk associated with groundwater ($8.3\text{x}10^{-8}$) was below the target risk range. The total HI was less than 1. For the future industrial worker (outdoor) exposures to groundwater, total cancer risk was elevated at $4.6\text{x}10^{-5}$ with benzo(a)pyrene and arsenic as the major drivers. The total HI was less than 1.

For the future industrial worker (indoor) exposures, risk from exposure to groundwater was elevated at $4.7\text{x}10^{-5}$, with the major risk drivers being benzo(a)pyrene, arsenic, and chloroform. Chloroform in groundwater, however, is related to the site's current use as part of the water treatment plant. The total HI was less than 1.

For the future excavation worker (based on 1.25 acres), risk from exposure to total soil was below the target range; however, the HI (HI = 5.96) was greater than 1, primarily due to manganese. Manganese has been shown to be within background concentrations. Risk from exposure to sediment was $1.0\text{x}10^{-6}$, with an HI of less than 1. Risks from exposure to surface water and groundwater were below the target range, with HIs of less than 1.

Although a residential scenario at SWMU 31 is unlikely, both future lifetime/adult and child residents were evaluated. For future adult residents, potential exposure to soil, sediment, and surface water all produced HIs of less than 1. Cancer risks form exposure to soil ($1.7\text{x}10^{-5}$) and sediment ($3.8\text{x}10^{-6}$) were slightly elevated, again with the major risk driver being arsenic. Cancer risks from surface water were below the target range. Risks from exposure to groundwater ($3.7\text{x}10^{-4}$) were above the target risk range, with the major risk drivers being benzo(a)pyrene, arsenic, and chloroform. As noted above, chloroform in groundwater is related to the site's current use as part of the water treatment plant. The total HI (HI = 2.4) was above 1; there was no major risk driver. For potential off-site residents, the cancer risks and HIs associated with groundwater exposures are assumed to be the same as those for future on-site residents.

For the future child resident, total soil cancer risk was in the target range ($1.2x10^{-5}$) with the major risk drivers being dioxins/furans and arsenic. The HI was 3.4, primarily due to iron (determined from margin of exposure evaluation to be within the allowable range) and vanadium (which was determined to be within the range of background concentrations). Potential child resident exposure to sediment was slightly elevated ($2.5x10^{-6}$) again due to arsenic, with a total HI less than 1. There were no risks associated with surface water. Risks from exposure to groundwater ($1.3x10^{-4}$) were above the target risk range, with the major risk drivers being benzo(a)pyrene and arsenic. The total HI (HI = 5.7) was above 1, primarily due to arsenic, iron (determined from margin of exposure evaluation to be within the allowable range), and vanadium. For potential off-site residents, the cancer risks and HIs associated with groundwater exposures are assumed to be the same as those for future on-site residents.

### *Screening Level Ecological Risk Assessment*

A SLERA (*Section 6.0*) was performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMU 31. Although four metals were initially identified as risk drivers in soil for the food chain pathway, all of these metals were subsequently determined to be related to background. The Tier 2 food chain assessment results suggested potential adverse impacts to terrestrial wildlife such as the shrew and American robin for modeled contact with 2,3,7,8-TCDD and DDT, respectively.

The direct contact assessment results for soil invertebrates suggested that a reduction in wildlife food supply, due to COPECs in surface soil, was unlikely. The direct contact results for surface water and sediment, however, indicated that aluminum, barium, iron, lead, endosulfan II, endrin, and pyrene in surface water, and 24 COPECs in sediment, may potentially affect aquatic biota.

Potential adverse impacts to amphibians in the lagoons were not expected to be a significant concern, as the results of the amphibian evaluation suggested that local populations of amphibians are not being significantly impacted by surface water or sediment COPECs. However, several screening COPEC concentrations were exceeded.

Migration of COPECs in groundwater to surface waters and sediment of the New River was determined not to be a significant ecological concern.

### *Conclusion*

Overall, there appears to be minimal to no risk to current workers at the site with the major risk driver being arsenic. The HHRA calculated elevated risks to future residential receptors. The SLERA concluded that aquatic biota may be impacted by lagoon surface water and sediment. There may be potential impact to amphibians as well from lagoon surface water and sediment.

It is recommended that a CMS be conducted to evaluate potential remedial alternatives for the site.

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# Appendix A

# Lithologic Boring Logs, Water Quality Parameters, Groundwater Contour Maps & Outfall 024 Data

# Appendix B
# Sample Location Coordinates and Elevations

# Appendix C
# Quality Assurance/Quality Control

**<u>This Appendix Contains:</u>**

# Appendix C-1
# Analytical Services and Procedures

# Appendix C-2
# Quality Assurance/Quality Control Evaluation

# Appendix C-3
# 2002 RFI Field Audit Report

# Appendix D
# Contaminant Fate and Transport

# Appendix E
# Human Health Risk Assessment Tables and Statistical Comparison Results

**<u>This Appendix Contains</u>:**

**Appendix E-1 Human Health Risk Assessment Tables**
**Appendix E-2 Statistical Comparison Results**
**Appendix E-3 Johnson and Ettinger Model Calculations**

# Appendix E-1
# Human Health Risk Assessment Tables

# Appendix E-2
# Statistical Comparison Results

# Appendix E-3
# Johnson and Ettinger Model Calculations

# Appendix F
# SLERA Site Reconnaissance Photographs, Supplemental SLERA Tables, and Selection of Screening Concentrations for the Evaluation of Non-Detected Constituents

**This Appendix Contains:**

| | |
|---|---|
| **Appendix F-1** | **SLERA Site Reconnaissance Photographs** |
| **Appendix F-2** | **SLERA Risk Characterization Tables** |
| **Appendix F-3** | **Selection of Screening Concentrations for the Evaluation of Non-Detected Constituents** |

# Appendix F-1
# SLERA Site Reconnaissance Photographs

# Appendix F-2
# SLERA Risk Characterization Tables

# Appendix F-3

# Selection of Screening Concentrations for the Evaluation of Non-Detected Constituents