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August 21, 1995

Mr. Jeffery A. Dodd (Mail Code 3HW33)
USEPA, Region III
Removal Enforcement Section
Hazardous Waste Managment Division
33 Methodist Building, 11th and Chaplain Streets
Wheeling, WV 26003

Dear Mr. Dodd:

On behalf of Mr. Scott Slagley, Project Coordinator for the Richmond, Fredericksburg and Potomac Railroad Company (RF&P), the WEINBERG CONSULTING GROUP Inc. (WEINBERG GROUP) is pleased to submit the enclosed revised Human Health and Ecological Risk Assessment for Potomac Yard in Alexandria, Virginia. RF&P is submitting this document in accordance with the requirements of the amended Administrative Order by Consent between RF&P and the U.S. Environmental Protection Agency (Docket No. III-92-61-DC), paragraph 8.3.c.ii.

The enclosed Risk Assessment has been revised to respond to comments on the Draft Human Health and Ecological Risk Assessment (June 7, 1995) provided by EPA Region III in a letter dated July 17, 1995 to Scott Slagley of RF&P Corporation. Also enclosed are tables summarizing EPA's comments, RF&P's responses, and the locations in the Risk Assessment where the comments are addressed. RF&P's revisions to the Risk Assessment reflect discussions held with EPA personnel to clarify issues raised in the July 17, 1995 comments.

By copy of this letter, the Human Health and Ecological Risk Assessment is being shipped separately to those persons shown below. If you have any questions, please contact Mr. Scott Slagley at (804)225-1608.

Very truly yours,

S Thomas Golojuch

WEINBERG CONSULTING GROUP Inc.
S. Thomas Golojuch

STG/bjp

Enclosure

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SUMMARY OF RESPONSES TO U.S. EPA REGION III COMMENTS ON THE HUMAN HEALTH RISK ASSESSMENT POTOMAC YARD SITE, CITY OF ALEXANDRIA AND ARLINGTON COUNTY, VIRGINIA

Comment	Response	Affected Section
1. Table 3-8. IRIS now includes an oral slope factor for arsenic of 1.5 per mg/kg/d, rather than the 1.75 shown in this table. Although apparently minor, this change will make a meaningful difference to the risk assessment.	The current IRIS oral slope factor for arsenic of 1.5 per mg/kg/d is listed in Table 3-8 and is used in the arsenic risk calculations.	Table 3-8; Section 3.4; risk quantitation tables.
2. Table 3-10. The reasoning by which it was decided to assess dermal exposures "qualitatively" is unclear. This line of argument should be expanded into something EPA can accept, or dermal exposure calculations should be added to the risk assessment.	A more complete discussion of the reasoning by which it was decided to assess dermal exposures qualitatively is provided in the risk assessment. Example calculations to show the relative contribution to potential risks are provided as part of this discussion.	Section 3.3.1; Appendix L.

Comment	Response	Affected Section
3. Table 3-10. The risk assessment determined that exposure pathways would not be complete for several receptor groups who could contact soil in landscaped areas after interim and final development of the site. The basis for this determination was an assumption that these areas would require the addition of clean topsoil in order to support vegetation. *EPA has already expressed concern about this assumption in a recent meeting with the PRP's consultant. The basis of our concern is that there is no evidence that the contaminated soil will not support vegetation. If the ROD does not contain a requirement to cover all landscaped areas with clean soil and the contaminated soil proves fertile enough to grow plants, then human exposure would be possible. EPA believes that such a requirement may be justified for this ROD, but this justification should be based on a quantitative assessment of future direct contact risks (which is missing from this draft). Future risks associated with direct contact with surface soil should be calculated and the results placed in the risk assessment. The calculations should be fairly simple, and since the PRPs have tacitly assumed that clean soil will need to be added anyway a requirement by the ROD to do so should not be onerous.*	The risks associated with the use of subsurface soil brought to the surface without the addition of topsoil prior to landscaping are evaluated. These evaluations are carried out for potential exposures occurring after interim development and after future development. They are completed for all site areas except Central Operations.	Appendix K; brief references to the analysis presented in Appendix K are made in relevant sections of the human health risk assessment. Summary results of this analysis are shown in the Section 3 risk quantitation tables.

AR105077

Comment	Response	Affected Section
4. Table 3-18 and elsewhere. A detailed explanation of the derivation of the proportions used to partition diesel and lubricating oils (footnote [I]) should be added to either the text of the report or an appendix.	Appendix D discusses, in detail, the derivation of the proportions used to partition diesel and lubricating oils. Footnote [I] in Table 3-18 refers to the discussion in Appendix D.	Appendix D; Table 3-18.
5. Table 3-19 and elsewhere. Region 3 has requested that the EPA Office of Research and Development (Superfund Technical Support Center, Cincinnati) review the basis for the PRP's recommendation of a 10% absorption rate for ingested arsenic. The first draft of ORD's review (which is still underway) suggested that the extraction procedure used in the study was overly simplistic. A more complete model of a human stomach would have had a digestion time of 6 hours rather than 2, and included more components of gastric juice. The lack of these two factors may have resulted in an underestimate of true bioavailability. The reviewer used various literature citations to support a suggestion of 50% bioavailability as a reasonable maximum. *Recognizing that this review is still in draft form and may change, there is probably no point in updating these risk calculations yet. If the final review retains the 50% recommendation, I will recommend that the "high end" risk estimates for ingested arsenic be multiplied by a factor of 5 (reflecting 50% bioavailability), but the "central tendency" risks remain the same (reflecting 10%).*	EPA's Office of Research and Development has not completed its review of the risk assessment's basis for a recommended absorption factor of 10% for ingested arsenic. Therefore, the risk assessment uses a 10% bioavailability factor for the "central tendency" risk estimates and both the 10% and 50% bioavailability factors for the "high end" risk estimates.	Sections 3.3, 3.4; Section 3 risk quantitation summary tables.

AR105078

Comment	Response	Affected Section
6. Table 3-22 and elsewhere. The assumption that earth-moving activities will occur only 25% of the year should be documented.	RF&P and their construction contractors, Christopher Consultants, evaluated existing site development plans and used professional judgment based on past experience to estimate the time periods over which earth-moving activities could be expected to occur. A brief discussion of the determination of periods of time during which earth-moving activities would occur is presented in Section 3.3.3. A letter from Christopher Consultants to RF&P, documenting their professional judgment on this issue is provided in Appendix N.	Section 3.3.3; Tables 3-22, 3-23; Appendix N.

Comment	Response	Affected Section
7. Appendix A, pp. A-4 and -5. Use of 2-tailed tests as a screen, followed by 1-tailed tests using the same alpha is not logical for two reasons. First, EPA has no regulatory interest in site concentrations that are statistically lower than background. Second, the 2-tailed test is less sensitive, and could well result in dropping site concentrations that would be statistically significant under the 1-tailed test. *The t-test and Mann-Whitney U test procedures should be revised as follows. First, drop all site sample averages that are numerically less than the average of background samples, eliminating potential "less-than-background" site averages. Then test those that remain against background using the 1-tailed test. In addition to being defensible, this strategy has the advantage of being less work.*	The risk assessment presents the results of the statistical comparisons of the site data with background as suggested. Site sample mean values less than the background mean values were dropped from consideration. Chemicals remaining after this step were compared to background using the appropriate 1-tailed statistical test. Chemical concentrations significantly higher than background are identified as chemicals of potential concern. It should be noted that the risk assessment used the appropriate alpha values for the 1-tailed comparisons that were carried out. However, these comparisons were not shown in the background comparison summary tables. Results of these tests were simply noted with footnotes. The text in Appendix A, as well as the background comparison summary tables, will be revised to reflect the recommended changes and to clarify the presentation of results.	Section 3.1 (modifications to COPCs); modifications made throughout Section 3 text and tables to reflect changes in selected COPCs; Appendix A (text and tables).

Comment	Response	Affected Section
8. Tables A-7 through A-12. According to the p values in these tables, several contaminants including beryllium, chromium, and some PAHs were apparently present at levels significantly above background. It is not clear why these were not included in the risk calculations.	The p values shown in Tables A-7 through A-12 were for 2-tailed tests to determine if site and background concentrations differed. The p values for the 1-tailed tests to determine if site concentrations were significantly higher than background concentrations were not shown in these summary tables. Chemicals for which the site concentrations were significantly higher than background concentrations (i.e., for which the 1-tailed p values were less than 0.05) were indicated with footnotes. In some cases, the p values for the 2-tailed tests shown in the summary tables were less than 0.05; however, on further evaluation it was determined that the site concentrations were less than background. These findings were identified with footnotes. All chemicals present on-site at concentrations significantly greater than background were identified as chemicals of potential concern. The revision of these summary tables as described in the response to Comment 7 will clarify the identification of chemicals of potential concern.	Tables A-7 through A-12

AR105081

Comment	Response	Affected Section
9. Contaminants of concern. This is the first risk assessment I have reviewed where polynuclear aromatic hydrocarbons were considered separately instead of as a group. Because carcinogenic PAHs occur at this site as components of a mixture, and because they all appear to interact with and mutate DNA by the same mechanism, distinguishing among these compounds seems to be artificial. The risk assessment should be revised to consider carcinogenic PAHs as a group, with concentrations expressed in terms of benzo[a]pyrene equivalence.	The risk assessment has been revised to consider carcinogenic PAHs as a group, with concentrations expressed in terms of benzo[a]pyrene equivalents. PAHs identified as carcinogens in the Region III RBC tables and detected at the site are considered in the risk assessment as a group; the relative potencies provided in existing EPA provisional guidance on PAH risk assessment will be used to express concentrations in terms of B[a]P equivalence.	Text and tables throughout the human health risk assessment have been modified to address PAHs as a group rather than individually.
10. The final ambient air concentrations achieved for all of the contaminants (antimony, arsenic, cadmium, chlordane, etc.) in the dust were not provided in Appendix B. While it is a simple (though time-consuming) matter to derive these concentrations from the modeling analysis, the lack of these numbers will make it difficult for the site toxicologist to review the actual risk assessment. The contaminant specific ambient air concentrations should be provided in the document.	The final ambient air concentrations for individual chemicals of potential concern in dust are provided in the risk summary tables in Appendix I. Appendix B will be revised to reference the appropriate summary tables in Appendix I.	Appendix B; Appendix I inhalation risk summary tables.

AR105082

Comment	Response	Affected Section
Use of groundwater as a potable supply.	The risk assessment addresses this issue, not specifically noted in the EPA Region III comments, in a more detailed discussion of the potential use of groundwater in the Middle Potomac Aquifer in the vicinity of the site as a potable supply. Reference is made to a conference call held on July 7, 1995 to discuss these issues in which RF&P and EPA participated.	Section 2.1; Appendix M.
Groundwater to surface water transport.	The risk assessment addresses this issue, not specifically noted in the EPA Region III comments, in a more detailed discussion of the potential transport of chemicals detected in on-site groundwater to surface water. Results of a groundwater solute transport modeling effort are provided.	Section 2.1; Appendix J.

SUMMARY OF RESPONSES TO U.S. EPA REGION III COMMENTS ON THE ECOLOGICAL RISK ASSESSMENT POTOMAC YARD SITE, CITY OF ALEXANDRIA AND ARLINGTON COUNTY, VIRGINIA

Comment	Response	Affected Section
1. On page 4-1, the ERA states that the "...overall objective... is to determine if chemicals associated with the site have the potential to affect the structure, function, or interactions of biological populations and communities within the study area." Later on the same page, the document goes on to state that the focus is on "...potential site-related impacts on the aquatic populations and communities of Four Mile Run and the Potomac River, but the ERA does not adequately address risks to either of these habitats.	RF&P continues to believe that it will not be possible to identify site-related chemical concentrations in the sediments and/or surface waters of Four Mile Run or the Potomac River. This is because (1) historical and continuing chemical releases to these water bodies from multiple sources within the watershed have contributed and continue to contribute substantially to the chemical loadings in these waters; (2) the chemical constituents associated with the site are no different than those associated with the regional watershed; (3) the tidal nature of the receiving water complicates a determination of "downgradient". Nevertheless, RF&P has agreed to address off-site sampling issues at a later date. The text of the ecological risk assessment (ERA) report has been modified to state that off-site sampling issues will be addressed at a later date.	Sections 4.3.3, 4.5.4.2, 4.7
2. During scoping sessions for collections of data to carry out the ERA, it was suggested that sampling of Four Mile Run and the Potomac River be carried out, but this has not been done. The reason given is that other sources of contamination cloud the picture. It is inconsistent now to attempt to extrapolate to these aquatic systems based upon data that is remote and not found in this document. This is a basic flaw and should be revised in the document.	See response to Comment 1.	See response to Comment 1.

AR105084

Comment	Response	Affected Section
3. Resources at risk are presented under Section 4.1.2 (Aquatic Habitats and Wildlife) on page 4-4 of the document. Only a brief description of aquatic resources in Four Mile Run and the Potomac River was presented and no information was provided as to how species utilize habitats in Four Mile Run and the Potomac River. Such information should be included in this screening ERA.	This information, including a site habitat map and species lists, was presented in detail in Section 2.5 of the ECS report. The ERA report presented only a synopsis of this information to reduce redundancy within the reports reviewed by USEPA. The ERA report has been modified to include an explicit cross reference to the ecological background information presented in Section 2.5 of the ECS report. In addition, the habitat map that was included in the ECS is also now included in the ERA report. This map was included in the ERA in response to a request made by BTAG members during an August 7, 1995 meeting between RF&P, EPA, and the WEINBERG GROUP.	Section 4.1.

Comment	Response	Affected Section
4. The ERA is based upon extrapolated data from on-site surface water and sediment samples. In calculating effects quotients for off-site locations, the risk assessor has used on-site data to determine a lack of risk or areas where data is either unavailable or has never been collected. While their reasoning that other sources of contamination masks impacts from the site may be valid, the conclusion is speculative as no data is offered to confirm this scenario. During scoping, it was suggested that calculations of effects quotients should only be considered for the time and place related to sampling information. It is not possible to use that data to draw conclusions about other points where sampling information is included. *For example, Section 4.5, Risk Characterization, discusses on-site as well as off-site areas, Four Mile Run and the Potomac River. The document states that surface water and sediments were evaluated by using data collected from the property boundary, but no data from the two waterways themselves. It may be a correct assumption that dilution and dispersion of contaminants will occur, but that begs the issue of long-term impacts from releases over many years. The document does not offer any information regarding contaminants in either the water or*	See response to Comment 1.	See response to Comment 1.

AR105086

Comment	Response	Affected Section
5. On page 4-7, the document states that the groundwater pathway is of little or no interest for reasons that may be contested by the EPA hydrogeologist. It is our understanding that groundwater may be more important as a pathway than implied and levels of contamination (though questioned) have not been conservatively considered in the ERA. The document did not contain either summarized or raw data regarding shallow groundwater data, which is the portion of the groundwater issue in which we are interested. If the groundwater contains contamination (as the ECS attests), then it must be concluded that contamination has moved to some degree and will continue to move towards surface water resources regardless of speed. As a result, its presence may pose a threat to ecological receptors.	The ERA report has been modified to include a detailed evaluation of the groundwater-to-surface water transport pathway and the potential risks to ecological receptors in these surface waters. Appendix J of the Risk Assessment report presents the methods, assumptions, and results of this analysis. The results are summarized in section 4.2.2.	Section 4.2.2; Appendix J.
6. Section 4.3.3.1 discusses the Four Mile Run and Potomac River outfalls, but no maps or descriptions of physical locations are provided as far as the reviewers can tell.	The ERA report has been modified to include an explicit cross reference to a sample location map in the ECS report. The report also has been modified to include a listing of the sample locations that were regarded as outfall locations for the ERA.	Section 4.3.3.

AR105087

Comment	Response	Affected Section
7. In Risk Characterizations section 4.4, it is stated that the arsenic TSV takes into account the fact that this contaminant has been shown by site-specific study to be less than 100% bioavailable. The specific study is not cited and should be, as it is difficult to agree with the assumption without detailed information.	The details regarding the site-specific arsenic bioavailability study are presented in Appendix E of the risk assessment report. The draft ERA report cross referenced this appendix as the basis of the arsenic bioavailability assumption used in the assessment. The cross reference was made in the last sentence of Section 4.4. The information requested by BTAG is contained in that appendix. Therefore, no change has been made to the ERA report.	None.
8. The Conclusions, Sect. 4.7, probably underestimates risk because of the flaws in the assessment. The uncertainties section (Sect. 4.6) states that risk is likely to be overstated using the screening level approach. While this may be the case, the number of contaminants excluded on a sample-by-sample basis (see Appendix G) may result in an underestimate.	The draft ERA report stated that risks could be underestimated at the site due to the exclusion of chemicals with high detection limits from the analysis. Therefore, no changes to the uncertainty section have been made. The ERA report has been modified, however, to include a comparison of toxicity screening values (TSVs) to the elevated detection limits for all chemicals listed in Appendix G. This has been included in the risk characterization section of the ERA.	Section 4.5.

Comment	Response	Affected Section
9. Table 20 lists the uncertainties and the first one relates to the issue of this subset of chemicals used in the evaluation. In the column describing the "Effect of Assumption on Risk Estimate," it is stated that the assumption is unlikely to underestimate risk. We have not been able to take the time to compare each sampling location with the list of contaminants that may have been left out of the calculations, but the list of serious contaminants dropped is impressive. We believe this is a major weakness in the assessment and should play a major role n the uncertainties as well as the conclusions.	The report has been modified to include a comparison of the detection limits of the chemicals listed in Appendix G to TSVs. See response to Comment 8.	Section 4.5.
10. The concluding remark at the end of the risk assessment asserts that development of the site may be beneficial in reducing risks to the environment. This may be true but the screening level risk assessment has not fully defined what these risks are. Additional studies can be recommended that will support a baseline risk assessment in Four Mile Run and the Potomac River in the vicinities of where drainage ditches from the site discharge to these bodies of water.	All statements that ecological risks will be reduced following site development have been modified to state the following: Ecological risks could be reduced following site development, given that most site habitats (and consequently exposure pathways) will be eliminated. These conclusions are not definitive, however, nor can they be further supported given the available data. Also, as mentioned in response to Comment 1, the ERA has been modified to state that off-site issues will be addressed at a later date.	Throughout the ERA report.

Comment	Response	Affected Section
11. It is recognized that there are likely many sources of contamination to Four Mile Run and Potomac River other than the Potomac Yard Site, however, the magnitude and the extent of the risk to aquatic receptors in these environments needs to be defined before any conclusion can be reached. A baseline risk assessment should be based on data collected from both Four Mile Run and the Potomac River. Surface water and sediments samples should be collected from both of these areas in support of a baseline risk assessment. Sediment bioassays may also provide useful information regarding the potential risk presented to receptors in Four Mile Run and the Potomac River.	See response to Comment 1.	See response to Comment 1.

Comment	Response	Affected Section
12. A major contaminant of concern that has been ignored through out this ERA is PCBs and not addressed in the ERA is PCBs. The Extent of Contamination Study for the Potomac Yard Site reported PCBs in the sediments of a drainage ditch that discharges to Four Mile Run at concentrations as high as 7.8 mg/kg, yet PCBs were not included as a contaminant of a concern. The screening level ERA should be revised to include PCBs or some justification provided as to why PCBs were not included as a contaminant of concern. Considering that a screening level risk assessment is intended to take a conservative approach, and given the environmental persistence and toxicity of PCBs, it is recommended that PCBs be included as contaminants of concern in the screening level risk assessment.	PCBs were selected as a chemical of concern (COC) for South Yard/South Tail and Potomac Greens. PCBs were not selected as a COC for the on-site ditch referred to in the comment because on-site ditches were not selected as habitats for evaluation in the ERA, and because no PCBs were detected in downgradient ditch sediments at the point that the ditch exits the site. The ERA has been modified to include an explanation as to why PCBs in the ditch were not selected as a COC. The report also has been modified to state that PCBs in the ditch sediments may pose a risk to ecological receptors because (1) PCBs have been detected in ditch sediments at concentrations that are potentially toxic to ecological receptors, and (2) PCBs are present in a ditch that drains to Four Mile Run. The risk assessment has been further modified to state that because PCBs are present in drainage ways that leave the site, they are a likely COC for consideration for any off-site investigation.	Sections 4.2.2 4.5, 4.7.

AR105091

Comment	Response	Affected Section
13. It is not clear that all the conclusions are supportable under the assumptions that Appendix G imposes on the risk assessment. By eliminating so many contaminants of concern over the number of sampling locations a media that the appendix represents, it is possible that many habitats are under represented in the risk assessment. The following observations are offered on a bullet-by-bullet basis:		
a. The conclusion that terrestrial receptors are free from any potential for risk is incorrect. The hazard quotient based upon chronic values for the surface waters of Potomac Green (see Table 4-12) are well above one for both the mean and maximum levels reported for zinc, at least one PAH, and several chlorinated hydrocarbons. Since it is expected that a wide variety of terrestrial and water-dependent species use this habitat, the potential for risk should be acknowledged. This bullet should be deleted and the second bullet used in replacement.	The hazard quotients (HQs) for Potomac Greens surface waters are based on aquatic receptors. Statements regarding the lack of risk for terrestrial receptors are based on HQs of less than 1 for all exposure pathways that were evaluated for terrestrial species. Therefore, no change to the risk assessment has been made in response to this portion of the comment. The risk assessment correctly acknowledges the risk to aquatic receptors (as indicated in the second bullet of the conclusions).	None.

Comment	Response	Affected Section
b. Bullet No. 2 acknowledges the potential for impacts from chlorinated pesticides, but includes the equivocating statement that "...the probable low bioavailability... suggests ..." low risk. These are assumptions and without any citations offered as backup.	The statements regarding pesticide bioavailability has been excluded from the conclusions.	Section 4.7.
The conclusion also presupposes that development will act as the remedy, but this is based upon assumptions as well. It is not clear that development will occur and that risk reduction will follow, as no document to this point in time has detailed any plans.	The statements regarding a risk reduction following development have been removed from the conclusions. The risk assessment also has been modified to indicate that development is, in fact, already occurring at the site.	Sections 4.1, 4.7.

Comment	Response	Affected Section
c. Bullet No. 3 states that the site, as a source of PAHs, metals, and pesticides, will not exist following development also begs the issue in the same fashion as the second bullet. In addition, it fails to acknowledge the long-term historical impacts of the site on the surrounding habitats. The ECS failed to characterize the extent of contamination and any conclusions in the ERA regarding potentials for risk to off-site receptors has no data in support.	The statements regarding pesticide bioavailability have been removed from the conclusions. The conclusions have been modified to state that the results of the ERA cannot be used to determine historical impacts of the site. (This was stated in earlier portions of the risk assessment.) An additional bullet has been added to the conclusions to state that off-site issues will be addressed at a later date.	Section 4.7.
d. BTAG agrees with the conclusion in bullet four.	No change required.	None.
e. The conclusion that the site would have negligible effects is speculative, as the extent of contamination study is incomplete. BTAG can only conclude that it is not known at this time if the site has had or continues to have an impact on the receptors associated with Four Mile Run or the Potomac Run.	An additional bullet has been added to the conclusions to state that off-site issues will be addressed at a later date.	Section 4.7.

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Comment	Response	Affected Section
f. The sixth bullet is also based upon the speculation that the site has negligible impacts. Since the ECS failed to look at the contamination in relation to off-site areas any conclusions regarding impacts or lack of potential risk is not substantiated.	Conclusions have been modified to state that off-site issues will be addressed at a later date.	Section 4.7.
14. Based on the information provided in Tables 4-10 through 4-17, the following conclusions seem appropriate.		
a. Tables 4-10 and 4-11 show that the potential for risk from soils is negligible. This conclusion should be revised, however, as zinc as well as some other contaminants are not included. The conclusion may be premature because the table fails to include the complement of contaminants associated with the site.	Zinc is not present in site soils at concentrations above background concentrations. Therefore, no *site-related* risks for zinc exist, and no change to the ERA conclusions is warranted. An additional bullet has been added to the ERA conclusions to state that risks could be underestimated because chemicals with high detection limits were excluded from the ERA.	Section 4.7.

AR105095

Comment	Response	Affected Section
b. The complement of contamination for sediment (Table 4-13) is also not included, but is probably among those in Appendix G. This table shows that risk is present for Beta-BHC (at a quotient of 1) and lead (at a level of 2). BTAG concludes that the potential for risk to ecological receptors exists in the sediment for the inorganic contaminants, arsenic and zinc. However, the table does not include the other site-related contaminants that should be included.	The ERA conclusions have been modified to state that risks could be underestimated due to the exclusion of chemicals with high detection limits from the analysis. Table 4-13 does not show a risk for beta-BHC nor zinc.	Sections 4.5, 4.6, 4.7.
c. The outfall data in Tables 4-15 & 4-16 show that the potential for risk boundaries of the site is expected to be very high. The hazard quotient developed from the conservative ER-Ls show that contamination is moving off-site. It is concluded by BTAG that a) a very high risk potential exists at the boundary of the site and b) the extent of risk extends to habitats off-site.	This conclusion is supported by bullet 4 of the ERA conclusions. Therefore, no change is needed.	None.

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Comment	Response	Affected Section
d. Table 4-17 also shows high risk potential in at least on depositional area off-site. Any conclusion that off-site risks are negligible are refuted by this table. It is concluded that a potential for off-site risk potential exists for off-site receptors and that level may be sufficient to warrant immediate action.	The ERA conclusions have been modified to state that off-site issues will be addressed at a later date.	Section 4.7.

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT POTOMAC YARD ALEXANDRIA/ARLINGTON, VIRGINIA

Prepared for:

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600 East Main Street
Richmond, Virginia

Prepared by:

WEINBERG CONSULTING GROUP Inc.
1220 Nineteenth St., NW
Washington, D.C.

August 21, 1995

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AR105100

EXECUTIVE SUMMARY

The Human Health and Ecological Risk Assessment was carried out to evaluate the risks to human health and the environment associated with potential exposures to chemicals in environmental media at the Potomac Yard Site in the City of Alexandria and in Arlington County, Virginia. The Risk Assessment is based on the findings of the Extent of Contamination Study (ECS) conducted by the Richmond, Fredricksburg & Potomac Railroad Company (RF&P). A report of the findings of the ECS was submitted to the U.S. Environmental Protection Agency (EPA) Region III on February 22, 1995.

The Risk Assessment was prepared to fulfill requirements set forth in Section 8.3.c.iii of the Administrative Order by Consent (Consent Order) between RF&P and the EPA (Docket No. III-92-61-DC). In accordance with Section 8.3.c.iii of the Consent Order, this Risk Assessment addresses potential risks to both human health and the environment. It was conducted in accordance with relevant federal and Region III guidance developed by EPA. The risk assessment incorporates responses to comments transmitted by EPA on July 17, 1995, and discussed in a subsequent conference call and meeting.

The Potomac Yard Site is a recently decommissioned, inactive rail yard consisting of approximately 342 acres extending from Crystal City in Arlington County, south to Braddock Road in the City of Alexandria. RF&P plans to develop the Site to include a regional transportation hub, mixed housing, and commercial development. These plans are in accordance with existing zoning and development master plans in place in the City of Alexandria and Arlington County.

The Human Health Risk Assessment followed the form specified in EPA's Risk Assessment Guidance for Superfund and in applicable Region III guidance documents. The primary objective of the Human Health Risk Assessment was to evaluate potential risks associated with exposure to chemicals at the Potomac Yard Site or released from the Site as a result of anticipated development activities. Chemicals of potential concern (COPC) were selected for each of six Site areas that are distinctive because of past rail yard activities and anticipated development plans. These areas include North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, and Potomac Greens.

An analysis of potential exposure pathways was conducted for each of the six main Site areas under current, interim, and future land-use scenarios. The most important receptors were found to be current trespassers and construction workers, on-site and off-site residents, utility workers, landscape workers, and commercial workers for interim and future land-use pathways. Inhalation of chemicals present in on-site soil and incidental ingestion of soil were found to be the most important routes of exposure for quantitative evaluation.

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The salient conclusions of the Human Health Risk Assessment are summarized as follows:

- All of the lifetime upperbound excess cancer risks were within or below EPA's risk range for risk management at Superfund sites. The hazard indices for noncancer health effects were predominantly below EPA's guideline of 1. In only one instance, the hazard index for high-end occupational inhalation exposure to petroleum hydrocarbons was slightly exceeded. However, all of the estimated air concentrations associated with the exposure were far below occupational standards and criteria. Where the cumulative cancer risk to individuals based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-cancer hazard index is less than 1, EPA has determined that action generally is not warranted for protection of human health.

- Under current land use conditions, potential exposures were associated with incidental ingestion of soil by a trespasser in the South Yard/South Tail area. During interim use, the highest potential exposures were to construction workers from the inhalation and ingestion of dust generated during development-related activities. Under future use conditions, the highest exposures were also industrial in nature, and they were associated with inhalation and ingestion of dust by a construction worker, and inhalation of petroleum hydrocarbons by a utility trench worker in a localized site area where diesel free product is being recovered. Estimated airborne chemical concentrations compatible for comparison with existing occupational standards and criteria did not exceed these limits in any scenario.

- Due to the fact that the majority of the yard will be paved and/or landscaped, there is little potential for exposure and, thus, a low risk to residents who could occupy the Site in the future.

- The primary chemical associated with the human health risks was arsenic, associated with cinder-based ballast.

The Ecological Risk Assessment used a screening-level assessment approach recommended by EPA Region III. Under this approach, estimated exposure concentrations were compared to screening-level toxicity values, such as ambient water quality criteria. Estimated exposures that exceeded the screening toxicity values indicate potential risk.

The objective of the Ecological Risk Assessment was to determine if chemicals associated with the Site have the *potential* to affect the structure, function, or interactions of biological populations and communities within the study area. The overall focus of the Ecological Risk Assessment was on potential site-related impacts on the aquatic populations and communities of Four Mile Run and the Potomac River. These two water bodies are the principal aquatic habitats

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of the area and, with the exception of small pockets of terrestrial habitat on Potomac Greens, will be the only source of natural habitat to remain once the Site is developed as a commercial and residential urban area. Potential risks associated with other areas of the Site that currently provide limited or marginal habitat also were evaluated, however, even though these habitats will not exist following development.

The conclusions of the screening-level Ecological Risk Assessment are as follows:

- The Site poses no risk to terrestrial wildlife feeding or otherwise using the Site.
- Pesticides in surface waters and sediments of Potomac Greens could cause a localized reduction in the abundance and diversity of aquatic insects.
- Potomac Yards is a source of low concentrations of PAHs, metals and pesticides to Four Mile Run and the Potomac River.
- Measured concentrations at the property boundary exceed toxicity criteria for sensitive species of aquatic life, possibly resulting in localized decreases in benthic species abundance and diversity.
- Risk could be over- or under-estimated. Factors contributing to a potential under-estimate of risk are the removal of high detection limits from the data set. Factors contributing to possible over-estimates of risk are the screening-level risk assessment approach and assumption of a 100% bioavailability of chemicals in exposure media.
- The available sampling data cannot be used to evaluate ecological risks associated with historical releases. Off-site risks associated with historical releases from the Potomac Yard Site will be addressed in the future as part of continuing activities at the Site. Chemical concentrations in sediments are the most relevant data for addressing historical releases. Chemicals potentially associated with the Site include PAHs, PCBs, and arsenic.

Overall from both the human health and ecological perspectives, the risk assessment indicated no barrier to development of the Site and, indeed, suggested that development will be beneficial in reducing risks both to human health and the natural environment.

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1.0 INTRODUCTION

This report presents an evaluation of the risks associated with potential exposures to chemicals detected at Potomac Yard (the Site) in the City of Alexandria and in Arlington County, Virginia. The risk assessment is based on the findings of the Extent of Contamination Study (ECS) conducted by the Richmond, Fredricksburg & Potomac Railroad Company (RF&P). A report of the findings of the ECS (ECS Report)[1] was submitted to the U.S. Environmental Protection Agency (EPA) Region III on February 22, 1995.

This risk assessment was prepared to fulfill requirements set forth in Section 8.3.c.iii of the Administrative Order by Consent (Consent Order) between RF&P and the EPA (Docket No. III-92-61-DC). In accordance with Section 8.3.c.iii of the Consent Order, this risk assessment addresses potential risks to both human health and the environment. It was conducted in accordance with relevant federal and Region III guidance developed by EPA. This risk assessment incorporates comments transmitted by EPA on July 17, 1995, and discussed in a subsequent conference call and meeting.

The risk assessment report will provide information characterizing potential risks to human health and the environment associated with chemicals introduced into environmental media as a result of past activities at the Site. This information is intended to provide a basis for decision-making regarding the need for additional cleanup activities at Potomac Yard. Potomac Yard is located in the center of a major urban area (i.e., the Washington, D.C. Metropolitan Area) and ultimately will be developed for residential and commercial uses that reflect surrounding developed and developing areas. Accordingly, this risk assessment evaluates potential risks to human health and the environment under current and future use conditions. The future use conditions analyzed in this Report will reflect existing development plans and the pattern of land use in surrounding areas.

The results of the risk assessment will (1) help determine the need for any additional cleanup or risk management actions at Potomac Yard; (2) provide a basis for determining locations and concentrations of chemicals that can remain onsite and be sufficiently protective of human health and the environment; and (3) provide a basis for comparing health and environmental impacts of remedial alternatives.

The remainder of the risk assessment report includes the following sections:

Section 2.0 - Site Background. The physical setting of the Site and surrounding areas are described. Historical, current, and expected future land uses at the site are summarized and discussed.

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[1] Extent of Contamination Study (ECS Report). 1995. Extent of Contamination Study, Potomac Yard, Alexandria, Virginia. Prepared for RF&P Railroad Company by Environmental Technology of North America, Inc. February 22, 1995.

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Section 3.0 - Human Health Risk Assessment. The risks to human health associated with potential exposure to Site related chemicals are evaluated.

Section 4.0 - Ecological Risk Assessment. The potential risks to aquatic life, terrestrial animals, and plants associated with potential exposure to Site related chemicals are evaluated.

Section 5.0 - Summary and Conclusions. The major findings of the human health and ecological risk assessments are summarized and discussed.

Appendices - Descriptions of procedures used in the risk assessment, and relevant supporting documentation are presented.

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2.0 SITE BACKGROUND

The Potomac Yard Site is located along the 2800 and 2900 blocks of Jefferson Davis Highway (U.S. Route 1) in the City of Alexandria and in Arlington County, Virginia. It is shown on the United States Geologic Survey (USGS) Alexandria, VA-DC-MD 7.5 minute series topographic map at 38 degrees, 50 minutes north latitude and 77 degrees, 3 minutes west longitude (Figure 2-1 of the ECS Report). The physical and ecological setting of the Potomac Yard Site is described in Section 2.0 of the ECS Report (1995). This section of the risk assessment report summarizes Site description information of primary importance to preparation of the risk assessment. It also discusses historical, current, and planned future land uses for the site.

2.1 Site Description

Potomac Yard is located in the southeastern portion of Arlington County, Virginia, and the northeastern portion of the City of Alexandria, Virginia, across the Potomac River from Washington, D.C. It is a long, relatively narrow area of approximately 342 acres extending from Crystal City in Arlington County, south to Braddock Road in the City of Alexandria (Plate 2-1 of the ECS Report). The Site is bounded on the west by Jefferson Davis Highway (U.S. Route 1) and on the east by the George Washington Memorial Parkway, both major commuter routes serving Washington, D.C. and Virginia. Potomac Yard is approximately 2.7 miles long and has a maximum width of approximately 2,000 feet near the center of the Site.

Historically, Potomac Yard has been described and characterized according to seven major subareas within the site. These areas primarily reflect past activities and operations carried out in these locations. All but two buildings and work areas formerly located within the rail yard have been removed as part of downsizing operations, the main railroad office building in the Central Operations Area, and a Metrorail substation. The Potomac Yard subareas have been discussed in detail in the ECS Report and are described briefly below. Their locations are delineated in Plate 2-1 of the ECS Report.

- **Central Operations Area.** The majority of the Potomac Yard buildings were located in this area. In addition, most refueling and maintenance operations took place in the Central Operations Area.

- **North Yard.** A number of storage, maintenance, and general rail yard activities buildings were located in this area. Rail car service, maintenance, and repair were carried out in this portion of the site. In addition, an electrical switching substation was formerly located in this area.

- **North Yard Tail.** This portion of the site contained primarily railroad switching tracks, which narrowed to the north and merged into five main rail lines near the northern terminus of the Site. A lube oil tank, switch air compressor building, and aboveground fuel storage tanks also were present in this area.

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- **South Yard.** This area reportedly was used for southbound classification and northbound receiving. A car oil tank was located in this area.

- **South Yard Tail.** This area consisted mainly of railroad switching tracks, which narrowed to the south and merged into four main rail lines near the southern terminus of the Site. A switch air compressor building also was located in this portion of the site.

- **Intermodal (Piggyback)/Slaters Lane Area.** Activities associated with intermodal (piggyback) transport activities were located in this area of the Site. Intermodal transport involves the movement of loaded truck trailers on railroad flatcars or cars of special design. This area is adjacent to Slaters Lane and is referred to as the Slaters Lane Area in this risk assessment. At one time, an engine house associated with the Washington & Old Dominion Railroad was located in this area. Activities carried out in association with this building could not be completely documented. However, typical activities expected to have been carried out include engine repair, maintenance, and storage. In addition, it is known that from 1969 the engine house was used for office space and for servicing and repair of trailers and tractors associated with the piggyback activities in this area.

- **Potomac Greens.** This area of the Site was not used for rail operations. However, three former retention (oil/water separator) ponds, a deposition area for fly ash from a nearby power plant, and a Corps of Engineers dredge spoils deposition area are located in this portion of the Site.

Climate

The climate in the Washington, D.C. metropolitan area is continental, humid, and temperate with warm summers, mild winters, and moderate annual precipitation. Details regarding the climate in the Washington, D.C. area are presented in Section 2.3.1 of the ECS Report.

Surface Water and Site Drainage

The major surface water bodies in the vicinity of Potomac Yard are the Potomac River and Four Mile Run. Regional drainage is generally from west to east toward the Potomac River. Drainage patterns in the vicinity of the Site are controlled principally by topographic relief and urbanization. In the low-lying areas near the site, natural drainage patterns are not well developed due to low relief, extensive placement of fill, and urbanization. In the urban areas, stormwater is managed primarily in subsurface pipes. Natural drainage patterns are heavily branched and fairly well developed in the upland areas west of the Site due to rolling topography.

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Drainage from higher areas around the Site generally flows to either Four Mile Run, which in turn discharges to the Potomac River, or directly to the Potomac River. The Potomac River flows south and ultimately discharges to the Chesapeake Bay.

Four Mile Run passes through the northern portion of Potomac Yard. The drainage area of Four Mile Run is approximately 17 square miles. This area is highly urbanized and includes portions of four municipalities (the City of Alexandria, Arlington County, Fairfax County, and Falls Church) with a total population of more than 150,000 people (Northern Virginia Planning District Commission, undated). Four Mile Run receives inflow from subsurface storm sewers, tributaries, ditches, and several discharges permitted under the Clean Water Act (see Table 2-3 in the ECS Report). In 1981 and 1982, the Virginia Institute of Marine Science (VIMS) found that the Arlington County Water Pollution Control Plant (WPCP) upstream from the Site discharged an average of 45 cubic feet per second (cfs) to Four Mile Run (Cerco 1985).

Surface water drainage adjacent to and upgradient of the Site discharges to either Four Mile Run or to storm sewers that run beneath Potomac Yard and discharge to the Potomac River. The Site ground surface generally slopes from the west to the east toward the Potomac River. However, topography over most of the site has been graded to a slight slope of approximately 1 percent to accommodate the railroad tracks. Surface water from the Site flows into either Four Mile Run or the Potomac River via a system of ditches and pipes.

The Potomac River in the vicinity of the Site is tidal. The tidal zone extends to the Fall Line at Chain Bridge, which is approximately 9 miles upstream from the mouth of Four Mile Run at National Airport. The tidal range of the Potomac River at Potomac Yard is approximately 3 feet (NOAA-National Ocean Services 1993). The mean discharge of the Potomac River is 11,510 cubic feet per second (cfs) at Chain Bridge (USGS 1987). Four Mile Run also is tidal in the vicinity of Potomac Yard. The tidal zone extends to the Mount Vernon/Arlington Ridge Road Bridge, which is approximately 1.5 miles upstream from Four Mile Run's confluence with the Potomac River, and .75 mile upstream from Potomac Yard. During the summers of 1981 and 1982, the Virginia Institute of Marine Science (VIMS) measured the mean tidal range of Four Mile Run at approximately 3 feet (Cerco 1985). VIMS calculated the mean annual flow of Four Mile Run to be approximately 14 cfs. The VIMS report does not identify the location of these measurements; however, the data suggest the location was upstream of the Arlington County Water Pollution Control Plant (WPCP) because the WPCP discharge alone ranges from approximately 40 to 54 cfs. Local surface water bodies and Site drainage are discussed in detail in Section 2.3.2 of the ECS Report.

As discussed in Section 6.6 (Migration of Detected Chemicals) of the ECS Report, organic and inorganic chemicals associated with previous activities at the Site could potentially migrate at relatively low concentrations to adjacent surface water, primarily through stormwater runoff. These chemicals, however, are generally characteristic of typical components of urban runoff in the vicinity of the Site and, in fact, would be mixed with stormwater discharge from surrounding offsite areas. Furthermore, the dilution potential in the two adjacent receiving waters, Four Mile

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Run and the Potomac River, is tremendous. Discharge points from the Site to surface water are not readily accessible to potential human receptors and, as a result, regular exposures at these locations are not expected. Finally, any existing releases from the Site would be eliminated as part of development activities. For these reasons, exposures at offsite surface water locations to chemicals associated with the Site and any attendant human health risks are expected to be negligible and will not be considered further in the human health risk assessment.

Hydrogeology and Geology

Potomac Yard is located near the western edge of the Atlantic Coastal Plain physiographic province. The Fall Line, located less than 5 miles west of Potomac Yard, marks the boundary between the Atlantic Coastal Plain and Piedmont physiographic provinces. The Atlantic Coastal Plain is an eastward thickening wedge of clastic sedimentary deposits overlying the basement of igneous and metamorphic rocks. The Atlantic Coastal Plain sediments consist of clays, silts, sands, and gravels deposited in fluvial-deltaic (river/marine) environments (Johnston 1964; Meng and Harsh 1988).

Groundwater in the Atlantic Coastal Plain (and in the vicinity of Potomac Yard) occurs under confined (artesian) and unconfined (water table) conditions. The ECS groundwater studies were confined primarily to shallow groundwater at the Site. Regional geology and previous site-specific subsurface investigation show a dense confining layer that impedes the movement of groundwater and contaminants through the confining unit to the underlying confined aquifer. Furthermore, as discussed in the ECS Report, information concerning the vertical hydraulic gradient between the upper and lower aquifers indicates a potential migration of water from the lower aquifer to the upper aquifer if any leakage occurs.

Shallow groundwater occurs at Potomac Yard under unconfined water table and perched water table conditions at depths ranging from about 10 feet to 25 feet below ground surface. Groundwater in the confined aquifers and the unconfined unit in the vicinity of Potomac Yard flows eastward from recharge areas toward discharge areas. Recharge to the confined aquifers occurs where Cretaceous sand units crop out along the Fall Line, 5 miles west of the Site. Discharge from the confined aquifers occurs at either the Potomac River, where the channel breaches the confining unit(s), or at the Atlantic Ocean baseline. Recharge to the water table unit occurs primarily from the infiltration of precipitation and interaction with local surface water bodies. A small portion of the recharge to the water table unit may be through upward leakage from the underlying confined units.

Ground water at the Site south of Four Mile Run flows eastward toward the Potomac River and Four Mile Run. North of Four Mile Run (the North Yard Tail), groundwater close to four Mile Run flows south. Further north of Four Mile Run, the pumping of ground water from basements in the Crystal City development along the northern edge of the North Yard Tail, creates a hydraulic depression and a localized reversal of groundwater flow toward the north and west.

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The discharge of ground water from the water table unit occurs at the Potomac River and Four Mile Run.

Free product in groundwater is present in the vicinity of the refueling area located within the Central Operations Area. Site characterization data reported in the ECS Report indicate that a trough exists between two areas of groundwater mounding in the Central Operations Area. The trough between the two areas of mounding provides a stagnant area in which free product collects and remains relatively immobilized. A free product recovery program is currently underway at the Site. In addition to the refueling area, two smaller areas of free product have been identified at Monitoring Well-25 and Monitoring Well-27 in the Central Operations Area. Recovery efforts are being undertaken at these locations.

Public water supplies in the vicinity of Potomac Yard are almost exclusively obtained from surface water sources (Johnston 1964; Herman 1995; and Hardy 1995). Groundwater from the deeper confined aquifers in the vicinity of the Site may be used for public water supply during emergency conditions (Hardy 1995). The nearest emergency public water supply wells in the vicinity of Potomac Yard are located 3,500 feet southwest of the Site, a location hydraulically upgradient from the Site. New groundwater wells for public water supplies are not expected to be installed at locations downgradient from the Site (i.e., between the Site and the Potomac River). Therefore, potential exposures to groundwater from the Site could only occur where the groundwater discharges to surface water. On July 7, 1995, a conference call was held to address EPA Region III's specific concern regarding the use of the Middle Potomac Aquifer as a drinking water supply. The conference call participants, including EPA Region III and local government representatives, agreed that future use of the Middle Potomac Aquifer as a drinking water supply is not practical or likely to occur. A letter from RF&P to EPA Region III summarizing the information presented in the conference call is provided in Appendix M.

The hydrogeological evidence leads to the conclusion that groundwater flow under the site is extremely slow and is not likely to result in substantial solute transport. A description of site hydrogeology and supporting calculations is presented in Section 2 (Site Description) and Appendix I of the ECS Report. A conservative groundwater solute transport modeling effort was carried out as part of this risk assessment to investigate the nature of the groundwater to surface water pathway. The results of the analysis are presented in Appendix J. The solute transport modeling indicates that discharge concentrations to the Potomac River are expected to be low, that travel times to the discharge points would be hundreds or thousands of years, and that dilution in the river would result in concentrations more than four orders of magnitude lower than the discharge concentrations. In addition, the organic chemicals are likely to undergo chemical or biological degradation and the inorganics are likely to undergo geochemical precipitation and complexation reactions. Thus, it may be readily seen that this pathway is inconsequential. Accordingly, potential exposures and human health risks associated with exposure to groundwater are expected to be negligible and will not be considered further in the human health risk assessment.

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The ECS Report describes, in detail, the geology of Potomac Yard from soil surface to bedrock based on logged boreholes completed at the site. The stratigraphic sequence at Potomac Yard consists of six units. In descending order, these units include: ballast material, fill material, Shirley Formation, Patapsco Formation, Arundel Clay Formation, and Patuxent Formation. The more surficial strata at the Site are of greatest importance for evaluating potential exposures by direct contact to chemicals in soil at the site. These strata consist of gravel, cinder-based ballast, fill material, and native soil.

Two types of material are present in the surficial strata at the Potomac Yard Site. Most of the surface area of the rail yard is covered with a layer of gravel, a material used as rail bed ballast at the Site. Ballast is used in a railroad bed to support the ties, hold the track in line, and facilitate drainage. When the ECS investigation began in 1992, the gravel layer was up to 2 feet thick in parts of the rail yard. Since that time, much of the gravel has been removed or graded in areas no longer occupied by track. Currently, a layer of gravel approximately 6 inches thick remains over most of the Main Yard (the Main Yard does not include Potomac Greens, an area where rail yard activities did not take place). Locations not completely covered with a gravel layer include portions of the South Yard, the South Yard Tail, and the Central Operations Area.

Cinder-based ballast (also known as sub-ballast) lies beneath the gravel over most of the rail yard. Cinder-based ballast consists of cinders (bottom ash) from coal-powered steam locomotives used prior to the introduction of diesel-electric locomotives in the 1950s. Cinder-based ballast is found at depths of up to 8 feet, with an average thickness of 3 feet. A portion of the North Yard Tail, the section of the Site that lies north of Four Mile Run, was developed in the 1950s, after the steam locomotive era. Cinder-based ballast was not found in this area. Cinder-based ballast also promotes drainage of stormwater from the track area. Grain size analysis shows the majority of the cinder-based ballast to be greater than 0.05 mm in diameter (see Table 2-8, Table 2-9, and Appendix G of the ECS Report). Although variable amounts of fines may be present, this material corresponds to a coarse grained sand under the Unified Soil Classification system.

A combination of fill material and native soil (Shirley Formation) underlies the gravel and cinder- based ballast at the Site. A significant portion of surficial soil along the Potomac River in the vicinity of Potomac Yard has been disturbed as a result of urban development. The composition and variable distribution of sediments of the Shirley Formation native soil and much of the fill material are similar. Therefore, it is difficult to distinguish between these units in the augered borehole logs. The combination of the fill material and Shirley Formation native soil extend to a depth of approximately 40 feet at Potomac Yard.

Section 2.3.3 of the ECS Report reviews in detail the regional and Site specific hydrogeologic and geologic conditions.

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2.2 Site History

A detailed history of operations at the Potomac Yard Site is presented in Section 3.0 of the ECS Report. The history of Potomac Yard was compiled by reviewing site maps and aerial photographs.

Railroad lines have traversed the Potomac Yard site for more than 100 years (from the mid 1800s) and development of the Site into a major rail yard began in the early 1900s. By 1937, the rail yard had expanded to approximately its maximum extent. Potomac Yard served several different railroad lines, and locomotive classification, switching, maintenance, servicing, and refueling (diesel-electric locomotives only) were carried out at the site. Coal-fired, steam powered locomotives were served from 1906 to the mid-1950s; electric locomotives were served from 1936 until 1980; and diesel-electric locomotives were served from the mid-1950s until 1990 at the Site. Maintenance and servicing operations also were carried out for other types of rail cars at the site.

In 1989, a decommissioning process began at the site and continued through 1993. During this period, buildings, tracks, and three stormwater retention ponds at Potomac Greens were removed. Currently, railroad activities at Potomac Yard are principally limited to mainline railroad traffic along the western and eastern portions of the Site.

From the early 1900s, a variety of industrial and commercial operations, as well as residential areas, have surrounded the Site. The course of Four Mile Run has been altered during the last century by placement of fill and various channelization efforts. In 1980, the U.S. Army Corps of Engineers completed a major rechanneling project in Four Mile Run to provide erosion and flood control. Four Mile Run was dredged and straightened, flood walls were erected, and the banks were armored with gabion mats (an erosion control device consisting of heavy steel mesh holding rock or stone in place). The channelized portion of Four Mile Run extends from its mouth to the East Glebe Road Bridge, approximately 3 miles upstream.

2.3 Current Land Use

Potomac Yard is centrally located in a development corridor extending from the Pentagon on the north to Interstate 95 on the south, and is one of the largest developable tracts of land in the urban core of Washington, D.C. Figure 2-1 of the ECS Report is the portion of the USGS 7.5 minute series map that includes Potomac Yard and surrounding areas. The Potomac Yard is bounded on the:

- North by Washington National Airport and the large scale hotels, shopping areas, and office buildings of Crystal City;
- East by Washington National Airport, the George Washington Memorial Parkway, the Potomac River, Daingerfield Island, the mid-rise Potowmack Crossing apartments, and

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City of Alexandria residential neighborhoods and commercial areas;

- South by Braddock Road, the Braddock Road Metrorail station, and City of Alexandria residential neighborhoods and commercial areas; and

- West by Jefferson Davis Highway (U.S. Route 1), light industrial and commercial properties along Jefferson Davis Highway, City of Alexandria and Arlington County residential neighborhoods, and the Arlington County Water Pollution Control Plant.

The population of the City of Alexandria is approximately 115,000 and that of Arlington County is approximately 170,000. Appendix J of the ECS Report contains census data characterizing the population in the vicinity of the Potomac Yard. Current land uses in the vicinity of Potomac Yard are typical of a densely developed urban area. These uses include a major urban airport; parking lots; small-, medium-, and large-scale hotels and office buildings; light industrial and commercial establishments; residential uses including single family homes, townhouses, and a range of small- to large-scale apartment buildings; a variety of public use buildings; and a variety of recreational resources, including marinas, parks, playgrounds, and bike paths.

Drinking water is provided by municipal water supplies. The City of Alexandria obtains potable water from the Virginia American Water Company (VAWC). VAWC purchases its water from the Fairfax County Water Authority; this water is obtained from the Occoquan Reservoir, located approximately 15 miles to the southwest. The VAWC also maintains two supply wells for emergency use, located approximately 3,500 feet southwest of Potomac Yard, a location hydraulically upgradient from the Site. Arlington County obtains potable water from the District of Columbia Water and Sewage Commission (DCWSC). Two intakes in the Potomac River provide water for the DCWSC. These intakes are located upstream of the site.

Except for existing main line railroad and Metrorail tracks, most of the rail operations at the Potomac Yard have been removed. With the exception of Potomac Greens, the Site is generally flat, with little vegetation, as a result of being graded in the past for rail operations. Steep slopes are present along the eastern side of the Metrorail Yellow Line near the eastern border of the rail yard and along the main line tracks near the western border of the Site.

2.4 Future Land Use

The City of Alexandria and Arlington County are long-established, densely populated urban areas. Any development or redevelopment in areas surrounding the Potomac Yard site is likely to reflect the existing mixed use development in these areas. Development of the site can be expected to occur generally according to Master Plans for Alexandria and Arlington, and RF&P's more specific site development plans.

The City of Alexandria portion of the Site, consistent with the 1992 Master Plan of the City of Alexandria (City of Alexandria 1992a), is zoned Coordinated Development District (CDD). This

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designation is applied to areas where major mixed use development is anticipated to take place within the City. CDD planning incorporates a review process to ensure that development exhibits a proper integration of uses, the highest quality of urban and architectural design, and consistency with the surrounding areas of the city. The Potomac Yard/Potomac Greens Small Area Plan chapter of the 1992 Master Plan of the City of Alexandria (City of Alexandria 1992b) and excerpts from the City of Alexandria Zoning Ordinance are provided in Appendices K and L, respectively, of the ECS Report.

The Small Area Plan serves as the basis for future City Council policy initiatives and actions affecting land use, zoning, capital improvements, and programs in the area addressed. It describes in some detail the land use, development opportunities, and historical context of the areas surrounding the Potomac Yard site. The Plan states the new community developed at the site is unlikely to mirror the lower density development patterns in some of the areas adjacent to the site and notes that these areas were built in earlier times and in response to different historical patterns. Rather, development policies for moderate heights and densities are encouraged (except near transit stations where higher densities are permitted). These goals are reflected in the City of Alexandria Zoning Ordinance. City of Alexandria zoning for the Potomac Yard/Potomac Greens area describes the amounts and types of development permitted at the site. The zoning provides for a variety of general land uses including: (1) a mix of offices, retail shops, restaurants, and higher density housing concentrated near a future transportation hub (which will serve Metrorail, Amtrak, and Virginia Railway Express); (2) a mix of housing types (townhouse and multifamily dwellings); (3) a possible shopping center to serve the district and nearby residential neighborhoods; (4) a variety of retail and service uses scattered throughout the district at appropriate locations; (5) a variety of parks and open spaces; and (6) community facilities as needed. The CDD specifically provides for interim uses of various locations at the Site planned for later phases of development subject to a special use permit process.

The Arlington portion of the site (designated by the County as South Tract) is currently zoned M-1 (Light Industry) and is designated Service Industry on the General Land Use Plan (Arlington County 1990). The Arlington County General Land Use Plan, an excerpt from the "M-1" Light Industrial Zoning regulations (Arlington County, undated), and background information on current Arlington County Land Use Alternatives (Arlington County 1991) are provided in Appendices M, N, and O, respectively, of the ECS Report. Both the zoning and master plan provide for wholesale, storage, and light manufacturing uses on a "by-right" basis. All current Arlington County Land Use Alternatives for the South Tract identify this area as 2/3 Low Density Office-Apartment-Hotel and 1/3 Medium Residential (e.g., townhouse and higher density).

RF&P's current development plans for Potomac Yard correspond with current zoning designations or requirements negotiated with the City of Alexandria and Arlington County. Although these plans are not final, they represent, conceptually, the types of development that will occur and, as such, provide a basis for developing appropriate exposure scenarios for the

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evaluation of potential risks to human health and ecological receptors under interim and future use conditions at the Site.

RF&P plans a variety of urban-density land uses, including a regional transportation hub (including a new Metrorail station), office, hotel, retail, and residential, as well as open space, at the Site. Also planned are open public areas such as small parks, recreational areas, and playing fields. The types of residential dwellings that will be constructed include townhouses, stacked townhouses, mixed-use dwellings, and low-, mid-, and high-rise buildings (maximum height of 110 feet under current CDD guidelines). Only a portion of the Slaters Lane section of Potomac Yard is being considered as a potential site for development of single family detached dwellings with private yards. Buildings are expected to be constructed at grade or sufficiently below grade to provide for parking. In general, areas surrounding residential, commercial, and retail locations will be common areas and landscaped or paved for roads, walkways, or bike paths. Landscaping will be maintained professionally (e.g., by the municipalities, developers, or residents associations). Open areas, including active and passive parks, common areas, and private yards, will be graded and covered with fill prior to appropriate landscaping. Development will begin in the Central Operations Area with construction of the regional transportation hub and higher density commercial, retail, hotel, and residential projects. Initiation of the regional transportation hub will begin in 1998, with anticipated completion in 2000. Additional development will move out radially from the centrally located Metrorail Station and transportation hub, with anticipated completion of development at the Site in approximately 2020.

Interim land uses may occur for periods of 15-20 years during completion of development of the Potomac Yard Site. These uses may include warehouses, "big-box" retail stores, parking lots, and similar developments. Interim development will take place primarily in the North Yard, North Yard Tail, South Yard, and South Yard Tail areas of the Site. Recently, RF& P Railroad Company has applied to the City of Alexandria for approval of a Site Plan (#94-021) for completion of a 107,004 square foot warehouse building to be leased to the U.S. General Services Administration in the South Yard area of the Site. This warehouse site is anticipated to be used for about 15-20 years before completion of the ultimate site development in the South Yard portion of the Site. Appendix P in the ECS Report provides details of RF&P's development plans. It includes conceptual drawings, site plans, building elevation plans, footprint plans, and details regarding the amounts and types of development currently envisioned. Construction activities for interim use are currently underway.

2.5 Potentially Exposed Populations and Activity Patterns

This section characterizes potential human receptors in the vicinity of the Potomac Yard Site. This consideration of potential human receptors summarizes information on locations of potentially exposed populations, anticipated human activity patterns, and subpopulations of potential concern.

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2.5.1 Locations of Potentially Exposed Populations

Currently, only a small number of individuals carry out rail yard or utility maintenance operations at the Potomac Yard Site. In addition, site characterization and remediation workers, RF&P employees, and other maintenance workers are periodically onsite. The site is not open to the public and access is restricted.

Populations of individuals in areas surrounding Potomac Yard include workers, local residents, and individuals taking part in recreational activities. Occupational categories in the surrounding areas include blue collar, white collar, and service industry sectors. Workplaces include high rise office buildings, shopping centers, store-front retail locations, a major urban airport, light industry, and commercial operations. Residential areas also are broadly represented and include single family detached homes, townhouses, and apartment buildings. There are a number of bike/pedestrian paths, parks, and play fields in the area, including parks along Four Mile Run and the Potomac River. Daingerfield Island is a 109-acre, federally owned park that is part of the George Washington Memorial Parkway System. The park is located east of the Parkway on the Potomac River and includes a sailing marina, a restaurant, a parking lot, several multi-purpose play fields, and a wooded park area. Fishing and boating are relatively popular activities in the Potomac River and in Four Mile Run near its confluence with the Potomac.

Populations that potentially could use the Potomac Yard Site in the future include local offsite populations, as described above, as well as persons associated with onsite development activities. Workers carrying out construction as part of development activities at the site may be present at various times over the approximately 20-year time frame for ultimate development at the site. In addition, after completion of phases of development at the site, additional groups of permanent and transient occupational, residential, and recreational receptors will become established at the Potomac Yard site. For example, landscape workers will be required to maintain planted areas at the developed site. Recreational opportunities at the site are likely to include open space parks, bike/pedestrian paths, playgrounds, and play fields.

2.5.2 Activity Patterns

Construction workers at the site typically would be transient workers. They would be expected to work on a project on a regular basis over a period ranging from days or weeks to months or longer.

Initially, interim development is likely to be established at the site in selected locations, and then replaced by the planned ultimate land uses for the site. Interim uses are likely to include operations such as warehouses, "big-box" retail outlets, and parking lots. Construction activities will result in relatively little soil disturbance and excavation. Construction would occur primarily at grade with relatively little subsurface excavation. The interim use operations would be staffed with permanent adult workers who will be present at the site on a regular basis prior to completion of final development at the site. In addition, transient users of the services provided

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completion of final development at the site. In addition, transient users of the services provided also would visit the site periodically.

As the site develops, permanent residential buildings, office buildings, hotels, commercial establishments, transportation facilities, and recreational areas will be built. Construction of some of these facilities will involve more extensive subsurface excavation than is expected for the interim use facilities. Onsite populations would include permanent and temporary workers, permanent residents, and transient visitors to the site such as shoppers and individuals using the hotel, restaurant, transportation, and recreational facilities.

2.5.3 Subpopulations of Potential Concern

Prior to and during development of the Potomac Yard Site, onsite receptors are expected to comprise adult workers. Trespassers also may occasionally use the site on a transient basis. The site is not readily accessible to unauthorized individuals; accordingly, it is unlikely that young children would trespass on the site. During construction, there will be both passive and active security measures around the construction areas. During construction activities at the site, occupational or residential receptors downwind of the site could potentially be exposed to dust generated at construction sites.

After portions of the site are developed for use, individuals of all ages are likely to have ready access to selected areas of the site. Employees working at the site will visit the site regularly, sometimes over periods of several years. In addition, some workers, such as landscape, utility, or maintenance workers will periodically visit the site. Some individuals will visit the site occasionally to make use of the commercial and recreational facilities, and some individuals would live at the site, possibly for extended time periods.

2.6 References

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3.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the methods used to assess potential risks to human health from exposure to chemicals of potential concern at the Potomac Yard Site. In general, this risk assessment is conducted in accordance with EPA guidance for performing risk assessments at Superfund sites (EPA 1989) in addition to more general guidance for exposure assessment and risk characterization (EPA 1992a). The section opens with a discussion of the identification of chemicals of potential concern based on site investigation data and screening methodologies. This is followed by a discussion of the toxicological and dose-response properties of the chemicals selected for evaluation. The concentrations of chemicals of potential concern obtained from the ECS are used in an exposure assessment, the results of which are combined with the dose-response data to yield a risk characterization. This section finishes with a discussion of the uncertainties associated with the risk assessment.

3.1 Identification of Chemicals of Potential Concern

This section presents the methodology and results of the process to identify chemicals of potential concern (COPCs) for use in the human health risk assessment. Only those samples collected as part of the Extent of Contamination Study (ECS) were considered in this evaluation. Details of the sampling locations and methodology are provided in Volume I, Section 5.0 of the ECS Report (1995). The ECS sampling program involved samples from various media; however, an evaluation of the completed exposure pathways for the human health risk assessment (Sections 2.1 and 3.3.1) indicated that only those samples collected from soil would be relevant. Therefore, this discussion is limited to soil samples. A detailed summary of the analytical results for the remaining media is provided in Volume I, Section 6.0 of the ECS Report.

The ECS soil sampling program provided data from a large number of surface locations and at various depths. The data were subdivided into six areas following the practice used in the ECS Report. Subdividing the data in this way provides a logical grouping according to common operational practices conducted at the site, as well as proposed development areas evaluated in the human health risk assessment. The data for each of the six operational areas were further subdivided by depth to support the human health risk assessment. Samples collected from a depth of 0 to 3 feet below ground surface were considered surface samples. These samples are used in conjunction with assessment of exposure to surface soil. Samples collected from >3 feet to 8 feet below ground surface were considered subsurface samples and are used in combination with the 0 to 3-foot depth interval for those development-related construction scenarios that involve deep excavation. Thus, these scenarios involve exposure to soil in the entire 0 to 8-foot depth interval. In addition, data for the >3 to 8-foot depth interval were used in scenarios involving use of soil below the surficial cinder-based ballast level as landscaping fill soil. Limited sampling was conducted beyond 8 feet below ground surface. However, because these samples were considered beyond the contact zone for potential receptors, and contained

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concentrations lower than those found in the shallower samples, they were not considered in this evaluation.

The actual depth intervals for soil samples collected for the ECS did not always conform to the surface and subsurface samples defined for the purpose of the human health risk assessment (i.e., 0 to 3 feet for surface, >3 to 8 feet for subsurface). A protocol was developed and applied to each soil sample to transform the ECS sampling intervals into a data set that would characterize the chemical concentrations in the surface and subsurface strata as defined for the risk assessment. Details of the protocol used are as follows:

- Soil sample analytical results were assigned into each stratum covered by the sampling interval. Thus a sample that represents 0 to 4 feet was assigned to the surface stratum (0 to 3 feet) and the subsurface stratum (> 3 to 8 feet). This has the net effect of including some sample points twice in the risk assessment.

- For sample locations where more than one sample was assigned to a specific stratum, the samples were averaged to determine a single representative concentration for the stratum at the sampling point. For example, a sample collected from a soil boring analyzed for depths of 0 to 2 feet and 2 to 5 feet would result in two analytical results assigned to the surface stratum (0 to 3 feet) for this location. The two samples would be averaged and the arithmetic mean would be selected to represent the chemical concentration at this location. The sample results for the 2 to 5 foot interval would also be assigned to the subsurface layer (>3 to 8 feet).

- When calculating the average concentration for a depth interval at a specific location, the following rules were used:

    1. if none of the samples were detected values and the chemical was anticipated to occur at a concentration lower than the detection limit, then the lowest detection limit from the group was used;

    2. if all of the samples had detected values, then the arithmetic average for the group was used;

    3. if the group of samples had a mix of detected and nondetected values, then the arithmetic average for the group, using one-half the detection limit for the nondetected values, was used (Note: when one-half the detection limit for a sample was greater than the maximum detected concentration in a group then the sample was not included in the average in accordance with EPA guidance [EPA 1989]).

After the vertical component of the ECS soil database was converted to characterize the surface and subsurface horizons defined for the risk assessment, several screening procedures were

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employed to focus the evaluation on the dominant chemicals with regard to potential human health risks. First, a toxicity-based screen was applied based primarily on EPA Region III Guidance for Selecting Contaminants of Concern (EPA 1993a). Using this guidance, Screening Risk-Based Concentrations (SRBCs) were compiled for both residential and industrial land use which correspond to a hazard quotient of 0.1 or a lifetime cancer risk of $1x10^{-6}$. The SRBCs used in the assessment were obtained using the approach outlined in the most recent EPA Region III Chemical of Concern Screening Table (March 1994) and the toxicity criteria and exposure guidance provided in the most recent EPA Region III Risk-Based Concentration (RBC) Table (March 1995). Chemicals whose maximum detected soil concentration exceeded the SRBCs were selected for further evaluation.

A statistical comparison with site-specific background concentrations was conducted for relevant chemicals that remained following the toxicity screen (i.e., inorganics and polycyclic aromatic hydrocarbons, PAHs). The chemicals that remained after this screening process were selected as COPCs. Total petroleum hydrocarbons (TPH) were not evaluated in this initial screening process. TPH was selected as a COPC for all areas where it was detected. This was done primarily to address concerns from the City of Alexandria regarding human health risks to public utility workers who could potentially be exposed during future excavation and trenching operations at the site. TPH as diesel is the primary substance at the site with appreciable volatility that could result in inhalation exposures in confined spaces (e.g., a utility trench).

For the toxicity screen, the data were first separated into the six areas defined for the site (i.e., North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, and Potomac Greens). Because the exposure pathways to be evaluated in the risk assessment involved potential contact with either or both the subsurface and surface soils, the toxicity screen was based on the maximum detected concentration found from 0 to 8 feet below ground surface. Before the toxicity screen was applied, an analysis was conducted for each area on the frequency of detection for the chemicals identified in that area. Those chemicals which had no detections across the 0 to 8 foot interval were deleted from further evaluation for that area.

In performing the toxicity screening, interim and future land use was considered. The Central Operations Area, as defined in this evaluation, is the hub for the transportation center development including a proposed Metro/VRE/Amtrack station and will have substantially less potential for residential use in the future. Therefore, the SRBCs developed for commercial/ industrial land use were used to screen chemicals in this area. In contrast, the development plans for the remaining areas have a land use component that leads to a higher probability of residential exposure, so the more conservative residential SRBCs were applied in screening chemicals for these areas.

While the SRBCs served as the primary basis for the toxicity screening, some chemicals detected at the site lacked SRBCs due to an absence of toxicity criteria (e.g., substituted alkanes, cyclo alkanes, aromatic and polycyclic compounds). Therefore, chemical surrogates were selected based on a similarity in chemical structure and potential toxicity. In the event that

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several chemicals with SRBCs could serve as potential surrogates, the chemical with the greatest toxicity and lowest SRBC was conservatively used in the screening process. The surrogates applied are identified in COPC screening summary tables presented in Appendix A. The toxicity screening value for lead was the preliminary remediation goal of 400 mg/kg reported in the EPA soil screening guidance (EPA 1994a). For the screening of PCB 1260, a 1 mg/kg value was used in accordance with EPA guidance for remediation of Superfund sites with PCB contamination (EPA 1990a). The 1 mg/kg value is an action level for identifying concentrations in residential soil that may require some type of remedial actions to reduce human health risks. Wastes within these action areas that comprise the principal threat at a site are considered to include soil contaminated at 2 to 3 orders of magnitude above the action level (i.e., 10 to 100 mg/kg). The process outlining key steps in identifying areas that may require development of remedial alternatives for PCB contamination is shown in Figure A-5. Five inorganic chemicals detected at the site (calcium, iron, magnesium, potassium, and sodium) are considered essential nutrients and, therefore, in accordance with EPA Region III guidance were eliminated as COPCs. Four organic chemicals (octamethylcyclotetrasiloxane, hexamethylcyclotrisiloxane, trimethylsilanol, and cyclotetrasiloxane) were identified as laboratory contaminants associated with operation of a GC/MS. These compounds were detected infrequently and were not considered site-related. Therefore, they were not considered for evaluation as COPCs.

The human health risk assessment evaluated carcinogenic PAHs in terms of benzo(a)pyrene [B(a)P] Equivalents. The B(a)P Equivalents are composed of the carcinogenic PAHs listed in the EPA Region III RBC table, including, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. In developing the B(a)P Equivalents, the concentrations for individual PAHs were first multiplied by their corresponding toxicity equivalency factor (TEF) to convert them to B(a)P Equivalent concentrations. TEFs were obtained from IRIS and from interim USEPA guidance on quantitative risk assessment of PAHs (EPA 1993b). An overall B(a)P equivalent concentration for the sample was then calculated by summing each individual values for a particular sample location. The maximum B(a)P Equivalent for each site area was compared to the SRBC for B(a)P. These comparisons are presented in Tables A-1 through A-6.

Appendix A provides a series of tables detailing the COPC screening described above. A table is provided for each area summarizing the chemicals evaluated, the maximum concentrations for the 0 to 8 foot depth, the toxicity screening value, and the results of the comparison. Chemicals selected for further consideration in the human health risk assessment based on the toxicity screening are identified below in a discussion keyed to six major areas of Potomac Yard.

A statistical comparison of background and on-site concentrations, by Site area, was conducted for a select group of inorganic chemicals and organic compounds following EPA Region III recommendations. This comparison was conducted to determine if the onsite concentrations of naturally occurring chemicals (i.e., inorganics) and organic compounds ubiquitous in urban soils (i.e., PAHs) were significantly (statistically) elevated above local background. For comparison to background concentrations, three depth intervals were used. The surface (0 to 3 feet) and

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subsurface (3 to 8 feet) concentrations were used to characterize potential exposures for current land-use conditions, interim development construction, and future-use residents. To characterize future development construction, during which potential exposures could occur in both surface and subsurface soils, the onsite concentrations from 0 to 8 feet were compared to background.

Background soil sampling from EPA-approved locations along Jefferson-Davis highway was reviewed to determine the availability of data for comparison to site concentrations. With the exception of antimony, cadmium, mercury, and thallium, all inorganics exceeding the toxicity screen were compared with background concentrations. These four metals were not detected in the background samples and were therefore considered to exist at elevated levels on the Site. It was assumed that PAHs could be considered ubiquitous, and, thus, eligible for the background comparison. The carcinogenic PAHs found in the background samples were converted to B(a)P Equivalents according to the procedures outlined above. Details of the methods and results of the background comparison are provided in Appendix A. Chemicals that were significantly elevated above background and therefore selected as chemicals of potential concern for the human health risk assessment are discussed below.

The remainder of this section provides a discussion of the COPCs selected for each area to be evaluated. Details of the methods and results for the screening procedures discussed above are presented in Appendix A.

North Tail Area COPCs

Five inorganic chemicals (aluminum, arsenic, beryllium, chromium, and manganese) exceeded the toxicity screen and were compared to background concentrations. None of these chemicals were significantly elevated above background concentrations. PAHs (expressed as B(a)P Equivalents) and dieldrin exceeded the toxicity screen. However, PAHs were screened out based on the background comparison. Dieldrin and TPH were retained as COPCs in the 0 to 3-foot, 3 to 8-foot, and 0 to 8-foot soil layers for the North Tail Area. TPH concentrations in the surface and subsurface soils were similar. Dieldrin was detected infrequently in both the surface (3 of 12 samples) and subsurface soils (1 of 12 samples), and showed a reduction in concentration with depth. Table 3-1 presents summary statistics of the surface (0 to 3 feet) and subsurface (3 to 8 feet) concentrations for the North Tail Area COPCs.

North Yard Area COPCs

For the North Yard Area, PAHs exceeded the toxicity screen, but were screened out of the analysis based on comparison to background. Chlordane exceeded the toxicity screen and was retained as a COPC for the 0 to 3-, 3 to 8-, and 3 to 8-foot soil depth intervals. Chlordane was detected infrequently in both the surface (5 of 48 samples) and subsurface (1 of 53 samples), and showed significantly lower concentrations in the subsurface layer. The low frequency of detection for this chemical could justify removing it from further consideration; however, it was conservatively retained as a COPC. TPH, also selected as a COPC for all depth intervals, was

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detected much more often in the surface layer (21 of 46 samples) and at higher concentrations than in the subsurface layer (8 of 53 samples). Although PCB 1260 was detected at 1.05 mg/kg as compared to a toxicity screening value of 1 mg/kg, this was not considered to be a meaningful exceedance of the screening value. This was the only PCB 1260 measurement that exceeded 1 mg/kg at the Site. This compound was detected in 19 of 113 samples in the North Yard area, at an average concentration of approximately 0.12 mg/kg. Because principal threats to human health in residential areas are considered to comprise PCBs in soil at concentrations of 10-100 mg/kg, and the value of 1.05 mg/kg was the only exceedance at the entire site and is not representative of PCB concentrations in general, PCB 1260 was not selected as a COPC in the North Yard Area.

For the inorganic chemicals detected in the North Yard Area, eleven exceeded the toxicity screen (aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, and thallium). Four of these chemicals (antimony, cadmium, mercury, and thallium) were not detected in the background samples, so they were assumed to be elevated above background without statistical comparison, and were retained as COPCs for the North Yard Area. While the maximum detections for all four of these chemicals was greater than the SRBC (based on a hazard quotient of 0.1) all were approximately two times lower than their respective RBC (based on a hazard quotient of 1). Antimony was detected at similar concentrations and low frequencies in the surface (8 of 48) and subsurface (5 of 53) layers. Cadmium concentrations decreased slightly from the surface to subsurface layer, as did the frequency of detection (23 of 48 in the surface and 15 of 53 in the subsurface). Mercury was detected more often in the surface layer (15 of 48 versus 6 of 53), but the concentrations were higher in the subsurface layer. Although it may be reasonable to reject thallium based on the low frequency of detection in both the surface (4 of 48) and subsurface (2 of 53) layers, it was retained because the maximum detected concentration exceeded the SRBC. Thallium concentrations were slightly lower in the subsurface layer relative to the surface.

The remaining inorganic chemicals, (aluminum, arsenic, beryllium, chromium, copper, lead, and manganese) were compared to background concentrations. All but arsenic were determined to be statistically similar to background concentrations for all soil depth intervals. The North Yard surface layer contained the highest maximum and mean arsenic concentrations of all the areas at the site. While the frequency of detection was high in both the surface (40 of 49 samples) and subsurface (44 of 54) layers, the maximum and mean concentrations in the subsurface layer were 3 and 5 times lower, respectively, in the subsurface layer. In the surface layer, 11 of the 40 detections were between 500 and 1710 mg/kg, six of which were at or above 1000 mg/kg. Over half of the 40 detections in the surface soil were above 100 mg/kg. In the subsurface soil, 30 of the 44 detections were at or below 10 mg/kg and the three highest detections were in the range of 512 to 595 mg/kg, with only 7 of the 54 samples exceeding 100 mg/kg. A statistical comparison indicated that the surface layer (0 to 3 feet) concentrations and combined 0 to 8-foot concentrations were elevated above background. However, the 3 to 8-foot layer concentrations were not elevated above background. Thus, arsenic was retained as a COPC for the North Tail Area, for the 0 to 3-foot and 0 to 8-foot soil depth intervals.

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Summary statistics for the North Yard Area COPCs are presented in Table 3-2.

Central Operations Area COPCs

Only the surface and 0 to 8-foot depth intervals were evaluated for the Central Operations Area. In the Central Operations Area, PAHs exceeded the SRBCs. However, they were found to be statistically equivalent to background concentrations and rejected from further considerations.

The TPH concentrations in the Central Operations Area were the highest detected at the site. The site-wide maximum of 12,600 mg/kg was detected in the surface layer. The maximum found in the subsurface layer, 9,100 mg/kg, was also higher than concentrations found at other locations on the Site. A closer examination of the concentration distribution for TPH indicates that the concentrations are predominantly localized in the area where diesel free product has been detected in groundwater, and is currently being recovered. In the surface layer, where TPH was detected in 11 of 28 samples, four of the detections exceeded 100 mg/kg, three of which exceeded 1,000 mg/kg. The three detections above 1,000 mg/kg were all located within approximately 300 feet of each other, just west of the Administration Building and Old Turntable Area. In the subsurface layer, where TPH was detected in only 7 of 29 samples, four of the samples exceeded 500 mg/kg, including two samples greater than 3,000 mg/kg. With the exception of the sample from MW-27, at 3,400 mg/kg, the other three elevated TPH concentrations were located in the same general area as the elevated surface concentrations. MW-27 is located approximately 500 feet southeast of this area. The remaining TPH detections in the surface and subsurface layers are similar to those detected in other areas of the Site.

Of the inorganic chemicals detected in the Central Operations Area, only arsenic and lead maxima were elevated above the SRBC criterion. A statistical comparison with background concentrations indicated that lead was not significantly different from background levels. However, arsenic concentrations exceeded background in both soil depth intervals evaluated and was retained as a COPC for the Central Operations Area.

Table 3-3 presents the summary statistics for the COPCs for the Central Operations Area.

South Yard/South Tail Area

In the South Yard/South Tail Area, PAHs exceeded the SRBC screening values. No significant difference between site and background concentrations of PAHs was found in any of the three soil depth intervals evaluated, and PAHs were not retained as COPCs.

TPH was detected in 11 of 28 surface samples and 7 of 29 subsurface samples. Subsurface TPH concentrations tended to be lower than surface concentrations.

For the inorganic chemicals detected in the South Yard/South Tail Area, ten exceeded the toxicity screen (aluminum, antimony, arsenic, beryllium, chromium, lead, manganese, selenium,

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vanadium, and zinc). All of the chemicals, except antimony, were statistically compared to background concentrations. The background comparison indicated that only arsenic was elevated above the local background concentrations. Both surface and subsurface soil had a very high frequency of detected values, 25 of 30 in the surface, and 25 of 27 in the subsurface. In the surface layer, 14 of the 25 detections were in excess of 100 mg/kg. In contrast, in the subsurface layer 18 of 25 detections were below 10 mg/kg, well within the range, and below the maximum concentration found in the local background samples. As was the case in the North Yard Area, arsenic in surface soil and in the 0 to 8-foot depth interval, but not in the 3 to 8-foot interval, was elevated above background levels. Based on the statistical background comparison, arsenic was retained as a COPC for the South Yard/South Tail Area for surface soil, and the 0 to 8-foot soil layer. Antimony was retained as a COPC for all three soil depth intervals.

Table 3-4 provides summary statistics for the COPCs in the South Yard/South Tail Area.

Slaters Lane Area

For the organic chemicals detected in the Slaters Lane Area, only PAHs had maximum concentrations in excess of the SRBCs. However, PAHs found in the Slaters Lane Area were not significantly different from the background concentrations, and were not retained as COPCs.

TPH was detected in only one out of five samples in both the surface and subsurface samples. The detected concentration in surface soil, 3255 mg/kg, was approximately 100 times greater than the concentration detected in the subsurface soil. Nevertheless, as noted previously, TPH was retained as a COPC for all site areas evaluated.

Eight inorganic chemicals detected in the Slaters Lane Area had maximum concentrations in excess of the SRBC (aluminum, antimony, arsenic, barium, beryllium, chromium, manganese, and vanadium). With the exception of antimony, all of these inorganic chemicals were statistically compared to background concentrations. This background comparison indicated that none of these chemicals were statistically elevated above local background. Although antimony is a naturally occurring substance, it was not detected in background samples and was therefore assumed to be at elevated levels the in Slaters Lane Area. However, it was only detected in 1 of the 6 subsurface samples, and 0 of the 5 surface samples. In addition, the single antimony detection of 4.3 mg/kg was only slightly greater than the SRBC criterion of 3.1 mg/kg. A comparison to the RBC, which is based on a hazard quotient of 1, rather than the SRBC, which is based on a hazard quotient of 0.1, would result in a toxicity screening value of 31 mg/kg, far greater than the single detected value in the Slaters Lane Area. Although it would be reasonable to reject antimony as a COPC, it was conservatively retained, but only for the 3 to 8-foot and 0 to 8-foot layers, as it was not detected in the surface soil layer.

Table 3-5 provides summary statistics for the COPCs in the Slaters Lane Area.

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Potomac Greens Area

In the Potomac Greens Area, the only detected organic chemicals to exceed the SRBCs were PAHs. However, a statistical comparison of site and background concentrations indicated no significant difference in concentrations and PAHs were not retained as COPCs.

TPH was detected in the surface and subsurface soil of the Potomac Greens Area, and was therefore selected as a COPC for all the soil depth intervals. In the surface layer, TPH was detected in 5 out of 10 samples. In the subsurface layer it was detected in 7 of 11 samples. The highest TPH detection was in the subsurface layer, but in the concentration distribution was similar in both layers.

For the inorganic chemicals detected at Potomac Greens, seven had maximum concentrations that exceeded the toxicity screen (aluminum, arsenic, barium, beryllium, manganese, thallium, and vanadium). Except for thallium, which was not compared to background, site concentrations for all of the inorganic chemicals were found to be statistically similar to background. Thallium was not detected in background samples and was therefore assumed to be at elevated levels in the Potomac Greens Area. The maximum concentration for thallium, 1.2 mg/kg, found in the surface layer, was approximately twice the SRBC value of 0.63 mg/kg. However, this maximum concentration would be well below the RBC of 6.3 mg/kg. The frequency of detection for thallium was relatively low in both the surface (2 of 10 samples) and subsurface layers (2 of 11). The concentrations detected in both layers were similar. Nevertheless, thallium was retained as a COPC for all soil layers in the Potomac Greens Area, based on the exceedance of the SRBC.

Table 3-6 provides summary statistics for the COPCs in the Potomac Greens Area.

Appendix A provides detailed information on the methodology and results of the toxicity screening and background comparisons. Table 3-7 provides a summary of the COPCs selected for the areas to be evaluated in the human health risk assessment.

3.2 Hazard Identification/Dose Response Characterization

In this section, a methodology for classifying health effects from exposure to chemicals is presented. This methodology has been developed by EPA (1986a,b, 1989, 1992a) and, where necessary, adapted to reflect the particular chemicals and types of exposures of concern in this risk assessment. First, the overall approach for the classification of health effects and development of health effects criteria is described to provide an analytical framework for this assessment. The quantitative health effects criteria used to derive estimates of risk are then presented.

Summaries of the health effects and derivation of toxicity criteria for the specific chemicals selected for evaluation are provided in Appendix C.

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3.2.1 Health Effects Classification and Criteria Development

For risk assessment purposes, individual chemicals are separated into two categories of chemical toxicity depending on whether they exhibit carcinogenic (cancer-causing) or noncarcinogenic effects. This distinction relates to the currently held scientific opinion that the mechanism of action for each category is different.

For chemicals potentially causing noncarcinogenic effects, it is believed that organisms have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the health 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.

For the purpose of assessing risks associated with potential carcinogens, EPA has adopted the science policy position that a small number of molecular events can evoke changes in a single cell, or a small number of cells, that can lead to tumor formation. This is described as a no-threshold initiator mechanism because there is essentially no level of exposure (i.e., a threshold) to a carcinogen that will not result in some finite possibility of causing the disease. Another assumption stemming from EPA's science policy is that the dose-response curve is linear at low doses. In reality, this curve can take many shapes depending on the exact biological mechanisms of action of a chemical. The dose-response curve will especially vary if the chemical behaves as a cancer promoter rather than as an initiator; the net effect in this case would be that the most accurate shape may be indicative of a threshold or quasi-threshold for response.

This nonthreshold hypothesis is undergoing internal EPA review. This action began some years ago with the publication of a EPA report that assumed that thresholds exist for assessing the risks from certain thyroid follicular cell tumors (EPA 1988). Recently, EPA's Office of Research and Development evaluated dose-response models for carcinogenesis resulting from chemicals believed to induce cancer by receptor-mediated events (e.g., PCDDs, PCDFs, PCBs) (EPA 1994b). While the results of that analysis have not yet been finalized, the draft report indicates that data are consistent with low-dose linearity, despite the acknowledged role of receptor-mediated events in cancer induction.

3.2.1.1 Health Effects Criteria for Noncarcinogens

Health effects criteria for chemicals potentially causing noncarcinogenic effects are generally developed using verified reference doses (RfDs) and reference concentrations (RfCs). These criteria are developed by EPA's RfD/RfC Work Group and are obtained from EPA's Integrated Risk Information System (IRIS) or from EPA's Health Effects Assessment Summary Tables (HEAST) (EPA 1994c). The RfD is expressed in units of dose (mg/kg/day), and the RfC is expressed in airborne concentration units (e.g., mg/m^3). For the purposes of this assessment,

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each RfC was converted into an RfD assuming a 70-kg individual inhales 20 m^3 of air per day. RfDs and RfCs are usually derived either from human studies involving workplace exposures or from toxicological studies and are adjusted using uncertainty factors. RfDs or RfCs can be developed to be protective for exposure over a lifetime or for a portion of a lifetime. The chronic RfD or RfC is an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of the daily exposure level for the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs or RfCs are specifically developed to be protective for long-term exposure to a chemical (as a Superfund program guideline, 7 years to lifetime). The subchronic RfD or RfC is an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an applicable risk of deleterious effects during a portion of a lifetime (as a Superfund program guideline, 2 weeks to 7 years).

The RfD/RfC is used as a reference point for gauging the potential effects of exposures. Usually, exposures that are less than the RfD are not likely to be associated with adverse health effects. Intakes that are greater than the RfD may indicate an increased probability of adverse effects; however, that probability is not a certainty. However, as the frequency and/or magnitude of the exposures exceeding the RfD increase, the probability of adverse effects in a human population also increases. It should be noted that the RfDs are approximate numbers, and although chemical intakes or air concentrations higher than the RfD have a greater chance of producing an adverse effect, it should not be categorically concluded that all doses and air concentrations below the RfD are "acceptable" (or will be risk-free) and that all doses and air concentrations in excess of the RfD are "unacceptable" (or will result in adverse effects).

RfDs are derived using uncertainty factors that reflect scientific judgment regarding the various types of data used to estimate them. 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 human exposure;
- the uncertainty in extrapolating from data obtained in a study that is less-than-lifetime exposure;
- the uncertainty in using lowest-observable-adverse-effect level (LOAEL) data rather than no-observable-adverse-effect-level (NOAEL) data; and
- the inability of any single study to adequately address all possible adverse outcomes in humans (EPA 1995).

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When considered together, these uncertainty factors may confer an extra margin of safety of up to a factor of 3,000.[1] The net result is that RfDs always bias risk estimates in the direction of overestimation. A conceptual model for deriving a RfD using uncertainty factors is presented in Figure 3-1.

3.2.1.2 Health Effects Criteria for Carcinogens

For chemicals exhibiting carcinogenic potential, EPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group has estimated the excess lifetime cancer risks associated with various levels of exposure to potential human carcinogens by developing cancer slope factors and unit risks. Cancer slope factors are expressed in terms of dose in units of (mg chemical/kg body weight/day)$^{-1}$. They describe the upper-bound increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure or dose, where the unit of exposure is expressed as mg chemical/kg body weight/day (mg/kg/day). Unit risks are expressed in terms of exposure as either an air concentration in units of ($\mu g/m^3$)$^{-1}$ or as a drinking water concentration in units of ($\mu g/L$)$^{-1}$. They are defined as the probability of an individual developing cancer over a 70-year lifetime per unit of concentration (e.g., 1 $\mu g/m^3$ or 1 $\mu g/L$). For the purposes of this assessment, each unit risk was converted into a slope factor assuming a 70-kg individual either inhales 20 m^3 of air per day or consumes 2 L of water per day. It is important to note that cancer slope factors and unit risks are derived assuming continuous exposure over a 70-year lifetime. Because regulatory efforts (e.g., reductions in emissions, required changes in processes) are generally geared to protect the public health, including even the most sensitive members of the population, the cancer slope factors and unit risks are derived using very conservative assumptions.

Cancer slope factors and unit risks are derived from the results of epidemiological studies or from 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 much lower than those tested in animal studies, the data are adjusted using mathematical models. Data from animal studies are typically fitted to the linearized multistage model to obtain a dose-response curve (see Figure 3-2 for a conceptual model for developing toxicity criteria for carcinogens using the linearized multistage model). In general, after the data are fit to the dose-response model, the 95 percent upper confidence limit of the slope of the resulting dose-response curve is calculated. This value is known as the slope factor and represents a 95 percent upper confidence limit on the probability of a response per unit intake of a chemical over a lifetime (i.e., there is only a 5 percent chance that the probability of a response could be greater than the estimated value on the basis of the experimental data and model used). This upper-bound slope of the dose-response relationship 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 exposure to a potential carcinogen quantitatively evaluated based on animal data are not likely to exceed the risks estimated using

[1]EPA is currently restricting total uncertainty factors to 3,000. Some older values with higher uncertainty factors will likely remain in the EPA databases until EPA review.

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these slope factors or unit risks, but they may be much lower. Dose-response data derived from human epidemiological studies are fitted to dose-time response curves on an *ad hoc* basis. These models provide rough, but plausible, estimates of the upper limits on lifetime risk. Slope factors and unit risks based on human epidemiological data are also derived using very conservative assumptions, and as such, they too are unlikely to underestimate risks. Therefore, whereas the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using a slope factor or unit risk, they could be considerably lower.

When the upper-bound cancer slope factor is multiplied by the lifetime average daily dose (LADD) of a potential carcinogen (in mg/kg/day), the product is an upper-bound lifetime excess individual cancer risk (or maximum probability of contracting, not dying from, cancer) associated with exposure at that dose or air concentration. Again, upper-bound means that the risk estimate is unlikely to be underestimated, but it may very well be overestimated. This is because of the inherent conservatism in the cancer slope factors and unit risks (i.e., they are upper-bound estimates) and because exposure assumptions used in risk assessments (including this one) are also conservative. An individual risk level of 1 in 1 million ($1x10^{-6}$), for example, represents an upper-bound probability of 0.0001 percent that an individual will develop cancer over his or her lifetime as a result of lifetime exposure to a potential carcinogen. By comparison, the average American's background risk of developing cancer is approximately 3 in 10 (i.e., 30 percent) (ACS 1993) or 300,000 times higher than a 1 in 1 million risk level.

EPA assigns weight-of-evidence classifications to potential carcinogens (EPA 1986a). Chemicals are classified in Group A, Group B1, Group B2, Group C, Group D, or Group E. The weight-of-evidence classification is an attempt to determine the likelihood that an agent is a human carcinogen; the classification thus affects the estimation of potential health risks although it does not affect numerical potency. Three major factors are considered in characterizing the overall weight-of-evidence for human carcinogenicity: (1) the quality of the evidence from human studies, (2) the quality of evidence from animal studies that are combined into a characterization of the overall weight-of-evidence for human carcinogenicity, and (3) other supportive information (e.g., structure/activity analysis, chemical structure, activity of similar chemicals, etc.) that is assessed to determine whether the overall weight-of-evidence should be modified. An alternate scheme for classifying weight-of-evidence for cancer has been developed by the International Agency for Research on Cancer in Lyon, France (IARC 1987). For the purposes of this assessment, however, the EPA's scheme has been adopted (EPA 1986a).

EPA's final classification of the overall evidence has five categories:

<u>Group A--Human Carcinogen</u>

This category indicates that there is sufficient evidence from epidemiological studies to support a causal association between an agent and cancer.

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Group B--Probable Human Carcinogen

This category generally indicates that there is at least limited evidence from epidemiological studies of carcinogenicity to humans (Group B1) or that, in the absence of adequate data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

Group C--Possible Human Carcinogen

This category indicates that there is limited evidence of carcinogenicity in animals and an absence of data in humans.

Group D--Not Classified

This category indicates that the evidence of carcinogenicity in animals is inadequate.

Group E-- No evidence of Carcinogenicity to Humans

This category indicates that there is no evidence of carcinogenicity in at least two adequate animal tests in different species or in both epidemiological and animal studies.

The estimated cancer risks in this report are all accompanied by this weight-of-evidence classification. The reader should note that, regardless of potency, there are important qualitative differences between chemicals that have been demonstrated to be human carcinogens and chemicals for which the evidence is limited. For example, the risks estimated to be associated with exposures to Group A chemicals (for example, arsenic) are characterized by less uncertainty than risks estimated for Group B2 chemicals (for example, benzo(a)pyrene).

3.2.2 Quantitative Health Effects Criteria

The quantitative dose-response health effects criteria that were used in the health risk assessment are presented in Table 3-8 (oral toxicity criteria), and Table 3-9 (inhalation toxicity criteria). Cancer slope factors were used to assess carcinogenic effects, and subchronic or chronic RfDs were used to assess noncarcinogenic effects. The primary sources of these criteria were EPA's IRIS (EPA 1995) and HEAST (EPA 1994b). These are EPA's recommended sources for health effects criteria, and they provide the most recent dose-response values available. The EPA-derived health effects criteria used in this assessment were selected preferentially from IRIS, then HEAST, since all toxicity values available on IRIS have undergone extensive peer review. The RfDs/RfCs reported in IRIS were developed by the RfD/RfC Work Group, which consists of approximately 15-20 members of various EPA offices with relevant expertise (e.g., Office of Pesticides and Toxic Substances, Office of Research and Development, Office of Solid Waste and Remedial Response). Cancer slope factors and unit risks in IRIS were similarly peer reviewed by the Carcinogen Risk Assessment Verification Endeavor (CRAVE). Verification of RfDs/RfCs, cancer slope factors, and unit

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risks entails a consensus among the work groups with respect to such factors as critical study, critical endpoint, safety factors, and modeling.

HEAST currently reports interim toxicity criteria values not yet verified for entry in IRIS. The interim health effects criteria developed for the HEAST document are not peer reviewed. This document is published by EPA's Environmental Criteria and Assessment Office (ECAO) in Cincinnati, Ohio, and toxicity values derived by this office are developed without input from other EPA offices. EPA Region III has, in some cases, obtained ECAO Regional Support provisional values for chemicals not addressed in IRIS or HEAST, and has listed these values in its Risk-Based Concentration Table.

Appendix C includes the IRIS and HEAST documentation for the health effects that have been associated with short-term and long-term exposures and the health effects criteria that have been developed for each compound evaluated in this risk assessment. In addition, Appendix D presents an evaluation of parameters selected for evaluation of exposures and risks associated with total petroleum hydrocarbons (TPH) at the Site. In many cases, the data discussed in the toxicity summaries in Appendix C were derived from animal and occupational health studies in which the doses of chemicals were very high and exposure was often short term. Thus, the doses of chemicals in such experimental and occupational studies that are associated with specific effects (e.g., tumors) are at levels much higher than those estimated in this risk assessment. The concentrations of chemicals to which laboratory animals were exposed or to which humans were exposed in an occupational setting should be considered in context relative to those concentrations that are estimated in various media for this risk assessment.

3.3 Human Exposure Assessment

This section of the human health risk assessment describes the potential for exposure to chemicals of potential concern at the Potomac Yard Site. Pathways judged to be most important with regard to potential risks to human health are selected and exposures for these pathways are quantified. The estimates for human exposure are used as a basis for evaluating potential risks at the Site.

3.3.1 Potential Exposure Pathways

Risk is characterized through the conceptualization of the potential for exposure at a site. This is an important component of the risk assessment because the presence of a chemical in an environmental medium does not in itself mean that exposure to a receptor can and will occur. The conceptualization of exposure begins with an understanding of site-specific exposure pathways. An exposure pathway describes the course a chemical takes from its source to the exposed individual or receptor. It is defined by four elements, which all must be present for exposure to occur:

- a source and mechanism of chemical release to the environment;
- an environmental transport or contact medium;

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- a point of potential contact with the medium by a receptor; and
- an exposure route (e.g., ingestion, dermal absorption, inhalation) at the exposure point.

An exposure pathway is considered complete only if all of these elements are present. Only complete exposure pathways are evaluated in exposure and risk evaluations. Exposure to chemicals at the Potomac Yard Site will be considered for three primary types of pathways: (1) current land-use pathways, (2) interim land-use pathways, and (3) future land-use pathways. Exposure scenarios associated with these pathway categories are based on consideration of current activities at the site and on expected future activities as the Site is developed.

Development of the Site is expected to occur, in general, according to the Master Plans for Alexandria and Arlington, and RF&P Corporation's more specific development plans. These plans all reflect the general long-term pattern of development that has been occurring in the vicinity of Potomac Yard and local zoning for these areas. Descriptions of the Potomac Yard Site, the surrounding areas, and development plans for the Site are presented in Section 2 of this report (Site Background), and in Section 2.4 of the ECS Report (Demography and Land Use). The following sections of this report describe the potential exposure pathways considered for evaluation in this risk assessment. Although several pathways are considered under the current, interim, and future land-use categories, only selected pathways are chosen for more detailed, quantitative evaluation. Scenarios which may be plausible under some conditions, but which do not possess each of the four elements defining an exposure pathway for the Potomac Yard Site represent incomplete pathways and are not considered in detail in this assessment. Tables 3-10, 3-11, and 3-12 summarize the conceptual model for evaluation of exposures and risks at the Site under current, interim, and future land-use conditions, respectively.

Groundwater Pathway

Although there is groundwater under the Site, exposure to chemicals of concern through this medium is incomplete from the standpoints of water resources and hydrogeology. When water resources are considered, the water bearing zones under the Site are of limited yield and subject to brackish water intrusion from the Potomac Estuary. In addition, the entire area is served by public water supplies from the City of Alexandria and Arlington County. The hydrogeological evidence leads to the conclusion that the groundwater under the Site moves at a sufficiently slow rate that chemicals originating at the site, if present in groundwater, are not likely to reach a surface water receptor point that could be contacted by humans in a reasonable amount of time or at appreciably elevated concentrations. (A detailed discussion of groundwater as a transport medium is found in Section 2.1 and Appendix J.) For these reasons, the groundwater pathway will not be considered in this risk assessment.

Surface Water Pathway

Surface water features currently remaining at the Potomac Yard Site are confined to drainage ditches and ponded water. These features are extremely small when compared to the remainder of the Site; thus, under current use conditions, exposure and risks associated with surface water are likely to be many times lower than exposures to surface soil. Following development, the

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surface water features will be eliminated and surface water will be managed in subsurface utilities and other engineered structures. Due to these reasons, a surface water pathway is not considered in this risk assessment.

Current Land-Use Exposure Pathways

Current activities at Potomac Yard are limited. Except for existing main line railroad and Metrorail tracks, most rail operations at Potomac Yard have been removed, structures have been demolished or decommissioned, and the Site graded. The Site is fenced and access is limited. However, it may be possible for occasional trespassers to enter the Site and potentially contact chemicals of potential concern present in soil. Exposure pathways under current use conditions are summarized in Table 3-10.

Exposure through direct contact with soil (i.e., incidental ingestion or dermal contact) affected by former Site activities is not expected to occur in the North Tail, North Yard, or Slaters Lane portions of the Site. These areas are covered by approximately 6 inches of gravel that is not contaminated by chemicals associated with former Site activities. However, this gravel layer is not present as extensively in the Central Operations, South Yard/South Tail, and Potomac Greens areas. Accordingly, exposure by direct contact to surface soil (0 to 3 feet) will be evaluated for individuals from nearby communities who may occasionally trespass on the Site. Incidental ingestion of soil will be quantitatively evaluated; dermal exposure is of minor importance with regard to potential risk and is discussed in Appendix L. Because the Site currently has limited use, and much of the Site has a clean gravel cover or is vegetated, dust dispersion is not a significant transport mechanism under current land-use conditions.

Exposure to airborne particulate matter will not be considered under current land-use conditions. Dust dispersion during construction activities will be considered under interim and future land-use conditions.

The scientific database for estimating dermal absorption from soil is very small; it is non-existent in the case of dermal absorption from cinder-based ballast similar to that found at the Site. EPA (1992a) has developed dermal absorption factors for only a few chemicals, which are chemicals of concern at the Site. Due to this, dermal absorption from soil will be discussed qualitatively in Appendix L and the uncertainty section.

Interim Land-Use Exposure Pathways

Interim land uses are expected to occur on North Tail, North Yard, and South Yard/South Tail portions of the Site for a period of time prior to the ultimate future development. These uses may include warehouses, "big-box" retail stores, parking lots, active or passive recreation areas, and similar developments. The exposure pathways associated with interim use are summarized in Table 3-11; Figure 3-3 shows the interim use Site map.

During interim development activities, on-site construction workers may be exposed to chemicals of potential concern primarily when taking part in work that involves earth-moving

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activities. Exposures under these conditions may involve direct contact with soil (ingestion and dermal contact) and inhalation of airborne soil particulates. Ingestion of soil and inhalation exposures will be quantitatively evaluated. Dermal exposures are discussed in Appendix L.

Off-site residents and on-site residents in previously developed portions of the Site also may be exposed to airborne soil particulates dispersed from the North Tail, North Yard, and South Yard/South Tail areas during interim land-use construction activities. Slaters Lane is expected to be the first area of the Site to be developed for residential use, and exposure to airborne dust will be evaluated for this on-site location as well as for nearby off-site locations just west of Jefferson Davis Highway.

Interim land-use construction is expected to involve grading and shallow excavation; therefore, surface soil (0 to 3 feet) is considered to be the source of potential exposure for these pathways.

After completion of interim land-use development projects, on-site retail, commercial, or office workers; landscape and maintenance workers; and consumers of services will be present at the Site. However, previously exposed areas of the Site will be covered by buildings, roads, and parking lots. Landscaped areas and recreational areas will require adequate topsoil to support vegetation for these anticipated uses. As a result, barriers preventing exposure to chemicals of potential concern will exist after completion of interim development projects and exposure scenarios for these types of pathways will not be considered.

Future Land-Use Exposure Pathways

Future land-use development is expected to occur on all portions of the Potomac Yard Site. Development will include a variety of urban-density land uses, including a regional transportation hub (including a new Metrorail station), office buildings, hotels, retail operations, residential areas, and active and passive recreation areas. The highest density development will occur in the central area of the Site in the vicinity of the regional transportation hub and will be less dense with distance radially from this central area. Residential dwellings will include townhouses, stacked townhouses, mixed-use dwellings, and low-, mid-, and high-rise buildings. Only a portion of the Slaters Lane section of the Site is being considered for potential development of single family detached dwellings with private yards. Figure 3-4 presents an artists rendition of the Site after development has occurred; Table 3-12 summarizes exposure pathways associated with future use.

During future development activities, on-site construction workers may be exposed to chemicals of potential concern primarily when taking part in work that involves earth-moving activities. Exposures under these conditions may involve direct contact with soil (ingestion and dermal contact) and inhalation of airborne soil particulates. Incidental ingestion of soil and inhalation exposures will be quantified. Exposures associated dermal absorption of chemicals in soil are anticipated to be negligible and are discussed in Appendix L.

Off-site residents and on-site residents in previously developed portions of the Site also may be exposed to airborne soil particulates dispersed from all areas of the Site during future land-use

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construction activities. Slaters Lane is expected to be the first area of the Site to be developed for residential use, and exposure to airborne dust will be evaluated for this on-site location as well as for nearby off-site locations just west of Jefferson Davis Highway. Future land-use construction is expected to involve grading and, in many cases, deep excavation; therefore, surface and subsurface soil (0 to 8 feet) is considered to be the source of potential exposure for these pathways.

During future land-use development activities and after final development of the Potomac Yard Site, it will be necessary to dig trenches for installation of utilities and for repair of utilities. Direct contact and inhalation exposures to chemicals of potential concern may occur under these conditions. Therefore, an exposure pathway for evaluation of this future land-use pathway will be considered. Ingestion of soil and inhalation exposures will be quantitatively evaluated. Dermal exposures are discussed in Appendix L.

Future development in the Slaters Lane Area of the Site may include single family detached residential dwellings with private backyards. Although it will be necessary to apply topsoil and landscaping materials to these areas prior to use, it is assumed that individuals in these areas could potentially dig into areas containing chemicals of potential concern. Exposure to chemicals of potential concern through direct contact with surface soil (0 to 3 feet) will be evaluated. Incidental ingestion of soil will be quantified, while dermal exposure is of minor importance and will be discussed in Appendix L. Because residential backyard areas will be covered with topsoil and vegetated, dust dispersion with subsequent inhalation exposure to chemicals of potential concern is unlikely to occur and will not be evaluated as a future land-use pathway.

After final future development, on-site residents in all areas of the Site other than Slaters Lane will not have access to private yard areas where exposure to chemicals of potential concern can occur. These residential areas will only include paved areas and walkways or common areas covered with clean topsoil and landscaping materials. Therefore, exposure to chemicals of potential concern in soil by direct contact or inhalation will not be evaluated for future on-site residents in areas other than Slaters Lane.

A number of potential pathways for exposure to chemicals of potential concern during recreational activities at the Site were considered. Many areas of Potomac Greens are well vegetated and would not require topsoil cover and landscaping materials for final future development. Therefore, exposure by direct contact to surface soil (0 to 3 feet) during walking, biking, or other recreational activities in the Potomac Greens Area will be considered in this assessment. Incidental ingestion of soil will be quantified; dermal exposure is anticipated to be negligible and is discussed in Appendix L. Potomac Greens is well vegetated and dust dispersion with subsequent inhalation exposure is unlikely in this area and will not be evaluated quantitatively.

Landscaped areas, passive parks, and playing fields will exist in the North Tail, North Yard, South Yard/South Tail, and Slaters Lane Areas after final future development. However, these areas will require clean topsoil and landscaping materials, and regular maintenance to support

vegetation appropriate for their intended uses. Direct contact and inhalation exposures by individuals using these recreational areas are unlikely to occur under these conditions and will not be considered in this assessment. However, it is possible that a landscape worker could contact chemicals in native soil present below the cinder-based ballast, left in place after final development, and used as topsoil to support vegetation in the landscaped areas. Therefore, exposure to chemicals of potential concern in native soil by direct contact will be evaluated in all development areas except Central Operations. Landscaping activities are not anticipated to occur in the Central Operations area, because this area will be dominated by high-density development, including a new Metro Station. Incidental ingestion of soil will be quantified. Dermal absorption of chemicals in soil is considered to be negligible and is discussed in Appendix L. After final development, the landscaped areas of the Site will be vegetated, therefore, inhalation exposure is likely to be negligible and will not be quantitatively evaluated.

After final future development, on-site commercial and office workers, and consumers of services will be present at all locations of the Site. Contact with chemicals of potential concern will be prevented by the presence of buildings, paved areas, and areas landscaped with clean topsoil and vegetation. Direct contact and inhalation exposures will not occur under these conditions and will not be considered in this assessment.

3.3.2 Quantification of Exposure Point Concentrations

One of the necessary components of a completed pathway analysis is a chemical concentration that will be representative of potential human exposure to the environmental media of interest. These concentrations are referred to exposure point concentrations, and they have been calculated for chemicals in soil and air to reflect the different exposures relevant to each type of receptor. Exposure point concentrations that characterize central tendency and high-end chemical concentrations in soil and air were developed based upon recommendations in EPA guidance (EPA 1992a). The derivation of these concentrations is discussed below.

3.3.2.1. Exposure Point Concentrations in Soil

Table 3-13 presents chemical exposure point concentration in soil over the two primary depth intervals relevant to this analysis: surface or 0 to 3 feet, and subsurface or 0 to 8 feet. The central tendency chemical concentration is the population mean of lognormal distributions or the arithmetic mean of normal distributions. The high-end chemical concentration is the 95 percent upper confidence limit (UCL) of the population mean calculated according to Land (Gilbert 1987), or the maximum concentration if this value was less than the UCL (EPA 1989). These chemical concentrations will be used to quantify central tendency and high-end exposure and risk through the incidental ingestion of soil under current, interim, and future land-use conditions; the inhalation of dust generated during construction activities during interim and future land-use conditions; and the inhalation of petroleum hydrocarbon vapors in a utility trench during future land-use conditions. Exposure point concentrations for the analysis of risks associated with exposure to native soil by a landscape worker are shown in Appendix K. The relevant soil depth intervals for this analysis are 0 to 3 feet for Potomac Greens and 3 to 8 feet for the other areas of the Site that were evaluated.

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3.3.2.2. Exposure Point Chemical Concentrations in Air

In this analysis, exposure point concentrations in air were estimated for both chemicals adsorbed to dust particles and for petroleum vapors in a utility trench. Off-site and on-site workers (commercial office workers, construction workers) and off-site and on-site residents (children and adults) were included in the evaluation. The time-frames and source areas used for air modeling were dependent upon development plans, and differ depending upon the land-use condition being evaluated.

Interim Land-Use Conditions

Dust dispersion to off-site residents and commercial office workers located across Jefferson Davis Highway, and to on-site residents who are living in the final development at Slaters Lane while interim development is on-going in other site areas are relevant to the analysis. Dust exposures to on-site construction workers are also considered. The Fugitive Dust Model (FDM) provided by EPA, which is specifically designed for the modeling of dust transport and dispersion, was used to estimate total suspended particulate concentrations (TSP) in air. As part of the modeling effort, the area of soil disturbed per month and the months over which earth-moving activities would occur was determined based upon projected development plans for the North Tail, North Yard and South Yard/South Tail Areas, and are presented on Table 3-14. The TSP concentrations for these receptors under interim land-use conditions are provided in Table 3-15. These concentrations were used together with central tendency chemical concentrations in soil at the appropriate depth, to develop airborne chemical concentrations for the different receptors considered in the evaluation. In accordance with EPA guidance, central tendency and high-end TSP concentrations in air were used to evaluate exposure. Central tendency TSP concentrations represent a spatial average over the receptor grid of interest, while high-end concentrations represent the maximum predicted long-term average for the same receptor grids. Because the maxima occurred in different receptor grid locations, exposure and risk calculated across areas cannot be summed. Five years of meteorological data were used in the evaluation, which is sufficient to provide a stable estimate of the expected transport and dispersion conditions. Details of the dust dispersion modeling are provided in Appendix B.

Future Land-Use Conditions

During final development under future land-use conditions, the same off-site and on-site residents, commercial office workers, and construction workers are pertinent to the evaluation. The development assumptions used for the North Tail, North Yard, Central Operations, South Yard/South Tail, Potomac Greens, and Slaters Lane Areas are shown on Table 3-16 and were obtained from the RF&P Railroad Company. In terms of dust generation, earth-moving activities were assumed to occur over 25 percent of the development period. This assumption is based on information provided by RF&P and its construction contractor, Christopher Consultants (See Appendix N). This area development information was used to model dust transport and dispersion, in order to obtain central tendency and high-end TSP concentrations at the relevant receptor locations. These TSP concentrations are presented in Table 3-17.

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In addition to fugitive dust, chemical concentrations of diesel fuel total petroleum hydrocarbons (TPH) in air within a utility trench were modeled. In this case, volatilization is the relevant transport mechanism. Chemicals representative of the major chemical classes in diesel fuel petroleum were selected as modeling surrogates. The major chemical classes are four groups of alkanes from C_8 to C_{22} (for which dodecane, tetradecane, octadecane and eicosane were selected as surrogates), low molecular weight PAHs (for which naphthalene was selected as a surrogate), and simple aromatics (for which o-xylene was selected as a surrogate). The estimated chemical concentrations for each of these diesel petroleum surrogates in the six evaluated areas are presented in Table 3-18. The concentrations of these modeling surrogates will be used to evaluate exposure. A discussion of the chemical classes composing total petroleum hydrocarbons and the selection of the surrogate compounds is provided in Appendix D.

3.3.3. Quantification of Chemical Dose

An average daily dose is used to quantify exposure to chemicals in an environmental medium. An average daily dose is simply the amount of a chemical taken into the body per unit body weight per unit time, and is expressed in units of mg/kg-day. For the quantification of potential carcinogenic effects, this dose is averaged over a lifetime of 70 years, and is therefore referred to as a lifetime average daily dose or LADD. In the case of noncarcinogenic effects, the average daily dose, or ADD, is averaged over the exposure duration. LADDs and ADDs are calculated differently depending upon the type of exposure and receptors being considered. For the Potomac Yard Site, the incidental ingestion of soil and the inhalation of dust generated during construction activities are the two types of exposures considered. Several types of receptors are relevant to the analysis, depending upon the land-use condition under evaluation: current, interim, or future. The exposure equations and parameters used to quantify LADDs and ADDs for each of these receptors are presented and discussed below. The chemical-specific LADDs and ADDs will be provided together with risk estimates in Section 3.4.

3.3.3.1. Current Land-Use Conditions

Under current land-use conditions, the relevant receptor is a trespasser who may incidentally ingest soil at the site. The equation used to evaluate this exposure and the parameters used in this equation are provided in Table 3-19.

Three areas were selected for the evaluation of direct contact exposure, Central Operations, South Yard/South Tail and Potomac Greens, because these areas are not entirely covered by pavement or gravel. Pavement and gravel exists over approximately 80 percent of the Central Operations Area and 50 percent of the South Yard/South Tail Area. Gravel is an average of 6 inches in depth. These site characteristics can be taken into account by considering the fraction of soil ingested from the contaminated source area (FI term of the equation) in order to better estimate the potential for exposure over the long-term (EPA 1989). In the Central Operations and South Yard/South Tail Area, FI terms of 0.20 and 0.50 were therefore selected for the central tendency exposure case. For the high-end exposure case, the FI term was increased by 20 percent to account for uncertainty in the estimate. No consideration of cover was made in the Potomac Greens Area, and thus an FI term of 1.0 was used in both exposure cases.

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The central tendency soil ingestion rate (IR) represents the best estimate of the population mean of soil ingestion rates for adults based upon the work of Thompson and Burmaster (1991) and Calabrese et al. (1990), while the high-end ingestion rate pertains to adults and children older than seven years of age based upon EPA guidance (EPA 1991a). Exposure frequencies (EF) of 48 days/year (two visits per week over a six month period) and 96 days/year (three visits per week over an eight month period) were selected for evaluation. Exposure durations (ED) of 5 and 10 years were considered to be conservative in combination with the selected exposure frequencies. An oral bioavailability of 10 percent for arsenic has been used in the evaluation of central tendency and high-end exposures based upon the geochemical analyses discussed in Appendix E. In addition, as requested by EPA Region III, high-end exposures also were evaluated assuming an arsenic bioavailability of 50 percent. The remaining terms of the exposure equation, body weight (BW) and averaging time (AT) are based upon EPA guidance (EPA 1991a).

3.3.3.2 Interim Land-Use Conditions

Interim development is currently planned for the North Tail, North Yard, and South Yard/South Tail Areas before final development will be accomplished in these areas. During interim land-use conditions, construction activities will involve the excavating and grading of soil to install slab foundations for the temporary structures. Although some deep utility trenches will be excavated, the disturbed soil will be predominantly from shallow depths (0 to 3 feet). Construction workers will come in direct contact with on-site surface soil, and the inhalation of dust from construction activities in the three areas is relevant to on-site construction workers, off-site receptors across Jefferson Davis Highway. Because final development in Slaters Lane will occur in 1996 while interim development activities in the three areas will be on-going, a residential child and adult receptor in this proposed development is considered under interim land-use conditions.

Ingestion Exposure

The exposure equation and parameters used to quantify the ingestion of surface soil by an on-site construction worker working within each of the three areas are provided on Table 3-20. The time-frames selected for evaluation are based upon current development information, and they represent the length of time earth-moving activities will occur in these areas. In the North Tail Area, interim development consists of the construction of a parking lot which will involve earth-moving activities over a 2-month period. In the North Yard Area, the construction of interim land-use retail space is estimated to involve earth-moving activities over a 13 month period to install the more immediate anchor structures and prepare for future satellite structures. In the South Yard/South Tail Area, the construction of five interim land-use warehouses will require a total of 15 months of earth-moving activities. These time-frames have been used to characterize central tendency exposures, and an increase in exposure of 20 percent, through an increase in the FI term of the exposure equation, has been used for the high-end exposure case to account for some additional time that construction workers may directly contact soil. A high-end exposure frequency of 250 days/year was used based upon EPA guidance (EPA 1991a), and the central tendency value of 230 days/year was based on the assumption that on average 20 work days

would be lost due to a combination of holidays and sickleave. These exposure frequencies require modification by the FI term discussed previously to account for the fact that direct contact with soil will not occur throughout this entire period.

Inhalation Exposure

The intake parameters for the inhalation of dust generated during interim land-use construction activities are presented in Table 3-21. On-site construction workers, off-site residential/commercial receptors and on-site residential receptors are relevant to this pathway. As discussed previously, the time-frames selected for evaluation are based upon earth-moving activities. In order to account for uncertainty in the high-end case, a 20 percent increase in exposure was assumed by increasing the exposure time from an 8-hour to a 10-hour day. Inhalation rates were obtained from Layton (1993). A 30 percent inhalation absorption factor for arsenic was utilized when estimating cancer risk in order be consistent with the derivation of the inhalation cancer slope factor (EPA 1984).

3.3.3.3 Future Land-Use Conditions

Future land-use conditions in this analysis characterizes the exposures during and after final development of the Potomac Yard Site. Final development will occur over different time periods in each of the six areas being evaluated: North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, and Potomac Greens. Some final development is scheduled for the near future (the Slaters Lane development, for example), and will exist while interim development is occurring in other areas. Final development will involve removal of existing interim development structures, tearing up of pavement, excavation of subsurface soil to install basements, utilities and pilings to support final development structures. Soil disturbance will occur at predominantly deeper depths than in the case of interim development, and the 0 to 8 foot depth interval was selected to characterize exposure.

Receptors and exposure parameters were selected to characterize the two overall phases of future land-use conditions: during and after final development activities. During construction activities, on-site construction workers will come in contact with soil and dust generated from earth-moving activities. Also during final development construction, off-site residential/commercial and on-site residential receptors will come in contact with dust generated from each of the areas. After final development occurs and most of the land surface is covered by pavement, buildings, and clean topsoil, inhalation exposure will not be relevant and ingestion exposure will be limited primarily to those areas where existing soil will remain or have a limited potential to be accessible such as Potomac Greens and Slaters Lane. The receptors conceptualized in the Potomac Greens Area are recreators in direct contact with surface soil. Limited potential for exposure is envisioned in Slaters Lane because clean topsoil will be brought in to create yards for detached single family dwellings. All other residential development is planned as stacked development with and without courtyards. Exposure to native on-site soil (exclusive of cinder-based ballast) by a landscape worker has been evaluated for selected portions of the Site. This analysis is shown in Appendix K.

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A utility worker was selected for evaluation under future land-use conditions, although this receptor could also be conceptualized under interim land-use conditions. The utility worker exposure is relevant either during construction activities, or after construction activities if repair of existing utility lines is required. Incidental ingestion of subsurface soil and inhalation of petroleum vapors are considered.

Ingestion Exposure

The exposure equation and parameters used to quantify the incidental ingestion of surface soil by the receptors chosen to evaluate exposure during and after final development activities are provided on Table 3-22. For the construction workers, the exposure durations selected for evaluation are based on current development plans, and are modified with an FI term to account for the fact that earth-moving activities will occur for 25 percent of the time during the year. This assumption is based on information provided by RF&P and its construction contractor, Christopher Consultants (See Appendix N). For the high-end exposure case, the time-frame of earth-moving activities was increased by 20 percent to account for any additional time a worker may be directly contacting soil. The other construction worker exposure parameters used in the equation were previously discussed.

After final development, ingestion exposures to any existing soil will be extremely limited. For this reason, the standard exposure durations based upon EPA guidance (EPA 1991a) for recreational and residential use of Potomac Greens and Slaters Lane were modified with an FI term which considers the fraction of acreage to be allocated as open space in these areas. The central tendency soil ingestion rates for children and adults are derived from the work of Thompson and Burmaster (1991). The remaining exposure parameters used in this evaluation are based on EPA guidance (1991a).

The utility worker exposure durations were based upon the assumption that a single worker during or after development in any of the six areas would install or repair 1,000 feet of utility lines at a rate of 75 feet per day. This involves a 13 day exposure to subsurface soil while working a trench. The high-end exposure case was increased by 20 percent to 16 days to account for uncertainty.

Details of the analysis of exposure of a landscape worker to on-site native soil (exclusive of cinder-based ballast) are provided in Appendix K.

Inhalation Exposure

The exposure equation and parameters used to quantify inhalation exposure under future land-use conditions are provided in Table 3-23. Inhalation exposures to dust have the potential to occur during final development activities, and are relevant to on-site construction workers, off-site residential/commercial receptors and on-site residential receptors. Exposure durations are based upon current development information and the length of time earth-moving activities will occur during development, or 25 percent of the year (see Appendix N). For the high end case, a 20 percent increase in exposure was incorporated to account for uncertainty by increasing the

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exposure time from an 8-hour to a 10-hour day. The duration of exposure is limited by the length of time over which development will occur. In the case of child and adult on-site and off-site residents, this duration was split between the adult and child such that the overall residential inhalation exposure would not exceed the time frame of development. Inhalation rates were obtained from Layton (1993). A 30 percent absorption factor for arsenic was utilized when estimating cancer risk in order be consistent with the derivation of the inhalation cancer slope factor (EPA 1984).

3.4 Risk Characterization

To quantitatively assess the risks to human health associated with potential exposures, LADDs and ADDs calculated with the equations and exposure assumptions discussed in the previous section are combined with the appropriate toxicity criteria. For potential carcinogens, excess upperbound lifetime cancer risks were obtained by multiplying the estimated LADD for each chemical by its cancer slope factor. The total upperbound excess lifetime cancer risk for each pathway was obtained by summing the chemical-specific risk estimates. This approach is consistent with EPA's guidelines for evaluating the effects of chemical mixtures (EPA 1989).

A cancer risk level of $1x10^{-6}$ (risks shown in scientific notation in tables, i.e., 1E-6) in this analysis represents an upperbound probability of one in one million that an individual could develop cancer due to exposure under the specified conditions. It is important to keep in mind that these risk levels are based on conservative upperbound assumptions and are not actuarial risks; that is, these estimates cannot be translated directly into actual cancer cases. The upperbound lifetime excess cancer risks derived in this report will be compared to EPA's risk range for health protectiveness at Superfund sites of 10^{-6} to 10^{-4} (EPA 1990b). This risk range was discussed in an EPA directive clarifying the role of the risk assessment in the Superfund process (EPA 1991b). With respect to potential human health impacts, the directive states that where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for current and future land use is less than 10^{-4}, and the non-carcinogenic hazard index is less than 1, action generally is not warranted.

In general, EPA cancer slope factors based on animal data are 95 percent upper confidence limit values based on the linearized multistage model. Thus, actual risks associated with exposure to potential carcinogens are not likely to be exceed the risks estimated using the cancer slope factors, and may be considerably lower.

Potential risks to noncarcinogens are calculated by first calculating the hazard quotient or ratio of the ADD to the chronic or subchronic reference dose (the hazard quotient) for each chemical. Subchronic exposures are defined as periods of 2 weeks to 7 years (EPA 1989). The sum of the hazard quotients for the chemicals under consideration is called the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures. In general, exposures with hazard indices that are less than 1 are not likely to be associated with any health risks, and are therefore less likely to be of regulatory concern than those with hazard indices greater than 1. In calculating the hazard index, the following approach was used. First, an overall hazard index was

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calculated for all the chemicals under evaluation. If the hazard index was less than 1, no further evaluation was made. However, if the hazard index was greater than 1, the exposures were evaluated with respect to the similarity of target organ or critical effect in accordance with EPA guidance (1989).

Dermal exposures to chemicals in soil were not quantitatively evaluated because there is no adequate data base for such a determination. A more detailed discussion on the potential risks and uncertainties associated with dermal exposure to chemicals in soil is presented in Appendix L. In addition, this pathway will be discussed in the uncertainty section of this report.

As noted above, the oral bioavailability of arsenic associated with cinder-based ballast was estimated to be 10 percent on the basis of geochemistry, leaching tests, and scientific literature (see Appendix E). Upon review of this information, EPA Region III requested that an additional analysis be performed in which the high-end arsenic bioavailability was assumed to be 50 percent. This analysis was conducted with the results being presented in brackets alongside the original results in the tables that summarize human health risks.

The exposure and risks quantified under current, interim, and future land-use conditions are summarized by exposure pathway and receptor in Tables 3-24 to 3-30. Because of the complexity of the Site and the large number of land-use conditions under evaluation, this summarized information is discussed by each area to be developed. A more detailed characterization of exposure, toxicity criteria, and risks associated with individual chemicals for each of the pathways considered is provided in Tables I-1 to I-79 in Appendix I and Tables K-2 to K-6 in Appendix K.

3.4.1 Risks Associated with the Development of the North Tail Area

Risks associated with the North Tail Area are related to development activities that will occur during interim and future land-use (final development) conditions. Interim development involves only the construction of a parking lot in this area, but future and final development will be extensive and will involve the building of high-rise office buildings and apartment buildings such as those that exist presently in Crystal City, Virginia. The time-frame for final development is estimated to be 18 years, during which period actual earth-moving activities are estimated to occur approximately 25 percent of the time. No exposure and risk was quantified under current land-use conditions because the North Tail Area is covered by an average of 6 inches of gravel. On-site and off-site risks calculated for interim and future (final) development in the North Tail Area are summarized in Tables 3-25 to 3-30, and are discussed below. A detailed characterization of risks for the North Tail Area is provided in Appendix I, Tables I-1 to I-15, and Table K-2 in Appendix K.

During the 2-month period during which earth-moving activities will occur under interim development, construction workers may incidentally ingest soil and inhale dust. The risks from these exposures are very low; for example, the combined central tendency and high-end

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excess upperbound lifetime cancer risks from these exposures range from 10^{-10} to 10^{-9}, and adverse noncarcinogenic effects are unlikely to occur.

Off-site residents across Jefferson Davis Highway and on-site child and adult residents who will be located at Slaters Lane may be exposed to dust generated by the construction workers. Risks are lower due to the effects of dispersion at these more distant locations, ranging from 10^{-13} to 10^{-11} for the off-site residents and commercial office workers, and 10^{-14} to 10^{-13} for on-site child and adult residents at Slaters Lane. As in the case of the construction worker, adverse noncarcinogenic effects are not likely to occur since all hazard indices were less than 1. These results indicate that interim development construction activities in the North Tail Area are not of concern with respect to human health, since all of these results are well below EPA's risk range for remedial alternatives.

Future development in the North Tail Area will involve the construction of high-rise apartment and office buildings, and earth-moving activities will extend over a considerably longer period of time than under interim land-use conditions. The combined ingestion and inhalation risks to a construction worker over an 18-year exposure range from 10^{-9} to 10^{-8} and adverse noncarcinogenic effects are not predicted to occur. Although these risks are higher than those observed for interim development, they are still very low when compared with EPA's risk range of 10^{-4} to 10^{-6}, and are not of concern with respect to human health.

Because of the long time-frame for development under future land-use conditions, a total residential risk can be calculated by summing the risks for child and adult exposures. The off-site residential inhalation risk ranges from 10^{-13} to 10^{-11}, while the risk to a resident at Slaters Lane ranges from 10^{14} to 10^{-13} from development activities in this area. Inhalation risks to off-site commercial office workers located across Jefferson Davis Highway are between 10^{-13} to 10^{-11}. Hazard indices for all receptors are below 1. All of these risks are well below levels of regulatory concern.

It was also assumed that under future land-use conditions, a landscape worker could incidentally ingest native soil during landscape activities. The excess upperbound lifetime cancer risks range from 10^{-10} to 10^{-9} and are well below EPA's risk range. The hazard indices are less than 1, indicating that noncarcinogenic effects are not likely to occur.

The last type of receptor evaluated in this area was a utility worker who would be exposed to chemicals through the incidental ingestion of subsurface soil and the inhalation of petroleum hydrocarbon vapors while working in a trench. The cancer risks associated with incidental ingestion by this receptor are between 10^{-11} to 10^{-10}, and no adverse noncarcinogenic effects are predicted from either the ingestion of soil or the inhalation of petroleum hydrocarbon (as diesel) vapors.

3.4.2 Risks Associated with the Development of the North Yard Area

As in the case of the North Tail Area, exposures and risks associated with interim and final development activities are relevant in this area. Interim development involves the construction

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of a large retail area. Earth-moving activities were assumed to occur over a 13-month period, during which time anchor buildings will be installed and the site will be developed for future satellite buildings. Under future and final development, interim structures and paving will be removed, and permanent buildings will be constructed. A combination of commercial office buildings, stacked residential development, and passive parks is planned for this area. The time-frame for final development activities is 14 years, during which period actual earth-moving activities are estimated to occur approximately 25 percent of the time. On-site and off-site risks calculated for interim and future development in the North Yard Area are summarized in Tables 3-25 to 3-30, and are discussed below. A detailed characterization of risks for the North Yard Area is provided in Appendix I, Tables I-16 to I-30, and Appendix K, Table K-3.

During interim land-use conditions, construction workers in the North Yard Area will be exposed to soil and dust. The excess upperbound lifetime cancer risk calculated for the combined ingestion and inhalation exposure ranges from $1x10^{-6}$ to $2x10^{-5}$ assuming that 10 percent of arsenic is bioavailable following incidental ingestion of soil. In addition, high-end risks were also calculated assuming that 50 percent of arsenic is bioavailable based on a preliminary estimate from the EPA Environmental Criteria and Assessment Office (ECAO). These risks are shown in brackets on Table 3-25. The high-end cancer risk is $4x10^{-5}$ for combined ingestion and inhalation exposure, while the combined hazard index is equal to 1 due to arsenic. These risks are well within EPA's acceptable risk range of 10^{-4} to 10^{-6}, and no adverse noncarcinogenic effects were predicted to occur assuming arsenic is 10 percent bioavailable.

Dust generated during interim development may be contacted by off-site and on-site residents. The risks to off-site children and adults range between 10^{-8} to 10^{-6} ($1x10^{-6}$), while the on-site children and adult residents at Slaters Lane have potential cancer risks ranging between 10^{-9} to 10^{-7}. These risks are well below EPA's acceptable risk range, and adverse noncarcinogenic effects are unlikely to occur.

Under future land-use conditions, the combined risks for the ingestion of subsurface soil and the inhalation of dust by a construction worker laboring for 14 years in the North Yard Area range from $1x10^{-6}$ to $4x10^{-5}$ assuming a 10 percent arsenic bioavailability factor. The combined high-end cancer risk calculated assuming a 50 percent arsenic bioavailability factor is $5x10^{-5}$. Risks for the other receptors from the inhalation of dust generated by the earth-moving activities are very low, ranging from 10^{-8} to 10^{-7} for off-site residents and commercial office workers, and from 10^{-9} to 10^{-8} for on-site residents. All hazard indices are less than one which indicates that adverse noncarcinogenic effects are unlikely to occur.

A utility worker who would be exposed to chemicals through the incidental ingestion of subsurface soil and the inhalation of petroleum hydrocarbon vapors while working in a trench was also evaluated in this area. The cancer risks associated with incidental ingestion of subsurface soil range between 10^{-9} to 10^{-8} assuming a 10 percent arsenic bioavailability factor while high-end cancer risks are $4x10^{-7}$ assuming arsenic is 50 percent bioavailable. No

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adverse noncarcinogenic effects were predicted from either the ingestion of soil or the inhalation of petroleum hydrocarbon (as diesel) vapors.

Under future land-use conditions, a landscape worker exposed to chemicals through incidental ingestion of native soil was also evaluated. The excess upperbound lifetime cancer risks range from 10^{-10} to 10^{-9} and are below EPA's risk range. The hazard indices are less than 1. Thus noncarcinogenic effects are not likely to occur.

3.4.3 Risks Associated with the Development of the Central Operations Area

Risks were quantified for the Central Operations Area under current and future (final) land-use conditions. Final development in this area will be dominated by Metrorail transit and commercial office buildings, and will take place over approximately 12 years, during which period actual earth-moving activities are estimated to occur approximately 25 percent of the time. On-site and off-site risks calculated for current and future (final) development in the Central Operations Area are summarized in Tables 3-24 and 3-28 to 3-30, and are discussed below. A detailed characterization of risks for the Central Operations Area is provided in Appendix I, Tables I-31 to I-40.

Under current land use conditions, approximately 20 percent of the area is not covered by pavement or gravel, and soil may therefore be directly contacted by trespassers. The excess upperbound lifetime cancer risks from the incidental ingestion of surface soil by a trespasser range between 10^{-8} to 10^{-6} ($3x10^{-6}$) assuming arsenic is 10 percent bioavailable and is $1x10^{-5}$ assuming arsenic is 50 percent bioavailable. These risks are below or within EPA's acceptable risk range, and no adverse noncarcinogenic effects are predicted to occur.

Under future land-use conditions, the construction of Metrorail structures and commercial office buildings will result in construction worker exposure to subsurface soil and dust. The combined excess upperbound lifetime cancer risk to a construction worker from the incidental ingestion of soil and the inhalation of dust over a 12-year exposure ranges from 10^{-7} to 10^{-5} ($2x10^{-5}$) assuming that 10 percent of arsenic in soil is bioavailable. The high-end cancer risk, based on a 50 percent arsenic bioavailability factor is $4x10^{-5}$. These risk levels are below or within EPA's risk range, and again, no adverse noncarcinogenic effects are likely to occur.

Future development activities will generate dust that may be inhaled by off-site residents, commercial office workers, and on-site residents. These inhalation cancer risks range between 10^{-9} to 10^{-7} for off-site residents across Jefferson Davis Highway, and between 10^{-9} to 10^{-7} for on-site residents at Slaters Lane and off-site commercial office workers across Jefferson Davis Highway. All hazard indices are well below 1.

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A utility worker who would be exposed to chemicals through the incidental ingestion subsurface soil and the inhalation of petroleum hydrocarbon vapors while working in was also evaluated in this area. The cancer risks associated with incidental ingestion subsurface soil are in the 10^{-9} to 10^{-7} range assuming that arsenic is 10 percent bioava while the high-end cancer risk is $5x10^{-7}$ assuming an arsenic bioavailability factor of ɔʊ percent. These risks are below EPA's risk range. Hazard indices equal to 1 and slightly greater than 1 (2) were calculated for central tendency and high-end combined exposures through inhalation of volatilized petroleum hydrocarbons, and incidental ingestion of soil, respectively. However, all of the estimated air concentrations were far below occupational standards and criteria. TPH in this area is largely localized where diesel free product was detected in groundwater and is being recovered.

3.4.4 Risks Associated with the Development of the South Yard/South Tail Area

Risks were quantified for the South Yard/South Tail Area under current, interim and future land-use conditions. Interim development involves the construction of five large warehouses in an area called the Potomac Technology Park. These warehouses will be constructed in a phased manner, and it is estimated that each warehouse will require 3 months of earth-moving activities, or a total of 15 months. Future and final development will involve the construction of a variety of commercial office buildings, stacked residential development, and the creation of passive parks and recreational areas. The time-frame for this development will be approximately 9 years. On-site and off-site risks calculated for current, interim, and future (final) land-use conditions in the South Yard/South Tail Area are summarized in Tables 3-24 to 3-30, and are discussed below. A detailed characterization of risks for the South Yard/South Tail Area is provided in Appendix I, Tables I-41 to I-56, and Table K-4 in Appendix K.

Under current land-use conditions, approximately 50 percent of the area is not covered by pavement or gravel, and soil may therefore be directly contacted by trespassers. The excess upperbound lifetime cancer risks in this area to a trespasser from the incidental ingestion of surface soil range from 10^{-8} to 10^{-6} ($1x10^{-6}$) assuming 10 percent of arsenic in soil is available for absorption. The high-end cancer risk assuming that 50 percent of arsenic is bioavailable is $5x10^{-6}$. These risks are below or within EPA's risk range and are below those of regulatory concern. Trespassers are not likely to experience noncarcinogenic effects.

Construction activities during interim development will result in incidental ingestion of surface soil and the inhalation of dust by construction workers. The combined ingestion and inhalation excess upperbound lifetime cancer risks for this receptor range from 10^{-7} to 10^{-6} ($6x10^{-6}$) assuming an arsenic bioavailability factor of 10 percent. The combined high-end cancer risk based on a 50 percent arsenic bioavailability factor is $9x10^{-6}$. Inhalation cancer risks for off-site residential and commercial receptors range from 10^{-9} to 10^{-7}. Potential risks to on-site receptors at Slaters Lane range from 10^{-8} to 10^{-7}. These interim land-use risks are all below or within EPA's risk range. Hazard indices for all receptors are below 1.

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Construction activities during final development will result in incidental ingestion of subsurface soil and the inhalation of dust by construction workers. The combined ingestion and inhalation excess upperbound lifetime cancer risks for these 9-year exposures range from 10^{-7} to 10^{-5} ($1x10^{-5}$) for an arsenic bioavailability of 10 percent. The high-end cancer risk for an arsenic bioavailability factor of 50 percent is $2x10^{-5}$. Inhalation cancer risks for off-site and on-site residential receptors range between 10^{-8} to 10^{-6} ($1x10^{-6}$), and for off-site commercial receptors between 10^{-8} and 10^{-7}. These risks during future development are below or within EPA's acceptable risk range. In addition, all hazard indices are well below 1.

A utility worker who would be exposed to chemicals through the incidental ingestion of subsurface soil and the inhalation of petroleum hydrocarbon vapors while working in a trench was also evaluated in this area. The cancer risks associated with incidental ingestion of subsurface soil range from 10^{-9} to 10^{-8}, assuming arsenic is 10 percent bioavailable, while the high-end risk is $3x10^{-7}$ assuming arsenic is 50 percent bioavailable. These risks are well below EPA's risk range. The hazard indices for the combined ingestion and inhalation exposures are less than 1 for both arsenic bioavailability factors, which indicates that it is unlikely that adverse noncarcinogenic effects will occur.

Under future land-use conditions, a landscape worker exposed to chemicals through incidental ingestion of native soil was also evaluated. The hazard indices are well below 1, which indicates that future landscape workers are unlikely to experience adverse health effects.

3.4.5 Risks Associated with the Development of the Slaters Lane Area

Risks associated with the Slaters Lane Area are related to development activities that will occur only during final development or future land-use conditions. This development is scheduled to begin in 1996, and thus there will be residential developments in use in this area during interim construction activities in the North Tail, North Yard and South Tail/South Yard Areas. Additionally, some residents at Slaters Lane will be present during the final and future development of all remaining areas: North Tail, North Yard, Central Operations, South Yard/South Tail, and Potomac Greens. The time-frame for complete final development in the Slaters Lane Area itself is estimated to be 7 years, during which period actual earth-moving activities are assumed to occur approximately 25 percent of the time. This means that a resident occupying Slaters Lane before the completion of development may be exposed to dust generated during the on-going Slaters Lane development. No exposure and risk was quantified under current land-use conditions because the Slaters Lane Area is covered by pavement and an average of 6 inches of gravel. On-site and off-site risks calculated for future (final) development in the Slaters Lane Area are summarized in Tables 3-26 to 3-30, and are discussed below. A detailed characterization of risks for the Slaters Lane Area is provided in Appendix I, Tables I-57 to I-67, and in Table K-5 in Appendix K.

Construction activities during final development in the Slaters Lane Area will result in incidental ingestion of subsurface soil and the inhalation of dust by construction workers. The combined ingestion and inhalation hazard indices for these exposures are well below 1, which indicates that construction workers are unlikely to experience adverse noncarcinogenic effects.

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Earth-moving activities at Slaters Lane will result in dust dispersion to off-site residents and commercial office workers across Jefferson Davis Highway, and inhalation hazard indices for these receptors are well below 1. All of these risks are extremely low and indicate that noncarcinogenic effects are not predicted.

As mentioned above, future on-site residents at Slaters Lane were chosen as receptors in this evaluation because they have the potential for exposure to dust generated during construction activities in all areas of the site. During interim land-use conditions, the total inhalation risk to such a resident from construction activities in the North Tail, North Yard, and South Yard/South Tail Areas is 10^{-8} for a child and an adult. During final development activities, which will include re-developing the interim use areas and developing the remaining areas, this on-site receptor at Slaters Lane will also be exposed to dust during earth-moving activities. This will result in an overall inhalation exposure for a child and adult in the 10^{-7} risk range, again below EPA's risk range of 10^{-6} to 10^{-4}. Hazard indices are all far less than 1, which means that adverse noncarcinogenic effects are not likely to occur. These risks are all well below levels of regulatory concern.

After final development, there will be little chance for inhalation exposures to dust, since the area will be paved, covered with buildings or covered with clean topsoil in order to support landscape vegetation. Some residential units with extremely small yards (approximately 15x20 feet) are planned for this area. Only limited contact with existing soil is anticipated to occur in these yards since they are extremely small and will be landscaped with clean topsoil, and 3 acres of parks and open space will be available to residents in this area. The hazards indices calculated for the incidental ingestion of soil by a resident are well below 1, which indicates that future residents are not likely to experience adverse noncarcinogenic effects.

Potential exposures to a utility worker were also evaluated for the Slaters Lane Area. For both the central tendency and the high end exposure cases, the noncancer hazard indices from combined soil ingestion and petroleum hydrocarbon vapor inhalation were less than 1, which indicates that adverse noncarcinogenic effects are unlikely to occur.

Under future land-use conditions, a landscape worker could be exposed to chemicals through the incidental ingestion of native soil during landscaping activities. The hazard indices are well below 1, indicating that noncarcinogenic effects are not likely to occur.

3.4.6 Risks Associated with the Development of the Potomac Greens Area

Risks were quantified for the Potomac Greens Area under current and future land-use conditions. Under current land-use conditions, it was assumed that a trespasser in this area may come in contact with existing soil. Future and final development will involve the construction of a variety of commercial office buildings, stacked residential development, and the creation of parks and open space. The time-frame for this development will be approximately 10 years. On-site and off-site risks calculated for current and future (final) land-use conditions in the Potomac Greens Area are summarized in Tables 3-24 and 3-28 to

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3-30, and are discussed below. A detailed characterization of risks for the Potomac Greens Area is provided in Appendix I, Tables I-68 to I-79, and in Appendix K, Table K-6.

Under current land-use conditions, it was assumed that a trespasser could come in contact with surface soil, and no consideration was made for gravel cover or pavement. The hazard indices are less than 1 for a trespasser exposed through the incidental ingestion of surface soil, indicating that trespassers are not likely to develop adverse health effects.

Under future land-use conditions during development, earth-moving activities will result in incidental soil ingestion and dust inhalation exposures to construction workers over a 10-year period. The hazard indices associated with these combined exposures are well below 1. Dust generated during construction activities is relevant to off-site residents and commercial office workers, and on-site residents at Slaters Lane. The inhalation hazard indices for these receptors are all extremely low, well below 1, therefore, adverse noncarcinogenic effects are not predicted to occur.

After final development occurs and earth-moving activities cease, dust inhalation exposures will no longer be of concern. At this stage, a large portion of the Potomac Greens Area will consist of parks and open space areas that will not likely require any topsoil cover. Residents in this area will use these open areas as recreational space, and thus the incidental ingestion of surface soil may occur. The hazard indices from incidentally ingesting surface soil during recreational use are well below 1 for a resident utilizing this area over a 30-year period. Therefore, no adverse noncarcinogenic effects are predicted to occur.

Exposures to a utility worker were also evaluated in this area under future land-use conditions. Hazard indices for ingestion and inhalation exposures are less than 1, which indicates that adverse noncarcinogenic effects are unlikely to occur. In addition, under future land-use conditions, a landscape worker could be exposed to chemicals through the incidental ingestion of native soil during landscaping activities. Based on consideration of the calculated hazard indices noncarcinogenic effects are not predicted to occur.

3.4.7 Risks to Off-Site Receptors Associated with Interim and Final Development

Inhalation risks to off-site commercial and residential receptors across Jefferson Davis Highway were modeled under interim and future land-use conditions. Risks under interim land-use conditions are presented in Tables 3-26 and 3-27, while risks under future land-use conditions can be found in Tables 3-29 and 3-30.

Construction activities during interim development involve earth-moving activities in primarily shallow soil in three areas of the site over a 2- to 15-month period. The inhalation excess upper bound lifetime cancer risks to a young child from development in all three areas during the earth-moving period is 10^{-7}, or in the case of an adult resident or commercial office worker is 10^{-8}. In the case of the child and adult residents, the exposures and risks were modeled separately for each receptor because of the short time frame being evaluated, that is, the exposure was not divided between the child and adult age categories and then summed (as was

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done under future land-use conditions). The hazard indices for all receptors were less than 1, which indicates that adverse noncarcinogenic effects are unlikely to occur.

During future and final development, construction activities will involve deeper excavation that will disturb soil with lower chemical concentrations. The earth-moving time period for future and final development is longer than under interim development, and exposures were divided between child and adult age categories. The total risk to an off-site residential or commercial receptor from inhalation of dust generated from all six areas of the site was estimated at 10^{-8}. The hazard indices for all receptors were less than 1, and adverse noncarcinogenic effects are thus not predicted to occur.

Inhalation risks were not summed across all development areas for the high-end exposure case. This is because maximum air TSP concentrations modeled for each of the six development areas occurred at different locations, and thus do not represent exposure to a single receptor. It would be inappropriate to combine these risk estimates.

3.5 Discussion of Uncertainties

The analysis, results, and conclusions presented in this assessment provide a basis for evaluating the nature and magnitude of human health risks potentially associated with exposure to chemicals at the Potomac Yard Site. This information can, in turn, be used to identify areas or exposure pathways of potential concern and to determine the need for risk management measures. All risk assessments involve the use of assumptions, professional judgement, and incomplete data to varying degrees. This section discusses uncertainties in the parameters used in the Potomac Yard human health risk assessment, and their potential effects on risk estimates.

Uncertainty in a risk assessment may arise from many sources, including:

- Environmental sampling and analysis;
- Selection of chemicals of potential concern;
- Conceptual and numerical estimation of exposure;
- Availability and quality of toxicological data; and
- Combinations of sources of uncertainty.

The effect of any given assumption on the results of a risk assessment may be to either over-or underestimate risk. On balance, the goal of the risk assessment process, as conducted under EPA guidelines, is to provide a conservative (in a health protective sense) evaluation of potential risks associated with exposure to chemicals at a site. Thus, most of the assumptions used in risk assessments carried out for EPA regulatory programs will tend to overestimate risk.

Table 3-31 summarizes key assumptions used in this human health risk assessment and provides an estimate of the level of uncertainty inherent in the assumption and the effect of the assumption on the risk estimate. The levels of uncertainty were characterized as follows:

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- Low--less than one order of magnitude effect;
- Moderate--one to two orders of magnitude effect; and
- High--greater than two orders of magnitude effect.

The effect of the assumption on the risk result was described by indicating whether the value used in the risk assessment would be more likely to underestimate risks, overestimate risks, or both. As may be seen from this table, there is a higher probability that, overall, the risks predicted from this risk assessment are over-estimated rather than underestimated.

One possible source of uncertainty not discussed in this table concerns the qualitative identification of chemical compounds at the Potomac Yard Site. Several nitrogenous compounds (dinitrophenol, dinitrotoluene, N-dinitrosodiphenylamine) were observed in results obtained from EPA's method 8270, despite the fact that there is no historical or environmental reason to believe that these chemicals should be present at the Site. Method 8270 is based on mass spectroscopy which often yields ambiguous results for nitrogenous compounds due to the fact that the N_2 fragment has the same molecular mass as several other common fragments (e.g., CO, C_2H_4) that are also likely to be present and in addition, due to the thermal instability of nitrosamines. This ambiguity could be resolved by using another detector or by using more sophisticated techniques of mass spectroscopy than those found in Method 8270.

Another group of compounds found at the Site without a historical basis are the organochlorine pesticides. Although it is possible, despite the lack of evidence, that these compounds were used for pest control purposes many decades ago, it is highly unlikely that such a wide variety was used. When this is considered in conjunction with the fact that PCBs are known to occur at the Site and the widely known interference between organochlorine pesticides and mixtures of PCBs (e.g., Cairns et al. 1986), it is possible that what have been identified as organochlorine pesticides are merely PCB congeners other than those typically used for PCB identification and quantification.

Last, the presence of dibenzo(a,h)anthracene at the levels found in soil at the Site is anomalous compared to other sites where PAHs are identified as chemicals of concern. PAHs from various sources typically present characteristic fingerprints (Chrostowski and Pearsall 1986) which aid in source identification. It is highly unusual to observe a mixture of PAHs in which the dibenzo(a,h)anthracene is substantially higher in concentration than benzo(a)pyrene, as was observed in the North Tail, South Yard/South Tail, and Potomac Greens Areas. It is quite likely that this is due to the use of analytical techniques than cannot resolve PAH isomers.

Despite the uncertainty in analytical identification, these chemicals have all been evaluated in the risk assessment.

The most significant chemical of concern at the site (with respect to risks) is arsenic. The carcinogenicity of ingested arsenic has been a matter of controversy for many years. Arsenic is a known human carcinogenic (Group A) by the oral and inhalation routes. There are several sources of uncertainty regarding arsenic's potency, however, including the fact that the dose-response curve may be less than linear causing the slope factor to overestimate risk at lower

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dose and arsenic may be an essential human nutrient at trace levels. A June 21, 1988, memorandum from the Administrator of the EPA regarding arsenic states that "risk managers must recognize and consider the qualities and uncertainties of risk estimates. The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens." The basis of this statement is the fact that the primary response in the epidemiology studies is skin tumors, which are relatively easily detected and treated and therefore, not often fatal. It should be noted, however, that more recent large-scale epidemiological studies in Taiwan now demonstrate clear associations and dose-response trends for arsenic exposure and internal cancers (EPA 1995). Thus, the uncertainty associated with the relative ease of detection and treatment of skin tumors caused by arsenic may no longer be an issue since internal cancers are also associated with the chemical.

There is also uncertainty associated with the arsenic RfD. EPA (1995) notes that strong scientific arguments can be made for RfD values within a factor of 2 or 3 of the current RfD.

3.6 References

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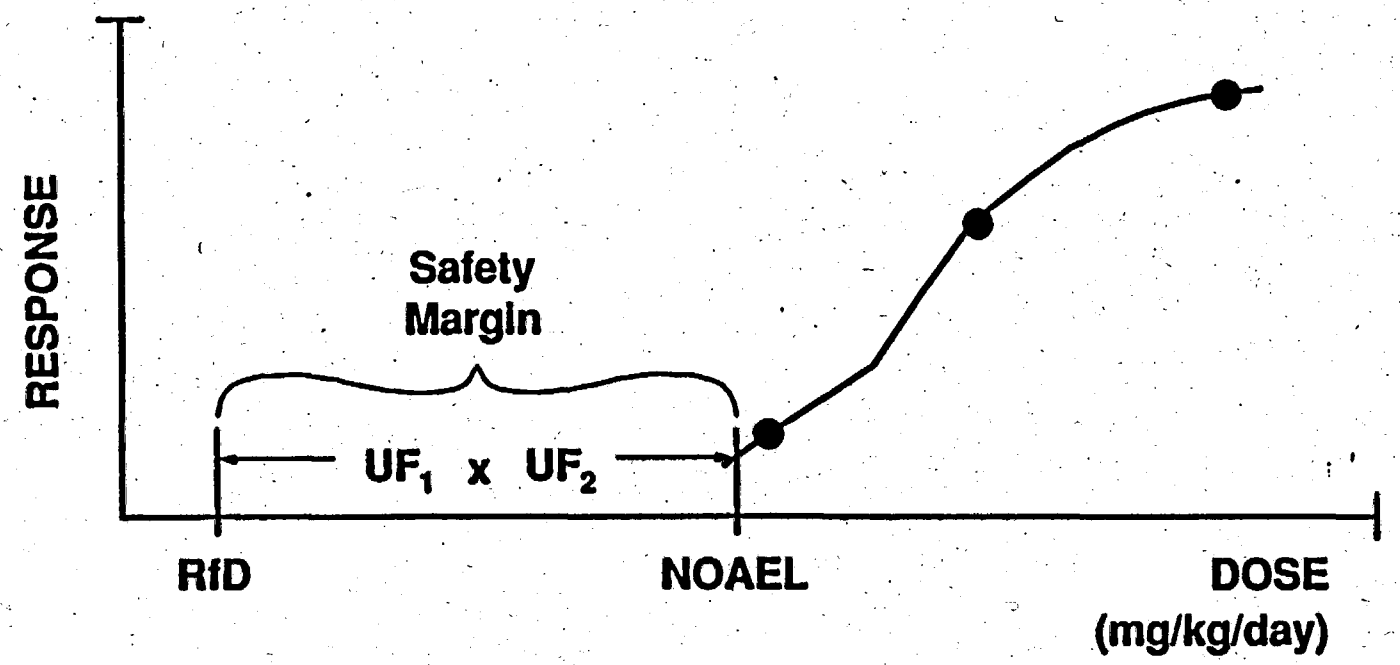
FIGURE 3-1

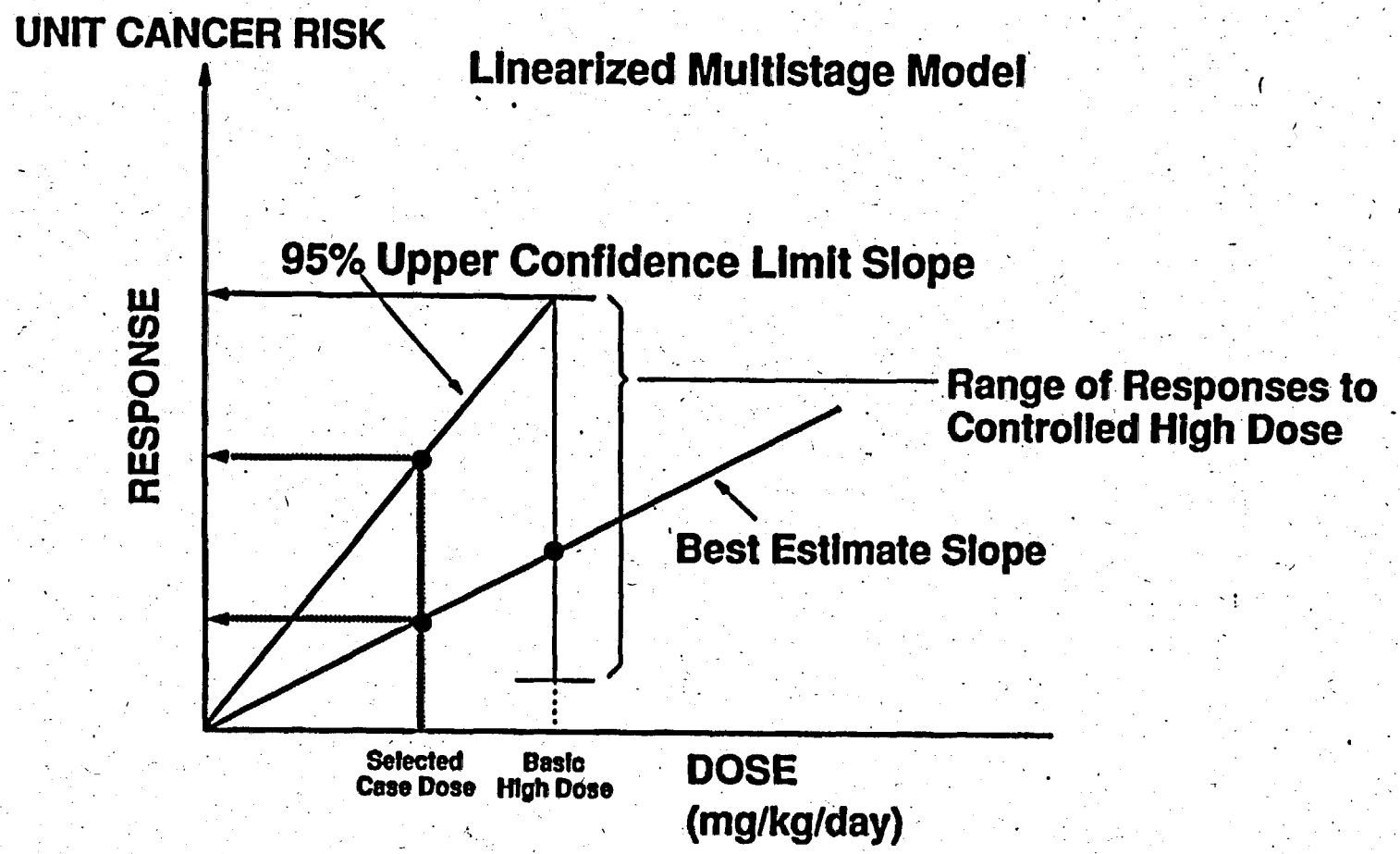
MODELS FOR NONCARCINOGENS



A Series of Decreasing Doses Finally Elicits No Adverse Effects. A Safety Margin Consisting of Uncertainty Factors UF_1 and UF_2 is Added to this No Adverse Effects Level (NOAEL) to Derive a Reference Dose (RfD).

FIGURE 3-2

MODELS FOR CARCINOGENS



Models like the Linearized Multistage Model transform high-dose data into low-dose estimates. Use of the 95% upper confidence limit ensures health protectiveness.

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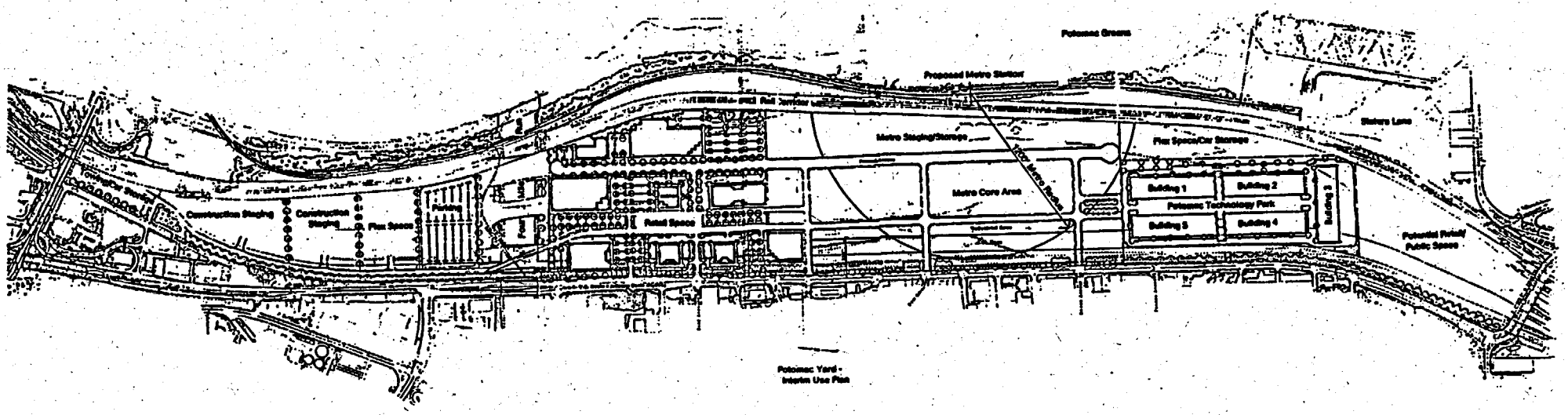

FIGURE 3-3
INTERIM LAND–USE SITE MAP

Source: RF&P Railroad Company

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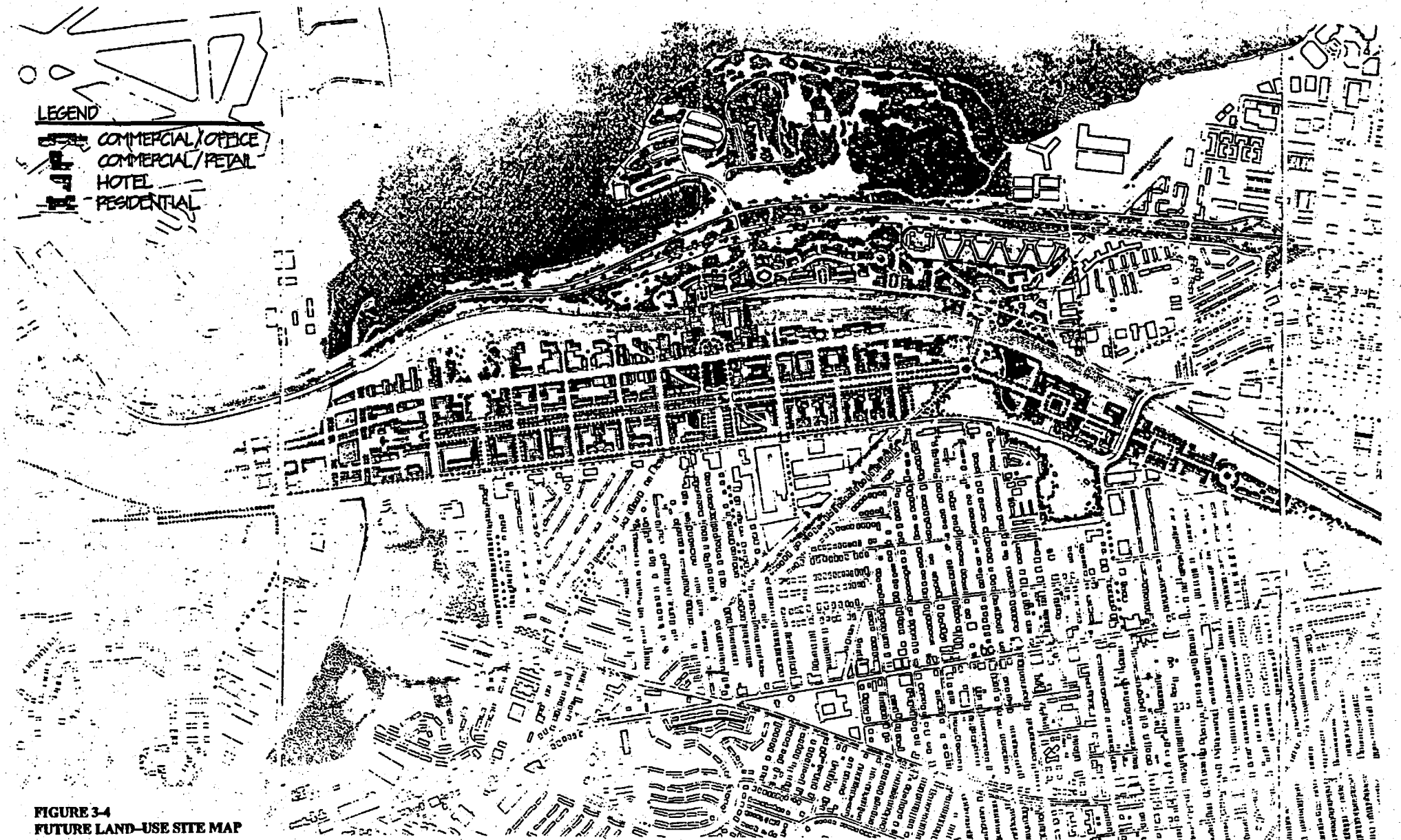

FIGURE 3-4
FUTURE LAND–USE SITE MAP

TABLE 3-1
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, NORTH TAIL AREA
(Concentrations reported in mg/kg)

Compound	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Dieldrin	3 / 12	8	0.024 - 0.068	0.02	0.0035 - 0.0039
Total Petroleum Hydrocarbons	6 / 11	11	5 - 120	33.2	2.3 - 12
3 TO 8 FEET (e)					
Dieldrin	1 / 12	8	0.01298	0.003	0.0037 - 0.004
Total Petroleum Hydrocarbons	4 / 11	11	3.9 - 125	25.1	2.3 - 12

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.

TABLE 3-2
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, NORTH YARD AREA
(Concentrations reported in mg/kg)

Compounds	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Antimony	8 / 48	48	3.77 - 19.3	5.87	3.6 - 21.5
Arsenic	40 / 49	49	3.1 - 1710	277	0.95 - 222
Cadmium	23 / 48	48	0.44 - 10.9	1.23	0.42 - 1.4
Chlordane	5 / 48	47	0.00654 - 2.082	0.08	5E-05 - 0.42
Mercury	15 / 48	48	0.11 - 5.13	0.19	0.05 - 0.12
Thallium	4 / 48	48	0.21 - 2.3	0.62	0.35 - 2.7
Total Petroleum Hydrocarbons	21 / 46	46	1.7 - 656	88.5	2.2 - 460
3 TO 8 FEET (e)					
Antimony	5 / 53	53	4.05 - 14.8	4.98	3.6 - 18.9
Arsenic	44 / 54	54	2.2 - 595	49.2	0.39 - 2.5
Cadmium	15 / 53	53	0.39 - 3.9	0.74	0.4 - 1.4
Chlordane	1 / 53	38	0.0148	0.003	5E-05 - 0.0196
Mercury	6 / 53	53	0.1 - 10.1	0.25	0.06 - 0.16
Thallium	2 / 53	18	0.22 - 0.44	0.23	0.34 - 0.83
Total Petroleum Hydrocarbons	8 / 53	53	4.23 - 360	16.7	2.2 - 32.1

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.

TABLE 3-3
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, CENTRAL OPERATIONS AREA
(Concentrations reported in mg/kg)

Compound	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Arsenic	26 / 29	29	2.8 - 1500	203	0.49 - 93
Total Petroleum Hydrocarbons	11 / 28	28	2.4 - 12600	1070	2.3 - 22000
3 TO 8 FEET (e)					
Arsenic (f)	21 / 30	30	1.9 - 328	40.7	0.44 - 117
Total Petroleum Hydrocarbons (f)	7 / 29	29	3.3 - 9100	490	2.2 - 88

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.
(f) Evaluation of exposure analyzed for 0 to 3 and 0 to 8 foot strata but not for the 3 to 8 foot stratum. Chemical data displayed only for summary purposes.

TABLE 3-4
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, SOUTH YARD/SOUTH TAIL AREA
(Concentrations reported in mg/kg)

Compound	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Antimony	6 / 30	30	2.6 - 22.51	4.51	2.2 - 17
Arsenic	25 / 30	30	3.9 - 588	173	1.9 - 229
Total Petroleum Hydrocarbons	19 / 29	29	1.9 - 2228	171	2.2 - 48
3 TO 8 FEET (e)					
Antimony	2 / 27	26	4.72 - 9.91	3.62	2.2 - 14
Arsenic	25 / 27	27	2 - 291	38.5	3 - 92.4
Total Petroleum Hydrocarbons	6 / 27	27	12.58 - 389.5	45.6	2.2 - 49

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.

TABLE 3-5
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, SLATERS LANE AREA
(Concentrations reported in mg/kg)

Compound	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Total Petroleum Hydrocarbons	1 / 5	5	3255 - 3255	657	2.2 - 26
3 TO 8 FEET (f)					
Antimony (e)	1 / 6	4	4.31	2.84	2.4 - 7.5
Total Petroleum Hydrocarbons	1 / 5	5	33	9.45	2.4 - 12

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Antimony was not detected in the 0 to 3 foot depth interval.
(f) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.

TABLE 3-6
SUMMARY STATISTICS FOR CHEMICALS OF POTENTIAL CONCERN
POTOMAC YARD, POTOMAC GREENS AREA
(Concentrations reported in mg/kg)

Compounds	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Average Concentration (c)	Range of Detection Limits (d)
0 TO 3 FEET					
Thallium	2 / 10	10	0.78 - 1.2	0.55	0.54 - 2
Total Petroleum Hydrocarbons	5 / 10	10	3.5 - 94	37.7	13 - 16
3 TO 8 FEET (e)					
Thallium	2 / 11	10	0.78 - 0.79	0.43	0.42 - 1.4
Total Petroleum Hydrocarbons	7 / 11	11	1.6 - 604	83.0	13 - 37

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) Arithmetic mean concentration.
(d) Excludes detection limits that were greater than twice the maximum detected concentration.
(e) Summary data shown for 3 to 8 foot depth interval if chemical was identified as a COPC for either the 3 to 8 foot or the 0 to 8 foot depth intervals. Table 3-7 indicates the COPCs for all three depth intervals.

TABLE 3-7

CHEMICALS OF POTENTIAL CONCERN IN SOIL (a)

Chemical	North Tail Area			North Yard Area			Central Operations Area		South Yard/ South Tail Area			Slater Lane Area			Potomac Greens Area		
	0-3	3-8	0-8	0-3	3-8	0-8	0-3	0-8	0-3	3-8	0-8	0-3	3-8	0-8	0-3	3-8	0-8
Antimony				X	X	X			X	X	X		X	X			
Arsenic				X		X	X	X	X		X						
Cadmium				X	X	X											
Chlordane				X	X	X											
Dieldrin	X	X	X														
Mercury				X	X	X											
Thallium				X	X	X									X	X	X
Total Petroleum Hydrocarbons	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(a) Exposure to 3-8 stratum was evaluated for all site areas except Central Operations.

TABLE 3-8

ORAL TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN

Chemical	Subchronic Reference Dose (mg/kg-day) (a) [Uncertainty Factor]	Chronic Reference Dose (mg/kg-day) (a) [Uncertainty Factor]	Confidence Level	Target Organ/ Critical Effect	Subchronic/ Chronic Reference Dose Source	Cancer Slope Factor (mg/kg-day)-1	USEPA Weight of Evidence Classification	Slope Factor Source
Organics:								
Chlordane	6E-5 [1,000]	6E-5 [1,000]	Low	liver	HEAST/IRIS	1.3E+0	B2	IRIS
Dieldrin	5E-5 [100]	5E-5 [100]	Medium	liver	HEAST/IRIS	1.6E+1	B2	IRIS
TPH Surrogates (f):	1E+0	1E-1	--	--	WCG			
Fluorene (f)	4E-1[300]	4E-2[3,000]	Low	hematological	HEAST/IRIS	--	D	IRIS
Nonane (f)	3E+0[300]	3E-1[3,000]	--	neurological	WCG (b)	--	--	--
Toluene (f)	2E+0[100]	2E-1[1,000]	Medium	liver, kidney	HEAST/IRIS	--	D	IRIS
Inorganics:								
Antimony	4E-4 [1,000]	4E-4 [1,000]	Low	mortality, blood	HEAST/IRIS	--	--	--
Arsenic	3E-4 [3]	3E-4 [3]	Medium	skin	HEAST/IRIS	1.5E+0 (e)	A	IRIS
Cadmium	1E-3[10] (g)	1E-3[10] (h)	High	kidney	--/IRIS	--	B1	IRIS
Mercury	3E-4[30]	3E-4 [30]	--	neurotoxicity	HEAST/IRIS	--	D	IRIS
Thallium (d)	8E-4 [300]	8E-5 [3,000]	Low	liver, blood, hair	HEAST/IRIS	--	--	--

CNS = Central Nervous System
HEAST = Health Effects Assessment Summary Tables - (March 1994), Supplement 1 (July 1994), and Supplement 2 (November 1994).
IRIS = Integrated Risk Information System
USEPA = U.S. Environmental Protection Agency
WCG = Weinberg Consulting Group
-- = No information available

(a) With the exception of the criteria for nonane and thallium, the chronic oral RfD was adopted by USEPA as the toxicity criterion for subchronic exposure.
(b) The subchronic and chronic criteria for nonane were derived from the results of an experimental animal study, as discussed in Appendix D.
(c) The cancer slope factor is presented as a benzo(a)pyrene equivalent and was derived by multiplying the benzo(a)pyrene slope factor by the appropriate order-of-magnitude relative potency factor [i.e., 1] developed for dibenzo(a,h)anthracene by USEPA (1993, 1994).
(d) The toxicity criterion for thallium sulfate was used to evaluate the potential health effects of thallium.
(e) IRIS notes that USEPA counsels that in reaching risk management decisions in a specific situation, risk managers must recognize and consider the qualities and uncertainties of risk estimates. The uncertainties associated with ingested inorganic arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens. The slope factor was calulated from a unit risk of 5E-5 (ug/L) -1 assuming a 70-kg individual ingests 2 liters of water per day.
(f) As discussed in Appendix D, three compounds were selected to evaluate the toxicity of the three primary classes of compounds making up Total Petroleum Hydrocarbons derived from diesel fuel. Fluorene, nonane, and toluene were selected to represent the toxicity of low molecular weight PAHs, aliphatic hydrocarbons, and substituted aromatics, respectively. The criteria for the TPH mixture are based on weighting the criteria for individual components according to their fractional concentration (by weight) in the TPH mixture.
(g) The chronic RfD was conservatively used to assess subchronic exposures.
(h) The RfD developed for non aqueous exposures was used to assess cadmium in soil.

TABLE 3-9

INHALATION TOXICITY CRITERIA FOR CHEMICALS OF POTENTIAL CONCERN

Chemical	Subchronic Reference Dose (mg/kg-day) (a,b) [Uncertainty Factor]	Chronic Reference Dose (mg/kg-day) (a,b) [Uncertainty Factor]	Confidence Level	Target Organ/ Critical Effect	Subchronic/ Chronic Reference Concentration Source	Cancer Slope Factor (mg/kg-day)-1	USEPA Weight of Evidence Classification	Slope Factor Source
Organics:								
Chlordane	--	--	--	--	--	1.3E+0 (e)	B2	IRIS
Dieldrin	--	--	--	--	--	1.6E+1 (e)	B2	IRIS
TPH Surrogates (h):	7E-1	1E-1	--	--	WCG			
Fluorene (h)	4E-1[300]	4E-2[3,000]	Low	hematological	(RT-to-RT) HEAST/IRIS	--	D	IRIS
Nonane (h)	3E+0[300]	3E-1[3,000]	--	neurological	WCG (d)	--	--	--
Toluene (h)	1.1E-1[300] (i)	1.1E-1[300] (i)	Medium	neuro., nasal cavity	IRIS	--	D	IRIS
Inorganics:								
Antimony	4E-4 [1,000]	4E-4 [1,000]	Low	mortality, blood	(RT-to-RT) HEAST/IRIS	--	--	--
Arsenic	--	--	--	--	--	5E+1 (c,e)	A	IRIS
Cadmium	--	--	--	--	--	6.3E+0 (e)	B1	IRIS
Mercury	8.6E-5 [30] (g)	8.6E-5 [30] (g)	--	neurotoxicity	HEAST/IRIS	--	D	IRIS
Thallium	8E-4 [300]	8E-5 [3,000]	Low	liver, blood, hair	(RT-to-RT) HEAST/IRIS	--	--	--

EPA Region III = Risk-Based Concentration (RBC) Table 3/7/95
HEAST = Health Effects Assessment Summary Tables - (March 1994) and Supplement I (July 1994) and Supplement 2 (November 1994).
IRIS = Integrated Risk Information System
RT-to-RT = Route-to-route extrapolation
USEPA = U.S. Environmental Protection Agency
WCG = Weinberg Consulting Group
-- = No information available

(a) With the exception of the criteria for mercury, nonane and toluene, the reported toxicity values are based on route-to-route extrapolation from the oral toxicity criteria for chemicals which exhibit systemic toxicity, assuming that similar absorption and pharmacokinetics exist for the oral and inhalation routes of exposure.
(b) With the exception of the criteria for thallium, and nonane the chronic inhalation RfD was adopted as the criterion for subchronic exposure.
(c) USEPA incorporated an absorption factor of 30% in deriving the arsenic inhalation cancer slope from the inhalation unit risk.
(d) The subchronic and chronic criteria for nonane were derived from results of an experimental animal study, as discussed in Appendix D.
(e) The IRIS inhalation slope factor was calculated from an inhalation unit risk assuming a 70-kg individual inhales 20 m3 of air per day.
(f) The cancer slope factor is presented as a benzo(a)pyrene equivalent and was derived by multiplying the withdrawn benzo(a)pyrene slope factor by the appropriate order-of-magnitude relative potency factor [i.e., 1] developed for dibenzo(a,h)anthracene by USEPA (1993, 1994).
(g) The inhalation RfD was calculated from the inhalation reference concentration (RfC) of 3E-4 mg/m3 assuming a 70-kg individual inhales 20 m3 of air per day.
(h) As discussed in Appendix D, three compounds were selected to evaluate the toxicity of the three primary classes of compounds making up Total Petroleum Hydrocarbons derived from diesel fuel. Fluorene, nonane, and toluene were selected to represent the toxicity of low molecular weight PAHs, aliphatic hydrocarbons, and substituted aromatics, respectively. The criteria for the TPH mixture are based on weighting the criteria for individual components according to their fractional concentration (by weight) in air.

TABLE 3-10

CURRENT LAND-USE EXPOSURE PATHWAYS

Receptor	Development Area	Medium	Route	Pathway Complete?	Comments
On-site Trespasser	Central Operations, South Yard/South Tail, Potomac Greens	Surface soil, 0-3 feet	Ingestion, dermal	Yes.	Individuals from nearby communities may occasionally come in contact with surface soil. Ingestion exposure will be quantified; dermal exposure is a pathway of minor importance and is discussed in Appendix L.
On-site Trespasser	North Tail, North Yard, Slaters Lane	Surface soil, 0-3 feet	Ingestion, dermal	No.	The North Yard, North Tail and Slaters Lane Areas are covered on average with six inches of gravel. Direct contact with soil beneath the gravel is not likely to occur.
On-site Trespasser	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, Potomac Greens	Air-borne particulate from surface soil, 0-3 feet	Inhalation	No.	Dust dispersion is not a significant transport mechanism under undisturbed baseline conditions. Dust dispersion during construction activities will be addressed under interim and future land-use conditions.

TABLE 3-11

INTERIM LAND-USE EXPOSURE PATHWAYS

Receptor	Development Area	Medium	Route	Pathway Complete?	Comments
During Interim Development					
On-site Construction Worker	North Tail, North Yard, South Yard/South Tail	Surface soil and airborne particulate from surface soil, 0-3 feet	Ingestion, dermal, inhalation	Yes.	Construction workers will engage in earth-moving activities to implement planned interim uses: creation of warehouses, retail and parking spaces, recreational areas and construction staging areas. Incidental ingestion of soil and inhalation of airborne particulate will be quantified; dermal exposure is a pathway of minor importance and is discussed in Appendix L.
Off-site Resident	North Tail, North Yard, South Yard/South Tail	Airborne particulate from surface soil, 0-3 feet	Inhalation	Yes.	Dust dispersion during construction activities is relevant during interim-use construction activities. Potential inhalation exposure will be quantified for receptors across Jefferson Davis Highway.
On-site Resident at Slaters Lane	North Tail, North Yard, South Yard/South Tail	Airborne particulate from surface soil, 0-3 feet	Inhalation	Yes.	Dust dispersion during construction activities is relevant during interim-use construction activities. Potential inhalation exposure will be quantified for receptors at the Slaters Lane development.
After Interim Development					
On-site Commercial Office Worker; Landscape and Maintenance Worker	North Tail, North Yard, South Yard/South Tail	Surface soil and airborne particulate from surface soil, 0-3 feet	Ingestion, dermal, inhalation	No.	Landscaped areas, passive parks will require adequate topsoil in order to support vegetation. Direct contact and inhalation exposures will not be relevant under these conditions.

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TABLE 3-12

FUTURE LAND-USE EXPOSURE PATHWAYS

Receptor	Development Area	Medium	Route	Pathway Complete?	Comments
During Final Development					
On-site Construction Worker	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, Potomac Greens	Surface and subsurface soil, 0-8 feet	Ingestion, dermal, inhalation	Yes.	Construction workers will engage in excavation and grading activities. Dust dispersion is relevant during construction activities. Incidental ingestion of soil and inhalation of particulate will be quantified; dermal exposure is a pathway of minor importance and is discussed in Appendix L.
Off-site Resident and Commercial Office Worker	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, Potomac Greens	Airborne particulate from surface and subsurface soil, 0-8 feet	Inhalation	Yes.	Dust dispersion is relevant during construction activities. Inhalation of particulate will be quantified for receptors across Jefferson Davis Highway.
On-site Resident at Slaters Lane	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters lane, Potomac Greens	Airborne particulate from surface and subsurface soil, 0-8 feet	Inhalation	Yes.	Dust dispersion is relevant during construction activities. Inhalation of particulate will be quantified for receptors at the Slaters Lane development.
During and After Final Development					
On-site Utility Worker	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, Potomac Greens	Surface and subsurface soil, 0-8 feet	Ingestion, dermal, inhalation	Yes.	Trenches will be dug to install utilities as part of development activities and utility repair may be required in the future. Incidental ingestion of soil and inhalation exposures to workers in a trench will be quantitatively evaluated; dermal exposure is a pathway of minor importance and is discussed in Appendix L.

TABLE 3-12 (continued)

FUTURE LAND-USE EXPOSURE PATHWAYS

Receptor	Development Area	Medium	Route	Pathway Complete?	Comments
After Final Development					
On-site Resident	Slaters Lane	Surface soil, 0-3 feet	Ingestion, dermal	Yes.	Current development plans assume single family residential housing with backyards in this area. Incidental ingestion exposure will be quantified; dermal exposure is a pathway of minor importance and is discussed in Appendix L.
On-site Resident	Slaters Lane	Airborne particulate from surface soil, 0- 3 feet	Inhalation	No.	Residential backyard areas will be well vegetated. Dust dispersion is not considered a relevant transport mechanism under these conditions.
On-site Resident	North Tail, North Yard, Central Operations, South Yard/South Tail, Potomac Greens	Surface soil, 0-3 feet	Ingestion, dermal, inhalation	No.	Development plans do not call for single family residential development with backyards in these areas. Residents will utilize this space as on-site recreators.
On-site Recreator	Potomac Greens	Surface soil, 0- 3 feet	Ingestion, dermal	Yes.	Many areas of Potomac Greens will not require topsoil cover for future development, and existing surface soil may be directly contacted. Incidental ingestion exposure will be quantified; dermal exposure is a pathway of minor importance and is discussed in Appendix L.
On-site Recreator	Potomac Greens	Airborne particulate from surface soil, 0- 3 feet	Inhalation	No.	Potomac Greens is well vegetated and dust dispersion is not considered a relevant transport mechanism under these conditions.
On-site Recreator	North Tail, North Yard, South Yard/South Tail, Slaters Lane	Surface soil, 0-3 feet	Ingestion, dermal, inhalation	No.	Landscaped areas, passive parks and playing fields will require adequate, clean topsoil cover in order to support vegetation. Direct contact and inhalation exposures will not be relevant under these conditions.

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TABLE 3-12 (continued)

FUTURE LAND-USE EXPOSURE PATHWAYS

Receptor	Development Area	Medium	Route	Pathway Complete?	Comments
On-site Landscape Worker	North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, Potomac Greens	Native soil	Inhalation	No.	After final development, landscaped areas will be vegetated. Inhalation exposures will not be relevant under these conditions.
On-site Landscape Worker	North Tail, North Yard, South Yard/South Tail, Slaters Lane, Potomac Greens	Native soil (a)	Ingestion, dermal	Yes.	In the event that native soil (exclusive of surface cinder-based ballast material) is used as topsoil for landscaped areas, a landscape worker may come in direct contact with soil. Ingestion exposure will be quantified; dermal exposure is a minor pathway and is discussed in Appendix L.
On-site Landscape Worker	Central Operations	Native soil	Ingestion, dermal	No.	The Central Operations Area will be dominated by industrial development including a new Metro station. Direct contact with soil in this area is not anticipated to occur.

(a) Data from the 3-8 ft soil interval was used to evaluate native soil (soil material excluding cinder-based ballast) that could be left in place after development and potentially used to support vegetation. Data from the 0-3 ft depth was used for Potomac Greens because this interval best reflects native soil without the presence of ballast material.

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TABLE 3-13

CHEMICAL EXPOSURE POINT CONCENTRATIONS IN SOIL, mg/kg

Chemical	North Tail Area		North Yard Area		Central Operations Area		South Yard/South Tail Area		Slaters Lane Area		Potomac Greens Area	
	Central Tendency (a)	High End (b)	Central Tendency (a)	High End (b)	Central Tendency (a)	High End (b)	Central Tendency (a)	High End (b)	Central Tendency (a)	High End (b)	Central Tendency (a)	High End (b)
Surface (0-3 foot depth)												
Antimony	NA	NA	5.88	7.12	NA	NA	4.45	5.73	NA	NA	NA	NA
Arsenic	NA	NA	477	1,210	450	1,500	173	225	NA	NA	NA	NA
Cadmium	NA	NA	1.15	1.49	NA	NA	NA	NA	NA	NA	NA	NA
Chlordane	NA	NA	0.213	1.05	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.0257	0.068 (c)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	0.106	0.142	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	0.621	0.770	NA	NA	NA	NA	NA	NA	0.555	0.833
Total Petroleum Hydrocarbons	38.8	120(c)	97.2	240	770	5840	182	692	1880	3,260 (c)	44.5	94.0
Subsurface (0-8 foot depth)												
Antimony	NA	NA	5.41	6.10	NA	NA	4.18	4.96	2.80	3.64	NA	NA
Arsenic	NA	NA	246	536	242	766	183	427	NA	NA	NA	NA
Cadmium	NA	NA	0.910	1.06	NA	NA	NA	NA	NA	NA	NA	NA
Chlordane	NA	NA	0.129	0.339	NA	NA	NA	NA	NA	NA	NA	NA
Dieldrin	0.00942	0.0287	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	0.093	0.112	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	NA	NA	0.637	0.731	NA	NA	NA	NA	NA	NA	0.513	0.651
Total Petroleum Hydrocarbons	32.6	103	38.6	60.6	471	1690	113	284	142	3,260 (c)	59.9	179

NA = Not applicable; chemical in this area was not selected for further evaluation.

(a) Central tendency value is the population mean of log-normally distributed chemicals or the arithmetic mean of normally distributed chemicals.

(b) The high-end value is the 95% upper confidence limit of the population mean calculated according to Land (Gilbert 1987) or the maximum concentration if this value was lower in accordance with USEPA guidance (USEPA 1989).

(c) Value is the maximum detected concentration.

TABLE 3-14

INTERIM LAND-USE CONDITIONS

DEVELOPMENT ASSUMPTIONS FOR THE POTOMAC YARD SITE

Development Area	Total Acres Absorbed	Development Time, months	Area Developed, acres/month
North Tail	11	2	5.5
North Yard	52	13	4
South Yard/South Tail	23	15	1.5

TABLE 3-15

INTERIM LAND-USE CONDITIONS
FDM MODELING RESULTS

Development Area	TSP Concentration, ug/m3	
	Central Tendency (a)	High End (b)
North Tail Area		
Off-Site Residents	12	110
On-Site Residents	1.1	1.3
On-Site Workers	330	1,000
North Yard Area		
Off-Site Residents	4.5	20
On-Site Residents	1.3	1.8
On-Site Workers	110	930
South Yard/South Tail Area		
Off-Site Residents	2.8	22
On-Site Residents	5.8	8.5
On-Site Workers	180	570

(a) Central tendency represents a spatial average over the receptor grids of interest. Highest average was selected, predicted from 5 years of meteorological data.

(b) High-end concentrations represent the highest of the maximum annual concentrations predicted from 5 years of meteorological data (1987 - 1991). Maximum concentrations occurred in different locations.

TABLE 3-16

FUTURE LAND-USE CONDITIONS

DEVELOPMENT ASSUMPTIONS FOR THE POTOMAC YARD SITE (a)

Area	Total Acres Absorbed	Development Time, yrs	Area Developed, acres/yr
North Tail	36	18	2
North Yard	99	14	7
Central Operations	38	12	3
South Yard/South Tail	73	9	8
Slaters Lane	23	7	3
Potomac Greens	32	10	3

(a) Based on information provided by RF&P Railroad Company.

TABLE 3-17

FUTURE LAND-USE CONDITIONS
FDM MODELING RESULTS

Development Area	TSP Concentration, ug/m3	
	Central Tendency (a)	High End (b)
North Tail Area		
Off-Site Residents	1.3	8.8
On-Site Residents	0.11	0.13
On-Site Workers	14	200
North Yard Area		
Off-Site Residents/Workers	2.4	9.8
On-Site Residents	0.93	1.3
On-Site Workers	39	770
Central Operations Area		
Off-Site Residents/Workers	1.0	4.3
On-Site Residents	1.4	2.9
On-Site Workers	31	500
South Yard/South Tail Area		
Off-Site Residents	6.1	43
On-Site Residents	15	32
On-Site Workers	30	770
Slaters Lane Area		
Off-Site Residents	0.49	1.3
On-Site Residents	11	23
On-Site Workers	43	410
Potomac Greens Area		
Off-Site Residents	0.45	1.1
On-Site Residents	2.1	6.3
On-Site Workers	32	510

(a) Central tendency represents a spatial average over the receptor grids of interest. Highest average was selected, predicted from 5 years of meteorological data.

(b) High-end concentrations represent the highest of the maximum annual concentrations predicted from 5 years of meterological data (1987 - 1991). Maximum concentrations occurred in different locations.

TABLE 3-18

SUMMARY OF 8-HOUR AVERAGE AIR CONCENTRATIONS OF PETROLEUM HYDROCARBONS IN UTILITY TRENCH

Chemical (a)	8-Hour Average Air Concentrations for Specific Area Investigated (mg/m3)					
	North Tail Area	North Yard Area	Central Operations Area	South Yard/Tail Area	Slaters Lane Area	Potomac Greens Area
C8-C12 Alkane/Alkenes (n-dodecane) (b)	1.20E+00	2.85E-01	1.74E+01	4.17E-01	6.82E-01	1.10E+00
C13-C16 Alkanes/Alkenes (n-tetradecane) (c)	1.98E-01	4.69E-02	2.86E+00	6.87E-02	1.12E-01	1.82E-01
C17-C19 Alkanes/Alkenes (n-octadecane) (d)	1.68E-05	3.98E-06	2.43E-04	5.83E-06	9.55E-06	1.55E-05
C20-C22 Alkanes/Alkenes (n-eicosane) (e)	4.21E-08	9.97E-09	6.08E-07	1.46E-08	2.39E-08	3.87E-08
Low Molecular Weight PAHs (naphthalene) (f)	1.21E+00	2.86E-01	1.74E+01	4.18E-01	6.84E-01	1.11E+00
Simple Aromatics (o-xylene) (g)	1.44E+00	3.42E-01	2.09E+01	5.01E-01	8.20E-01	1.33E+00
Soil TPH (mg/kg) (h)	32.6	7.7 (i)	471	11.3 (i)	18.5 (i)	30.0 (i)

(a) Chemicals selected as modeling surrogates to reflect the composition of diesel fuel petroleum hydrocarbons. Surrogate for chemical class is shown in parenthesis.
(b) Fraction of the C8-C12 surrogate in the TPH mixture = 0.135.
(c) Fraction of the C13-C16 surrogate in the TPH mixture = 0.296.
(d) Fraction of the C17-C19 surrogate in the TPH mixture = 0.162.
(e) Fraction of the C20-C22 surrogate in the TPH mixture = 0.0566.
(f) Naphthalene selected as surrogate for low molecular weight PAHs. Fraction of this chemical class in the TPH mixture = 0.30.
(g) o-Xylene selected as surrogate for simple aromatics. Fraction of this chemical class in mixture = 0.05.
(h) Average concentration of TPH in 0-8 foot depth soil used for volatilization modeling.
(i) The subsurface soil TPH concentrations shown reflect the amount of diesel versus lubricating oil present in the area. Exposure point TPH concentrations in soil were thus multiplied by the following fractions which reflect site-specific data: North Yard 0.20; South Yard/South Tail, 0.10; Slaters Lane, 0.13; and Potomac Greens, 0.50; derivation of these fractions is discussed in Appendix D.

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TABLE 3-19

CURRENT LAND-USE CONDITIONS

INTAKE PARAMETERS FOR THE INGESTION PATHWAY EVALUATION

$$\textit{Average Daily Dose (mg/kg-day)} = \frac{(CS)(ABS)(IR)(10^{-6})(FI)(EF)(ED)}{(BW)(AT)}$$

Parameter	Trespasser	
	Central Tendency	High End
CS = Concentration in Soil (mg/kg)	(a)	(a)
IR = Ingestion Rate (mg/day)	34 (b)	100 (c)
ABS = Absorption Factor Arsenic (d)	0.10	0.10
FI = Fraction Ingested from Contaminated Source Area		
Central Operations	0.20 (e)	0.24 (e)
South Yard/South Tail	0.50 (f)	0.60 (f)
Potomac Greens	1.0	1.0
EF = Exposure Frequency (days/yr)	48 (g)	96 (h)
ED = Exposure Duration (years)	5	10
BW = Body Weight (kg) (c)	70	70
AT = Averaging Time (days) (c)		
Noncarcinogens	365 x ED	365 x ED
Carcinogens	25,550	25,550

(a) Concentration in air is chemical - and area-specific.
(b) Best estimates of population mean from Thompson and Burmaster (1991).
(c) Based on USEPA guidance (USEPA 1989, 1991).
(d) Bioavailability calculated from geochemical analysis. See Appendix.
(e) Central tendency value based on assumption that 80% of the Central Operations Area is covered with a pavement or gravel. The high-end value incorporates a 20% increase in FI term due to uncertainty.
(f) Central tendency value based on assumption that 50% of South Yard/South Tail Area is covered with pavement or gravel. High-end value incorporates a 20% increase in FI term due to uncertainty.
(g) Based on assumption trespasser may visit site 3 days per week over an 8 month period.
(h) Based on assumption trespasser may visit site 2 days per week over a 6 month period.

TABLE 3-20

INTERIM LAND-USE CONDITIONS

INTAKE PARAMETERS FOR THE INGESTION PATHWAY EVALUATION

$$Average\ Daily\ Dose\ (mg/kg\text{-}day) = \frac{(CS)(ABS)(IR)(10^{-6})(FI)(EF)(ED)}{(BW)(AT)}$$

Parameter		Construction Worker	
		Central Tendency	High End
CS =	Concentration in Soil (mg/kg)	(a)	(a)
IR =	Ingestion Rate (mg/day)	34 (b)	100 (c)
ABS =	Absorption Factor Arsenic (d)	0.10	0.10
FI =	Fraction of Contaminated Soil Ingested from Source Area (e)		
	North Tail	0.17	0.20
	North Yard	0.54	0.65
	South Yard/South Tail	0.625	0.75
EF =	Exposure Frequency (days/yr)	230 (f)	250 (c)
ED =	Exposure Duration (years) (e)		
	North Tail	1	1
	North Yard	2	2
	South Yard/South Tail	2	2
BW =	Body Weight (kg) (c)	70	70
AT =	Averaging Time (days) (c)		
	Noncarcinogens	365 x ED	365 x ED
	Carcinogens	25,550	25,550

(a) Concentration in air is chemical- and area-specific.
(b) Best estimate of population mean from Thompson and Burmaster (1991).
(c) Based on USEPA guidance (USEPA 1991).
(d) Bioavailability based on geochemical analysis. See appendix.
(e) Based on information from RF&P Railroad Company. Earth-moving activities are assumed to occur over the following periods: 2 months in the North Tail Area; 13 months in the North Yard Area; 15 months in the South Yard/South Tail Area. High-end values incorporate a 20% increase to account for uncertainty.
(f) Derived from USEPA guidance (USEPA 1991) with the assumption that 20 additional work days are lost on average due to holidays and sickleave.

TABLE 3-21

INTERIM - LAND USE CONDITIONS
INTAKE PARAMETERS FOR THE INHALATION PATHWAY EVALUATION

$$\textit{Average Daily Dose (mg/kg-day)} = \frac{(CA)(ABS)(IR)(ET)(FR)(EF)(ED)}{(BW)(AT)}$$

Parameter	Construction Worker		Young Child Resident		Adult Resident / Commerical Office Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
CA = Concentration in Air (mg/m^3)	(a)	(a)	(a)	(a)	(a)	(a)
IR = Inhalation Rate (m^3/hr)	1.2 (b)	1.9 (c)	0.70 (d)	1.1 (e)	0.84 (f)	1.6 (g)
ABS = Absorption Factor Arsenic (h)	0.30	0.30	0.30	0.30	0.30	0.30
ET = Exposure Time (hrs/day) (i)	8	10	8	10	8	10
EF = Exposure Frequency (days/yr)	230 (j)	250 (k)	230 (j)	250 (k)	230 (j)	250 (k)
FR = Fraction of year earth moving activities will occur (l)						
North Tail	0.17	0.17	0.17	0.17	0.17	0.17
North Yard	0.54	0.54	0.54	0.54	0.54	0.54
South Yard/South Tail	0.625	0.625	0.625	0.625	0.625	0.625
ED = Exposure Duration (years) (l)						
North Tail	1	1	1	1	1	1
North Yard	2	2	2	2	2	2
South Yard/South Tail	2	2	2	2	2	2
BW = Body Weight (kg) (k)	70	70	15	15	70	70
AT = Averaging Time (days) (k)						
Noncarcinogens	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED
Carcinogens	25,550	25,550	25,550	25,550	25,550	25,550

TABLE 3-21 (continued)

INTERIM - LAND USE CONDITIONS
INTAKE PARAMETERS FOR THE INHALATION PATHWAY EVALUATION

(a) Concentration in air is chemical - and area-specific.
(b) Assumes 3 hours at light activity, 4 hours at moderate activity, and 1 hour sedentary (Layton 1993). Calculated with male inhalation rates from 18 to < 30 years and 30 to < 60 years.
(c) Assumes 3 hours at light activity, 2 hours at moderate activity, 2 hours at heavy activity, and 1 hour sedentary (Layton 1993). Calculated with male inhalation rates from ages 18 to < 30 years and 30 to < 60 years.
(d) Assumes 2 hours at light activity and 6 hours at moderate activity (Layton 1993). Calculated with gender-averaged inhalation rates from ages 0.5 to < 3 years and 3 to < 10 years.
(e) Assumes 2 hours at heavy activity, 4 hours at moderate activity, and 2 hours at light activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 0.5 to < 3 years and 3 to < 10 years.
(f) Assumes 2 hours at sedentary activity, 4 hours at light activity, and 2 hours at moderate activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 10 to < 18 years and 18 to < 30 years.
(g) Assumes 4 hours at light activity, 2 hours at moderate activity, and 2 hours at heavy activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 10 to < 18 years and 18 to < 30 years.
(h) Arsenic absorption factor of 0.30 used to be consistent with derivation of toxicity criterion (USEPA 1984).
(i) 8-hour work day assumed for central tendency case and increased by 20% to a 10-hour work day to account for uncertainty.
(j) Derived from USEPA guidance (USEPA 1991) with the assumption that 20 additional work days are lost on average due to holidays and sick leave.
(k) Based on USEPA guidance (USEPA 1991).
(l) Based on information from RF&P Railroad Company. Earth-moving activities are assumed to occur over the following periods: 2 months in the North Tail Area; 13 months in the North Yard Area and 15 months in the South Yard/South Tail Area. High-end values incorporate a 20% increase to account for uncertainty.

FUTURE LAND-USE CONDITIONS
INTAKE PARAMETERS FOR THE INGESTION PATHWAY EVALUATION

$$\textit{Average Daily Dose (mg/kg-day)} = \frac{(CS)(ABS)(IR)(10^{-6})(FI)(EF)(ED)}{(BW)(AT)}$$

Parameter	Construction Worker		Utility Worker		Young Child Resident/Recreator		Adult Resident/Recreator	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
CS = Concentration in Soil (mg/kg)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
IR = Ingestion Rate (mg/day)	34 (b)	100 (c)	34 (b)	100 (c)	43 (b)	200 (c)	34 (b)	100 (c)
ABS= Absorption Factor								
Arsenic (d)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
FI = Fraction of Ingestion from Contaminated Source Area (e)								
Slaters Lane	0.25	0.30	1.0	1.0	0.12	0.14	0.12	0.14
Potomac Greens	0.25	0.30	1.0	1.0	0.35	0.42	0.35	0.42
All Remaining Areas	0.25	0.30	1.0	1.0	NA	NA	NA	NA
EF = Exposure Frequency (days/yr)	230 (f)	250 (c)	13 (g)	16 (g)	287 (h)	350 (c)	175 (h)	350 (c)
ED = Exposure Duration (years) (i)								
North Tail	18	18	1	1	NA	NA	NA	NA
North Yard	14	14	1	1	NA	NA	NA	NA
Central Operations	12	12	1	1	NA	NA	NA	NA
South Yard/South Tail	9	9	1	1	NA	NA	NA	NA
Slaters Lane	7	7	1	1	1.8	6	7.2	24
Potomac Greens	10	10	1	1	1.8	6	7.2	24
BW = Body Weight (kg) (c)	70	70	70	70	15	15	70	70
AT = Averaging Time (days) (c)								
Noncarcinogens	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED
Carcinogens	25,550	25,550	25,550	25,550	25,550	25,550	25,550	25,550

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TABLE 3 (continued)

FUTURE LAND-USE CONDITIONS
INTAKE PARAMETERS FOR THE INGESTION PATHWAY EVALUATION

NA = Not applicable.

(a) Concentration in soil is chemical - and area-specific.
(b) Best estimate of population mean from Thompson and Burmaster (1991).
(c) Based on USEPA guidance (USEPA 1991).
(d) Bioavailability calculated from geochemical analysis. See Appendix E.
(e) Based on information from RF&P Railroad Company (See Appendix N). During construction, earth-moving activities will occur for 25% of the year. After development, the FI term for Slaters Lane and Potomac Greens is based on the amount of acreage used as open space versus the total acreage developed. High-end values incorporate a 20% increase to account for uncertainty.
(f) Derived from USEPA guidance (USEPA 1991) with the assumption that 20 additional work days are lost on average due to holidays and sickleave.
(g) Based on assumption that 1,000 feet of utility trenches per year will be installed in each area, and that this will require 13 days to complete (75 feet per day). The high-end value incorporates a 20% increase to account for uncertainties.
(h) Exposure frequency of 350 days per year adjusted to reflect hours away from home (AIHC 1994). Children are away from home 18% of the time on average, and adults are away from home 50% of the time on average.
(i) Based on information provided from RF&P Railroad Company. Exposure durations for workers are based on number of years actual earth-moving activities could occur. Central tendency exposure duration for adults and children based on USEPA guidance (USEPA 1989).

TABLE 3-23

FUTURE - LAND USE CONDITIONS
INTAKE PARAMETERS FOR THE INHALATION PATHWAY EVALUATION

$$Average\ Daily\ Dose\ (mg/kg\text{-}day) = \frac{(CA)(ABS)(IR)(ET)(FR)(EF)(ED)}{(BW)(AT)}$$

Parameter	Construction Worker		Commercial Office Worker		Utility Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
CA = Concentration in Air (mg/m³)	(a)	(a)	(a)	(a)	(a)	(a)
IR = Inhalation Rate (m³/hr)	1.2 (b)	1.9 (c)	0.84 (f)	1.6 (g)	1.2 (b)	1.9 (c)
ABS = Absorption Factor						
Arsenic (h)	0.30	0.30	0.30	0.30	NA	NA
ET = Exposure Time (hrs/day) (i)	8	10	8	10	8	10
EF = Exposure Frequency (days/yr)	230 (j)	250 (k)	230 (j)	250 (k)	13 (l)	13 (l)
FR = Fraction of year earth moving activities will occur (m)	0.25	0.25	0.25	0.25	NA	NA
ED = Exposure Duration (years) (n)						
North Tail	18	18	18	18	1	1
North Yard	14	14	14	14	1	1
Central Operations	12	12	12	12	1	1
South Yard/South Tail	9	9	9	9	1	1
Slaters Lane	7	7	7	7	1	1
Potomac Greens	10	10	10	10	1	1
BW = Body Weight (kg) (k)	70	70	70	70	70	70
AT = Averaging Time (days) (k)						
Noncarcinogens	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED	365 x ED
Carcinogens	25,550	25,550	25,550	25,550	25,550	25,550

TABLE 3-23 (continued)

FUTURE - LAND USE CONDITIONS
INTAKE PARAMETERS FOR THE INHALATION PATHWAY EVALUATION

Parameter	Young Child Resident		Adult Resident	
	Central Tendency	High End	Central Tendency	High End
CA = Concentration in Air (mg/m³)	(a)	(a)	(a)	(a)
IR = Inhalation Rate (m³/hr)	0.70 (d)	1.1(e)	0.84 (f)	1.6 (g)
ABS = Absorption Factor Arsenic (h)	0.30	0.30	0.30	0.30
ET = Exposure Time (hrs/day) (i)	8	10	8	10
EF = Exposure Frequency (days/yr)	230 (j)	250 (k)	230 (j)	250 (k)
FR = Fraction of year earth moving activities will occur	0.25	0.25	0.25	0.25
ED = Exposure Duration (years) (o)				
North Tail	1.8	6	7.2	12
North Yard	1.8	6	7.2	8
Central Operations	1.8	6	6	6
South Yard/South Tail	1.8	6	3	3
Slaters Lane	1.8	6	1	1
Potomac Greens	1.8	6	4	4
BW = Body Weight (kg)	15	15	70	70
AT = Averaging Time (days)				
Noncarcinogens	365 x ED	365 x ED	365 x ED	365 x ED
Carcinogens	25,550	25,550	25,550	25,550

NA = Not applicable; dust inhalation not applicable.

(a) Concentration in air is chemical - and area-specific.
(b) Assumes 3 hours at light activity, 4 hours at moderate activity, and 1 hour sedentary (Layton 1993). Calculated with male inhalation rates from 18 to < 30 years and 30 to < 60 years.
(c) Assumes 3 hours at light activity, 2 hours at moderate activity, 2 hours at heavy activity, and 1 hour sedentary (Layton 1993). Calculated with male inhalation rates from ages 18 to < 30 years and 30 to < 60 years.
(d) Assumes 2 hours at light activity and 6 hours at moderate activity (Layton 1993). Calculated with gender-averaged inhalation rates from ages 0.5 to < 3 years and 3 to < 10 years.
(e) Assumes 2 hours at heavy activity, 4 hours at moderate activity, and 2 hours at light activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 0.5 to < 3 years and 3 to < 10 years.
(f) Assumes 2 hours at sedentary activity, 4 hours at light activity, and 2 hours at moderate activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 10 to < 18 years and 18 to < 30 years.
(g) Assumes 4 hours at light activity, 2 hours at moderate activity, and 2 hours at heavy activity (Layton 1993). Calculated with gender-averaged inhalation rates for ages 10 to < 18 years and 18 to < 30 years.
(h) Arsenic absorption factor of 0.30 used to be consistent with derivation of toxicity criterion (USEPA 1984).

TABLE 3-23 (continued)

FUTURE - LAND USE CONDITIONS
INTAKE PARAMETERS FOR THE INHALATION PATHWAY EVALUATION

(i) 8-hour work day assumed for central tendency case and increased by 20% to a 10-hour work day to account for uncertainty.
(j) Derived from USEPA guidance (USEPA 1991) with the assumption that 20 additional work days are lost on average due to holidays and sick leave.
(k) Based on USEPA guidance (USEPA 1991).
(l) Based on assumption that 1,000 feet of utility trenches per year will be installed in each area, and that this will require 13 days to complete (75 feet per day). The high-end value incorporates a 20% increase to account for uncertainties.
(m) Earth-moving activities assumed to occur 25% of the year based on information from RF&P Railroad Company (See Appendix N).
(n) Exposure duration based upon development time provided by RF&P Corporation.
(o) Exposure duration based upon development time was divided between a child and adult receptor such that the sum of child and adult exposures would not exceed the development time.

TABLE 3-24

CURRENT LAND-USE CONDITIONS
SUMMARY OF INGESTION RISKS

Development Area	Excess Upperbound Lifetime Cancer Risks (a)	
	On-Site Trespasser	
	Central Tendency	High End
Central Operations Area	6E-08	3E-06 [1E-05]
South Yard/South Tail Area	6E-08	1E-06 [5E-06]
Potomac Greens	NA	NA

Development Area	Noncancer Risks (a)	
	On-Site Trespasser	
	Central Tendency	High End
Central Operations Area	<1 (2E-03)	<1 (5E-02) [2E-01]
South Yard/South Tail Area	<1 (2E-03)	<1 (2E-02) [9E-02]
Potomac Greens	<1 (5E-04)	<1 (4E-03)

NA = Not applicable

(a) Risk in brackets was calculated assuming a bioavailability factor of 50% for arsenic based on a preliminary estimate from the USEPA Environmental Criteria and Assessment Office (ECAO).

TABLE 3-25

INTERIM LAND-USE CONDITIONS
SUMMARY OF INGESTION RISKS

Development Area	Excess Upperbound Lifetime Cancer Risks (a)	
	On-Site Construction Worker	
	Central Tendency	High End
North Tail Area	3E-10	3E-09
North Yard Area	3E-07	3E-06 [2E-05]
South Yard/South Tail Area	1E-07	7E-07 [4E-06]

Development Area	Noncancer Risks (a)	
	On-Site Construction Worker	
	Central Tendency	High End
North Tail Area	<1 (3E-5)	<1 (3E-4)
North Yard Area	<1 (3E-2)	<1 (3E-1) [1E+0]
South Yard/South Tail Area	<1 (1E-2)	<1 (7E-2) [3E-01]

(a) Risk in brackets was calculated assuming a bioavailability factor of 50% for arsenic based on a preliminary estimate from the USEPA Environmental Criteria and Assessment Office (ECAO).

TABLE 3-26

INTERIM LAND-USE CONDITIONS
SUMMARY OF INHALATION EXCESS UPPER BOUND LIFETIME CANCER RISKS

Development Area	Off-Site Receptors Across Jefferson Davis Highway					
	Child Resident		Adult Resident		Commercial Office Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	3E-12	6E-11	7E-13	2E-11	7E-13	2E-11
North Yard Area	1E-07	1E-06	3E-08	3E-07	3E-08	3E-07
South Yard/South Tail Area	3E-08	5E-07	8E-09	2E-07	8E-09	2E-07
Total Risk (a)	1E-07		4E-08		4E-08	

Development Area	On-Site Receptors					
	Child Resident (b)		Adult Resident (b)		Construction Worker (c)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	3E-13	7E-13	7E-14	2E-13	3E-11	2E-10
North Yard Area	3E-08	1E-07	9E-09	3E-08	1E-06	2E-05
South Yard/South Tail Area	6E-08	2E-07	2E-08	6E-08	7E-07	5E-06
Total Risk (a)	9E-08		3E-08		(c)	

(a) Total risk across areas applicable for central tendency case which represents a spatial average across the receptor grid. Maximum concentrations utilized in high-end evaluation occurred at different locations for each area evaluated. Risks cannot be summed for high-end case since a different receptor is thus modeled for each area.
(b) On-site residential receptor is located at Slaters Lane.
(c) Construction worker modeled as an individual working in a single area. Risks across areas cannot be summed.

TABLE 3-27

INTERIM LAND-USE CONDITIONS
SUMMARY OF INHALATION NONCANCER RISKS

Development Area	Off-Site Receptors Across Jefferson Davis Highway					
	Child Resident		Adult Resident		Commercial Office Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	<1 (3E-08)	<1 (5E-07)	<1 (7E-09)	<1 (2E-07)	<1 (7E-09)	<1 (2E-07)
North Yard Area	<1 (9E-06)	<1 (9E-05)	<1 (2E-06)	<1 (3E-05)	<1 (2E-06)	<1 (3E-05)
South Yard/South Tail Area	<1 (5E-06)	<1 (8E-05)	<1 (1E-06)	<1 (2E-05)	<1 (1E-06)	<1 (2E-05)
Total Risk (a)	<1 (1E-05)		<1 (3E-06)		<1 (3E-06)	

Development Area	On-Site Receptors					
	Child Resident (b)		Adult Resident (b)		Construction Worker (c)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	<1 (2E-09)	<1 (6E-09)	<1 (6E-10)	<1 (2E-09)	<1 (3E-07)	<1 (2E-06)
North Yard Area	<1 (3E-06)	<1 (8E-06)	<1 (7E-07)	<1 (3E-06)	<1 (9E-05)	<1 (1E-03)
South Yard/South Tail Area	<1 (1E-05)	<1 (3E-05)	<1 (2E-06)	<1 (9E-06)	<1 (1E-04)	<1 (8E-04)
Total Risk (a)	<1 (1E-05)		<1 (3E-06)		(c)	

(a) Total risk across areas applicable for central tendency case which represents a spatial average across the receptor grid. Maximum concentrations utilized in high-end evaluation occurred at different locations for each area evaluated. Risks cannot be summed for high-end case since a different receptor is thus modeled for each area.
(b) On-site residential receptor is located at Slaters Lane.
(c) Construction worker modeled as an individual working in a single area. Risks across areas cannot be summed.

TABLE 3-28

FUTURE LAND-USE CONDITIONS - SUMMARY OF INGESTION RISKS

Development Area	Excess Upperbound Lifetime Cancer Risks (d)					
	Child Resident/Recreator (a)		Adult Resident/Recreator (a)		Resident Total (b)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	NA	NA	NA	NA	NA	NA
North Yard Area	NA	NA	NA	NA	NA	NA
Central Operations Area	NA	NA	NA	NA	NA	NA
South Yard/South Tail Area	NA	NA	NA	NA	NA	NA
Slaters Lane	NA	NA	NA	NA	NA	NA
Potomac Greens	NA	NA	NA	NA	NA	NA

Development Area	Noncancer Risks (d)					
	Child Resident/Recreator (a)		Adult Resident/Recreator (a)		Resident Total (b)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	NA	NA	NA	NA	NA	NA
North Yard Area	NA	NA	NA	NA	NA	NA
Central Operations Area	NA	NA	NA	NA	NA	NA
South Yard/South Tail Area	NA	NA	NA	NA	NA	NA
Slaters Lane	<1 (5E-04)	<1 (6E-03)	<1 (5E-04)	<1 (6E-03)	<1 (1E-03)	<1 (1E-02)
Potomac Greens	<1 (6E-04)	<1 (6E-03)	<1 (6E-04)	<1 (7E-03)	<1 (1E-03)	<1 (1E-02)

TABLE 3-28 (continued)

FUTURE LAND-USE CONDITIONS - SUMMARY OF INGESTION RISKS

Development Area	Excess Upperbound Lifetime Cancer Risks (d)					
	Construction Worker (c)		Utility Worker (c)		Landscape Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	3E-09	3E-08	4E-11	4E-10	1E-09	3E-08
North Yard Area	6E-07	5E-06 [2E-05]	9E-09	7E-08 [4E-07]	2E-10	5E-09
Central Operations Area	5E-07	6E-06 [3E-05]	9E-09	1E-07 [5E-07]	NA	NA
South Yard/South Tail Area	3E-07	2E-06 [1E-05]	7E-09	6E-08 [3E-07]	NA	NA
Slaters Lane	NA	NA	NA	NA	NA	NA
Potomac Greens	NA	NA	NA	NA	NA	NA

Development Area	Noncancer Risks (d)					
	Construction Worker (c)		Utility Worker (c)		Landscape Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	<1 (4E-05)	<1 (5E-04)	<1 (4E-06)	<1 (4E-05)	<1 (6E-05)	<1 (1E-03)
North Yard Area	<1 (8E-03)	<1 (6E-02) [3E-01]	<1 (2E-03)	<1 (1E-02) [6E-02]	<1 (8E-03)	<1 (1E-02)
Central Operations Area	<1 (7E-03)	<1 (8E-02) [4E-01]	<1 (1E-03)	<1 (2E-02) [8E-02]	NA	NA
South Yard/South Tail Area	<1 (6E-03)	<1 (5E-02) [2E-01]	<1 (1E-03)	<1 (1E-02) [4E-02]	<1 (2E-03)	<1 (1E-02)
Slaters Lane	<1 (5E-04)	<1 (4E-03)	<1 (1E-04)	<1 (8E-04)	<1 (1E-03)	<1 (8E-03)
Potomac Greens	<1 (5E-04)	<1 (3E-03)	<1 (1E-05)	<1 (6E-05)	<1 (1E-03)	<1 (8E-03)

NA = Not Applicable

(a) Resident is the receptor at Slaters Lane Area, recreator is receptor at Potomac Greens Area.
(b) Represents the sum of the child and adult risks. Because of the longer time-frame involved, exposure modeled for a combined child and adult receptor, and then summed.
(c) Construction workers and utility workers modeled as an individual working within a single area.
(d) Risk in brackets was calculated using a bioavailability factor of 50% for arsenic based on a preliminary estimate from the USEPA Environmental Criteria and Assessment Office (ECAO).

TABLE 3-29

FUTURE LAND-USE CONDITIONS
SUMMARY OF INHALATION EXCESS UPPER BOUND LIFETIME CANCER RISKS

Development Area	Off-Site Receptors Across Jefferson Davis Highway							
	Child Resident		Adult Resident		Resident Total (a)		Commercial Office Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	3E-13	1E-11	3E-13	9E-12	6E-13	2E-11	8E-13	1E-11
North Yard Area	1E-08	4E-07	1E-08	2E-07	2E-08	6E-07	3E-08	3E-07
Central Operations Area	5E-09	2E-07	5E-09	5E-08	1E-08	2E-07	9E-09	1E-07
South Yard/South Tail Area	3E-08	1E-06	1E-08	2E-07	4E-08	1E-06	3E-08	6E-07
Slaters Lane	NA	NA	NA	NA	NA	NA	NA	NA
Potomac Greens	NA	NA	NA	NA	NA	NA	NA	NA
Total Risk (b)	4E-08		2E-08		7E-08		7E-08	

Development Area	On-Site Receptors							
	Child Resident (c)		Adult Resident (c)		Resident Total (a)		Construction Worker (d)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	3E-14	2E-13	3E-14	1E-13	6E-14	3E-13	1E-11	4E-10
North Yard Area	5E-09	5E-08	5E-09	2E-08	1E-08	7E-08	6E-07	3E-05
Central Operations Area	8E-09	1E-07	7E-09	4E-08	2E-08	1E-07	4E-07	1E-05
South Yard/South Tail Area	6E-08	9E-07	3E-08	1E-07	9E-08	1E-06	2E-07	1E-05
Slaters Lane	NA	NA	NA	NA	NA	NA	NA	NA
Potomac Greens	NA	NA	NA	NA	NA	NA	NA	NA
Total Risk (b)	7E-08		4E-08		1E-07		(d)	

NA = Not applicable.

(a) Represents the sum of the child and adult risks. Because of the longer time-frames involved, exposure modeled for a combined child/adult exposure, and then summed.
(b) Total risk across areas applicable for central tendency case which represents a spatial average across the receptor grid. Maximum concentrations utilized in high-end evaluation occurred at different locations for each area evaluated. Risks cannot be summed for high-end case since a different receptor is thus modeled for each area.
(c) On-site residential receptor is located at Slaters Lane.
(d) Construction worker modeled as an individual working in a single area. Risks across areas cannot be summed.

TABLE 3-30

FUTURE LAND-USE CONDITIONS
SUMMARY OF INHALATION NONCANCER RISKS

Development Area	Off-Site Receptors Across Jefferson Davis Highway							
	Child Resident		Adult Resident		Resident Total (a)		Commercial Office Worker	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	<1 (4E-09)	<1 (5E-08)	<1 (6E-09)	<1 (1E-07)	<1 (1E-08)	<1 (2E-07)	<1 (6E-09)	<1 (1E-07)
North Yard Area	<1 (2E-06)	<1 (2E-05)	<1 (8E-07)	<1 (9E-06)	<1 (3E-06)	<1 (3E-05)	<1 (8E-07)	<1 (9E-06)
Central Operations Area	<1 (4E-08)	<1 (4E-07)	<1 (1E-08)	<1 (1E-07)	<1 (5E-08)	<1 (5E-07)	<1 (7E-08)	<1 (8E-07)
South Yard/South Tail Area	<1 (4E-06)	<1 (6E-05)	<1 (1E-06)	<1 (2E-05)	<1 (5E-06)	<1 (8E-05)	<1 (1E-06)	<1 (2E-05)
Slaters Lane	<1 (2E-07)	<1 (1E-06)	<1 (5E-08)	<1 (4E-07)	<1 (2E-07)	<1 (1E-06)	<1 (5E-08)	<1 (4E-07)
Potomac Greens	<1 (2E-08)	<1 (1E-07)	<1 (5E-09)	<1 (3E-08)	<1 (2E-08)	<1 (1E-07)	<1 (5E-08)	<1 (3E-07)
Total Risk (b)	<1 (6E-06)		<1 (2E-06)		<1 (8E-06)		<1 (2E-06)	

Development Area	On-Site Receptors							
	Child Resident (c)		Adult Resident (c)		Resident Total (a)		Construction Worker (d)	
	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End	Central Tendency	High End
North Tail Area	<1 (3E-10)	<1 (8E-10)	<1 (5E-10)	<1 (2E-09)	<1 (8E-10)	<1 (3E-09)	<1 (1E-07)	<1 (3E-06)
North Yard Area	<1 (8E-07)	<1 (3E-06)	<1 (3E-07)	<1 (1E-06)	<1 (1E-06)	<1 (4E-06)	<1 (2E-05)	<1 (8E-04)
Central Operations Area	<1 (6E-08)	<1 (2E-07)	<1 (1E-08)	<1 (8E-08)	<1 (7E-08)	<1 (3E-07)	<1 (3E-06)	<1 (1E-04)
South Yard/South Tail Area	<1 (9E-06)	<1 (4E-05)	<1 (2E-06)	<1 (1E-05)	<1 (1E-05)	<1 (5E-05)	<1 (8E-06)	<1 (4E-04)
Slaters Lane	<1 (5E-06)	<1 (2E-05)	<1 (1E-06)	<1 (6E-06)	<1 (6E-06)	<1 (3E-05)	<1 (7E-06)	<1 (1E-04)
Potomac Greens	<1 (9E-08)	<1 (6E-07)	<1 (2E-08)	<1 (2E-07)	<1 (1E-07)	<1 (8E-07)	<1 (5E-06)	<1 (2E-04)
Total Risk (b)	<1 (1E-05)		<1 (3E-06)		<1 (2E-05)		(d)	

Development Area	On-Site Receptors							
	Utility Worker (d)							
	Central Tendency	High End						
North Tail Area	<1 (8E-02)	<1 (2E-01)						
North Yard Area	<1 (2E-02)	<1 (4E-02)						
Central Operations Area	= 1 (1E+00)	>1 (2E+00)						
South Yard/South Tail Area	<1 (3E-02)	<1 (6E-02)						
Slaters Lane	<1 (5E-02)	<1 (9E-02)						
Potomac Greens	<1 (7E-02)	<1 (1E-01)						
Total Risk (b)	(d)							

(a) Represents the sum of the child and adult risks. Because of the longer time-frames involved, exposure modeled for a combined child/adult exposure, and then summed.
(b) Total risk across areas applicable for central tendency case which represents a spatial average across the receptor grid. Maximum concentrations utilized in high-end evaluation occurred at different locations for each area evaluated. Risks cannot be summed for high-end case since a different receptor is thus modeled for each area.
(c) On-site residential receptor is located at Slaters Lane.
(d) Construction worker and utility worker modeled as an individual within a single area. Risks cannot be summed.

TABLE 3-31

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE HUMAN HEALTH RISK ASSESSMENT

Assumption	Magnitude of Uncertainty (a)	Effect of Assumption on Risk Estimate
Site Characterization Data		
Site characterization data are representative of the spatial distribution of chemicals at the site.	Low	May overestimate risk. A large number of samples were collected and analyzed across the site. Many samples were collected in suspected source areas; thus, detected concentrations may represent the high end of potential exposure concentrations.
Chemicals not detected due to high detection limits do not substantially alter risk estimates.	Low	May over- or underestimate risk. High detection limits for some chemicals (e.g., PAH, PCB) were typically associated with the presence of high concentrations of TPH. These chemicals were not shown to be associated with TPH and a sufficiently large number of alternative samples were taken to provide a sufficient estimation of the levels of chemicals with occasionally high detection limits.
Selection of Chemicals of Potential Concern		
Subset of chemicals evaluated in the risk assessment contribute the majority of potential risk.	Low	May over- or underestimate risk. Chemicals not significantly greater than background and chemicals less than Region III Risk-Based Screening Criteria were not included in the analysis. Although not all chemicals potentially associated with past site activities were considered, the chemicals expected to contribute the greatest portion of risk were selected for individual portions of the site according to EPA guidance. Conversely, some chemicals not detected in background samples may be expected to occur naturally in some locations.
Exposure Assessment		
Future use exposure scenarios incorporate anticipated development plans for Potomac Yard.	Low	May underestimate risk, but considered unlikely. Development plans used as a basis for future use reflect RF&P development plans, local zoning, municipal land use plans, and local development patterns. Major likely scenarios were considered.

TABLE 3-31 (continued)

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE HUMAN HEALTH RISK ASSESSMENT

Assumption	Magnitude of Uncertainty (a)	Effect of Assumption on Risk Estimate
Residents in Slaters Lane may contact chemicals of potential concern in soil.	Low	May overestimate risk. Private yard areas will be covered with clean topsoil and landscaping materials prior to use by residents. Contact with chemicals of potential concern in soil is expected to be unlikely.
Exposure to chemicals of potential concern in surface water or sediment is insignificant with regard to human health risks.	Low	May underestimate risk, but considered unlikely. Direct access to local surface water bodies near the Site is limited. Release of chemicals of potential concern to surface water is expected to be low currently and negligible in the future. Site contributions to offsite areas expected to be indistinguishable from other local urban sources after considering dilution in receiving waters.
High-end estimates of exposures were made, in addition to central tendency estimates, for all exposure pathways evaluated.	Low	Likely to overestimate risk.
Conservative assumptions and modeling approaches were used in air emissions and dispersion modeling for airborne exposure estimates.	Low	Likely to overestimate risk.
Health risks associated with dermal exposure do not contribute substantially to overall risks.	Low	May underestimate risk. The available data for evaluating transdermal exposure to chemicals in soil are limited. Available data for most chemicals of potential concern indicate that these chemicals tend to be strongly bound to the soil matrix (e.g., pesticides, arsenic), are unlikely to pass readily through the skin (inorganics, in general), and, thus, are unlikely to be absorbed through the skin to a great extent.
Enclosed space (i.e., trench) exposures of utility workers to TPH are based on average TPH concentrations in areas of potential concern.	Low	May over- or underestimate risk. Workers in the immediate vicinity of soil containing high concentrations of TPH may experience higher exposures while in these areas, and workers in the vicinity of soil containing little or no TPH may experience little or no exposure while in these areas.

TABLE 3-31 (continued)

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE HUMAN HEALTH RISK ASSESSMENT

Assumption	Magnitude of Uncertainty (a)	Effect of Assumption on Risk Estimate
Chemicals are 100% bioavailable to exposed individuals.	Low to moderate	May overestimate risk. This is likely to be an overestimate, especially for chemicals in cinder based ballast. As discussed in Appendix E, site specific data were used to conservatively estimate arsenic bioavailability in cinder based ballast at 10%. Other metals associated with ballast are expected to have similar bioavailabilities.
Toxicity Assessment		
Conservatively derived cancer slope factors, chronic reference doses, and short term reference criteria were used to evaluate risk.	Low to High	May overestimate risk. For noncancer effects, combinations of uncertainty factors along with dose-response data, often from laboratory animals, are used to derive criteria to protect the most sensitive human receptors. For cancer effects, dose-response data are used to derive slope factors that estimate an upper limit on risk associated with a given exposure. Actual risk could be much lower.
Toxicity criteria, in some cases, were derived using route-to-route extrapolation for chemicals exhibiting systemic toxicity, assuming no differences in bioavailability and pharmacokinetics.	Low to Moderate	May over- or underestimate risk.
Existing EPA toxicity criteria for arsenic are reasonable approximations of dose-response.	Low to Moderate	May overestimate risk. Recent data on arsenic epidemiology, toxicology, and dose-response suggests that existing criteria may overestimate risks associated with exposure to arsenic in cinder based ballast (see Appendix F).
Risks to human health were assumed to be additive although they may be antagonistic, potentiating, or synergistic.	Low	May over- or underestimate risk. Recent research has confirmed the validity of additivity at low doses.

TABLE 3-31 (continued)

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE HUMAN HEALTH RISK ASSESSMENT

Assumption	Magnitude of Uncertainty (a)	Effect of Assumption on Risk Estimate
Risk Characterization		
Aspects of the planned development at the Site will serve as effective physical barriers to exposure.	Low	May underestimate risk, but not considered likely.
The potential risks associated with high-end or reasonable maximum exposures were evaluated in this assessment.	Low to High	Likely overestimate risk.

(a) Low = Less than or equal to one order-of- magnitude effect.
Moderate = One to two orders- of -magnitude effect.
High = Greater than two orders-of- magnitude effect.

4.0 ECOLOGICAL RISK ASSESSMENT

This section presents an evaluation of potential ecological risks associated with the Potomac Yard Site. This assessment has been conducted in accordance with ecological assessment guidance published by EPA headquarters (1989a, 1992) and EPA Region III (1994). This assessment is a *screening-level* assessment as defined by EPA Region III (EPA 1994) and, as such, is based on conservative estimates of exposure and toxicity. Less conservative exposure and toxicity scenarios that more closely reflect site-specific conditions and species-specific behavior and toxicity would likely provide better estimates of true site risks, but are excluded here to satisfy Agency requests for a maximally conservative (worst case) screening-level assessment for the Potomac Yard Site. Given the conservative nature of this assessment, however, the results should not be used to substantiate claims of impact, damage, or definitive risk. They can, however, be used to identify potential problem areas that may require risk management.

The overall objective of the ecological assessment is to determine if chemicals associated with the Site have the potential to affect the structure, function, or interactions of biological populations and communities within the study area. This is conservatively done here by estimating exposure and risk for *individual organisms* within the population and community and assuming that this is representative of risks to the population or community as a whole. Factors that affect the translation of individual-based risk to population- or community-level risk, such as the spatial distribution of receptor populations and chemicals, are addressed qualitatively.

The overall focus of the ecological assessment is on potential site-related impacts on the aquatic populations and communities of Four Mile Run and the Potomac River. These two water bodies are the principal aquatic habitats of the area and, with the exception of small pockets of terrestrial habitat on Potomac Greens, will be the only source of natural habitat to remain once the Site is developed as a commercial and residential urban area.[1] Nevertheless, this assessment also will address potential risks associated with other areas of the Site that currently provide limited or marginal habitat, even though these habitats will not exist following development. This is being done to provide the range of risk information that has been requested by EPA.

This assessment is based primarily on chemical concentration data collected during the ECS and on general information on site ecology collected during site surveys. This site-specific information is supplemented by information on species composition and ecology obtained from field guides and contacts with regional wildlife specialists, and ecotoxicological data obtained from the literature. All the supporting chemical concentration and ecology data have been presented previously in the ECS Report. This assessment presents a subset of the available data, focusing on that which is particularly relevant to the assessment of site ecological risks.

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[1] Section 2.4 of this risk assessment describes Site development plans in detail.

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The remainder of this assessment is divided into seven principal sections:

- Receptor Characterization
- Problem Definition
- Exposure Assessment
- Ecological Effects Characterization
- Risk Characterization
- Uncertainty Analysis
- Conclusions

4.1 Receptor Characterization

The section presents a subset of the available ecological characterization data, focusing on that which is particularly relevant to the assessment of site ecological risks. Section 2.5 and related appendices of the ECS Report should be reviewed for a complete description of regional and site ecology, and for terrestrial and aquatic species lists. A habitat map for the site has been reproduced from the ECS Report, and is included here as Figure 4-1.

The Potomac Yard Site occupies 342 acres within a high-density urban area of the City of Alexandria and Arlington County. Residential and commercial neighborhoods surround the Site to the south, west, and north. The western boundary of the Site is separated from these communities by Jefferson Davis Highway (U.S. Route 1). Washington National Airport is adjacent to the northernmost portion of the Site. Daingerfield Island, a mixed-use recreational facility, lies to the east of the Site, separated from the Site by the George Washington Memorial Parkway (GW Parkway), a major Washington area commuter route. Regional ecology generally reflects this urban character, although pockets of more natural habitat are scattered throughout the area.

Site-specific ecology is influenced to a large degree by the physical habitat modifications that have occurred as part of the previous rail yard operation. During the more than 100 years of rail operations, over 300 acres of the Site were completely cleared of vegetation and covered by a combination of gravel and cinder-based ballast material to provide structural support and drainage for railroad beds. Recently, most of this area has been graded and covered with a layer of gravel. This 300-acre area that was the center of historical railroad activity covers the portion of the Site that is currently referred to as the main yard.[2] Cinder-based ballast (a by-product of coal combustion) consists of highly-mineralized (20% iron oxide; 50% other minerals in a silicate matrix) particles that are low in moisture and nutrients and largely absent of humic

[2] The main yard is further divided into geographic subareas. These are Central Operations, North Yard/North Tail, South Yard/South Tail, and Slaters Lane. These subareas correspond to historical investigation units at the Site and also to planned development units. Plate 2-4 of the ECS shows the locations of these subareas. (Slaters Lane is termed the Intermodal Area on that figure.)

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material.[3] Consequently, the majority of the Site is covered by substrate that provides a low-productivity environment for plants and soil-dwelling animals. Overall productivity of the main yard is expected to be low, and species adapted to disturbed, low-nutrient environments are expected to dominate.

Site development is expected to further reduce the habitat value of the main yard as open space and habitat is replaced by buildings and pavement. Site development already has begun on the main portions of the yard, with RF&P's continuing construction of a warehouse complex on the South Yard/South Tail portions of the Site.

The remaining 38 acres of the Site occupy an area known as Potomac Greens. This area was used previously as a drainage catchment area for the main yard. The area soils are a mixture of native soils, Corps of Engineers (COE) dredge material from Four Mile Run, and coal fly ash from a nearby power plant; no ballast material is present. Consequently, physical habitat modifications have not had as dramatic an effect on the ecology of the Potomac Greens area as they have had on the main yard.

4.1.1 Terrestrial Habitats and Wildlife

The results of the vegetative survey that was conducted as part of the ECS confirm the presence of a sparse and low diversity vegetative community on the main yard (see Figure 4-1). Large portions of the main yard are unvegetated, generally corresponding to areas where the gravel layer is thickest (e.g., North Yard). Vegetation that does occur on the main yard is comprised primarily of grasses and forbs characteristic of disturbed environments.

No detailed survey has been conducted of the soil fauna of the Site. However, a limited survey by the WEINBERG GROUP of over 20 locations in the South Yard/South Tail, Central Operations area, and North Yard/North Tail conducted during a risk assessment Site visit revealed no soil invertebrates of any kind (soils examined on the surface and excavated to an approximate 6-inch depth). Given this absence of prey, it also is considered likely that no insectivorous mammals occur on the main yard of the Site, although herbivorous species are likely to occur where food and cover exist. Wildlife use of the main yard is expected to be limited primarily to species characteristic of urban environments. ECS Report Appendix R presents a list of wildlife species common to the city of Alexandria including those likely to occur at Potomac Yard. During Site visits, the most commonly observed species of the main yard were pigeon, common crow, European starling, house sparrow, mockingbird, and mourning dove. House mouse and Norway rat, although not observed, also are expected to commonly use the main yard. Other species that were observed less frequently on the main yard were red-tailed hawk, kestrel, cottontail rabbit, and red fox.

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[3] See Appendix E for a more detailed discussion and analysis of cinder ballast composition.

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Potomac Greens provides a more diverse mixture of terrestrial habitats than the main yard. Approximately 10 acres of palustrine emergent wetland are located on Potomac Greens (see ECS Report Appendix S). The wetland has developed primarily as a result of alteration in Potomac Greens topography associated with rail yard use and the construction of the Parkway. The majority of the wetland area occurs as a narrow strip along the eastern edge of the property adjacent to the Parkway. *Phragmites australis* is the dominant wetland plant. This species is characteristic of disturbed wetland environments. The overall wildlife habitat value of *Phragmites*-dominated wetlands is generally accepted as being considerably less than that offered by more diverse and undisturbed wetland communities. The primary functions of the Potomac Greens wetlands are likely to be surface water runoff control, and possibly sediment removal, although sediment run-off from the highly vegetated Potomac Greens is likely minimal. The remainder of Potomac Greens is composed of open upland habitat dominated by forbs, grasses, and shrubs. Saplings and trees are scattered throughout.

Potomac Greens likely supports a greater abundance and diversity of wildlife than the main yard, given the presence of a more dense and diverse vegetative community to provide forage and cover. Wildlife identified in Potomac Greens during this investigation include cottontail rabbit, turkey, snapping turtle, chickadee, cardinal, house sparrow, downy woodpecker, red-headed woodpecker, and flicker. Raccoon tracks and squirrel nests also were observed and frogs were heard. Other animals not observed but potentially present include Norway rat, house mouse, opossum, shrew, box turtle, toads, and snakes.

4.1.2 Aquatic Habitats and Wildlife

On-site aquatic habitats are limited to intermittent or semi-permanent drainage ditches and pools in topographic depressions where surface runoff collects. The aquatic life in these waters is likely dominated by aquatic insects (e.g., dipterans), which can use these areas as seasonal breeding sites. Amphibian larvae may use the ditches and pools of Potomac Greens. Aquatic life in the main yard ditches is expected to be limited somewhat by the low suitability of the cinder ballast as benthic habitat.

The intermittent drainage ditches of the Site discharge either to Four Mile Run or the Potomac River. Four Mile Run discharges occur at the property boundary. Potomac River discharges exit the property's eastern boundary and travel between 400 and 1,700 feet to the river.

Four Mile Run is a channelized urban drainageway. Bank and riparian vegetation are sparse or absent along much of its course. The average width of Four Mile Run near the Site is approximately 200 feet with a depth of between 5 and 10 feet. Common local aquatic wildlife includes long-nose gar, largemouth bass, smallmouth bass, gizzard shad, bluegill, red-breasted sunfish, carp, channel catfish, darters, American eel, and crayfish. In addition, waterfowl and wading bird species may forage in these waters.

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The Potomac River is a tributary river of the Chesapeake Bay. Aquatic communities of the area are somewhat typical of tidal freshwater estuaries of the Chesapeake Bay, supporting a range of forage, game, commercial, and anadromous fish, as well as a mixture of invertebrates and water-associated birds and amphibians.

Both Four Mile Run and the Potomac River have been heavily impacted by point and non-point source pollution of the Washington, D.C. metropolitan area. Immediately upstream of the Potomac Yard Site, Four Mile Run receives inflow from subsurface storm sewers, ditches, and permitted releases at the Arlington County Water Pollution Control Plant (ACWPCP) and four concrete companies. Downstream of the Site, Four Mile Run receives surface and storm drainage from National Airport. The Potomac River receives similar discharges from across a much larger drainage basin. The Washington Navy Yard and Blue Plains Sewage Treatment Plant discharge to the Potomac River opposite the Potomac Yard Site.

Collectively, these historical and on-going regional discharges have resulted in a high chemical burden in the sediments of Four Mile Run and the Potomac River. Wade et. al (1994) recently reported the results of sediment surveys conducted in the Potomac River and reported total hydrocarbon concentrations in the range of 100 to more than 1,000 mg/kg (ppm). These levels are probably associated with urban runoff. The concentrations of PAHs ranged from the low ppm range to over 100 ppm. PCBs were detected at concentrations ranging between 0.07 ppm to well over 3 ppm. Two organochlorine pesticides (DDT and chlordane) also were detected at concentrations greater than 0.1 ppm. The ECS Report (Table 2-5) presented similar data for chemicals in Four Mile Run. In addition, metals including lead, mercury, cadmium, copper, and chromium have been detected at high concentrations in surface water and sediment of Four Mile Run and the Potomac River. Recent benthic toxicity surveys of the Potomac River (upstream of the Potomac Yard Site) found 75% mortality in *Hyalella azteca* (Schlekat et al. 1994). In addition, recent fish tissue residue surveys of the Potomac River conducted by the U.S. Fish and Wildlife Service (1990) found total PCB residues of over 6 ppm in Potomac River fish.

4.1.3 Endangered and Threatened Species

Bald eagle and peregrine falcon have been observed roosting in trees at the Site. Both species are currently classified as endangered, although the bald eagle has been proposed for reclassification as threatened. Both were observed in November 1994 and were likely migrating through the area; neither is known to breed in the Site vicinity. No other endangered or threatened species has been observed on site or are expected to occur given the current level of development at and around the rail yard.

4.2 Problem Definition

This section presents a conceptual model for the Site by identifying the principal chemical sources at the Site, the likely mechanisms of release, and the probable fate and transport pathways, as well as the general receptor groups and exposure pathways of concern. The output

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of this section is an identification of the receptor groups and pathways that will be the focus of this assessment.

4.2.1 Chemical Release, Fate, and Transport

The principal sources of chemicals at the Potomac Yard Site are believed to be (1) the cinder-based ballast that was used as fill across the Site and (2) past surface releases that occurred during rail yard operations. Cinder-based ballast is a potential source of metals and possibly trace sources of certain organic compounds that are natural constituents of coal. Past surface releases as a result of tank car spills or leaks, day-to-day yard activities (e.g., fueling locomotives, oil changes) are additional sources of organic and inorganic compounds. The largest spills recorded at the Potomac Yard Site were a 1,000 gallon release of potassium hydroxide during a tank car derailment, and a 20,000 gallon spill of oil from a tank car (ECS Report). Other potential sources at the Site include atmospheric deposition from National Airport, the nearby power plant, and other urban sources. In addition, the Site received surface water run-on from nearby roads and city storm sewers (e.g., onto Potomac Greens).

Following initial release to the surface, chemicals may have volatilized, absorbed to surface particles, or dissolved in soil water or surface precipitation. Transport may have occurred via wind entrainment of surface particles, surface runoff in either particulate or dissolved form, or downward leaching through subsurface fill and soils toward the water table. Liquid releases of sufficient volume could have been transported via overland drainages, resulting in sediment absorbed chemicals in on-site drainage ditches or discharge directly to surrounding surface waters. In addition to these initial processes, chemicals that are present in ballast or remain absorbed to soils and sediments can act as a continuing chemical source for each of these transport pathways. Under existing conditions, surface transport of soils is likely limited by the layer of gravel ballast that covers much of the surface of the main yard.

Chemicals detected at the Site include petroleum and petroleum-related compounds, PAHs, metals, volatile and miscellaneous semi-volatile compounds, pesticides, and PCBs (see ECS Report). Petroleum-related compounds, PAHs, and metals are the most frequently detected chemicals at the Site. Concentrations are generally greatest in soils (near former source areas and in ballast material) and sediments, and less in surface water and groundwater. This media-specific distribution is consistent with what is expected for these chemicals based on their physical-chemical properties. PAHs and metals also are the most frequently detected chemicals in groundwater (see ECS Report Table 6-21), although concentrations are substantially reduced over those in soils. More mobile organic chemicals (e.g., volatile chemicals) also are present in groundwater, but generally with detection frequencies of 5 percent or less. Dieldrin (1 out of 46 samples) was the only pesticide/PCB detected in groundwater (typical detection limit range between 0.03 to 1 µg/l, with a few samples having detection limits up to 10 µg/l; see ECS Report

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6.3 and Table 6-28)[4]. Metals are the predominant constituents detected in site surface waters, although miscellaneous organic chemicals and pesticides also have been detected at concentrations ranging from < 0.1 µg/l to 14 µg/l.

In summary, the historical information and recent sampling data collectively suggest a site conceptual model where the primary chemical sources are the cinder-based ballast, which has been used as fill across most of the Site, and past surface releases. Non-ballast soils and sediments can act as additional, secondary sources. Chemicals in surface soils (fill, ballast, and non-ballast) and sediments can remain in place or be transported in particulate form via surface runoff, with some transport of dissolved phase chemicals occurring in groundwater and surface water. Petroleum-related compounds, PAHs, and metals are the principal constituents of concern at the Site. Other chemicals occur sporadically and/or at low concentrations.

4.2.2 Principal Receptors and Exposure Pathways

Ecological receptors may be exposed to chemicals present in surface soils (including cinder-based ballast), surface water, sediment, and air. In addition, chemicals that are present in groundwater may be transported to surface waters, and thereby reach ecological receptors. This ecological assessment focuses on potential exposures in surface water, sediment, and soils.

Air exposure pathways are not considered important under the baseline conditions at the Potomac Yard Site because (1) wind entrainment of surface particles is not likely to occur due to the gravel cover across most of the Site; (2) volatile organic chemicals (VOCs) generally are present at low concentrations in surface soils at the Site; (3) areas of high VOC concentration are localized; (4) volatilized chemicals would be quickly diluted to negligible concentrations in ambient air; and (5) the soil wildlife community (including borrowing mammals) is limited in occurrence and abundance by the gravel and cinder-based ballast materials that constitute surface soils across most of the Site. Ambient air concentrations could be greater during interim construction activities, but site wildlife use at this time is expected to be minimized by the construction disturbances.

Groundwater transport pathways also will not be considered further in this assessment. Appendix J presents a detailed analysis of potential ecological risks associated with transport of chemicals in groundwater to surface water. This analysis indicates that groundwater discharge to surface water does not pose a risk to aquatic receptors, as the estimated chemical concentrations in

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[4] The exception to this was well MW-25, which had high TPH concentrations and a consequent PCB detection limit of 1,000 µg/l. MW-25 is located outside the Central Operations area, however. The Central Operations area is where free diesel product is present in groundwater and where PCBs would be most likely to occur, in association with the non-aqueous phase. The detection limits for PCBs in the wells nearest to the Central Operations area were in the range of 0.7 to 1.0 µg/l. No PCBs were detected in this area. Because no PCBs have been detected at these lower detection limits in wells near the free product, it is considered unlikely that the higher detection limits in the MW-25 sample is masking the presence of PCBs.

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surface waters resulting from groundwater discharge are below the chronic ambient water quality criteria (AWQC) established by USEPA. Therefore, this pathway is not evaluated further in this assessment.

Table 4-1 summarizes the pathways by which ecological receptors may be exposed to chemicals in surface water, sediment, and soil, and identifies the pathways that will be evaluated in this risk assessment. The rationale for inclusion or exclusion of pathways from further evaluation also is provided. Overall, the exposure pathways that are likely to be associated with the greatest exposure or risk were selected for evaluation in this screening-level assessment. Exposure pathways that would result in lesser exposures or that would occur in marginal habitats (e.g., main yard drainage ditches) were excluded in some cases. For example, no potential exposure pathways associated with main yard ditches have been selected for quantitative evaluation because (1) the ballast and gravel material that forms the substrate of these ditches does not support a benthic community and (2) the ditches are intermittent and do not provide permanent aquatic habitat nor a reliable drinking water source for terrestrial species. However, PCBs have been detected in one of the ditch sediment samples at a concentration of over 7 mg/kg. This concentration is above that known to be toxic to some benthic species, but is not quantitatively evaluated in this assessment because the ditches provide habitat for no (or very few) organisms. This ditches could serve as a conduit for off-site transport of chemicals, however. Therefore, chemical concentrations in the ditches at the point where they exit the property will be evaluated in this risk assessment.

The exposure pathways to be evaluated in this assessment are as follows:

- **South Yard/South Tail.** Ingestion of soil by terrestrial wildlife while foraging or grooming. Portions of this area are not covered by the layer of gravel. Therefore, cinder-based ballast is exposed at the surface and available for contact with wildlife. Although wildlife use of any main yard habitat is expected to be infrequent, wildlife use has been noted in this area. Because cinder ballast is exposed, exposure could occur. Exposures cannot occur in those areas of the main yard that are covered by a layer of gravel (i.e., North Yard, North Tail, Slaters Lane) because this layer prevents contact with contaminated material. Exposures in the Central Operations area are considered unlikely because the areas not currently covered by gravel do not provide food or cover due to excavation, railroad decommissioning, and remediation activities in this area. Wildlife use of this area has not been noted. Exposures following the completion of remediation activities in this area will not occur because the area is to be developed as a commercial area and transportation hub. In fact, development has already begun in this area of the Site with RF&P's continuing construction of a warehouse complex. Other receptors and pathways are not considered appropriate for the South Yard/South Tail because of habitat limitations. For example, site surveys of the cinder ballast material in the South Yard/South Tail area show that it does not support a soil invertebrate community. This is likely due to the

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physical and nutrient limitations of the ballast material, rather than a contaminant-related phenomenon. Given this absence of prey, it also is considered likely that no insectivorous mammals occur on the main yard of the Site. Vegetation is generally sparse, and therefore, use of the South Yard/South Tail by herbivores also is expected to be limited.

- **Potomac Greens.** Several exposure pathways have been selected for evaluation in this area, which currently provides a greater diversity of habitats than the main yard: (1) ingestion of soil by terrestrial wildlife while foraging or grooming; (2) ingestion of soil invertebrate prey by terrestrial wildlife; (3) soil ingestion and dermal contact exposures in terrestrial invertebrates (qualitative evaluation only); (4) respiration and dermal contact exposures in aquatic life contacting surface water in Potomac Greens ditches and ponded areas; and (5) dermal contact and ingestion exposures in benthic species contacting sediment in these same water bodies. These pathways are only valid for the current land-use condition. Following development, Potomac Greens will consist of only small patches of natural habitat, and surface drainage is likely to be controlled largely by underground pipes.

- **Four Mile Run and Potomac River.** As mentioned previously, the principal focus of the ecological assessment is on potential exposures and risks associated with chemicals that have been transported from the Site via surface runoff. Exposure pathways to be evaluated are (1) respiration and dermal contact exposures in aquatic life contacting surface water in Four Mile Run and the Potomac River; and (2) dermal contact and ingestion exposures in benthic species contacting sediment in these same water bodies.

Potential exposures in bald eagle and peregrine falcon will not be evaluated further in this assessment. Although, both of these species were observed in Site trees on single occasions during fall migration, neither is believed to be a year-round or seasonal resident. Any exposures to Site chemicals that could occur during migration or occasional site use are likely to be insignificant given the limited seasonal use of the Site by both species, their foraging range and habitat preferences, and the concentrations of chemicals that have been detected in exposure media at the Site.

4.3 Exposure Assessment

This section presents the chemical concentration data that will be used to assess exposures for each of the above pathways. All analytical data that were collected as part of the ECS were considered for the ecological assessment. For most media, samples were collected over two or more sampling periods, generally to fill spatial or analytical gaps. These data are summarized collectively here, regardless of sample time. In cases where the same location was sampled more than once, each sampling event was treated as an independent sample (i.e., data were not

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averaged across time). Not all samples were analyzed for the complete set of TCL and TAL chemicals. Hence, the total number of samples for individual analytes within a given medium varies.

All data were initially screened to remove non-detected chemicals for which one-half of the detection limit exceeded the maximum detected concentration. Consistent with EPA (1989b) guidance, this was done to prevent the estimated mean concentration from being artificially biased upward by high detection limits. Appendix G presents the chemicals and detection limits removed based on this procedure. The risk implications of removing high detection limits from the data set will be addressed in the risk characterization and uncertainty sections. The risk characterization section also presents a comparison of environmental toxicity criteria to the chemical-specific elevated detection limits listed in Appendix G. This comparison provides an indication of the degree to which risks could be underestimated.

Tentatively identified compounds (TICs) also were screened from the database because of uncertainties regarding chemical identity and concentration. The risk implications of excluding TICs from the data set are addressed in the uncertainty section.

The discussion of analytical data is organized below for each potential exposure area.

4.3.1 South Yard/South Tail

Cinder ballast collected from a 0 to 3 foot depth will be used to assess potential soil ingestion exposures in terrestrial wildlife in the South Yard/South Tail. Initially, inorganic chemicals and PAHs from this data set were compared to background concentrations to determine if on-site concentrations were significantly (statistically) elevated above background. Background soil data collected from EPA-approved locations were used. PAHs were considered in the evaluation, along with naturally occurring inorganic chemicals, because they are ubiquitous constituents of urban soils. Only PAHs that were detected in every background sample were included in the statistical evaluation, however. The chemicals eliminated from further consideration based on the statistical evaluation are anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene, pyrene, aluminum, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium, vanadium and zinc. Appendix A presents the details and results of the statistical analysis.

Table 4-2 summarizes the PAHs and inorganic chemicals that were detected above background concentrations, as well as all other organic chemicals that were detected in South Yard/South Tail cinder ballast. As can be seen, PAHs are the most frequently detected organic chemicals, and arsenic is the most frequently detected inorganic chemical. PAHs are likely present due to past surface releases of petroleum products, and arsenic is present as a constituent of the cinder-based ballast. Miscellaneous organic chemicals and pesticides also were detected, but relatively infrequently. PCBs were detected in a third of the samples. There is no consistent pattern with

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respect to the spatial distribution of chemical maxima, suggesting that isolated "hot spots" do not exist.

All chemicals that were detected in less than 5% of the samples were excluded from further evaluation in the ecological risk assessment, with the rationale that infrequently detected chemicals will not contribute significantly to soil ingestion exposures in wildlife. This is because wildlife will be exposed to these chemicals only very rarely as they roam the Site. Further, none of the infrequently detected chemicals are present at concentrations that are of concern with respect to terrestrial wildlife exposures. Therefore, they are not considered further in this risk assessment.

Total petroleum hydrocarbons (TPH) also were not selected for further evaluation because toxicity data with which to interpret exposures to this chemical mixture are lacking. Overall, however, chemical toxicity of this mixture is expected to be low. As discussed in the human health risk assessment, the probable source of the TPH is diesel fuel, which consists predominantly of long-chained aliphatic hydrocarbons (e.g., dodecane, octadecane). These compounds have relatively low toxicity to environmental receptors, and therefore are not likely to pose a significant risk. The other probable diesel constituents are low molecular weight PAHs (30%) and substituted aromatics (5%). Although these compounds are potentially more toxic to environmental receptors than long-chained aliphatic hydrocarbons, they are comprised of constituents that are on EPA's TCL. Therefore, they are evaluated in this risk assessment as the individual constituents, rather than as components of a mixture.

Finally, potassium, sodium and volatile organic chemicals (VOCs) were eliminated from further evaluation given their low toxicity to wildlife and the low concentrations (relative to toxic concentrations) that were detected at the Site. The resulting list of chemicals of potential concern (COPCs) selected for further evaluation in the ecological risk assessment are identified in Table 4-2 by an asterisk.

4.3.2 Potomac Greens

Environmental exposures will be evaluated for chemicals in soil, surface water, and sediment for the Potomac Greens area. Chemicals may be present in Potomac Greens as a result of past use of this area as a catchment basin during rail yard operations or as result of City of Alexandria stormwater that discharges to this area.

4.3.2.1 Soil

Surface soil collected from a 0 to 3 foot depth will be used to assess potential soil exposures in terrestrial wildlife at Potomac Greens. As was done with South Yard/South Tail cinder ballast data, inorganic chemical and PAH concentrations were initially compared to background concentrations using the procedures described above. The chemicals eliminated from further consideration based on the statistical evaluation are anthracene, benzo(a)anthracene,

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benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-c,d)pyrene, phenanthrene, pyrene, aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc. Appendix A presents the details and results of the statistical analysis.

Table 4-3 summarizes the PAHs and inorganic chemicals that were detected above background concentrations, along with the other organic chemicals that were detected in Potomac Greens soils. As can be seen, a mixture of pesticides, PCBs, metals, and miscellaneous organic chemicals have been found in the soils at Potomac Greens. Pesticide/PCB concentrations are in the low ppb range; PAHs and trace metals are in the low ppm range. TPH, VOCs and sodium are eliminated from further evaluation for the reasons presented above. No chemicals were eliminated based on low frequency. All the remaining chemicals were selected as chemicals of potential concern.

4.3.2.2 Surface Water

Surface water data collected from ditches and ponded areas on Potomac Greens are summarized in Table 4-4. The inorganic chemical concentrations are dissolved chemical concentrations. The dissolved concentrations are used here, consistent with EPA (1993a, 1995b) guidance which recommends the use of dissolved chemical concentrations when comparing to AWQC. No statistical analyses were conducted on the surface water data because suitable background data were not available. PAHs, pesticides, VOCs, carbon disulfide, and inorganic chemicals were detected in Potomac Greens surface water. Carbon disulfide is likely to be a laboratory artifact, but is retained for evaluation due to lack of definitive evidence that it is not site-related. TPH was eliminated as a chemical of concern, as discussed above. Calcium, magnesium, potassium, and sodium were eliminated from further evaluation given their low toxicity to aquatic life and the low concentrations (relative to toxic concentrations) that were detected. All other chemicals were selected as COPCs.

4.3.2.3 Sediment

Sediment data collected from ditches and ponded areas on Potomac Greens are summarized in Table 4-5. No statistical analyses were conducted because suitable background data were not available. PAHs, pesticides, phthalates, and inorganic chemicals were detected. Calcium, barium, and magnesium were eliminated from further evaluation given their low toxicity to aquatic life and the low concentrations (relative to toxic concentrations) that were detected. TPH was again eliminated as a chemical of concern. All other chemicals were selected as COPCs.

4.3.3 Four Mile Run and Potomac River

As stated previously, Four Mile Run and the Potomac River are the focus of the ecological risk assessment. Surface water and sediment data collected from drainage ditches and storm sewers

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at the property boundary will be used as upper-bound estimates of potential exposure concentrations in Four Mile Run and the Potomac River as a result of surface releases from the Potomac Yard Site. Four Mile Run outfalls exit the property boundary and discharge directly to the creek. Potomac River outfalls exit the Site on the eastern property boundary and travel between 400 and 1,700 feet before reaching the River. Sample locations at the property boundary are as follows.

- Four Mile Run outfalls: SSSW-1, SSSW-2, SSSW-3, SSSW-4, SSSW-5, SSSW-6, SSSW-7, EPASW-11, EPASW-13, SW12, SSSED-2, SSSED-3, SSSED-5, SSSED-6, SSSED-7.

- Potomac River outfalls: NYSW-2, NPDSW2, SPDSW3, NYSED-2, NPDSED-2, SPDSED-3.

Plate 5-1 of the ECS Report identifies these sample locations.

Data from the property boundary will be used as the surrogate exposure point concentrations for Four Mile Run and the Potomac River in lieu of actual off-site sampling data from these waters. This is done because historical and continuing chemical releases to these water bodies from multiple sources within the watershed (e.g., the Arlington County WPCP, National Airport, City of Alexandria and Arlington County storm sewers, run-off from adjacent roadways) have contributed substantially to the chemical loadings. As a result, the relative incremental chemical contribution to these waters from the Potomac Yard Site would be impossible to characterize using samples collected from these waters given that: (1) the discharge volume and chemical loading from these other sources is high; (2) the chemical constituents associated with the Potomac Yard Site and the regional watershed (e.g., PAHs, metals, pesticides) are similar (i.e., there is no unique set of chemicals that can be linked to the Site); (3) the receiving waters are tidal, which complicates the definition of "downgradient" with respect to the Site; and (4) the likely source of many of the chemicals is urban runoff and deposition, which will continue in both on- and off-site areas in the future.

The proposed approach for characterizing surface water and sediment exposure concentrations in Four Mile Run and the Potomac River using property boundary samples is believed to be a conservative approach given that chemicals released from the rail yard will be diluted and dispersed within the receiving waters. This approach, however, does not address potential chemical concentrations in the Four Mile Run or the Potomac River that might have resulted from past releases. The implications of potential effects of past releases will be discussed in the risk characterization and uncertainty sections. In addition, off-site sampling of Four Mile Run and/or the Potomac River will be addressed in the future as part of continuing activities at the Site.

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4.3.3.1 Surface Water

Tables 4-6 and 4-7 present the surface water sampling data collected from Four Mile Run and Potomac River outfalls, respectively. No statistical analyses were conducted. Inorganic chemical data are dissolved concentrations.

The discharges entering Four Mile Run primarily contain inorganic chemicals, although miscellaneous organic chemicals also were detected at low levels (low ppb range). Arsenic is the trace metals detected at the highest concentrations. There do not appear to be significant differences in chemical constituents or concentrations at discharge points in non-storm vs. storm conditions.[5] All chemicals are selected as COPCs except calcium, magnesium, sodium, and potassium, which are eliminated as COPCs based on their relatively low toxicity to aquatic life and their detection at low levels (relative to toxic concentrations).

Potomac River outfalls contain a greater number of organic chemicals, including pesticides, phthalates, PAHs, and VOCs. Zinc and manganese are the only trace metals detected in Potomac River outfalls. All organic chemicals, except TPH, are selected as COPCs for the assessment. Zinc, iron, and manganese are the metals selected.

4.3.3.2 Sediment

Tables 4-8 and 4-9 present the sediment sampling data for Four Mile Run and Potomac River outfalls, respectively. No statistical comparison to background concentrations were made. PAHs and metals are the principal constituents of sediment from both areas, although phthalates and pesticides (Four Mile Run only) also were detected. All chemicals except TPH and low toxicity metals are selected as COPCs for this evaluation.

4.4 Ecological Effects Characterization

To the extent possible, this screening-level risk assessment relies on published ecotoxicological criteria and guidance values as the basis of toxicity screening values (TSVs) for the evaluation of ecological risk. This approach to toxicity assessment is a conservative approach in that it generally relies on the use of toxicity data for the most sensitive species or species group within a particular habitat. In addition, toxicity criteria are derived assuming continuous exposure to a chemical and 100% bioavailability, which adds an additional element of conservatism to the analysis.[6]

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[5] This is also true with respect to total concentrations (see ECS Volume IV), suggesting that the Site is not a significant source of particulates to Four Mile Run.

[6] The only exception to this bioavailability assumption is arsenic in cinder-based ballast, for which a site-specific bioavailability of 10% was derived (see below and Appendix E).

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For surface water, acute and chronic ambient water quality criteria (AWQC) are used to evaluate surface water toxicity. AWQC are designed to be protective of 95% of all aquatic species, including invertebrates, fish, and amphibians. If no AWQC are available, acute and chronic no-effect or lowest-effect concentrations (NOECs, LOECs, respectively) reported by EPA are used. If no toxicity criteria are available for a chemical of potential concern, data for closely related chemicals are used, as available. For example, endosulfan criteria are used here for endosulfan sulfate. For PAHs, chemical similarity was roughly approximated based on the number of aromatic rings in the chemical structure. Metals AWQC, based on total recoverable concentrations, have been adjusted to dissolved criteria using the conversion factors derived by EPA (1995b).

Sediment quality criteria developed by EPA (EPA 1993b) and effects levels published by Long and MacDonald (1992) and Long and Morgan (1991) are used as sediment TSVs in this assessment. The sediment quality criteria (SQC) developed by EPA are based on the equilibrium partitioning approach, and are the estimated chemical concentrations in sediment that will result in non-toxic chemical concentrations in sediment pore water. SQC have been proposed for five chemicals to date. In the absence of a SQC, effect-level values published by Long and MacDonald and Long and Morgan are used. These values are based on chemical monitoring and biological response data collected as part of the National Oceanic and Atmospheric Administration (NOAA) nationwide Status and Trends Program. Two effect-based concentrations have been defined: effects-range low (ER-L) and effects-range median (ER-M). The ER-L corresponds to the 10th percentile of the distribution of all sediment concentration data that were associated with adverse biological effects. The ER-M is the 50th percentile of this distribution. In very general terms, sediment concentrations that exceed the ER-L could result in adverse effects in sensitive benthic species, whereas sediment concentrations that exceed the ER-M could result in adverse effects in a greater number of less sensitive benthic species. The ER-L and ER-M values for all chemicals except pesticides are based strictly on data from marine and estuarine systems. Therefore, their applicability to the freshwater systems of Potomac Yards is unknown. For some chemicals, such as arsenic, toxicity in freshwater species is less than that in marine or estuarine species (Eisler 1988). Therefore, use of marine or estuarine based toxicity values might overestimate risks for freshwater species.

Toxicity screening criteria similar to aquatic criteria have not been published for terrestrial wildlife exposed to soil. Therefore, soil TSVs were derived for this assessment for terrestrial wildlife. The exposure scenario used to derive TSVs for all chemicals of concern is soil ingestion by avian wildlife. Additionally, a bioaccumulation exposure scenario is used to derive a second set of soil TSVs for pesticides and PCBs, based on the assumption that these chemicals could accumulate in avian soil invertebrate prey to levels greater than those present in soil. Birds were selected as the ecological receptors of interest because they have been observed on site, are sensitive wildlife receptors, and have a larger toxicological database than wild mammals.

The soil TSVs derived here are estimates of the chemical concentrations in soil that would not be associated with toxic effects in the exposed organism. Both acute and chronic exposures are

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considered. Chronic criteria are based on the assumption that an individual organism is continuously exposed to the chemical at that concentration level. The TSVs are not prorated to take into account the foraging range of mobile species; such considerations would lead to higher TSV values. Also 100% bioavailability is assumed in all cases except arsenic. The arsenic TSV takes into account the fact that arsenic present in the cinder ballast material has been shown to be 10% bioavailable, based on the results of site-specific investigations, and assuming that the avian digestive system has a pH similar to that of the acid used in the bioavailability studies. Appendix E provides the details on the arsenic bioavailability study and Appendix H provides the toxicity data, methods, and assumptions used to derive avian soil TSVs.

4.5 Risk Characterization

Consistent with the screening-level approach outlined by EPA Region III (EPA 1994), screening-level risks are characterized by dividing the exposure concentrations by the TSV for each chemical in each exposure medium. The resultant value is termed the hazard quotient (HQ). HQs of one 1 or less are interpreted as indicating no environmental risk. HQs greater than 1 are interpreted as indicating a potential risk. Based on EPA Region III guidance, HQs between 10 and 100 represent moderate risk, and those above 100 represent high risk.[7]

HQs are calculated here for mean[8] and maximum chemical concentrations. The use of the maximum concentration in the risk assessment is a more conservative approach than the use of the 95% upper confidence limit (UCL) on the mean as the exposure concentration. This is because EPA risk assessment guidance (EPA 1989b, 1994) dictates the use of the *lower value* of the UCL or the maximum detected concentration. Consequently, the UCL exposure concentration will never be greater than the maximum concentration used here.

Under the approach adopted in this risk assessment, if the HQs calculated for the maximum chemical concentration exceed 1, the particular sample locations where the exceedence occurred are identified. This approach has been adopted as a way to highlight particular areas of the Site that might require risk management. This approach also is a very conservative approach in that it is implicitly based on the assumption that an organism spends its entire life at a single location.

The HQs are presented below for each of the exposure areas considered in this risk assessment. This is followed by an evaluation of the magnitude, frequency, and ecological significance of any predicted risks.

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[7] All HQs have been rounded to one significant figure.

[8] Arithmetic mean concentrations are used as the central tendency exposure concentration in the ecological risk assessment rather than the population mean, which was used in the human health risk assessment. The population mean will provide the best estimate of the mean for log-normally distributed data, but was not used here based on concerns expressed by the Region III BTAG (during a November 1994 meeting) regarding the appropriateness of this statistic.

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4.5.1 South Yard/South Tail

Ingestion of cinder ballast by birds while foraging or grooming was evaluated for the South Yard/South Tail area of the Site. TSVs were derived for both acute and chronic exposures. Acute exposure are considered the most probable exposure scenario for the Site because birds are more likely to use the South Yard/South Tail area of the Site occasionally rather than continuously throughout a season or lifetime, given the relatively low habitat value of the area.

Table 4-10 compares the mean and maximum chemical concentrations to acute and chronic TSVs. As can be seen, none of the HQs are greater than 1, suggesting that cinder ballast in this area does not present a hazard to birds using the Site. In addition, as shown in Table 4-11, none of the chemicals that were removed from the database because of elevated detection limits had detection limits that exceeded any of these TSVs. (Appendix G provides the sample-specific detection limits for all chemicals that were screened from the database.) Therefore, there is no environmental risk to birds using the main yard. Some of the chemicals present in the South Yard/South Tail soil are above generic ecological screening values informally used by the Region III BTAG to evaluate site-specific ecological risks[9]. These BTAG screening values are not believed be applicable for use in the South Yard/South Tail area because the area supports very little wildlife given the cinder ballast and gravel cover. Consequently, the most applicable exposure pathway for ecological receptors is soil ingestion by birds (evaluated above). Based on this comparison, no environmental risk is expected to birds or other terrestrial wildlife using the main yard.

The ecological assessment of the main yard does not include an evaluation of potential exposures in the on-site ditches. These areas were excluded from evaluation because (1) the ballast and gravel material that forms the substrate of these ditches does not support a benthic community and (2) the ditches are intermittent and do not provide permanent aquatic habitat nor a reliable drinking water source for terrestrial species. PCBs have been detected in the on-site ditch sediments at concentrations that have been shown to be toxic to some benthic species. Because benthic species do not inhabit the main yard diches, no risk exists, however. Nevertheless, because PCBs are present in a ditch that drains the site, they could be considered a chemical of concern for any off-site investigation that is conducted. (PCBs have not been detected in sediment samples collected at the property boundary, however.)

4.5.2 Potomac Greens

Exposures and risks were evaluated for Potomac Greens soils, surface waters, and sediments.

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[9]The chemicals are: PCB 1260, acenaphthylene, dibenz(a,h)anthracene, fluorene, naphthalene, 2,4-dinitrophenol, antimony, arsenic, cadmium, mercury, silver, and thallium.

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4.5.2.1 Soil

Table 4-12 compares the mean and maximum chemical concentrations to acute and chronic TSVs for soils. Two exposure pathways were considered for Potomac Greens soils: (1) ingestion of soil by birds foraging or grooming in the area; and (2) ingestion of soil invertebrate prey that have accumulated chemicals from soil by birds foraging in the area. The bioaccumulation pathway was evaluated for pesticides and PCBs; the soil ingestion pathway was evaluated for the other chemicals. As can be seen, none of the HQs exceed 1 and, in fact, most are many orders of magnitude below 1, leading to the conclusion that chemicals in the soils at Potomac Greens do not pose a risk to birds foraging in the area.

There is some uncertainty associated with this conclusion, however. As can be seen in Table 4-13, the maximum elevated detection limit of endrin ketone that was screened from the data set (0.050 mg/kg) exceeds the TSV of 0.03 mg/kg. Elevated detection limits above the TSV occur at DSA1-1-B and DSA2-B for endrin ketone (see Appendix G). However, because endrin ketone was not detected at a concentration above the TSV in any of the 10 other samples collected from Potomac Greens (with detection limits below the TSV), it is considered most likely that, if present, it is below TSV concentration.

Soil chemical concentrations also appear to be below concentrations potentially toxic to soil invertebrates. For example, the concentrations of cadmium and mercury in Potomac Green soils are well below the soil invertebrate NOECs of 37 mg/kg and 3 mg/kg, respectively, identified by van Straalen (1993). Few soil invertebrate toxicity data are available for the other chemicals of concern at Potomac Greens, but data from similar chemicals suggest that the Potomac Greens soil concentrations are well below levels of concern. For example, Venter et al. (1985) determined a NOEC based on earthworm growth for the organochlorine pesticide dieldrin of 50 mg/kg soil. Although dieldrin was not detected in Potomac Green soils, other organochlorine compounds were, and were present at concentrations orders of magnitude below this. Neuhauser et al. (1985) reported a soil LC_{50} of 173 mg/kg for the PAH fluorene, and 550 mg/kg for the phthalate, dimethylphthalate. PAH and phthalate concentrations in Potomac Green soils are well below these concentrations. Based on these data, soil invertebrates do not appear to be at risk from chemical exposures at Potomac Greens.

Some of the chemicals present in Potomac Greens' soil are above generic ecological screening values informally used by the Region III BTAG to evaluate site-specific ecological risks[10]. These BTAG screening values are not believed be applicable for use in the Potomac Greens area of the Site because they do not reflect site-specific exposure pathways. The Potomac Greens exposure pathways evaluated in this risk assessment (soil ingestion, food chain bioaccumulation, and soil invertebrate toxicity) are site-specific exposure pathways. No risks exist for ecological

[10]These are dibenz(a,h)anthracene, antimony, mercury, silver, and thallium.

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receptors exposed via these pathways, and therefore no risks exist for terrestrial wildlife inhabiting Potomac Greens.

4.5.2.2 Surface Water

Surface water exposures were evaluated for aquatic insects and amphibians that might use Potomac Greens surface waters as seasonal breeding areas. Table 4-14 compares the mean and maximum chemical concentrations to acute and chronic TSVs for surface water. As can be seen, the mean and maximum concentrations of several pesticides, phenanthrene, and zinc exceed chronic TSVs, as does the maximum concentration of anthracene. In addition, the mean and maximum concentration of zinc and the maximum concentration of phenanthrene and endosulfan sulfate exceed acute TSVs. These comparisons suggest that the pesticides in Potomac Greens surface waters pose a moderate risk to aquatic life. Zinc and anthracene pose a low risk. These risks are conditional on the actual exposures matching those assumed in this risk assessment.

These risks are further discussed in Section 4.5.4.

Table 4-15 compares the range of elevated detection limits for chemicals that have been eliminated from the quantitative assessment because the detection limits were more than twice the maximum detected value. As can be seen, the elevated detection limits are well below the TSVs.

4.5.2.3 Sediment

Sediment exposures also were evaluated for aquatic insects and amphibians that might use Potomac Greens surface water as seasonal breeding areas. These comparisons are presented in Table 4-16. Comparisons to the ER-L values are regarded here as evaluation of potential impacts in the most sensitive species, whereas comparisons to the ER-M are considered here to encompass a broader range of species that vary in sensitivity. Mean and maximum pesticide, PAH and metal concentrations exceed the ER-L values, suggesting low to moderate risk for sensitive benthic species. The maximum concentration of lead exceeds the ER-M.

The ER-L and ER-M comparisons suggest a moderate to high risk level for the pesticides. However, the overall confidence in the validity of these numbers as indicators of potential toxic effects has been rated by Long and Morgan (1991) as low. Therefore, the overall confidence in the pesticide risk estimate for Potomac Green sediments is low.

These risks are further discussed in Section 4.5.4.

The predicted risks could be underestimated because chemicals with high detection limits were removed from the quantitative assessment. As can be seen from Table 4-17, the maximum detection limits for many PAHs and two pesticides exceed the ER-L and ER-M values. If these

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chemicals are in fact present in Potomac Greens sediment, risks could be greater than those estimated here.

4.5.3 Four Mile Run and Potomac River

Potential risks for Four Mile Run and Potomac River surface water and sediments were evaluated by using chemical concentration data collected from the property boundary. As stated previously, this approach will overestimate risks associated with current releases to these waters from the Site, given that chemicals will be diluted and dispersed within Four Mile Run and the Potomac River.

4.5.3.1 Surface Water

Tables 4-18 and 4-19 compare surface water concentrations to TSVs. For the Four Mile Run outfalls during non-storm conditions, the maximum concentrations of aluminum, arsenic and zinc exceed the chronic TSV. The maximum zinc concentration also exceeds the acute criterion. During storm conditions, the mean and maximum concentrations of aluminum and the maximum concentration of lead exceeded their respective chronic TSVs. The highest HQ is 5, suggesting that discharges of these metals are posing a low overall risk to Four Mile Run.

For the Potomac River outfalls, the mean and maximum concentrations of pesticides exceed chronic TSVs, and the maximum concentration of zinc exceeds both the acute and chronic TSVs. The HQs for the pesticides suggest a moderate level of risk, and that for zinc a low level of risk.

These risks are further discussed in Section 4.5.4.

None of the elevated detection limits exceed TSVs (see Tables 4-20 and 4-21). Therefore, risks are not likely to be underestimated because of elevated detection limits.

4.5.3.2 Sediment

Tables 4-22 and 4-23 compare sediment concentrations to TSVs. For the Four Mile Run outfalls, the mean and maximum concentration of endrin ketone, PAHs, and copper exceed the ER-L. The mean and maximum concentration of PAHs also exceed the ER-M. The HQs suggest low to moderate risk for copper and the PAHs and high risk for endrin ketone. However, as mentioned previously, the overall confidence in the pesticide TSVs is low, therefore, this risk could be overestimated.

For the Potomac River outfalls, the mean and maximum concentrations of PAHs and several metals exceed the ER-L. The HQs suggest an overall low level of risk.

Sediment risks for both the Four Mile Run outfalls and the Potomac River outfalls could be underestimated, however, because several of the chemicals that were removed from the

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quantitative risk assessment because of elevated detection limits, have detection limits that exceed TSVs (see Tables 4-24 and 4-25).

These risks are further discussed in Section 4.5.4.

4.5.4 Magnitude, Frequency, and Significance of Predicted Risks

Tables 4-26 and 4-27 identify the frequencies of TSV exceedence for each chemical for which a HQ greater than 1 was calculated. The table also identifies the particular sample locations that exceed the TSV along with the overall risk level for each chemical, based on the hazard quotient results.

As can be seen, metals, PAHs and pesticides are the constituents associated with elevated risks. Risks associated with metals and PAHs are low, however ($1 < HQ < 10$). Those associated with the pesticides are generally moderate ($10 \leq HQ < 100$).

The possible ecological significance of these findings is discussed below.

4.5.4.1 Potomac Greens

The risk evaluation suggests that aquatic insects and amphibian larvae using Potomac Greens surface waters might be adversely affected by chemical in surface water and sediment. Pesticides contribute most significantly to the predicted risks, based on pesticide concentrations in the low ppb range.

If impacts are occurring, the possible consequences of pesticide exposures are a decreased abundance and diversity of the aquatic insect community and a decreased abundance of the amphibian population on Potomac Greens. The degree to which this has occurred or is occurring at Potomac Greens is unknown. Insect and amphibian life have been observed on Potomac Greens, however, which at a minimum means that exposures have not resulted in exclusions of these receptors from the Site. If pesticide-induced impacts are occurring, they are most likely limited to aquatic insects. Toxicity data for the pesticides detected at the Site indicate that insects are generally more sensitive to pesticides than amphibians (data presented in AQUIRE 1995), and that the concentrations that have been measured on site are below those typically associated with toxicity in amphibians.

There are likely no long-term ecological consequences of the pesticide concentrations at Potomac Greens. This is because, following development, Potomac Greens will consist of only small patches of natural habitat, with surface water carried in culverts and no natural open water areas. As discussed previously, development has already begun at the Site.

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4.5.4.2 Four Mile Run and Potomac River

The risk evaluation suggests that chemicals released from the Site to Four Mile Run and the Potomac River are present at concentrations that could impact aquatic life. Once again, the risk driving chemicals are pesticides, although dibenz(a,h)anthracene and copper also are associated with moderate levels of risk.

As stated previously, use of chemical concentration data from the property boundary will result in an overestimate of risks associated with the current condition because chemical concentrations in the receiving waters will be substantially lower than those at the Site boundary as a result of dilution and dispersion. A combination of reduced bioavailability and dilution of between less than 10 to more than 100 would be required to reduce chemical concentrations released from the Site to levels below TSVs. These dilutions are routinely achieved in Four Mile Run and the Potomac River.

It is difficult to predict the ecological impact of these release on the overall chemical burden and ecology of Four Mile Run and the Potomac River. Given the volume of release from the Potomac Yard Site relative to other chemical inputs from the watershed, it is considered likely that releases from the Site would have negligible impact. Four Mile run receives inflow from subsurface storm sewers, tributaries, ditches, and several point sources, including a major sewage treatment plant, from throughout a 17 square mile drainage basin. Upstream sources on the Potomac River include pulp and paper manufacturing, agriculture, and urban run-off. The Potomac River receives similar types of discharges from a substantially larger, multi-state area. Sampling data from the region indicate a high chemical burden of PAHs, metals, organochlorine pesticides, and PCBs (Wade et al. 1994) and others. Therefore, the contaminant contribution of the 342 acre site to these waters bodies is likely to be insignificant.

The sampling data do indicate that the Potomac Yard Site is a source of chemical input to Four Mile Run and the Potomac River. If impacts are occurring as a result of these releases, they are considered most likely to occur in areas adjacent to Site discharge points, where the concentrations of site-released chemicals will be the greatest (i.e., prior to dilution and attenuation). Sessile benthic species are considered the receptors most susceptible to exposures and impacts because they could be continuously exposed to site releases. If impacts are occurring, the possible consequences are a decreased abundance and diversity of the benthic invertebrate community. Such site-related impacts likely would be difficult to verify given the probable low abundance and diversity of the benthic community throughout this urban watershed.

This assessment does not address potential risks associated with past chemical releases. As mentioned previously, chemicals could have been released to the surface as a result of spills or leaks and been transported to adjacent surface waters. Off-site risks associated with historical releases from the Potomac Yard Site will be addressed in the future as part of continuing activities at the Site. Chemical concentrations in sediments are the most relevant data for

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addressing historical releases. Chemicals potentially associated with the site include PAHs, PCBs, and arsenic.

4.6 Uncertainties

There are scientific uncertainties associated with this risk evaluation due primarily to the number of conservative assumptions that have been made to generate estimates of ecological risk. As a result, the findings of this risk assessment have an associated degree of uncertainty. This screening-level risk assessment generally employed conservative assumptions regarding toxicity and exposure, such that true risks for the Site are likely overestimated. However, some assumptions used in this assessment might have resulted in underestimates of risk.

Some of the principal sources of uncertainty of this ecological assessment and their anticipated effect on the estimates of risk are outlined in Table 4-28.

4.7 Conclusions

The conclusions of the screening-level risk assessment are as follows:

- The Site poses no risk to terrestrial wildlife feeding or otherwise using the Site.
- Pesticides in surface waters and sediments of Potomac Greens could cause a localized reduction in the abundance and diversity of aquatic insects.
- Potomac Yards is a source of low concentrations of PAHs, metals and pesticides to Four Mile Run and the Potomac River.
- Measured concentrations at the property boundary exceed toxicity criteria for sensitive species of aquatic life, possibly resulting in localized decreases in benthic species abundance and diversity.
- Risk could be over- or under-estimated. Factors contributing to a potential under-estimate of risk are the removal of high detection limits from the data set. Factors contributing to possible over-estimates of risk are the screening-level risk assessment approach and assumption of a 100% bioavailability of chemicals in exposure media.
- The available sampling data cannot be used to evaluate ecological risks associated with historical releases. Off-site risks associated with historical releases from the Potomac Yard Site will be addressed in the future as part of continuing activities at the Site. Chemical concentrations in sediments are the most relevant data for addressing historical releases. Chemicals potentially associated with the Site include PAHs, PCBs, and arsenic.

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AR105227

EPA REGION III
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOC ID 157231
PAGE # 1052928

IMAGERY COVER SHEET
UNSCANNABLE ITEM

SITE NAME Potomac Yard

OPERABLE UNIT ERF-Removal

ADMINISTRATIVE RECORDS- SECTION VA VOLUME X

REPORT OR DOCUMENT TITLE Revised Human Health and Ecological Risk Assessment

DATE OF DOCUMENT 1-16-95

DESCRIPTON OF IMAGERY Habitat map

NUMBER AND TYPE OF IMAGERY ITEM(S) 1-oversized map

TABLE 4-1

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Soil				
Surface soil (cinder ballast)	North Yard/North Tail Slaters Lane	Terrestrial wildlife	Ingestion of soil while foraging or grooming	No. Area is completely covered by a layer of gravel, and therefore, underlying cinder ballast is not accessible to wildlife.
	Central Operations	Terrestrial wildlife	Ingestion of soil while foraging or grooming	No. Portions of area are covered by gravel. Portions that are not are highly disturbed as a result of excavation and remediation activities. No vegetative cover, high level of human activity, and no observations of wildlife use of this area. No future exposures will occur following remediation because the area will be developed.
	South Yard/South Tail	Terrestrial wildlife	Ingestion of soil while foraging or grooming	Yes. Cinder-based ballast exposed in surficial patches in some portions, although it is under gravel cover across a large portion of South Yard/South Tail.
Surface soil	Potomac Greens	Terrestrial wildlife	Ingestion of soil while foraging or grooming	Yes (for non-bioaccumulative chemicals). Although this area is highly vegetated, wildlife will use this area and could be exposed minimally to chemicals in soils. Soil ingestion is considered a conservative exposure pathway for non-bioaccumulative chemicals in this area.

AR105229

TABLE 4-1 (Continued)

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Surface soil (cinder ballast)	Central Operations North Yard/North Tail South Yard/South Tail Slaters Lane	Terrestrial wildlife	Ingestion of prey or plants that have accumulated chemicals from soil	No. The gravel and cinder-based ballast that covers the majority of the main yard does not provide suitable habitat for a soil invertebrate community. Therefore, no (or limited) soil invertebrate prey is available and this pathway is not of concern. Further, none of the chemicals that are present in cinder-based ballast are known to accumulate in plants or in herbivorous rodents to any significant degree. Therefore, exposures to herbivores or their predators (e.g., hawks) will be negligible.
Surface soil	Potomac Greens	Terrestrial wildlife	Ingestion of prey or plants that have accumulated chemicals from soil	Yes (for bioaccumulative chemicals in invertebrates). Several pesticides and PCBs have been detected at low concentrations in soils of this area. These chemicals can accumulate in soil invertebrates. Soils invertebrates likely occur in the non-ballast soils of Potomac Greens. Therefore, exposure of insectivorous wildlife will be evaluated. Exposure in higher level predators (e.g., hawks) are expected to be less because a large portion of their diet is comprised of herbivorous rodents which do not accumulate pesticides to the same degree as soil invertebrates. No (for accumulation in plants). See reasons presented above.
Surface soil (cinder ballast & soil)	All areas	Terrestrial wildlife	Dermal contact	No. Exposures expected to be less than ingestion pathways.

AR105230

TABLE 4-1 (Continued)

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Surface soil (cinder ballast)	Central Operations North Yard/North Tail South Yard/South Tail Slaters Lane	Terrestrial invertebrates	Ingestion, dermal contact	No. No or limited soil invertebrate community present. Gravel and cinder-based ballast do not provide a suitable habitat for soil invertebrates due to (1) very large particle sizes of some surface materials (gravel-sized chunks); (2) the highly mineral nature of ballast material; (3) the presence of carbon in a form typical of coal deposits and not the humic material of soils; and (4) the low availability of nutrients.
Surface soil	Potomac Greens	Terrestrial invertebrates	Ingestion, dermal contact	Yes (qualitative evaluation only). Few data are available for assessing toxicity in terrestrial invertebrates.
Surface Water				
Surface water	Four Mile Run Potomac River	Aquatic life	Respiration, dermal absorption, ingestion of chemicals transported from the site via surface runoff	Yes. Aquatic life could be continuously exposed to chemicals released from the site. Expected to be most sensitive environmental receptors associated with site releases.
		Terrestrial wildlife	Ingestion, dermal absorption of chemicals that have been transported from the site via surface runoff	No. Exposures and risks in terrestrial wildlife expected to be lower than those for aquatic life.
			Ingestion of aquatic prey that has accumulated chemicals released from the site	No. The majority of chemicals released to surface water do not bioaccumulate appreciably in aquatic life. Those that can are present at very low concentrations. Overall, exposures and risks expected to be lower than those for aquatic life.

AR105231

TABLE 4-1 (Continued)

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Surface water	Main Yard intermittent drainage ditches	Aquatic insects	Respiration, dermal exposures	No. Ditches at the site are intermittent and likely support minimal aquatic life. Ballast substrate not conducive to establishment of benthic community. Ditches are most important as a conduit for transport of chemicals to off site water bodies.
		Terrestrial wildlife	Ingestion, dermal absorption	No. Intermittent drainage ditches provide unreliable drinking water source. More reliable sources available nearby. Occasional intermittent use not likely to be associated with high exposures or risk.
			Ingestion of aquatic prey that has accumulated chemicals	No. Invertebrate prey in intermittent ditches expected to be sparse and therefore, ditches do not provide a reliable food source.
Surface water	Potomac Green ditches and ponded areas	Aquatic insects, amphibians	Respiration, dermal contact	Yes. Surface waters located on Potomac Greens are less ephemeral than those on the main yard. Also, provide better aquatic habitat due to presence of bank vegetation and more natural substrates.
		Terrestrial wildlife	Ingestion, dermal absorption	No. Exposures and risks in terrestrial wildlife expected to be lower than those for aquatic life.
			Ingestion of aquatic prey that has accumulated chemicals	No. The majority of chemicals detected in surface water do not bioaccumulate appreciably in aquatic life. Those that can are present at very low concentrations. Overall, exposures and risks expected to be lower than those for aquatic life.

AR105232

TABLE 4-1 (Continued)

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Sediment				
Sediment	Four Mile Run Potomac River	Benthic species	Ingestion, dermal absorption of chemicals that have been transported from the site via surface runoff	Yes. Benthic species could be continuously exposed to chemicals released to sediment. Along with other aquatic life, expected to be most sensitive environmental receptors associated with site releases.
		Terrestrial wildlife	Ingestion, dermal absorption of chemicals that have been transported from the site via surface runoff	No. Exposures and risks in terrestrial wildlife expected to be lower than those for aquatic life.
			Ingestion of aquatic prey that has accumulated chemicals released from the site	No. The majority of chemicals released to surface water do not bioaccumulate appreciably in aquatic life. Those that can are present at very low concentrations. Overall, exposures and risks expected to be lower than those for aquatic life.
Sediment	Main Yard intermittent drainage ditches	Aquatic insects	Ingestion, dermal absorption	No. Ballast substrate of Main Yard ditches not conducive to benthic community development.
		Terrestrial wildlife	Ingestion, dermal absorption	No. Intermittent drainage ditches provide unreliable drinking water source. More reliable sources available nearby. Occasional intermittent use not likely to be associated with high exposures or risk.
			Ingestion of aquatic prey that has accumulated chemicals	No. Invertebrate prey in intermittent ditches expected to be sparse and therefore, does not provide a reliable food source.

AR105233

TABLE 4-1 (Continued)

SUMMARY OF POTENTIAL SOIL, SURFACE WATER, AND SEDIMENT EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS

Exposure Medium	Exposure Area	Receptor	Exposure Route	Selected for Evaluation? Reason.
Sediment	Potomac Greens ditches and ponded areas	Aquatic insects, amphibians	Ingestion, dermal absorption	Yes. Surface waters located on Potomac Greens are less ephemeral than those on the main yard. Also, provide better aquatic habitat due to presence of bank vegetation and more natural substrates.
		Terrestrial wildlife	Ingestion, dermal absorption	No. Exposures and risks in terrestrial wildlife expected to be lower than those for aquatic life.
			Ingestion of aquatic prey that has accumulated chemicals	No. The majority of chemicals in surface water do not bioaccumulate appreciably in aquatic life. Those that can are present infrequently and at very low concentrations. Overall, exposures and risks expected to be lower than those for aquatic life.

AR105234

TABLE 4-2

DATA SUMMARY FOR CHEMICALS IN SURFACE SOIL: SOUTH YARD/SOUTH TAIL
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides/PCBs						
Chlordane	1 / 30	12	2.98	S25A'.25-B	1.75	2.00 - 4.8
alpha-Chlordane	1 / 28	10	2.98	S25A'.25-B	1.19	1.80 - 2.40
* 4,4-DDD	2 / 24	18	5.30 - 16.5	S5C-B	7.38	0.03 - 21.0
* 4,4-DDE	5 / 24	19	8.80 - 47.0	S10A-B	10.3	0.01 - 19.2
* 4,4-DDT	6 / 30	30	9.10 - 95.0	S7A-B	24.5	0.04 - 190
* Dieldrin	5 / 30	24	0.88 - 35.0	S28A'.75-B	7.53	0.01 - 19.2
Endosulfan I	1 / 24	18	7.30	S6B-B	3.62	0.05 - 10.4
Endosulfan II	1 / 24	18	12.4	S5C-B	7.34	0.01 - 19.2
Endosulfan sulfate	1 / 24	6	8.87	S5C-B	2.80	0.23 - 4.60
Endrin	1 / 24	2	0.97	S5C-B	0.49	0.02
Methoxychlor	1 / 24	2	7.29	S5C-B	3.80	0.63
* PCB 1260	10 / 34	33	56.0 - 460	S10A-B	91.5	34.0 - 520
Phthalates						
* Bis(2-ethylhexyl)phthalate	2 / 31	12	71.8 - 74.2	S5C-B	39.0	15.0 - 130
* Di-n-butyl phthalate	2 / 31	31	36.7 - 14,600	S25A'.25-B	749	16.0 - 3,400
Di-n-octyl phthalate	1 / 31	31	1600	S31A'.5-B	288	15.0 - 1,940
PAHs/Petroleum						
* Acenaphthene	2 / 31	5	66.0 - 96.0	S20BB.5-B	52.8	65.0 - 71.0
* Acenaphthylene	9 / 31	29	44.0 - 447	S15B-B	194	83.0 - 790
* Dibenz(a, h)anthracene	12 / 31	31	86.0 - 30,000	S28A'.75-B	1230	1.1 - 1,940
* Dibenzofuran	14 / 28	28	43.0 - 800	S12B-B	235	330 - 790
* Fluorene	2 / 31	31	811 - 1,300	S31A'.5-B	302	8.00 - 1,940
* 2-Methylnaphthalene	21 / 28	28	38.6 - 3,100	S12B-B	469	350 - 750
* Naphthalene	18 / 31	31	82.5 - 2,900	S12B-B	333	65.0 - 750
Total petroleum hydrocarbons	19 / 29	29	1,900 - 2,230,000	S9E-B	171,000	2,200 - 48,000
Volatiles						
Acetone	1 / 28	17	10.7	S8C-B	6.57	9.00 17.0
Benzene	2 / 28	28	4.00	S6B-B	3.05	5.00 7.00
2-Butanone	2 / 28	2	1.00 - 2.00	S15B-B	1.50	NA
Chloroform	2 / 28	2	1.66 - 1.69	S8C-B	1.68	NA
Methylene chloride	2 / 28	17	5.93 - 11.1	S5C-B	4.21	1.00 - 22.0
Tetrachloroethlene	3 / 28	28	4.40 - 62.0	S22A'.5-B	6.03	5.00 - 7.00
1,1,2,2-Tetrachloroethene	1 / 28	28	5.10	GW-59-B	3.03	5.00 - 7.00
Toluene	7 / 28	28	1.00 - 35.0	S22A'.5-B	5.10	5.00 - 7.00
Trichloroethene	2 / 28	28	9.50	S22A'.5-B	3.50	5.00 - 10.0
Xylenes (total)	2 / 24	24	3.00 - 16.0	S13A-B	3.47	5.00 - 7.00
m-Xylene	1 / 4	4	15	S22A'.5-B	6.05	5.7 - 6.5
o-Xylene	1 / 4	4	15	S22A'.5-B	6.05	5.7 - 6.5
Other Organics						
* 2,4-Dinitrophenol	2 / 27	3	240 - 260	S11E-B	181	88.0
* 2-Hexanone	2 / 28	2	2.00 - 3.00	S18AA-B	2.50	NA
Inorganics						
* Antimony	6 / 30	30	2.60 - 22.5	S15B-B	4.51	2.20 - 17.0
* Arsenic	25 / 30	30	3.90 - 588	S15AA.5-B	173	1.90 - 229
* Cadmium	16 / 30	30	0.52 - 3.11	S31A'.5-B	0.99	0.36 - 1.40
* Cobalt	11 / 30	30	2.84 - 30.6	S31A'.5-B	5.50	2.40 - 14.0
* Mercury	9 / 30	30	0.09 - 1.53	GW-60-B	0.12	0.05 - 0.14
Potassium	7 / 30	30	200 - 1,000	S15B-B	323	89.3 - 1,400
* Silver	2 / 30	30	0.55 - 2.82	S31A'.5-B	0.64	0.15 - 2.80
Sodium	10 / 30	30	53.7 - 1,140	S5F-B	257	37.6 - 1,400
* Thallium	2 / 30	24	0.40 - 0.42	S12B-B	0.26	0.23 - 0.71

/ = Not available. All non-detected samples had detection limits more than twice the maximum detected concentration.

* Selected as a chemical of potential concern. See text.

TABLE 4-2

DATA SUMMARY FOR CHEMICALS IN SURFACE SOIL:
SOUTH YARD/SOUTH TAIL

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.

TABLE 4-3

DATA SUMMARY FOR CHEMICALS IN SURFACE SOILS:
POTOMAC GREENS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides/PCBs						
* beta-BHC	3 / 10	10	4.9 - 13	S10H-B	7.14	2.2 - 25
* Chlordane	1 / 10	9	23	DSA1-1-B	6.61	1.9 - 25
* alpha-Chlordane	1 / 9	9	23	DSA1-1-B	6.61	1.9 - 25
* beta-Chlordane	3 / 9	9	5.98 - 27	DSA1-1-B	8.14	2.2 - 25
* 4,4-DDD	1 / 10	6	10	S10G-B	3.87	3.8 - 8.6
* 4,4-DDE	2 / 10	6	3.6 - 4.4	S10H-B	3.22	4.3 - 8.6
* 4,4-DDT	3 / 10	7	5.8 - 20.9	GW-54-B	8.01	3.8 - 27
* Endosulfan I	1 / 10	4	2	S10H-B	1.36	2.2 - 2.4
* Endrin ketone	2 / 10	6	5.3 - 13	DSA3-B	5.63	4.3 - 17
* Heptachlor	2 / 10	5	2.38 - 3.2	S10H-B	2.01	2.2 - 4.3
* PCB 1260	1 / 10	6	44	S10G-B	28.8	38 - 86
Phthalates						
* Bis(2-ethylhexyl)phthalate	1 / 10	4	76	S10H-B	62	84 - 140
* Di-n-butyl phthalate	1 / 10	2	93	DSA3-B	84	150
* Di-n-octylphthalate	1 / 10	7	443	GW-53-B	316	140 - 880
PAHs/Petroleum						
* Dibenz(a,h)anthracene	1 / 10	8	1,020	S10H-B	436	350 - 1,100
Total petroleum hydrocarbons	5 / 10	10	3,500 - 94,000	GW-55-B	37,700	13,000 - 16,000
Volatiles						
2-Butanone	1 / 9	2	16	DSA3-1-B	10.8	11
Tetrachloroethene	1 / 9	9	12.9	S10H-B	4.48	6 - 8.3
Toluene	1 / 9	9	4.7	S10H-B	3.58	6 - 8.3
Trichloroethene	1 / 9	8	3.7	S10H-B	3.38	6 - 7.3
Inorganics						
* Antimony	2 / 10	9	2.83 - 3	DSA2-B	1.78	2.3 - 4.2
* Cadmium	2 / 10	10	0.75 - 1.3	DSA3-B	0.42	0.33 - 1
* Mercury	4 / 10	10	0.1 - 0.2	FA-B	0.1	0.12 - 0.17
* Silver	1 / 10	10	2.3	DSA1-1-B	0.78	0.87 - 2
Sodium	4 / 10	9	171 - 313	FA-B	168	81.6 - 540
* Thallium	2 / 10	10	0.78 - 1.2	FA-B	0.55	0.54 - 2

* Selected as a chemical of potential concern. See text.

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.

TABLE 4-4

DATA SUMMARY FOR CHEMICALS IN SURFACE WATER:
POTOMAC GREENS
(Concentrations reported in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides						
* Aldrin	1 / 4	4	0.08	NPDSW-1	0.04	0.05
* beta-chlordane	1 / 4	4	0.09	NPDSW-1	0.04	0.05
* Endosulfan sulfate	1 / 4	4	0.33	NPDSW-1	0.12	0.11
* Endrin	1 / 4	4	0.13	NPDSW-1	0.07	0.11
* Heptachlor epoxide	1 / 4	4	0.06	NPDSW-1	0.03	0.05
PAHs/Petroleum						
* Anthracene	1 / 5	5	15.0	NPDSW-1	7.30	10.0 - 11.0
* Benzo(a)anthracene	1 / 5	5	30.0	NPDSW-1	10.3	10.0 - 11.0
* Benzo(g,h,i)perylene	1 / 5	5	5.60	NPDSW-1	5.42	10.0 - 11.0
* Chrysene	1 / 5	5	45.0	NPDSW-1	13.3	10.0 - 11.0
* Fluoranthene	1 / 5	5	82.0	NPDSW-1	20.7	10.0 - 11.0
* Indeno(1,2,3-c,d)pyrene	1 / 5	1	2.60	NPDSW-1	2.60	NA
* Phenanthrene	1 / 5	5	47.0	NPDSW-1	13.70	10.0 - 11.0
* Pyrene	1 / 5	1	2.70	NPDSW-1	2.70	NA
Total petroleum hydrocarbons	1 / 4	4	21,000	NPDSW-1	5,330	200
Volatiles						
* Benzene	1 / 4	4	41.0	NPDSW-1	10.6	1.00
* Carbon disulfide	1 / 4	4	48.0	NPDSW-1	19.5	20.0
* Ethylbenzene	1 / 4	4	17.0	NPDSW-1	4.63	1.00
* Xylenes	2 / 8	8	75.0	NPDSW-1	19.9	3.00
Inorganics (f)						
* Arsenic	1 / 4	4	10.7	MPDSW-1	4.18	4.00
Calcium	4 / 4	4	12,000 - 150,000	SPDSW-2	62,600	NA
* Iron	1 / 4	4	831	SPDSW-1	226	35.0
Magnesium	3 / 4	4	8,480 - 27,300	SPDSW-2	12,200	830
* Manganese	3 / 4	4	107 - 487	SPDSW-1	265	15.0
Potassium	2 / 4	4	5,600 - 9,660	SPDSW-2	4,560	1,390 - 4540
Sodium	4 / 4	4	12,100 - 24,100	MPDSW-1	16,800	NA
* Zinc	2 / 4	4	175 - 650	NPDSW-1	211	20.0

* Selected as a chemical of potential concern. See text.

NA = Not available. Either all non-detected samples had detection limits more than twice the maximum detected concentration, or the chemical was detected in every sample.

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.
(f) Dissolved concentrations.

TABLE 4-5

DATA SUMMARY FOR CHEMICALS IN SEDIMENT:
POTOMAC GREENS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides						
* beta-BHC	2 / 4	4	20 - 98	NPDSED-1	31.0	6.00 - 6.10
* beta-Chlordane	1 / 4	3	6.90	SPDSED-1	4.32	6.00 - 6.10
* Endrin ketone	1 / 4	3	12.0	SPDSED-1	8.00	12.0
Phthalates						
* Bis(2-ethylhexyl)phthalate	1 / 4	3	1,500	SPDSED-1	617	320 - 380
* Di-n-octyl phthalate	2 / 4	2	150 - 370	MPDSED-1	260	NA
PAHs/petroleum						
* Acenaphthene	1 / 4	1	470	MPDSED-1	470	NA
* Anthracene	1 / 4	1	170	MPDSED-1	170	NA
* Benzo(a)anthracene	2 / 4	2	190 - 420	SPDSED-1	305	NA
* Benzo(a)pyrene	1 / 4	1	380	SPDSED-1	380	NA
* Benzo(g,h,i)perylene	1 / 4	1	340	SPDSED-1	340	NA
* Benzo(b)fluoranthene	1 / 4	1	470	SPDSED-1	470	NA
* Benzo(k)fluoranthene	2 / 4	2	300 - 360	MPDSED-1	330	NA
* Chrysene	2 / 4	2	230 - 500	SPDSED-1	365	NA
* Fluorene	1 / 4	1	340	MPDSED-1	340	NA
* Fluoranthene	3 / 4	3	130 - 960	SPDSED-1	573	NA
* Indeno(1,2,3-c,d)pyrene	1 / 4	1	320	SPDSED-1	320	NA
* Naphthalene	1 / 4	1	180	MPDSED-1	180	NA
* Phenanthrene	2 / 4	3	510 - 880	MPDSED-1	663	1,200
* Pyrene	3 / 4	3	160 - 820	SPDSED-1	507	NA
Total petroleum hydrocarbons	2 / 4	4	110,000 - 2,000,000	NPDSED-1	532,000	18,000
Inorganics						
* Aluminum	4 / 4	4	2,300 - 3,550	SPDSED-1	2,960	NA
* Arsenic	4 / 4	4	4.00 - 13.0	MPDSED-1	9.9	NA
Barium	4 / 4	4	74.6 - 204	SPDSED-1	132	NA
* Beryllium	1 / 4	4	13.3	SPDSED-2	4.36	0.20 - 6.30
* Cadmium	1 / 4	4	0.96	SPDSED-2	0.46	0.55 - 0.63
Calcium	4 / 4	4	1,720 - 4,240	MPDSED-1	2,970	NA
* Cobalt	2 / 4	4	9.8 - 10.1	SPDSED-1	6.06	4.20 - 4.50
* Copper	4 / 4	4	24.7 - 159	NPDSED-1	61.5	NA
* Iron	4 / 4	4	4,260 - 13,300	NPDSED-1	7,230	NA
* Lead	4 / 4	4	14.5 - 412	NPDSED-1	129	NA
Magnesium	2 / 4	4	972 - 1,180	NPDSED-1	706	472 - 871
* Manganese	4 / 4	4	63.6 - 185	SPDSED-1	123	NA
* Mercury	2 / 4	4	0.24 - 0.77	NPDSED-1	0.30	0.18 - 0.19
* Vanadium	4 / 4	4	15.8 - 39.4	NPDSED-1	23.6	NA
* Zinc	4 / 4	4	28.5 - 78.1	SPDSED-2	42.1	NA

* Selected as a chemical of potential concern. See text.

NA = Not available. Either all non-detected samples had detection limits more than twice the maximum detected concentration, or the chemical was detected in every sample.

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Includes detection limits that were greater than twice the maximum detected concentration.

TABLE 4-6

DATA SUMMARY FOR CHEMICALS IN SURFACE WATER:
FOUR MILE RUN OUTFALLS (Non-storm & Storm Events)
(Concentrations reported in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
NON-STORM EVENT						
Phthalates						
* Di-methyl phthalate	1 / 5	1	4.00	SSSW-5	4.00	NA
PAHs/Petroleum						
* Pyrene	1 / 6	1	0.35	SSSW-2	0.35	NA
Volatiles						
* Chlorobenzene	1 / 5	3	1.00	EPASW-13	0.67	1.00
* 1,1-Dichloroethene	1 / 5	3	1.00	EPASW-13	0.67	1.00
* Tetrachloroethene	1 / 5	3	2.00	SW12	1.00	1.00
Other organics						
* 2,6-Dinitrotoluene	1 / 5	5	13.0	SSSW-5	6.60	10.0
* N-nitrosodi-N-propylamine	1 / 5	5	12.0	SSSW-5	6.4	10.0
Inorganics (f)						
* Aluminum	1 / 7	7	345	SW12	109	120 - 177
* Arsenic	3 / 7	7	206 - 375	EPASW-13	118	3.60 - 4.00
Calcium	7 / 7	7	19,600 - 57,400	SSSW-5	29,800	NA
Magnesium	3 / 7	7	5,560 - 11,000	SSSW-5	4,250	2,530 - 4,640
* Manganese	2 / 7	7	15.2 - 1,050	SSSW-5	156	1.7 - 15
Sodium	7 / 7	7	5,740 - 12,600	SSSW-5	8,160	NA
* Zinc	6 / 7	7	42.6 - 553	EPASW-11	143	20.0
STORM EVENT						
Phthalates						
* Bis(2-ethylhexyl)phthalate	2 / 5	2	2.00	SSSW-3ST	2.00	NA
Volatiles						
* Trichloroethene	1 / 5	5	13.0	SSSW-2ST	3.00	1.00
Other Organics						
* 2,6-Dinitrotoluene	1 / 5	5	14.0	SSSW-5ST	6.80	10
Inorganics (f)						
* Aluminum	3 / 8	8	223 - 441	SSSW-6F	173	100 - 145
* Arsenic	4 / 8	8	11.8 - 162	SSSW-2F	35.0	4.00 - 6.90
Calcium	8 / 8	8	14,400 - 22,000	SSSW-2F	17,500	NA
* Iron	8 / 8	8	147 - 861	SSSW-6P	538	NA
* Lead	5 / 8	8	3.00 - 4.90	SSSW-1P	3.04	3.00
Potassium	2 / 8	8	5,700 - 6,040	SSSW-6P	2,310	1,810 - 3,010
* Zinc	6 / 8	8	28.0 - 115	SSSW-2P	48.4	12.0 - 14.0

* Selected as a chemical of potential concern. See text.

NA = Not available. Either all non-detected samples had detection limits more than twice the maximum detected concentration, or the chemical was detected in every sample.

(a) Number of samples in which chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.
(f) Dissolved concentrations.

TABLE 4-7

DATA SUMMARY FOR CHEMICALS IN SURFACE WATER:
POTOMAC RIVER OUTFALLS
(Concentrations reported in ug/L)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides						
* Aldrin	1 / 3	3	0.07	NPDSW-2	0.04	0.05
* beta-chlordane	1 / 3	3	0.06	SPDSW-3	0.04	0.05
* Endosulfan sulfate	2 / 3	3	0.16 - 0.17	NPDSW-2	0.13	0.10
* Heptachlor	1 / 3	3	0.06	NPDSW-2	0.40	0.05
Phthalates						
* Bis(2-ethylhexyl)phthalate	1 / 4	2	2.00	NPDSW-2	1.25	1.00
* Butylbenzylphthalate	1 / 4	2	1.30	SPDSW-3	0.78	0.5
* Di-n-octyl phthalate	1 / 4	2	1.80	SPDSW-3	1.40	2.00
PAHs/Petroleum						
* Benzo(a)anthracene	1 / 5	2	4.80	NPDSW-2	2.40	0.01
* Benzo(g,h,i)perylene	1 / 5	2	0.74	NPDSW-2	0.39	0.08
* Chrysene	1 / 5	3	1.90	SPDSW-3	0.80	0.16 - 0.82
* Fluoranthene	2 / 5	5	4.40 - 11.0	NPDSW-2	5.10	0.22 - 10.0
* Phenanthrene	2 / 5	5	2.00 - 7.20	NPDSW-2	3.91	0.67 - 10.0
* Pyrene	1 / 5	3	2.70	SPDSW-3	1.20	0.28 - 1.50
Total petroleum hydrocarbons	2 / 3	3	1,300 - 17,000	NPDSW-2	6,130	200
Volatiles						
* Benzene	1 / 3	3	6.00	NPDSW-2	2.33	1.00
* Ethylbenzene	1 / 3	3	2.20	NPDSW-2	1.07	1.00
Toluene	1 / 3	3	19.0	NPDSW-2	6.67	1.00
Xylenes	2 / 4	4	16.0	NPDSW-2	8.75	3.00
Other organics						
* Carbon disulfide	1 / 3	1	6.90	NPDSW-2	6.90	NA
Inorganics (f)						
Calcium	3 / 3	3	18,100 - 63,800	NPDSW-2	34,900	NA
* Iron	1 / 3	3	111	SPDSW-3	48.7	35.0
Magnesium	1 / 3	3	11,800	NPDSW-2	5050	2,970 - 3,700
* Manganese	3 / 3	3	85.3 - 316	NPDSW-2	184	NA
Potassium	1 / 3	3	5,920	NPDSW-2	3,100	2,430 - 4,350
Sodium	3 / 3	3	13,200 - 23,300	NPDSW-2	19,600	NA
* Zinc	2 / 3	3	113 - 299	NPDSW-2	141	20.0

* Selected as a chemical of potential concentration. See text.

NA = Not available. All non-detected samples had detection limits more than twice the maximum detected concentration. or the chemcial was detected in every sample.

(a) Number of samples in which chemical was detected divided by the total number of samples analyzed for that chemical.

(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.

(c) See plate 5-1 of the ECS Report for sample location.

(d) Arithmetic mean concentration.

(e) Excludes detection limits that were greater than twice the maximum detected concentration.

(f) Dissolved concentrations.

TABLE 4-8

DATA SUMMARY FOR CHEMICALS IN SEDIMENT:
FOUR MILE RUN OUTFALLS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Pesticides						
* beta-BHC	1 / 4	4	5.2	SSSED-7	2.89	4.00 - 4.50
* delta-BHC	1 / 4	4	7.9	SSSED-6	3.59	4.20 - 4.50
* Endrin ketone	1 / 4	4	8	SSSED-6	5.21	8.30 - 8.90
* Methoxychlor	1 / 4	4	160	SSSED-6	56.1	42.0 - 45.0
Phthalates						
* Di-n-butyl phthalate	2 / 5	4	250	SSED-5 DUP	226	400 - 410
PAHs/Petroleum						
* Acenaphthylene	1 / 8	7	560	SSSED-5	272	110 - 840
* Benzo(a)anthracene	3 / 8	4	28.0 - 51.0	SSSED-7	29.2	1.50
* Benzo(b)fluoranthene	1 / 8	4	110	SSSED-7	53.4	5.50 - 120
* Benzo(k)fluoranthene	2 / 8	8	100 - 340	SSSED-3	124	1.90 - 450
* Benzo(a)pyrene	3 / 8	4	59.0 - 110	SSSED-7	64.5	2.10
* Chrysene	4 / 8	6	48.0 - 120	SSSED-3	59.0	7.00 - 31.0
* Dibenzo(a,h)anthracene	2 / 8	8	340 - 4,600	SSSED-6	757	13.0 - 840
* Fluorene	1 / 8	3	170	SSSED-7	66.0	9.90 - 46
* Fluoranthene	5 / 8	6	85.0 - 150	SSSED-7	94.0	9.90
* 2-Methylnaphthalene	1 / 4	1	55.0	SSSED-7	55.0	NA
* Phenanthrene	1 / 8	4	70.0	SSSED-7	55.0	30.0 - 140
* Pyrene	3 / 8	5	45.0 - 180	SSSED-5	66.3	13.0 - 56.0
ganics						
* Aluminum	4 / 4	4	831 - 3,380	SSSED-6	1,990	NA
* Arsenic	1 / 4	4	8.10	SSSED-6	4.09	3.90 - 6.80
Barium	1 / 4	3	35.0	SSSED-7	20.5	25.3 - 27.9
Calcium	4 / 4	4	991 - 13,600	SSSED-6	4,560	NA
* Copper	4 / 4	4	10.8 - 393	SSSED-5	119	NA
* Iron	4 / 4	4	3,060 - 9,440	SSSED-6	5,920	NA
* Lead	4 / 4	4	11.9 - 21.3	SSSED-6	15.6	NA
Magnesium	1 / 4	4	2,190	SSSED-7	832	283 - 1,580
* Manganese	4 / 4	4	105 - 1120	SSSED-6	390	NA
* Vanadium	2 / 4	4	11.5 - 24.9	SSSED-6	10.5	5.40 - 5.90
* Zinc	4 / 4	4	28.1 - 193	SSSED-6	81.4	NA

* Selected as a chemical of potential concern. See text.

NA = Not available. Either all non-detected samples had detection limits more than twice the maximum detected concentration, or the chemical was detected in every sample.

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.

TABLE 4-9

DATA SUMMARY FOR CHEMICALS IN SEDIMENT
POTOMAC RIVER OUTFALLS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Frequency of Detection (a)	Mean Sample Size (b)	Range of Detected Concentrations	Location of Maximum (c)	Average Concentration (d)	Range of Detection Limits (e)
Phthalates						
* Bis(2-ethylhexyl)phthalate	1 / 4	2	360	NYSED-2	275	380
* Di-n-bytyl phthalate	1 / 4	4	31,000	NYSED-2	10800	340 - 23,000
PAHs/Petroleum						
* Acenaphthene	1 / 4	2	120	NYSED-2	83.8	95.0
* Anthracene	1 / 4	2	170	NYSED-2	93.8	35.0
* Benzo(a)anthracene	2 / 4	2	37.0 - 430	NYSED-2	234	NA
* Benzo(a)pyrene	1 / 4	2	410	NYSED-2	206	5.40
* Benzo(b)fluoranthene	1 / 4	2	390	NYSED-2	196	4.60
* Benzo(g,h,i)perylene	1 / 4	2	220	NYSED-2	113	13.0
* Benzo(k)fluoranthene	1 / 4	2	440	NYSED-2	220	0.89
* Chrysene	2 / 4	2	71.0 - 460	NYSED-2	266	NA
* Dibenzofuran	1 / 3	1	58.0	NYSED-2	58	NA
* Fluorene	1 / 4	2	110	NYSED-2	58	11.0
* Fluoranthene	3 / 4	3	49 - 1100	NYSED-2	246	NA
* Indeno (1,2,3-c,d)pyrene	1 / 4	2	210	NYSED-2	119	56.0
* Phenanthrene	2 / 4	3	45.0 - 720	NYSED-2	455	1,200
* Pyrene	3 / 4	3	120 - 570	NYSED-2	283	NA
Total petroleum hydrocarbons	2 / 3	3	350,000 - 810,000	NPDSED-2	390,000	18,000
Inorganics						
* Aluminum	3 / 3	3	2,070 - 3,550	SPDSED-2	3040	NA
Arsenic	3 / 3	3	2.30 - 13.7	NPDSED-2	8.57	NA
Barium	3 / 3	3	45.4 - 204	SPDSED-2	147	NA
Beryllium	2 / 3	3	0.96 - 13.3	SPDSED-2	4.79	0.20
* Cadmium	3 / 3	3	0.96 - 1.30	NYSED-2	1.12	NA
Calcium	3 / 3	3	1,860 - 2,950	SPDSED-2	2500	NA
* Cobalt	1 / 3	3	10.0	NPDSED-2	5.12	4.50 - 6.20
* Copper	3 / 3	3	37.4 - 83.4	NPDSED-2	60.4	NA
* Iron	3 / 3	3	5,940 - 8,810	NPDSED-2	7040	NA
* Lead	3 / 3	3	44.5 - 183	NPDSED-2	93.4	NA
Magnesium	1 / 3	3	1,290	NYSED-2	625	472 - 699
* Manganese	3 / 3	3	63.6 - 171	NPDSED-2	110	NA
* Mercury	1 / 3	3	0.30	NPDSED-2	0.16	0.16 - 0.18
Sodium	1 / 3	3	2,680	NYSED-2	939	135 - 138
* Vanadium	3 / 3	3	13.7 - 23.4	SPDSED-2	19.2	NA
* Zinc	3 / 3	3	78.1 - 181	NYSED-2		NA

* Selected as a chemical of potential concentration. See text.

NA = Not available. All non-detected samples had detection limits more than twice the maximm detected concentrations or chemical detected in every sample.

(a) Number of samples in which the chemical was detected divided by the total number of samples analyzed for that chemical.
(b) Number of samples considered valid for calculation of the mean concentration. Excludes those non-detect samples in which the detection limit was more than twice the maximum detected value. Also excludes samples eliminated as a result of data validation.
(c) See Plate 5-1 of the ECS Report for sample location.
(d) Arithmetic mean concentration.
(e) Excludes detection limits that were greater than twice the maximum detected concentration.

TABLE 4-10

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SURFACE SOIL:
SOUTH YARD/SOUTH TAIL
(Concentrations reported in mg/kg)

Chemical	TSV (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)		Hazard Quotient (Maximum)	
	Acute	Chronic			Acute	Chronic	Acute	Chronic
Pesticides/PCBs								
4,4-DDD	2,100	94	0.00738	0.0165	0.000004	0.00008	0.000008	0.0002
4,4-DDE	920	11	0.0103	0.047	0.00001	0.0009	0.00005	0.004
4,4-DDT	630	22	0.0245	0.095	0.00004	0.001	0.0002	0.004
Dieldrin	240	6	0.00753	0.035	0.00003	0.001	0.0001	0.006
PCB 1260	830	83	0.0915	0.46	0.0001	0.001	0.0006	0.006
Phthalates								
Bis(2-ethylhexyl)phthalate	1,900	1,400	0.0390	0.0742	0.00002	0.00003	0.00004	0.00005
Di-n-butyl phthalate	5,600	1,400	0.749	14.6	0.0001	0.0005	0.003	0.01
PAHs								
Acenaphthene	NA	22,000	0.0528	0.0960	NC	0.000002	NC	0.000004
Acenaphthylene	NA	22,000	0.194	0.447	NC	0.000009	NC	0.00002
Dibenz(a, h)anthracene	NA	22,000	1.23	30.0	NC	0.00006	NC	0.001
Dibenzofuran	NA	22,000	0.235	0.800	NC	0.00001	NC	0.00004
Fluorene	NA	22,000	0.302	1.30	NC	0.00001	NC	0.00006
2-Methylnaphthalene	NA	22,000	0.469	3.10	NC	0.00002	NC	0.0001
Naphthalene	NA	22,000	0.333	2.90	NC	0.00002	NC	0.0001
Other Organics								
2-Butanone	NA	NA	0.00150	0.002	NC	NC	NC	NC
2,4-Dinitrophenol	NA	NA	0.181	0.260	NC	NC	NC	NC
2-Hexanone	NA	NA	0.00250	0.003	NC	NC	NC	NC
Inorganics								
Antimony	NA	NA	4.51	22.5	NC	NC	NC	NC
Arsenic	8,800	560	173	588	0.02	0.3	0.1	1
Cadmium	850	6	0.99	3.11	0.001	0.2	0.004	0.5
Cobalt	NA	26	5.50	30.6	NC	0.2	NC	1
Mercury	580	4	0.12	1.53	0.0002	0.03	0.003	0.4
Silver	NA	1,700	0.64	2.82	NC	0.0004	NC	0.002
Thallium	640	NA	0.26	0.42	0.0004	NC	0.0007	NC

NA = Not available.
NC = Not calculated.

(a) Based on soil ingestion pathway for birds. See Appendix H for basis of derivation.

TABLE 4-11

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO
TOXICITY SCREENING VALUES (TSVs):
SOUTH YARD/SOUTH TAIL SURFACE SOIL
(Concentrations reported in mg/kg)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			Acute	Chronic
Pesticides/PCBs				
9H-Carbazole	3	0.41 - 0.45	NA	NA
Chlordane	18	0.018 - 1.889	270	NA
alpha-Chlordane	18	0.009 - 0.096	NA	NA
4,4-DDD	6	0.09 - 0.19	2,100	94
4,4-DDE	5	0.18 - 0.19	920	11
Dieldrin	6	0.09 - 0.19	240	6
Endosulfan I	6	0.045 - 0.095	640	NA
Endosulfan II	6	0.09 - 0.19	NA	NA
Endosulfan sulfate	18	0.018 - 0.19	NA	NA
Endrin	22	0.0036 - 0.19	NA	NA
Methoxychlor	22	0.018 - 0.95	NA	NA
PCB 1260	1	1.9	830	83
Phthalates				
Bis(2-ethylhexyl)phthalate	19	0.16 - 1.94	1,900	1,400
PAHs				
Acenaphthene	26	0.33 - 1.94	NA	22,000
Acenaphthylene	2	1.9 - 1.94	NA	22,000
Anthracene	1	1.94	NA	NA
Volatiles				
Acetone	11	0.03 - 0.14	NA	NA
Chloroform	26	0.005 - 0.007	NA	NA
Methylene chloride	11	0.024 - 0.16	NA	NA
Other Organics				
2-Butanone	26	0.01 - 0.14	NA	NA
2,4-Dinitrophenol	24	0.88 - 4.704	NA	NA
2-Hexanone	26	0.01 - 0.068	NA	NA
Inorganics				
Thallium	6	0.95 - 2.8	640	NA

NA = Not available.
NC = Not calculated.

(a) Based on soil ingestion pathway for birds. See Appendix H for basis of derivation.

TABLE 4-12

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SURFACE WATER:
POTOMAC GREENS
(Concentrations reported in ug/L)

Chemical	TSV (a)	Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)	Hazard Quotient (Maximum)
Pesticides/PCBs					
Aldrin	3	0.04	0.08	0.0E+00	0.0E+00
beta-Chlordane	NA	0.04	0.09	NC	NC
Endosulfan sulfate	NA	0.12	0.33	NC	NC
Endrin	0.0023	0.07	0.13	3E+01	6E+01
Heptachlor epoxide	0.0038	0.03	0.06	8E+00	2E+01
PAHs					
Anthracene	0.1	7.3	15	7E+01	2E+02
Benzo(a)anthracene	6.3	10.3	30	2E+00	5E+00
Benzo(g,h,i)perylene	NA	5.42	5.6	NC	NC
Chrysene	NA	13.3	45	NC	NC
Fluoranthene	3,980	20.7	82	5E-03	2E-02
Indeno(1,2,3-c,d)pyrene	NA	2.60	2.6	NC	NC
Phenanthrene	6.3 (b)	13.7	47	2E+00	7E+00
Pyrene	NA	2.7	2.7	NC	NC
Volatiles					
Benzene	5,300	10.6	41	2E-03	8E-03
Carbon disulfide	2	19.5	48	1E+01	2E+01
Ethylbenzene	32,000	4.63	17	1E-04	5E-04
Xylenes	6,000	19.9	75	3E-03	1E-02
Inorganics					
Arsenic	874	4.2	10.7	5E-03	1E-02
Iron	320 (c)	226	831	7E-01	3E+00
Manganese	14,500 (d,e)	265	487	3E+00	3E-02
Zinc	30 (e)	211	650	7E+00	2E+01

NA = Not available.
NC = Not calculated.

(a) Based on EPA Region III.
(b) Proposed criterion.
(c) Invertebrate.
(d) pH-dependent criterion.
(e) Hardness-dependent criterion.

TABLE 4-13

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO TOXICITY SCREENING VALUES (TSVs): POTOMAC GREENS SURFACE SOIL (Concentrations reported in mg/kg)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			Acute	Chronic
Pesticides/PCBs				
2-Butanone	7	0.11 - 0.15	NA	NA
Chlordane	1	0.084	5	NA
4,4-DDD	4	0.027 - 0.05	38	1.7
4,4-DDE	4	0.027 - 0.05	17	0.2
4,4-DDT	3	0.044 - 0.05	11	0.4
Endosulfan I	6	0.0043 - 0.025	12	NA
Endrin ketone	4	0.027 - 0.05	1	0.03
Heptachlor	5	0.0084 - 0.025	6	0.03
PCB 1260	4	0.27 - 0.5	15	1.5
Phthalates				
Bis(2-ethylhexyl)phthalate	6	0.35 - 2.2	1,900	1,400
Di-n-butyl phthalate	8	0.35 - 2.5	5,600	1,400
Di-n-octylphthalate	3	1.1 - 2.5	5,600	1,400
PAHs				
Anthracene	8	0.35 - 2.5	NA	NA
Benzo(a)anthracene	4	0.87 - 2.5	NA	NA
Benzo(a)pyrene	3	0.87 - 2.5	NA	NA
Benzo(b)fluoranthene	2	0.87 - 0.88	NA	NA
Benzo(g,h,i)perylene	4	0.87 - 2.5	NA	NA
Benzo(k)fluoranthene	3	0.88 - 2.5	NA	NA
Chrysene	1	2.5	NA	NA
Dibenzo(a,h)anthracene	2	2.2 - 2.5	NA	22,000
Fluoranthene	1	2.5	NA	NA
Indeno(1,2,3-c,d)pyrene	2	2.2 - 2.5	NA	NA
Phenanthrene	4	0.87 - 2.5	NA	NA
Pyrene	1	2.5	NA	NA
Volatiles				
Trichloroethylene	1	0.0083	NA	NA
Inorganics				
Antimony	1	12	NA	NA
Sodium	1	1000	NA	NA

NA = Not available.
NC = Not calculated.

(a) Values for pesticides/PCBs based on soil-to-worm-to-bird diet exposure pathway. Values for other chemicals are based on soil ingestion pathway for birds. See Appendix H for derivation.

TABLE 4-14

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SURFACE WATER:
POTOMAC GREENS
(Concentrations reported in ug/L)

Chemical	TSV (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)		Hazard Quotient (Maximum)	
	Acute	Chronic			Acute	Chronic	Acute	Chronic
Pesticides/PCBs								
Aldrin	3	NA	0.04	0.08	0.01	NC	0.03	NC
beta-Chlordane	2.4 (b)	0.0043 (b)	0.04	0.09	0.02	9	0.04	20
Endosulfan sulfate	0.22 (c)	0.056 (c)	0.12	0.33	0.5	2	2	10
Endrin	0.18	0.0023	0.07	0.13	0.4	30	1	60
Heptachlor epoxide	0.52	0.0038	0.03	0.06	0.06	8	0.1	20
PAHs								
Anthracene	30 (d,e)	6.3 (d,e)	7.30	15.0	0.2	1	0.5	2
Benzo(a)anthracene	3,980 (f,g)	NA	10.3	30.0	0.003	NC	0.01	NC
Benzo(g,h,i)perylene	3,980 (f,g)	NA	5.42	5.60	0.001	NC	0.001	NC
Chrysene	3,980 (f,g)	NA	13.3	45.0	0.003	NC	0.01	NC
Fluoranthene	3,980 (f,g)	NA	20.7	82.0	0.005	NC	0.02	NC
Indeno(1,2,3-c,d)pyrene	3,980 (f,g)	NA	2.60	2.60	0.0007	NC	0.0007	NC
Phenanthrene	3,980	NA	13.7	47.0	0.003	NC	0.01	NC
Pyrene	3,980 (f,g)	NA	2.70	2.70	0.0007	NC	0.0007	NC
Volatiles								
Benzene	5,300 (d)	NA	10.6	41.0	0.002	NC	0.01	NC
Carbon disulfide	NA	NA	19.5	48.0	NC	NC	NC	NC
Ethylbenzene	32,000 (d)	NA	4.63	17.0	0.0001	NC	0.0005	NC
Xylenes	NA	NA	19.9	75.0	NC	NC	NC	NC
Inorganics (h)								
Arsenic	360 (i)	190 (i)	4.18	10.7	0.01	0.02	0.03	0.06
Iron	NA	1,000	226	831	NC	0.2	NC	1
Manganese	NA	NA	265	487	NC	NC	NC	NC
Zinc	139 (i, j)	127 (i, j)	211	650	2	2	5	5

NA = Not available.
NC = Not calculated.

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Value is for chlordane.
(c) Value is for endosulfan.
(d) Proposed criterion.
(e) Value is for phenanthrene
(f) Lowest-observed-effect level identified by EPA (1995a).
(g) Value is for fluoranthene.
(h) Dissolved concentrations.
(i) Dissolved criterion. Calculated from total recoverable criterion using EPA (1993a, 1995b) conversion factors, as follows: arsenic = 1; zinc = 0.978 (acute); 0.986 (chronic).
(j) Hardness-dependent criterion. A hardness of 126 mg CaCO3/L used based on site-specific data.

TABLE 4-15

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO
TOXICITY SCREENING VALUES (TSVs):
POTOMAC GREENS SURFACE WATER
(Concentrations reported in ug/L)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			Acute	Chronic
PAHs				
Indeno(1,2,3-c,d)pyrene	4	10 - 11	3,980 (b,c)	NA
Pyrene	4	10 - 11	3,980 (b,c)	NA

NA = Not available.
NC = Not calculated.

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Lowest-observed-effect level identified by EPA (1995a).
(c) Value is for fluoranthene.

TABLE 4-16

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SEDIMENT:
POTOMAC GREENS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	TSV (a) ER-L	TSV (a) ER-M	Mean Concentration	Maximum Concentrations	Hazard Quotient (Mean) ER-L	Hazard Quotient (Mean) ER-M	Hazard Quotient (Maximum) ER-L	Hazard Quotient (Maximum) ER-M
Pesticides								
beta-BHC	NA	NA	31.0	98	NC	NC	NC	NC
beta-Chlordane	0.5 (b,f)	6 (b,f)	4.32	6.9	9	0.7	10	1
Endrin ketone	0.02 (b,e)	45 (b,e)	8.00	12	400	0.2	600	0.3
Phthalates								
Bis(2-ethylhexyl)phthalate	NA	NA	617	1,500	NC	NC	NC	NC
Di-n-octyl phthalate	NA	NA	260	370	NC	NC	NC	NC
PAHs								
Acenaphthene	22,100 (c)	--	470	470	0.02	NC	0.02	NC
Anthracene	85.3	1,100	170	170	2	0.2	2	0.2
Benzo(a)anthracene	261	1,600	305	420	1	0.2	2	0.3
Benzo(g,h,i)perylene	430 (d)	1,600 (d)	340	340	0.8	0.2	0.8	0.2
Benzo(b)fluoranthene	430 (d)	1,600 (d)	470	470	1	0.3	1	0.3
Benzo(k)fluoranthene	430 (d)	1,600 (d)	330	360	0.8	0.2	0.8	0.2
Chrysene	384	2,800	365	500	1	0.1	1	0.2
Fluorene	19	540	340	340	20	0.6	20	0.6
Fluoranthene	15,300 (c)	--	573	960	0.04	NC	0.1	NC
Indeno(1,2,3-c,d)pyrene	430 (d)	1,600 (d)	320	320	0.7	0.2	0.7	0.2
Naphthalene	160	2,106	180	180	1	0.09	1	0.
Phenanthrene	1,800 (c)	--	663	880	0.4	NC	0.5	NC
Pyrene	665	2,600	507	820	0.8	0.2	1	0.3
Inorganics								
Aluminum	NA	NA	2,960	3,550	NC	NC	NC	NC
Arsenic	8.2	70	9.9	13.0	1	0.1	2	0.2
Barium	NA	NA	132	204	NC	NC	NC	NC
Beryllium	NA	NA	4.36	13.3	NC	NC	NC	NC
Cadmium	1.2	9.6	0.46	0.96	0.4	0.05	0.8	0.1
Cobalt	NA	NA	6.06	10.1	NC	NC	NC	NC
Copper	34	270	61.5	159	2	0.2	5	0.6
Iron	NA	NA	7,230	13,300	NC	NC	NC	NC
Lead	46.7	223	129	412	3	0.6	9	2
Manganese	NA	NA	123	185	NC	NC	NC	NC
Mercury	0.15	0.71	0.30	0.77	2	0.4	5	1
Vanadium	NA	NA	23.6	39.4	NC	NC	NC	NC
Zinc	150	410	42.1	78.1	0.3	0.1	0.5	0.2

NA = Not available.
NC = Not Calculated.
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected by Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range median (ER-M) is the 50th percentile of this distribution.
(b) ER-L and ER-M from Long and Morgan (1990).
(c) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediments, based on site-specific data.
(d) Value is for benzo(a)pyrene.
(e) Value is for endrin.
(f) Value is for chlordane.

TABLE 4-17

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO
TOXICITY SCREENING VALUES (TSVs):
POTOMAC GREENS SEDIMENT
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			ER-L	ER-M
Pesticides				
beta-Chlordane	1	35	0.5 (b,c)	6 (b,c)
Endrin ketone	1	70	0.02 (b,d)	45 (b,d)
Phthalates				
Bis(2-ethylhexyl)phthalate	1	68,000	NA	NA
Di-n-octyl phthalate	2	1,200 - 68,000	NA	NA
PAHs				
Acenaphthene	3	1,200 - 68,000	22,100 (e)	--
Anthracene	3	1,200 - 68,000	85.3	1,100
Benzo(a)anthracene	2	1,200 - 68,000	261	1,600
Benzo(a)pyrene	3	1,200 - 68,000	430	1,600
Benzo(b)fluoranthene	3	1,200 - 68,000	430 (f)	1,600 (f)
Benzo(g,h,i)perylene	3	1,200 - 68,000	430 (f)	1,600 (f)
Benzo(k)fluoranthene	2	1,200 - 68,000	430 (f)	1,600 (f)
Chrysene	2	1,200 - 68,000	384	2,800
Fluorene	3	1,200 - 68,000	19	540
Fluoranthene	1	68,000	15,300 (e)	--
Indeno(1,2,3-c,d)pyrene	3	1,200 - 68,000	430 (f)	1,600 (f)
Naphthalene	3	1,200 - 68,000	160	2,106
Phenanthrene	1	68,000	1,800 (e)	--
Pyrene	1	68,000	665	2,600

NA = Not available.
NC = Not calculated.
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range by median (ER-M) is the 50th percentile of this distribution.
(b) ER-L and ER-M from Long and Morgan (1990).
(c) Value is for chlordane.
(d) Value is for endrin.
(e) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediment, based on site-specific data.
(f) Value is for benzo(a)pyrene.

TABLE 4-18

COMPARISON OF TOXICITY SCREENING VALUES (TSVs) WITH CHEMICAL CONCENTRATIONS IN SURFACE WATER: FOUR-MILE RUN OUTFALLS (Non-storm & Storm Events) (Concentrations reported in ug/L)

Chemical	TSV (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)		Hazard Quotient (Maximum)	
	Acute	Chronic			Acute	Chronic	Acute	Chronic
NON-STORM EVENT								
Phthalates								
Di-methyl phthalate	2,100 (b,c)	160 (b,c)	4.00	4.00	0.002	0.03	0.002	0.03
PAHs								
Pyrene	3,980 (b,d)	NA (b,d)	0.35	0.35	0.00009	NC	0.00009	NC
Volatiles								
Chlorobenzene	NA	NA	0.67	1.00	NC	NC	NC	NC
1,1-Dichloroethene	118,000 (b,e)	20,000 (b,e)	0.67	1.00	0.000006	0.00003	0.000008	0.00005
Tetrachloroethene	5,280 (b)	840 (b)	1.00	2.00	0.0002	0.001	0.0004	0.002
Other organics								
2,6-Dinitrotoluene	330 (b,f)	230 (b,f)	6.60	13.0	0.02	0.03	0.04	0.06
N-nitrosodi-N-propylamine	NA	NA	6.4	12.0	NC	NC	NC	NC
Inorganics (g)								
Aluminum	750	87	109	345	0.1	1	0.5	4
Arsenic	360 (h)	190 (h)	118	375	0.3	0.6	1	2
Zinc	139 (h, i)	127 (h, i)	143	553	1	1	4	4
STORM EVENT								
Phthalates								
Bis(2-ethylhexyl)phthalate	2,100	160	2.00	2.00	0.001	0.01	0.001	0.01
latiles:								
Trichloroethene	45,000 (b)	21,900 (b)	3.00	13.0	0.00007	0.0001	0.0003	0.0006
Inorganics (g)								
Aluminum	750	87	173	441	0.2	2	0.6	5
Arsenic	360 (h)	190 (h)	35.0	162	0.1	0.2	0.5	0.9
Iron	NA	1,000	538	861	NC	0.5	NC	0.9
Lead	87 (h, i)	3 (h, i)	3.04	4.90	0.03	1	0.06	2
Zinc	139 (h, i)	127 (h, i)	48.4	115	0.3	0.4	0.8	0.9

NA = Not available.
NC = Not calculated.

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Lowest-observed-effect-level, as identified by EPA (1995a).
(c) Value is for bis-2-ethylhexyl phthalate.
(d) Value is for fluoranthene.
(e) Value is for 1,2-dichloroethane.
(f) Value is for 2,4-dinitrotoluene.
(g) Dissolved concentrations.
(h) Dissolved criterion. Calculated from total recoverable criterion using EPA (1993a, 1995b) conversion factors, as follows: arsenic = 1; zinc = 0.978 (acute); 0.986 (chronic); lead = 0.791.
(i) Hardness-dependent criterion. A hardness of 126 mg CaCO3/L used based on site-specific data.

TABLE 4-19

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SURFACE WATER:
POTOMAC RIVER OUTFALLS
(Concentrations reported in ug/L)

Chemical	Toxicity Screening Value (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (mean)		Hazard Quotient (maximum)	
	Acute	Chronic			Acute	Chronic	Acute	Chronic
Pesticides/PCBs								
Aldrin	3	NA	0.04	0.07	0.01	NC	0.02	NC
beta-Chlordane	2.4 (b)	0.0043 (b)	0.04	0.06	0.02	9	0.03	10
Endosulfan sulfate	0.22 (c)	0.056 (c)	0.13	0.17	0.6	2	0.8	3
Heptachlor	0.52	0.0038	0.04	0.06	0.08	10	0.1	20
Phthalates								
Bis(2-ethylhexyl)phthalate	2,100 (d)	160 (d)	1.25	2.00	0.0006	0.008	0.001	0.01
Butylbenzylphthalate	2,100 (d,e)	160 (d,e)	0.78	1.30	0.0004	0.005	0.001	0.01
Di-n-octyl phthalate	2,100 (d,e)	160 (d,e)	1.40	1.80	0.0007	0.009	0.001	0.01
PAHs								
Benzo(a)anthracene	3,980 (d,f)	NA	2.40	4.80	0.0006	NC	0.001	NC
Benzo(g,h,i)perylene	3,980 (d,f)	NA	0.39	0.74	0.0001	NC	0.0002	NC
Chrysene	3,980 (d,f)	NA	0.80	1.90	0.0002	NC	0.0005	NC
Fluoranthene	3,980 (d)	NA	5.10	11.0	0.001	NC	0.003	NC
Phenanthrene	30 (g)	6.3 (g)	3.91	7.20	0.1	0.6	0.2	1
Pyrene	3,980 (d,f)	NA	1.20	2.70	0.0003	NC	0.001	NC
Volatiles								
Benzene	5,300 (d)	NA	2.33	6.00	0.0004	NC	0.001	NC
Ethylbenzene	32,000 (d)	NA	1.07	2.20	0.00003	NC	0.0001	NC
Toluene	17,500 (d)	NA	6.67	19.0	0.0004	NC	0.001	NC
Xylenes	NA	NA	8.75	16.0	NC	NC	NC	NC
Other organics								
Carbon disulfide	NA	NA	6.90	6.90	NC	NC	NC	NC
Inorganics (h)								
Iron	NA	1000	48.7	111	NC	0.05	NC	0.1
Manganese	NA	NA	184	316	NC	NC	NC	NC
Zinc	139 (i, j)	127 (i, j)	141	299	1	1	2	2

NA = Not available.
NC = Not calculated

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Value is for Chlordane.
(c) Value is for endosulfan.
(d) Lowest-observed-effect-level, as identified by EPA (1995a).
(e) Value is for bis-2-ethylhexylphthalate.
(f) Value is for fluoranthene.
(g) Proposed criterion.
(h) Dissolved concentrations.
(i) Hardness-dependent criterion. A hardness of 126 mg CaCO3/L used based on site-specific data.
(j) Dissolved criterion. Calculated from total recoverable criterion using EPA (1993a, 1995b) conversion factors, as follows: zinc = 0.978 (acute); 0.986 (chronic).

TABLE 4-20

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO TOXICITY SCREENING VALUES (TSVs): FOUR-MILE RUN OUTFALLS (Non-storm & Storm Events) SURFACE WATER (Concentrations reported in ug/L)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			Acute	Chronic
NON-STORM EVENT				
Phthalates				
Di-methyl phthalate	4	10	2,100 (b,c)	160 (b,c)
PAHs				
Pyrene	5	10	3,980 (b,d)	NA (b,d)
Volatiles				
Chlorobenzene	2	5	NA	NA
1,1-Dichloroethylene	2	5	NA	NA
Tetrachloroethylene	2	5	5,280 (b)	840 (b)
STORM EVENT				
Phthalates				
Bis(2-ethylhexyl)phthalate	3	10	2,100 (b)	160 (b)

NA = Not available.
NC = Not calculated.

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Lowest-observed-effect-level, as identified by EPA (1995a).
(c) Value is for bis-2-ethylhexyl phthalate.
(d) Value is for fluoranthene.

TABLE 4-21

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO TOXICITY SCREENING VALUES (TSVs): POTOMAC RIVER OUTFALLS SURFACE WATER
(Concentrations reported in ug/L)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	Toxicity Screening Value (a)	
			Acute	Chronic
Phthalates				
Bis(2-ethylhexyl)phthalate	2	10 - 12	2,100 (b)	160 (b)
Butylbenzylphthalate	2	10	2,100 (b,c)	160 (b,c)
Di-n-octyl phthalate	2	10	2,100 (b,c)	160 (b,c)
PAHs				
Benzo(a)anthracene	3	10 - 11	3,980 (b,d)	NA
Benzo(g,h,i)perylene	3	10 - 11	3,980 (b,d)	NA
Chrysene	2	10	3,980 (b,d)	NA
Pyrene	2	10	3,980 (b,d)	NA
Other organics				
Carbon disulfide	2	20	NA	NA

NA = Not available.
NC = Not calculated.

(a) EPA Ambient Water Quality Criteria (AWQC) for the protection of freshwater aquatic life (EPA 1995a), except as noted.
(b) Lowest-observed-effect-level, as identified by EPA (1995a).
(c) Value is for bis-2-ethylhexylphthalate.
(d) Value is for fluoranthene.

TABLE 4-22

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SEDIMENT:
FOUR MILE RUN OUTFALLS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	TSV (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)		Hazard Quotient (Maximum)	
	ER-L	ER-M			ER-L	ER-M	ER-L	ER-M
Pesticides								
beta-BHC	NA	NA	2.89	5.2	NC	NC	NC	NC
delta-BHC	NA	NA	3.59	7.9	NC	NC	NC	NC
Endrin ketone	0.02 (b,c)	45 (b,c)	5.21	8	300	0.1	400	0.2
Methoxychlor	NA	NA	56.1	160	NC	NC	NC	NC
Phthalates								
Di-n-butyl Phthalate	NA	NA	226	250	NC	NC	NC	NC
PAHs								
Acenaphthylene	15,300 (d, f)	--	272	560	0.02	NC	0.04	NC
Benzo(a)anthracene	261	1,600	29.2	51.0	0.1	0.02	0.2	0.03
Benzo(b)fluoranthene	430 (e)	1,600 (e)	53.4	110	0.1	0.03	0.3	0.1
Benzo(k)fluoranthene	430 (e)	1,600 (e)	124	340	0.3	0.08	0.8	0.2
Benzo(a)pyrene	430	1,600	64.5	110	0.2	0.04	0.3	0.07
Chrysene	384	2,800	59.0	120	0.2	0.02	0.3	0.04
Dibenzo(a,h)anthracene	63.4	260	757	4,600	10	3	70	20
Fluorene	19	540	66.0	170	3	0.1	9	0.3
Fluoranthene	15,300 (f)	--	94.0	150	0.006	NC	0.01	NC
2-Methylnaphthalene	70	670	55.0	55.0	0.8	0.08	0.8	NC
Phenanthrene	1,800 (f)	--	55.0	70.0	0.03	NC	0.04	NC
Pyrene	665	2,600	66.3	180	0.1	0.03	0.3	0.1
Inorganics								
Aluminum	NA	NA	1,990	3,380	NC	NC	NC	NC
Arsenic	8.2	70	4.09	8.10	0.5	0.06	1	0.1
Copper	34	270	119	393	4	0.4	10	1
Iron	NA	NA	5,920	9,440	NC	NC	NC	NC
Lead	46.7	223	15.6	21.3	0.3	0.07	0.5	0.1
Manganese	NA	NA	390	1,120	NC	NC	NC	NC
Vanadium	NA	NA	10.5	24.9	NC	NC	NC	NC
Zinc	150	410	81.4	193	0.5	0.2	1	0.5

NA = Not available.
NC = Not calculated
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected by Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range median (ER-M) is the 50th percentile of this distribution.
(b) ER-L and ER-M as reported by Long and Morgan(1991).
(c) Value is for endrin.
(d) Value is for fluoranthene.
(e) Value is for benzo(a)pyrene.
(f) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediment, based on site-specific data.

TABLE 4-23

COMPARISON OF TOXICITY SCREENING VALUES (TSVs)
WITH CHEMICAL CONCENTRATIONS IN SEDIMENT:
POTOMAC RIVER OUTFALLS
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	TSV (a)		Mean Concentration	Maximum Concentration	Hazard Quotient (Mean)		Hazard Quotient (Maximum)	
	ER-L	ER-M			ER-L	ER-M	ER-L	ER-M
Phthalates								
Bis(2-ethylhexyl)phthalate	NA	NA	275	360	NC	NC	NC	NC
Di-n-butyl phthalate	NA	NA	10,800	31,000	NC	NC	NC	NC
PAHs								
Acenaphthylene	15,300 (b,e)	--	83.8	120	0.005	NC	0.008	NC
Anthracene	85.3	1,100	93.8	170	1	0.09	2	0.2
Benzo(a)anthracene	261	1,600	234	430	0.9	0.1	2	0.3
Benzo(a)pyrene	430	1,600	206	410	0.5	0.1	1	0.3
Benzo(b)fluoranthene	430 (c)	1,600 (c)	196	390	0.5	0.1	1	0.2
Benzo(g,h,i)perylene	430 (c)	1,600 (c)	113	220	0.3	0.07	0.5	0.1
Benzo(k)fluoranthene	430 (c)	1,600 (c)	220	440	0.5	0.1	1	0.3
Chrysene	384	2,800	266	460	0.7	0.1	1	0.2
Dibenzofuran	160 (d)	2,106 (d)	58	58.0	0.4	0.03	0.4	0.03
Fluorene	19	540	58	110	3	0.1	6	0.2
Fluoranthene	15,300 (e)	--	426	1,100	0.03	NC	0.07	NC
Indeno(1,2,3-c,d)pyrene	430 (c)	1,600 (c)	119	210	0.3	0.07	0.5	0.1
Phenanthrene	1,800 (e)	--	455	720	0.3	NC	0.4	NC
Pyrene	665	2,600	283	570	0.4	0.1	0.9	0.2
Inorganics								
Aluminum	NA	NA	3,040	3,550	NC	NC	NC	NC
Arsenic	8.2	70	8.57	13.7	1	0.1	2	0.2
Beryllium	NA	NA	4.79	13.3	NC	NC	NC	NC
Cadmium	1.2	906	1.12	1.3	0.9	0.001	1	0.001
Cobalt	NA	NA	5.12	10	NC	NC	NC	NC
Copper	34	270	60.4	83.4	2	0.2	2	0.3
Iron	NA	NA	7,040	8,810	NC	NC	NC	NC
Lead	46.7	223	93.4	183	2	0.4	4	0.8
Manganese	NA	NA	110	171	NC	NC	NC	NC
Mercury	0.15	0.71	0.16	0.3	1	0.2	2	0.4
Vanadium	NA	NA	19.2	23.4	NC	NC	NC	NC
Zinc	150	410	130	181	0.9	0.3	1	0.4

NA = Not available.
NC = Not calculated.
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected by Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range median (ER-M) is the 50th percentile of this distribution.
(b) Value is for fluoranthene.
(c) Value is for benzo(a)pyrene.
(d) Value is for naphthalene.
(e) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediment, based on site-specific data.

TABLE 4-24

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO TOXICITY SCREENING VALUES (TSVs): FOUR-MILE RUN OUTFALLS SEDIMENT
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			ER-L	ER-M
Phthalates				
Di-n-butyl phthalate	1	840	NA	NA
PAHs				
Acenaphthylene	1	24,000	15,300 (b,d)	--
Benzo(a)anthracene	4	140 -840	261	1,600
Benzo(a)pyrene	4	240 - 450	430	1,600
Benzo(b)fluoranthene	4	260 - 840	430 (c)	1,600 (c)
Chrysene	2	450 - 1,600	384	2,800
Fluorene	5	400 - 2,200	19	540
Fluoranthene	2	450 - 2,200	15,300 (d)	--
2-Methylnaphthalene	3	400 - 840	70	670
Phenanthrene	4	400 - 6,700	1,800 (d)	--
Pyrene	3	450 - 2,800	665	2,600
Inorganics				
Barium	1	70.8	NA	NA

NA = Not available.
NC = Not calculated.
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range by median (ER-M) is the 50th percentile of this distribution.
(b) Value is for fluoranthene.
(c) Value is for benzo(a)pyrene.
(d) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediment, based on site-specific data.

TABLE 4-25

COMPARISON OF ELEVATED DETECTION LIMITS (DLs) TO TOXICITY SCREENING VALUES (TSVs): POTOMAC RIVER OUTFALLS SEDIMENT
(Concentrations reported in ug/kg for organics, mg/kg for inorganics)

Chemical	Number of Samples With Elevated Detection Limits (DLs)	Concentration Range of Elevated DLs	TSV (a)	
			ER-L	ER-M
Phthalates				
Bis(2-ethylhexyl)phthalate	2	4,900 - 6,200	NA	NA
PAHs				
Acenaphthene	2	1,200 - 23,000	22,100 (b)	--
Anthracene	2	1,200 - 23,000	85.3	1,100
Benzo(a)anthracene	2	1,200 - 23,000	261	1,600
Benzo(a)pyrene	2	1,200 - 23,000	430	1,600
Benzo(b)fluoranthene	2	1,200 - 23,000	430 (c)	1,600 (c)
Benzo(g,h,i)perylene	2	1,200 - 23,000	430 (c)	1,600 (c)
Benzo(k)fluoranthene	2	1,200 - 23,000	430 (c)	1,600 (c)
9H-Carbazole	2	1,200 - 23,000	NA	NA
Chrysene	2	1,200 - 23,000	384	2,800
Dibenzofuran	2	1,200 - 23,000	160 (d)	2,106 (d)
Fluorene	2	1,200 - 23,000	19	540
Fluoranthene	1	23,000	15,300 (b)	--
Indeno(1,2,3-c,d)pyrene	2	1,200 - 23,000	430 (c)	1,600 (c)
Phenanthrene	1	23,000	1,800 (b)	--
Pyrene	1	23,000	665	2,600

NA = Not available.
NC = Not calculated.
-- = Not applicable. EPA sediment quality value available.

(a) Sediment screening values developed by Long and MacDonald (1992), except as noted. Effects-range low (ER-L) corresponds to the 10th percentile of the distribution of all sediment concentration data collected Long and MacDonald (1992) that were associated with adverse biological effects. The effects-range by median (ER-M) is the 50th percentile of this distribution.
(b) EPA sediment quality value (EPA 1993b), assuming 1.4 percent organic carbon in sediment, based on site-specific data.
(c) Value is for benzo(a)pyrene.
(d) Value is for naphthalene.

TABLE 4-26

FREQUENCY AND MAGNITUDE OF PREDICTED SURFACE WATER RISKS

Area/Chemical	Chronic TSV Exceedences		Acute TSV Exceedences		Overall Risk Level (c)
	Frequency (a)	Location (b)	Frequency (a)	Location (b)	
Four Mile Run Outfalls: Non-storm					
Aluminum	1/7	SW-12	NE	NE	Low
Arsenic	3/7	SW12DUP, SSSW-2, EPASW-13	1/7	EPASW-13	Low
Zinc	1/7	EPASW-11	1/7	EPASW-11	Low
Four Mile Run Outfalls: Storm					
Aluminum	3/8	SSSW-1P, SSSW-6P, SSSW-6F	NE	NE	Low
Lead	1/8	SSSW-6F	NE	NE	Low
Potomac River Outfalls					
beta-Chlordane	1/3	SPDSW-3	NE	NE	Moderate
Endosulfan sulfate	2/3	SPDSW-3, NPDSW-2	NE	NE	Low
Heptachlor	1/3	NPDSW-2	NE	NE	Moderate
Zinc	1/3	NPDSW-2	1/3	NPDSW-2	Low
Potomac Greens					
beta-Chlordane	1/4	NPDSW-1	NE	NE	Low to Moderate
Endosulfan sulfate	1/4	NPDSW-1	1/4	NPDSW-1	Low to Moderate
Endrin	1/4	NPDSW-1	NE	NE	Low to Moderate
Heptachlor epoxide	1/4	NPDSW-1	NE	NE	Low to Moderate
Anthracene	1/5	NPDSW-1	NA	NA	Low
Zinc	2/4	SPDSW-1, NPDSW-1	2/4	SPDSW-1, NPDSW-1	Low

NE = No Exceedences

(a) Number of samples in which the chemical was detected above the TSV divided by the total number of samples analyzed for that chemcical. Frequencies in parentheses indicate exceedences when considering detection limits.

(b) See Plate 5-1 of the ECS Report.

(c) Based on Hazard Quotient, as follows: >1>10 = Low; ≥ 10 - 100 = Moderate; > 100 = High.

TABLE 4-27

FREQUENCY AND MAGNITUDE OF PREDICTED SEDIMENT RISKS

Area/Chemical	ER-L Exceedences		ER-M Exceedences		Overall Risk Level (c)
	Frequency (a)	Location (b)	Frequency (a)	Location (b)	
Four Mile Run Outfalls					
Endrin ketone	1/4	SSSED-6	NE	NE	High
Dibenz(a,h,)anthracene	2/8	SSSED-6, SSSED-7	2/8	SSSED-6, SSSED-7	Moderate
Fluorene	1/8	SSSED-7	NE	NE	Low
Copper	2/4	SSSED-5, SSSED-6	1/4	SSSED-5	Low to Moderate
Potomac River Outfalls					
Anthracene	14	NYSED-2	NE	NE	Low
Benzo(a)anthracene	1/4	NYSED-2	NE	NE	Low
Fluorene	1/4	NYSED-2	NE	NE	Low
Arsenic	2/3	SPDSED-2, NPDSED-2	NE	NE	Low
Copper	3/3	SPDSED-2, NYSED-2, NPDSED-2	NE	NE	Low
Lead	2/3	NYSED-2, NPDSED-2	NE	NE	Low
Mercury	1/3	NPDSED-2	NE	NE	Low
Potomac Greens					
beta-Chlordane	1/4	SPDSED-1	1/4	SPDSED-1	Moderate
Endrin ketone	1/4	SPDSED-1	NE	NE	High
Anthracene	1/4	MPDSED-1	NE	NE	Low
Benzo(a)anthracene	1/4	SPDSED-1	NE	NE	Low
Fluorene	1/4	MPDSED-1	NE	NE	Moderate
Arsenic	3/4	SPDSED-2, NPDSED-1, MPDSED-1	NE	NE	Low

TABLE 4-27 (continued)

FREQUENCY AND MAGNITUDE OF PREDICTED SEDIMENT RISKS

Area/Chemical	ER-L Exceedences		ER-M Exceedences		Overall Risk Level (c)
	Frequency (a)	Location (b)	Frequency (a)	Location (b)	
Copper	2/4	SPDSED-2, NPDSED-1	NE	NE	Low
Lead	1/4	NPDSED-1	1/4	NPDSED-1	Low
Mercury	2/4	NPDSED-1, MPDSD-1	1/4	NPDSED-1	Low

NE = No Exceedences

(a) Number of samples in which the chemical was detected above the TSV divided by the total number of samples analyzed for that chemcical.

(b) See Plate 5-1 of the ECS Report.

(c) Based on Hazard Quotients as follows: > 1 < 10 = Low; ≥10 - 100 = moderate; > 100 = High.

TABLE 4-28

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE ECOLOGICAL RISK ASSESSMENT

Assumption (a)	Magnitude of Uncertainty (b)	Effect of Assumption on Risk Estimate
Selection of Chemicals		
Subset of chemicals evaluated in the risk assessment contribute the majority of potential risk	Low	May underestimate risk. Only chemicals present at background concentrations were eliminated from the risk assessment. Therefore, unlikely to underestimate site risk.
Tentatively identified compounds (TICs) do not contribute substantially to risk	Low	May underestimate risk. Most TICs are believed to be petroleum-related compounds and are not expected to be highly toxic to environmental receptors.
Chemicals not detected due to high detection limits do not substantially alter risk estimates	Low	May underestimate risk. For some chemicals, principally pesticides, the detection limits achieved in the ECS were above surface water and sediment TSVs. However, underestimate of risk are considered unlikely, because the bioavailability of these chemicals in the environment will be substantially lower than that achieved in the laboratory studies that were used as the basis of the TSV. Detection limits for soil were below TSVs.
ECS sampling and analytical data reflect the range of chemicals associated with site	Low	May underestimate risk. Not all potential site-related chemicals were included in all sample analyses.
ECS sampling and analytical data reflect the spatial and temporal distribution of chemicals	Low to moderate	May over- or underestimate risk. Many ECS samples were biased towards suspected source areas, therefore, chemical concentrations may represent the upper end of potential exposure concentrations. Changes in chemical concentration over time cannot be evaluated using the available data.
Selection of Receptor Species		
Receptor species selected for evaluation are those for which exposures and/or risks will be greatest	Low	May underestimate or overestimate risk. Environmental receptors believed to be most susceptible to exposure were selected for evaluation. This may or may not be representative of site conditions.

TABLE 4-28 (Continued)

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE ECOLOGICAL RISK ASSESSMENT

Assumption (a)	Magnitude of Uncertainty (b)	Effect of Assumption on Risk Estimate
Exposure Assessment		
Exposure pathways evaluated represent the dominant exposure pathways for each of the selected receptor species	Low	May underestimate risk, but considered unlikely.
Transport of chemicals from groundwater to surface water does not contribute significantly to surface water exposures in Four Mile Run and the Potomac River.	Low	May underestimate risk. In wells nearest the surface water bodies, chemicals are present at concentrations that are below aquatic life criteria. Groundwater concentrations of some metals in other areas of the site are above surface water criteria, however, groundwater transport to surface water from these areas would take hundreds to thousands of years. The available data also suggest that PCBs transport to surface water is not of concern, but the certainty of this statement is reduced because groundwater samples collected in wells nearest surface water had detection limits that were above aquatic life criteria.
Receptor species spend their entire life in the study area	Moderate to high (for mobile species	May overestimate risk. Terrestrial wildlife use of the site is expected to be limited due to poor habitat quality of the site. For surface waters, area impacted by site releases is anticipated to be small.
Chemicals are 100% bioavailable to the selected receptor species	Low to Moderate	May overestimate risk. Likely overestimate for chemicals in cinder ballast, as well as pesticides and other hydrophobic organic chemicals in surface waters.
Chemical concentrations in surface water and sediment at the property boundary are representative of chemical concentrations in Four Mile Run and the Potomac River	Moderate to high	May overestimate risk. Chemical releases from the site will be substantially diluted within Four Mile Run and the Potomac River.
Chemical concentrations in surface water and sediment at the property boundary are representative of past discharges to Four Mile Run and the Potomac River	Low to Moderate	May under- or overestimate risk. Historical chemical releases might have been lesser or greater than those currently measured. Chemicals associated with cinder ballast likely were similar in magnitude to currently measured concentrations. Chemicals released as a result of surficial spills could have been greater.

TABLE 4-28 (Continued)

MAJOR ASSUMPTIONS AND UNCERTAINTIES IN THE ECOLOGICAL RISK ASSESSMENT

Assumption (a)	Magnitude of Uncertainty (b)	Effect of Assumption on Risk Estimate
Maximum chemical concentrations detected at the site are representative of potential exposures in ecological receptor populations	Moderate	May overestimate risk.. Exposure concentrations for the majority of exposed population will closer approximate the mean.
Toxicity Assessment		
Receptor species at the site are as sensitive as the most sensitive species reported in the literature	Low to Moderate	May overestimate or underestimate risk. Data from the most sensitive species reported in the literature was selected, therefore, overestimate of risk considered most likely.
The chemicals for which no toxicity data are available will not contribute substantially to overall risk	Low to Moderate	May underestimate risk.
Sediment screening values for marine and estuarine sediments from NOAA database are representative of potential effects in freshwater species at the site	Low to Moderate	May over or underestimate risk. Overestimate considered most probable given nature of dataset, low predictability of some screening-level values (e.g. for pesticides and some metals), and general limitations associated with application of NOAA data to site specific situation.
Chemical toxicity is not additive, antagonistic, potentiating or synergistic	Low to Moderate	May underestimate risk.
Risk Characterization		
The risk assessment approach based on exposure and toxicity in individual organisms provides an estimate of potential risks in aquatic and terrestrial wildlife populations	Low to High	Likely overestimates risk.

(a) These assumptions are in addition to those identified in Section 4, and are unique to the ecological assessment.
(b) Low = Less than or equal to one order-of- magnitude effect.
Moderate = greater than one to less than or equal to two orders- of -magnitude effect.
High = greater than two orders-of- magnitude effect.

5.0 SUMMARY AND CONCLUSIONS

Human health and ecological risk assessments were performed for the Potomac Yard Site on behalf of the RF&P Railroad Company. The Potomac Yard Site is a recently decommissioned inactive rail yard consisting of approximately 342 acres extending from Crystal City in Arlington County, south to Braddock Road in the City of Alexandria. RF&P plans to develop the Site to include a transportation hub, mixed housing, and commercial development. This development is anticipated to take several decades to accomplish. In the interim, several non-permanent projects are proposed for use of the Site including warehousing, retail, and parking lots. For the purpose of this evaluation, the Site has been divided into six overall areas: North Tail, North Yard, Central Operations, South Yard/South Tail, Slaters Lane, and Potomac Greens. Historically, each of these areas has been associated with varying forms of rail operations and has different development plans. The risk assessments evaluated the potential for human health and ecological impacts during the Site's current condition as well as during interim and future final use.

A set of chemicals of potential concern was developed based on investigations conducted during the ECS. Chemicals that were present at concentrations not significantly higher than naturally occurring background concentrations, or that were associated with operation of sampling or the analytical laboratories were eliminated from further consideration. In addition, toxicology-based screening approaches were used to eliminate those chemicals of low toxicity that would not likely contribute appreciably to either human health or ecological risk.

Arsenic was found to be an important chemical of concern due to its presence in cinder-based ballast. Due to this, a geochemical investigation was undertaken to better determine the form and behavior of the arsenic. It was found that virtually all of the arsenic was in the form of As(V) and strongly bound to iron in the matrix. These results were used to derive a mammalian bioavailability of 10% for ingestion exposure to arsenic. At EPA's request a bioavailability factor of 50 percent was also used in developing the high-end risk estimates presented in the report.

The human health risk assessment followed the form specified in EPA's Risk Assessment Guidance for Superfund. An analysis of exposure pathways was conducted for each of the six areas of the Site under current, interim, and future use. The most relevant receptors were found to be current trespassers, construction workers, landscape workers, and nearby residents and commercial office workers. Inhalation and incidental ingestion of soil were found to be the most important routes of exposure for further quantitative evaluation. Dose-response data for the chemicals of concern was developed from EPA sources. In the case of total petroleum hydrocarbons, a surrogate toxicity criterion was developed based on the components of diesel fuel. An exposure assessment was performed that evaluated the central tendency and high-end exposures of each of the receptors to chemicals found at the six areas over the three land-use conditions. EPA air dispersion models were used to assess exposure to wind-borne dust that could be generated as a result of construction. A model derived from the scientific literature was

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used to assess exposure to workers from volatile chemicals that could potentially accumulate in utility trenches. Health risks associated with exposure to both potential carcinogens and systemic toxicants were calculated by combining exposure point concentrations with appropriate exposure factors and dose-response criteria.

The salient conclusions are summarized as follows:

- All of the upperbound excess cancer risks were within or below EPA's risk range for risk management at Superfund sites. The hazard indices for noncancer health effects were predominantly below EPA's guideline threshold of 1. The hazard index for high-end occupational inhalation exposure was slightly exceeded in only one localized area of the Site. However, all of the estimated air concentrations associated with this exposure were far below occupational standards and criteria.

- Under current land use conditions, potential exposures were associated with incidental ingestion of soil by a trespasser in the South Yard/South Tail area. During interim use, the highest potential exposures were to construction workers from the inhalation and ingestion of development-related dust. Under future use conditions, the highest exposures were also industrial in nature, and they were associated with inhalation and ingestion of dust by a construction worker and inhalation of petroleum hydrocarbons by a utility trench worker in a localized site area where diesel free product is being recovered. Estimated airborne chemical concentrations compatible for comparison with occupational standards and criteria did not exceed these limits in any scenario.

- Due to the fact that the majority of the Site will ultimately be paved and/or landscaped, there is little potential for exposure and, thus, a low risk to residents who could occupy the Site in the future.

- The primary chemical associated with the human health risks was arsenic, associated with cinder-based ballast.

An ecological risk assessment also was conducted for the Potomac Yard Site. The objective of the ecological assessment was to determine if chemicals associated with the Site have the *potential* to affect the structure, function, or interactions of biological populations and communities within the study area. The overall focus of the ecological assessment was on potential site-related impacts on the aquatic populations and communities of Four Mile Run and the Potomac River. These two water bodies are the principal aquatic habitats of the area and, with the exception of small pockets of terrestrial habitat on Potomac Greens, will be the only source of natural habitat to remain once the Site is developed as a commercial and residential urban area. Potential risks associated with other areas of the Site that currently provide limited or marginal habitat also were evaluated, however, even though these habitats will not exist following development.

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The potential for ecological effects was conservatively evaluated using a screening-level assessment approach recommended by EPA Region III. Under this approach, estimated exposure concentrations were compared to screening-level toxicity values, such as ambient water quality criteria. Estimated exposures that exceed the screening toxicity values indicate potential risk.

The conclusions of the screening-level risk assessment are as follows:

- The Site poses no risk to terrestrial wildlife feeding or otherwise using the Site.
- Pesticides in surface waters and sediments of Potomac Greens could cause a localized reduction in the abundance and diversity of aquatic insects.
- Potomac Yards is a source of low concentrations of PAHs, metals and pesticides to Four Mile Run and the Potomac River.
- Measured concentrations at the property boundary exceed toxicity criteria for sensitive species of aquatic life, possibly resulting in localized decreases in benthic species abundance and diversity.
- Risk could be over- or under-estimated. Factors contributing to a potential under-estimate of risk are the removal of high detection limits from the data set. Factors contributing to possible over-estimates of risk are the screening-level risk assessment approach and assumption of a 100% bioavailability of chemicals in exposure media.
- The available sampling data cannot be used to evaluate ecological risks associated with historical releases. Off-site risks associated with historical releases from the Potomac Yard Site will be addressed in the future as part of continuing activities at the Site. Chemical concentrations in sediments are the most relevant data for addressing historical releases. Chemicals potentially associated with the Site include PAHs, PCBs, and arsenic.

Overall from both the human health and ecological perspectives, the risk assessment indicated no barrier to development of the Site and, indeed, suggested that development will be beneficial in reducing risks both to human health and the natural environment.

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