SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT FOR

MARSH RUN PARK
NEW CUMBERLAND, FAIRVIEW TOWNSHIP,
YORK COUNTY, PENNSYLVANIA
FUDS No. C03PA040301

Prepared for

U.S. Army Corps of Engineers, Baltimore District
Engineering Division-HTRW Branch
10 South Howard Street
10th Floor – CENAB-EN-HT
Baltimore, Maryland 21201
Contract W912DR-09-D-0018
Delivery Order 0003

Prepared by

EA Engineering, Science, and Technology, Inc.
15 Loveton Circle
Sparks, Maryland 21152

June 2012

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QUALITY REVIEW STATEMENT

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In compliance with EA's Senior Technical Review Program, I hereby certify that I reviewed this final deliverable as the assigned Senior Technical Reviewer for this project. I consequently conclude that the information presented in this report/deliverable was prepared in accordance with the approved scope of services for the project and reflects a proper presentation of the data and/or the conclusions drawn and/or the analyses or design completed during the conduct of the work. This statement is based upon the standards identified in the contract and/or the standard of care existing at the time of the preparation.

Senior Technical Reviewer Signature:

Christine Papageorgis, Ph.D., AICP 22 February 2012
Senior Technical Reviewer

Lead Senior Technical Reviewer Signature:

Frank T. Barranco, P.G., Ph.D. 27 February 2012
Senior Technical Reviewer

INDEPENDENT TECHNICAL REVIEW STATEMENT

This document has been produced within the framework of EA's total quality management system. As such, an independent technical review has been conducted, appropriate to the level of risk and complexity inherent in the project. This included review of assumptions (methods, procedures, and material used in analyses); alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the project objectives. Comments and concerns resulting from review of the document have been addressed and corrected as necessary.

Independent Technical Reviewer Signature:

Barbara C. Roeper, P.E. 27 February 2012
Independent Technical Reviewer

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

95UCLM	95 percent upper confidence limit of the mean
B	Not detected substantially above the level reported in laboratory or field blanks
BAF	Bioaccumulation Factor
bgs	Below Ground Surface
COPC	Constituents of Potential Concern
CSM	Conceptual Site Model
dw	Dry Weight
EcoSSL	Ecological Soil Screening Level
ERA	Ecological Risk Assessment
ft	Foot/feet
FUDS	Formerly Used Defense Site
g/g/day	Gram per gram of body weight per day
HPAH	High Molecular Weight Polycyclic Aromatic Hydrocarbon
HQ	Hazard Quotient
J	Analyte present. Reported value may not be accurate or precise.
K	Analyte present. Reported value may be biased high. Actual value is expected lower.
kg	Kilogram
LOAEL	Lowest Observed Adverse Effect Level
LPAH	Low Molecular Weight Polycyclic Aromatic Hydrocarbon
mg/kg	Milligrams per Kilogram
mg/kg/day	Milligram per Kilogram of Body Weight per Day
MW	Molecular Weight
µg/L	Microgram per Liter
NA	Not Applicable
NH	New Hampshire
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NS	Not Sampled
NSV	No Screening Value
NY	New York
OH	Ohio

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS (continued)

PA	Pennsylvania
PADEP	Pennsylvania Department of Environmental Protection
PAH	Polycyclic Aromatic Hydrocarbon
ROC	Receptor of Concern
SLERA	Screening Level Ecological Risk Assessment
SQuiRTs	Screening Quick Reference Tables
SSL	Soil Screening Level
TRV	Toxicity Reference Value
U	Not Detected. The associated number indicates approximate sample concentration necessary to be detected.
UCLM	Upper Confidence Limit on the Mean
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
ww	Wet Weight
WI	Wisconsin

EXECUTIVE SUMMARY

A Screening Level Ecological Risk Assessment (SLERA) has been performed for surface soil, sediment, and surface water at the Marsh Run Park Formerly Used Defense Site (FUDS). The SLERA followed United States Environmental Protection Agency (U.S. EPA) guidance and Pennsylvania Act 2 requirements, and consisted of a hazard assessment, exposure assessment, toxicity assessment, and risk characterization. The area examined for ecological risk was those soil areas outside of the fence and the adjacent wetland, and utilized all available data (1987-2011). Soil from within the fenced playing fields and landfill area were not included in the SLERA because they are maintained, and do not represent viable habitat for ecological receptors. Risks were characterized for terrestrial plants and invertebrates, aquatic organisms, benthic organisms, and terrestrial birds and mammals. There is no indication of negative effects to ecological organisms in soil, sediment, or surface water. No threatened, endangered or listed species have been identified at the Marsh Run Park FUDS. The samples taken in 2011 confirm the conclusion that the location of relatively high metal and PAH concentrations found in soil in 1988 is localized and does not represent an unacceptable risk to populations of terrestrial organisms. As a result, the conclusions reached in the 1990 SLERA that acceptable ecological risks have been found at the site have been confirmed. Acceptable population-level risk levels are found at the site for terrestrial plants, invertebrates, birds and mammals, aquatic, and benthic organisms.

1. INTRODUCTION

The data for the Marsh Run Park Formerly Used Defense Site (FUDS) has been evaluated in the light of the potential for ecological risk and in support of obtaining relief of liability under the Pennsylvania Department of Environmental Protection (PADEP) Act 2 program. Also in support of the Act 2 process, a human health risk assessment has been conducted and is presented under separate cover (EA 2012).

The Marsh Run Park property was previously owned by New Cumberland Army Depot. A portion of the property was formerly used as a landfill for the disposal of base-derived waste material starting in approximately 1917 and continuing until the late 1950's. The property was transferred to Fairview Township exclusively for public park or public recreational purposes (as stated in the "Quitclaim Deed", April 23, 1976, Recorder of Deeds, County of York, State of Pennsylvania, Record Book 70E, p. 1034) (York County 1976). The fill area was graded with fill to create a recreational field that was used from 1976 through 1987. The former landfill is surrounded by a perimeter fence, with an adjacent freshwater wetland (Figure 1). The fenced area has been maintained as a mowed grass field since 1987, with the exception of the soil vapor extraction area in the central portion of the field, where a geomembrane cap covers the turf. The intended future use of the area within the fence is recreational fields and an associated parking area.

A complete Screening Level Ecological Risk Assessment (SLERA) was completed in 1990 and data used for that risk assessment, along with new soil data collected in June 2011 and new sediment and surface water data collected in December 2011, have been used for this ecological risk evaluation (EA 1990). The 1990 SLERA concluded that some of the contaminants could be attributed to upgradient sites, and that most of the metals were within expected background concentrations.

This revised SLERA has been conducted based on historical and more recently collected soil, sediment, and surface water data from within the FUDS boundary, but exterior of the field and field perimeter fence. The purpose of the SLERA is to determine if, under expected exposure conditions, chemicals and metals found in soil, sediment, and surface water at Marsh Run Park are at concentrations that may cause unacceptable risk to ecological receptors in the area. The results will be used to support the Act 2 process. The exposure area assessed in this SLERA includes the area within the FUDS boundary but outside of the field perimeter fence. The area within the field perimeter fence is proposed for site restoration to support the proposed future use of the area as recreational soccer fields. As such, a minimum of one foot of clean soil is

proposed for placement across the current field to allow for grading without disturbing the fill material that was historically placed onsite. Because offsite fill has already been placed within the perimeter fence (in 1976), a minimum of one foot of clean fill is proposed to complete site restoration, and since the field has not historically been managed for ecological use, the area of the field within the perimeter fence was not included in the exposure area for this SLERA. Species and resources of concern are located in the vicinity of the site (e.g., the Susquehanna River); however the immediate vicinity of the former landfill does not constitute essential habitat for protection of these resources (PNDI 2012). The goal of this ecological risk assessment is to evaluate whether site constituents have potential adverse effects on populations of the various organisms that live at and in the vicinity of the site.

U.S. Environmental Protection Agency (U.S. EPA) utilizes an eight-step process for assessing ecological risk (U.S. EPA 1997). A SLERA consists of Steps 1 and 2, which is a preliminary screening process using very conservative assumptions. The risk assessment process is designed to be overly conservative to detect the potential for risk. Consequently, a second tier of the risk assessment process has been performed consistent with U.S. EPA guidance, specifically refining exposure assumptions, which will provide a more site-specific, realistic assessment of potential risks to ecological receptors at the Marsh Run Park site (U.S. EPA 2001).

U.S. EPA Region III uses the Federal U.S. EPA Guidance for designing and conducting ecological risk assessments (U.S. EPA 1997), and these procedures have been accepted by PADEP under the Act 2 program.. The ecological risk assessment approach incorporates the following available guidance on ecological risk assessment:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA 1997)
- Guidelines for Ecological Risk Assessment (U.S. EPA 1998)
- The Role of Screening-Level Risk Assessments and Refining Constituents of Concern in Baseline Ecological Risk Assessments (U.S. EPA 2001)

2. CONCEPTUAL SITE MODEL

The conceptual site model (CSM) is a description of the physical and ecological characteristics of the site, potential exposure scenarios, identification of receptors of concern (ROC), and assessment and measurement endpoints.

A major element in the CSM is a description of the exposure scenarios. This consists of four elements:

- Source of constituents of potential concern (COPC) and release mechanism(s)
- Transport medium and mechanism of transfer from primary to subsequent media
- Point (or area) of potential ROC contact with the COPC
- Route of uptake by the ROC

As discussed in Section 1, this SLERA is focused on soil data collected outside of the fence (all earlier 1988-1989 data as well as the June 2011 data), and sediment and surface water collected from the wetland adjacent to the landfill. Sample locations are included in Figure 1.

The CSM for Marsh Run Park is shown in Figure 2. On the basis of this CSM, there are complete exposure pathways to surface soil, sediment, and surface water for ecological receptors at Marsh Run Park.

2.1 RECEPTORS OF CONCERN

Ecological ROCs are species or guilds of species that are important to the ecology of the study area and that may be susceptible to chemical constituents detected at the site. Selection of ROCs is systematic, representative, and ecologically based to ensure that assessment endpoints are adequately addressed. Criteria used to identify ecological ROCs include the following (Suter 1993):

- **Presence** – known or expected to occur onsite
- **Susceptibility** – exposure pathway is likely complete and of sufficient duration/magnitude to represent potential concern
- **Representative** – of the food web and/or guild
- **Data Availability** – sufficient and appropriate type of toxicity and exposure information
- **Societal Importance** – species merits public attention

Ecological ROCs identified for Marsh Run Park include:

- **Soil Receptors**—Surface soil ROCs include terrestrial plants and invertebrates, birds (represented by a robin) and mammals (represented by a shrew).
- **Surface Water Receptors**—Surface water ROCs include aquatic plants and animals. COPCs may impact these receptors in the streams and wetlands found at the site.
- **Sediment Receptors**—Sediment ROCs at the site include benthic organisms, such as oligochaetes (worms), and the larvae of mayflies and midges that live in the sediments found in wetlands. In addition, birds and mammals may be exposed to COPCs in sediment. To be conservative, the same receptors used for soil (robin and shrew) are used for this exposure scenario, because they have a small habitat range and an area use factor of 1. The robin and shrew serve as surrogates for birds and mammals likely to be exposed to a marsh, such as a heron or raccoon. These latter receptors have habitat ranges much larger than the Marsh Run Park habitat, and they consume a much smaller proportion of their body weight in food on a daily basis compared to the robin and shrew.

2.2 ASSESSMENT AND MEASUREMENT ENDPOINTS

U.S. EPA guidance stresses the importance of ecologically significant endpoints. As discussed by U.S. EPA, "Assessment endpoints are explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes." (U.S. EPA 1998). Failure to select appropriate assessment and measurement endpoints can result in the inability to answer the risk questions central to an Ecological Risk Assessment (ERA). Several criteria are applicable for endpoint selection (Suter 1993; U.S. EPA 1998):

- **Unambiguous Definition**—Assessment endpoints should indicate a subject and a characteristic of the subject (such as fish reproduction).
- **Accessibility to Prediction and Measurement**—Assessment endpoints should be reliably predictable from measurements.
- **Susceptibility to the Hazardous Agent/Stressor**—Susceptibility of an organism (plant or animal) results from the combination of potential for exposure and the sensitivity to the concentrations of constituents or other stressors of concern.
- **Biological Relevance**—Biological relevance of impacts to an individual organism is determined by the importance of the impact to higher levels of biological organization such as populations or communities.
- **Social Relevance and Policy Goals**—Assessment endpoints should be of value to decision-makers and the public. The assessment endpoints should represent effects that could warrant consideration of site remediation or alteration of project plans. Assessment

endpoint selection should also include endpoints that may be mandated legally (e.g., protected species).

The extent to which these items are considered varies from site to site, and it depends on several factors including the level of public involvement, the ecological character of the site, and the lead regulatory agency involved in the assessment.

Based on the ROCs identified for Marsh Run Park, the habitat, and the above observations, the following ecological assessment endpoints are defined:

1. Ecological health of terrestrial plants and soil invertebrates, to ensure that these organisms that live in the surface soil do not experience adverse effects on survival, growth, and reproduction.
2. Ecological health of birds and mammals that may come into contact with surface soil at the site, to ensure that this exposure does not result in adverse effects on survival, growth, and reproduction.
3. Ecological health of aquatic water column communities, to ensure that aquatic organisms that live in the streams and wetlands do not experience adverse effects on survival, growth, and reproduction.
4. Protection of benthic organisms that live in the sediment of streams and wetlands, to ensure that COPCs in these media do not have adverse effects on survival, growth, and reproduction.

Measurement endpoints are measurable ecological characteristics that are related to the assessment endpoints (U.S. EPA 1998). Because it is difficult to "measure" assessment endpoints, measurement endpoints were selected that permit inference regarding the above-described assessment endpoints. The measurement endpoints selected for this risk assessment include:

1. **Media Chemistry for Soil**—The measurement of chemical constituent concentrations in soil provides the means, when compared to appropriate soil screening values, to assess the protection of terrestrial organisms that live in the soil (first endpoint above).
2. **Chemical Doses for Terrestrial Birds and Mammals**—The calculation of chemical constituent doses to birds and mammals provides the means, when compared to toxic doses, for drawing inferences regarding the protection of birds and mammals that live at Marsh Run Park (second endpoint above).
3. **Media Chemistry for Surface Water**—The measurement of chemical constituent concentrations in surface water provides the means, when compared to water quality criteria, for drawing inferences regarding the protection of aquatic organisms that live in

the water column (third endpoint above).

4. **Media Chemistry for Sediment**—The measurement of chemical constituent concentrations in sediment provides the means, when compared to appropriate sediment screening values, to assess the protection of aquatic organisms that live in the sediment (fourth endpoint above).

3. SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

3.1 CONSTITUENT OF CONCERN SELECTION

3.1.1 Surface Soil

The ecological risk evaluation has been limited to surface soil, because ecological organisms are only exposed to soil in the "root zone," which is bounded by the top 6 inches to no greater than 2 feet (ft) below ground surface (bgs). Further, because the capped area within the perimeter fence is to be used for recreational fields and parking areas, and because the extent and depth of clean fill placed on the site by the Township is unknown, surface soil samples collected from this area have not been included in the soil ecological risk evaluation (Figure 1). There is no evidence of environmental impacts, such as denuded vegetation, in the terrestrial environment.

The terrestrial environment surrounding the perimeter fence is forested, and has been described in the SLERA (EA 1990). Eight surface soil samples ranging from 0 to 2 ft bgs have been identified as being collected in the terrestrial environment outside of the perimeter fence, and are shown in Table 1 and Figure 1. Table 1 includes all detected analytes for the samples collected from 1988 through 2011. To identify COPCs, ecological screening values were identified for these analytes using the following sources:

- The lowest identified Ecological Soil Screening Level (EcoSSL) terrestrial screening value for the protection of plants, soil invertebrates, mammals, and birds, and in the event that EcoSSL values were not available
- The lowest terrestrial screening value found in the National Oceanic and Atmospheric Administration's (NOAA's) Screening Quick Reference Tables (SQuiRTs) summary (Buchman 2008)

The following chemicals exceeded the conservative risk screening values in one or more surface soil samples and are thus identified as COPCs (Table 1):

- *Cadmium*: S-3, S-11
- *Chromium:* S-3
- *Copper*: S-3
- *Lead*: MW-7A, S-3, S-11, SB-4, SB-9, SB-11, SS-7 (Note, the soil lead screening value of 11 mg/kg is less than the expected background concentration of this element) (U.S. EPA 2005b)
- *Manganese:* MW-7A
- *Mercury*: SS-1, SS-7

- *Selenium*: S-3, S-11
- *Silver*: S-3
- *Thallium*: S-3, S-11
- *Vanadium*: MW-7A
- *Zinc:* MW-7A, S-3, S-11, SS-1, SS-7
- Total Low Molecular Weight PAHs: SB-4
- Total High Molecular Weight PAHs: S-3, SB-4, SB-11

3.1.2 Sediment

Wetlands are located adjacent to the former landfill and Marsh Run creek itself (Figure 1). The wetland has been examined and delineated, found to be healthy, and contained the expected wetland species (EA 2011). Sediment samples were collected from Marsh Run creek, a nearby tributary, and/or the wetlands in 1987 (Sample IDs SD-1, SD-2, SD-3, and SD-4), 1989 (Sample IDs SS-1, SS-2, SS-3, SS-4, SS-5), and 2011 (SD-5, SD-6, SD-7, SD-8, and SD-9) (Table 2), and these sample results have been used to compare to sediment benthic organism screening values. Risk screening values used for this screen were consensus-based freshwater sediment values, which are shown in Table 2 (MacDonald et al. 2000). In the absence of consensus-based sediment screening values, the lowest freshwater sediment screening value shown in Buchman (2008) has been used (Buchman 2008). The results of this comparison show that the following chemicals were measured above screening values in one or more sediment samples.

Metals

- *Arsenic*: SS-1, SS-2, SS-3, SS-4, SD-7, and SD-9
- *Cadmium*: SS-4, SD-6, SD-8, and SD-9
- *Lead*: SD-3, SS-4, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Manganese*: SD-1, SD-2, SD-3, SS-5, SD-8, and SD-9
- *Zinc*: SD-5, SD-6, SD-7, SD-8, and SD-9

Polycyclic Aromatic Hydrocarbons (PAH)

- *Dibenz[a,h]anthracene*: SD-8 and SD-9
- *Phenanthrene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Fluorene*: SD-9
- *Indeno[1,2,3-c,d]pyrene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Pyrene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Chrysene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Benzo(a)anthracene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9

- *Benzo(a)pyrene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Benzo(k)fluoranthene*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9
- *Total PAHs*: SS-5, SD-5, SD-6, SD-7, SD-8, and SD-9

Other Chemicals

- 4,4'-DDD: SS-4
- 4,4'-DDE: SS-4
- 4,4'-DDT: SS-4
- Total DDT: SS-4
- Di-n-butylphthalate: SS-5

3.1.3 Surface Water

The results for detected analytes from two 1987 (SW-1 and SW-2), five 1989 (SWS-1, SWS-2, SWS-3, SWS-4, and SWS-5), and two 2011 (SW-5 and SW-8) surface water samples are shown in Table 3 and compared to Pennsylvania chronic water quality standards (Criteria Continuous Concentrations). Based on this comparison the following metals were found to exceed screening values in one or more samples:

- *Copper*: SWS-5
- *Lead*: SW-2 and SWS-5
- *Mercury*: SWS-2

3.2 EXPOSURE ASSESSMENT

For the food-web (measurement assessment endpoint 2), the exposure assessment represents the estimation of constituent concentrations to which ecological receptors are exposed. Field duplicates were taken at sediment sample SD-9 and surface water sample SW-8 in December 2011. The concentrations shown in Tables 2 and 3 for these sample locations were calculated as the average of the two reported concentrations (initial and duplicate sample). For food- web exposure, the exposure concentration is estimated based on the 95 percent Upper Confidence Limit of the Mean (UCLM). An attempt was made to calculate the 95 percent UCLM with the soil data, however due to the limited data set and highly skewed data, the maximum detected concentration invariably exceeded the UCLM. As discussed above, a conservative assumption was made that terrestrial food web organisms (robin and shrew) were also exposed to sediment. For sediment there were sufficient data to determine the 95 percent UCLM using ProUCL Version 4.2 for all soil COPC except mercury, silver and thallium, and these were used as the exposure concentration in the SLERA. The dry weight 95 percent UCLM for soil COPC are

shown in Table 2. For the food-web, it was assumed that the robin and shrew consume wet-weight soil, and it was assumed that soil and sediment contained 20 percent water.

A food-web model was used to estimate the dietary intake of COPCs by wildlife species. The model utilized life history information for receptors (e.g., body weight, food-ingestion rate, etc.), in conjunction with site surface-soil concentrations of COPCs, to estimate the daily intake of COPCs (i.e., the exposure).

Dietary exposures for ROCs were estimated as body-weight-normalized daily doses for comparison to body-weight-normalized daily dose Toxicity Reference Values (TRVs). Separate doses were calculated for food ingestion and incidental soil ingestion, and these were summed to produce the total dose for each ROC.

$$Dose_{total} = Dose_{food} + Dose_{soil}$$

where:

$Dose_{total}$	=	Total daily dose of COPC received by receptor; mg COPC/kg-body weight/day
$Dose_{food}$	=	Daily dose of COPC received by receptor; mg COPC/kg-body weight/day from food items
$Dose_{soil}$	=	Daily dose of COPC received by receptor; mg COPC/kg-body weight/day from incidentally ingested soil

The total dose from food is given by:

$$Dose_{food} = \sum (F_f \times C_f \times fx_f) \times U$$

where:

Σ	=	Represents summing of the dose for each food item
F_f	=	Total daily feeding rate in kg food/kg-body weight of ROC/day (wet basis)
C_f	=	Concentration of COPC in food item; calculated based on Bioaccumulation Factors (BAFs) (mg chemical/kg food)
f_{xf}	=	Fraction of the food item in the receptor diet
U	=	Habitat usage factor (fraction of habitat range represented by site) for receptor

The total dose from incidental soil is given by:

$$Dose_{soil} = F_s \, x \, U \, x \, C_s$$

where:

F_s	=	Total daily incidental soil feeding rate in kg/ kg-body weight of ROC/day (wet basis)
U	=	Habitat usage factor (fraction of habitat range represented by site, 100 percent for the robin and shrew) for receptor
C_s	=	Concentration of COPC in soil; mg/kg (wet basis)

Lastly, the total daily soil ingestion rate is given by:

$$F_s = F_f \times F_{xsoil}$$

where:

F_s	=	Total daily incidental soil feeding rate in kg/ kg-body weight of ROC/day (wet basis)
F_f	=	Total daily feeding rate in kg food/day (wet basis)
F_{xsoil}	=	Fraction of incidental soil ingestion as a proportion of food ingestion rate

Information necessary for calculations includes organism body weight, food ingestion rate (F_f), fraction incidental soil ingestion as a proportion of food ingestion rate (F_{xsoil}), food item fractions, area use factors, and analyte concentrations of ingested materials. Information specifically relevant to the ecology of the ROCs (i.e., body weights, food ingestion rates, and incidental soil ingestion rates) is presented in Table 4. The primary source used for these exposure parameters was the Wildlife Exposure Factors Handbook (U.S. EPA 1993); other sources for parameters are documented in Table 4.

Exposure assessments consider the propensity for a COPC to bioaccumulate in the food organism. Chemicals that bioaccumulate are chemicals with higher concentrations in organisms than found in the abiotic matrix (e.g., soil). Non-polar organic compounds such as pesticides are known to bioaccumulate. In contrast, many inorganic chemicals and some organic compounds do not bioaccumulate, and may be found in lower concentrations in food items. Where available, appropriate accumulation factors were used in the food-web exposure assessment, as this is

superior to a default assumption that food-item concentrations equal soil concentrations (i.e., BAF=1.0).

Table 5 presents available BAFs that were used in this SLERA. To the extent possible, BAFs have been identified from the scientific literature for soil invertebrates and terrestrial plants, each of which represents food for one or more ROC. In Sample et al. (1999), the scientific literature for uptake into earthworms was reported (Sample et al. 1999). When sufficient toxicological data points were located, a log-log regression equation was developed directly relating expected concentrations in the organism relative to concentrations in the soil:

$$\ln [X]_{earthworm} = B_0 + B_1 \, x \, \ln [X]_{soil}$$

where:

ln[X]earthworm=	the natural log of the concentration of chemical X in earthworm (dry weight), B_0 and B_1 are constants identified in Sample et al. (1999)
ln $[X]_{soil}$ =	the natural log of the concentration of chemical X in soil (dry weight)

Earthworm regression relationships were available for cadmium, copper, lead, mercury, selenium, and zinc, and values for B_0 and B_1 for these chemicals are shown in Table 6. In the absence of sufficient data to produce regression relationships, uptake factors, which are the equivalent of a bioaccumulation factor, were developed by Sample et al. (1999) for some chemicals (Sample et al. 1999). The uptake factor or bioaccumulation factor is used as follows:

$$[X]_{earthworm} = [X]_{soil} \, x \, BAF$$

where:

$[X]_{earthworm}$	=	the concentration of chemical X in earthworm (dry weight)
BAF	=	the bioaccumulation factor
$[X]_{soil}$	=	the concentration of chemical X in soil (dry weight)

In the absence of any literature-based BAFs for silver, thallium and vanadium, concentrations in earthworms were assumed to be the same as in wet weight soil (Table 5).

Similar to the regression equations and uptake factors discussed above for earthworms, Bechtel (1998) report B_0 and B_1 values or uptake factors for plants (Bechtel 1998).

As described above dietary doses are calculated on a wet weight basis. Within the food-web exposure model, after the food-item concentrations are calculated on a dry weight basis, they are converted to a wet weight basis by multiplying the dry-weight food-item concentration by the proportion of the food-item that is dry matter. These dry matter proportions were obtained from U. S. EPA and are: 0.16 (earthworms) and 0.15 (plant leaves) (U.S. EPA 1993). The dry-matter proportions of incidental soil (0.80) used in the model is based on average soil moisture.

3.3 TOXICITY ASSESSMENT

In this SLERA, toxicity of COPCs to wildlife is based on estimated dietary doses. Potential risks of these doses are based on comparison to threshold dietary doses termed TRVs. The TRVs were obtained from relevant scientific literature describing the effects of various chemicals on animals. To the fullest extent possible, TRVs were chosen that are based on effects on animal reproduction (e.g., decreased eggshell thickness in birds, reduced sperm count in mammals). Reproductive endpoints are most appropriate for use in ecological risk assessment because they can have population implications.

TRVs have been selected and compiled in Table 7 for the soil COPCs. Both No Observed Adverse Effects Level (NOAEL) and Lowest Observed Adverse Effects Level (LOAEL) TRVs were used for the Marsh Run Park FUDS SLERA. Exceedance of a NOAEL TRV may or may not represent risk, depending on the nature of the underpinning study.

The TRVs were obtained from several primary sources, in a hierarchical fashion. For several metals, TRVs were available from the U.S. EPA's EcoSSL program. These were developed from a rigorous scientific review process, and are preferred when available. After the EcoSSL values, Oak Ridge National Laboratory TRVs were selected as available (Sample et al. 1996).

3.4 RISK CHARACTERIZATION

Risk characterization in the wildlife assessment was analogous to the initial screening and lower trophic-level assessment, i.e., Hazard Quotients were calculated, as follows:

$$HQ = \frac{Calculated\ \ Dose\ \ from\ EU}{TRV}$$

If the wildlife dose from the site was less than the NOAEL TRV, the HQ was less than 1.0, and negligible risk was inferred. If the wildlife dose was greater than the NOAEL TRV (HQ>1), but less than the LOAEL TRV (HQ<1), there may or may not be risk, and this was evaluated qualitatively on a case-by-case basis. If a LOAEL HQ exceeded 1.0, there was an indication of potential risk.

3.4.1 Surface Soil

As discussed above, because of the limited surface soil data, as well as the highly skewed nature of the data, the maximum soil concentration was used to assess food-web risks. The results of this assessment are shown in Tables 8 and 9 for the robin and shrew respectively. LOAEL HQs exceed 1.0 for copper, lead, zinc and total HPAH for the robin (Table 8) and lead, thallium, and total HPAH using the maximum detected concentration for the shrew (Table 9).

Sample S-3, collected in 1988, contained reported concentrations of multiple metals exceeding the ecological screening value (e.g., cadmium, copper, lead, selenium, silver, thallium, and zinc) and also contained moderate levels of both high and low molecular weight PAHs. SB-4, collected in June 2011, contained reported concentrations of lead in exceedance of the screening value. Sample SB-4 contained the highest reported concentrations of high and low molecular weight PAHs; however, the sediment samples collected in the wetland adjacent to this location had reported PAH concentrations orders of magnitude lower than that reported in SB-4 (e.g., total PAH 2,962 mg/kg at SB-4 versus 13 mg/kg at SD-9). It is not known whether the exceedances reported in S-3 and SB-4 are due to contamination associated with the landfill or with fill material placed in this area; however, they appear to be localized to that immediate vicinity. Because of the extreme variance associated with these samples, the food-web was run without including data from these two samples. These food-web models are shown in Tables 10 and 11 for the robin and shrew respectively. For the robin, there are still some small NOAEL exceedances for the robin, but no LOAEL exceedances. For the shrew the only LOAEL exceedance is for thallium. This exceedance is based on a TRV from Sample et al. (1996), which is highly conservative (Sample 1996). The EcoSSL committee did not examine thallium; consequently, there are few other data to use for this TRV. It is expected that the shrew thallium TRV used in this assessment is conservatively low.

Because the exceedances noted above appear to be limited to the general vicinity of S-3 and SB-4, they are not expected to result in unacceptable population-level risks to terrestrial organisms including plants, soil invertebrates, mammals, or birds.

3.4.2 Sediment

With respect to sediment invertebrates the exceedances shown in Table 2 are all relative to threshold effect levels, below which harmful effects are unlikely to be observed (MacDonald et al. 2000). None of the measured metal concentrations exceeded probable effect levels (above which harmful effects are likely to be observed). It is likely that measured arsenic, lead, manganese and zinc are representative of background for the area, and not an indication of landfill issues. Cadmium exceeded the threshold effect level in four of fourteen samples, which

is not indicative of a wide-spread population-level problem. As with metals, none of the measured PAH sample concentrations exceeded probable effect levels. These PAH concentrations in sediment are orders of magnitude lower than those measured in the surface soil samples collected from S-3 and SB-4. Sediment sample SS-5, collected in 1989 and located upgradient of the landfill, had high PAH concentrations, and likely do not represent a site-related condition. As with metals, population-level effects are not expected from exposure to PAH in these Marsh Run Park sediment samples.

In addition, as discussed above, a food-web model has been performed, using the same COPCs, receptors, exposure assumptions, and TRVs as used for soil to assess potential impacts to birds and mammals. The results of the food-web assessment are shown in Tables 12 and 13 for the robin and shrew respectively. With the exception of vanadium for the robin and thallium for the shrew, no LOAEL TRVs were exceeded based on exposure to the 95 percent UCLM in sediment. As discussed above, the shrew thallium TRV is uncertain, and likely too conservative. The vanadium LOAEL TRV is based on multiple endpoints, but is likely a conservative value because it is lower than many of the other accepted NOAEL TRVs (U.S. EPA 2005c). In addition, the dry weight 95 percent UCLM for vanadium was 40 mg/kg, which is in the expected range for background vanadium (U.S. EPA 2005c). Consequently, it is not expected that birds such as the robin are at risk from exposure to vanadium in the sediment

No impacts such as denuded vegetation were observed in the wetland that would be indicative of chemical contamination, and the marsh contained high-value habitat. No metals or PAH exceeded probable effect levels, indicative of a low risk to ecological receptors. With the exception of DDT detected in a single sample, none of these chemicals are expected to bioaccumulate; consequently, impacts on mammals or birds that may consume organisms in the marsh are not expected. Food-web analyses indicated that, with the exception of thallium for the shrew and vanadium for the robin, no LOAEL risk TRVs are exceeded, indicative of protection of these species. For thallium and vanadium these TRVs are likely too conservative, and it is unlikely that these chemicals will affect populations of birds or mammals. In summary, it is not expected that populations of sediment-dwelling organisms, birds or mammals are at risk from exposure to the chemicals measured in Marsh Run sediment.

3.4.3 Surface Water

Three COPCs were identified in surface water (copper, lead, and mercury). Surface water sample locations SWS-2 and SWS-5 are located on Marsh Run creek upstream of the FUDS. SW-2 was located east of the fill area. It is important to note that these metal concentrations are total, and not the more appropriate dissolved fraction; consequently, this is a conservative assessment. None of these concentrations exceed acute water quality criteria, and the

exceedances of chronic criterion are localized. Given the high-quality nature of the marsh vegetation, the absence of apparent toxic effects from chemicals, the use of total metals instead of dissolved metals, and the very few exceedances of chronic dissolved water quality standards, it is not expected that aquatic organisms are being affected by concentrations of chemicals in the water.

4. UNCERTAINTY

U.S. EPA (1997) defines uncertainty as "…imperfect knowledge of the degree of hazard or of its spatial and temporal distribution" (U.S. EPA 1997). Sources of uncertainty associated with this SLERA include:

Sampling in site investigations is typically biased toward areas of known or suspected contamination which may have the effect of biasing risk estimates higher than they actually are.

Toxicological data that underpin the screening values are inherently uncertain because laboratory data are extrapolated to field sites. Because conservative screening values were used, the uncertainty was biased in the direction of overestimation of risks.

For a number of chemicals detected at Marsh Run there were no available screening values (e.g., "NSV" on Tables 1, 2, and 3). This resulted in a lack of assessment of some receptors. This resulted in unavoidable uncertainty.

COPCs were assumed to be 100 percent available to receptors. This is a highly unlikely circumstance based on soil chemistry. Under many circumstances, both inorganic and organic compounds are chemically bound in the soil matrix and are not available for uptake by receptors. This resulted in overestimation of risks.

5. ECOLOGICAL RISK SUMMARY

A SLERA has been performed for Marsh Run. The SLERA followed U.S. EPA guidance and Pennsylvania Act 2 requirements, and consisted of a hazard assessment, exposure assessment, toxicity assessment, and risk characterization. The area examined for ecological risk was those soil areas outside of the fence and the adjacent wetland, and utilized all available data (1987-2011). Risks were characterized for terrestrial plants and invertebrates, aquatic organisms, benthic organisms, and terrestrial birds and mammals. There is no indication of negative effects to ecological organisms in soil, sediment, or surface water. No threatened, endangered or listed species have been identified in Marsh Run. The samples taken in 2011 help to support the conclusion that the location of relatively high metal and PAH concentrations found in soil in 1988 is localized, and does not represent an unacceptable risk to populations of terrestrial organisms. As a result, the conclusions reached in the 1990 SLERA that acceptable ecological risks have been found at the site have been confirmed. Acceptable population-level risk levels are found at the site for terrestrial plants, invertebrates, birds and mammals, aquatic, and benthic organisms.

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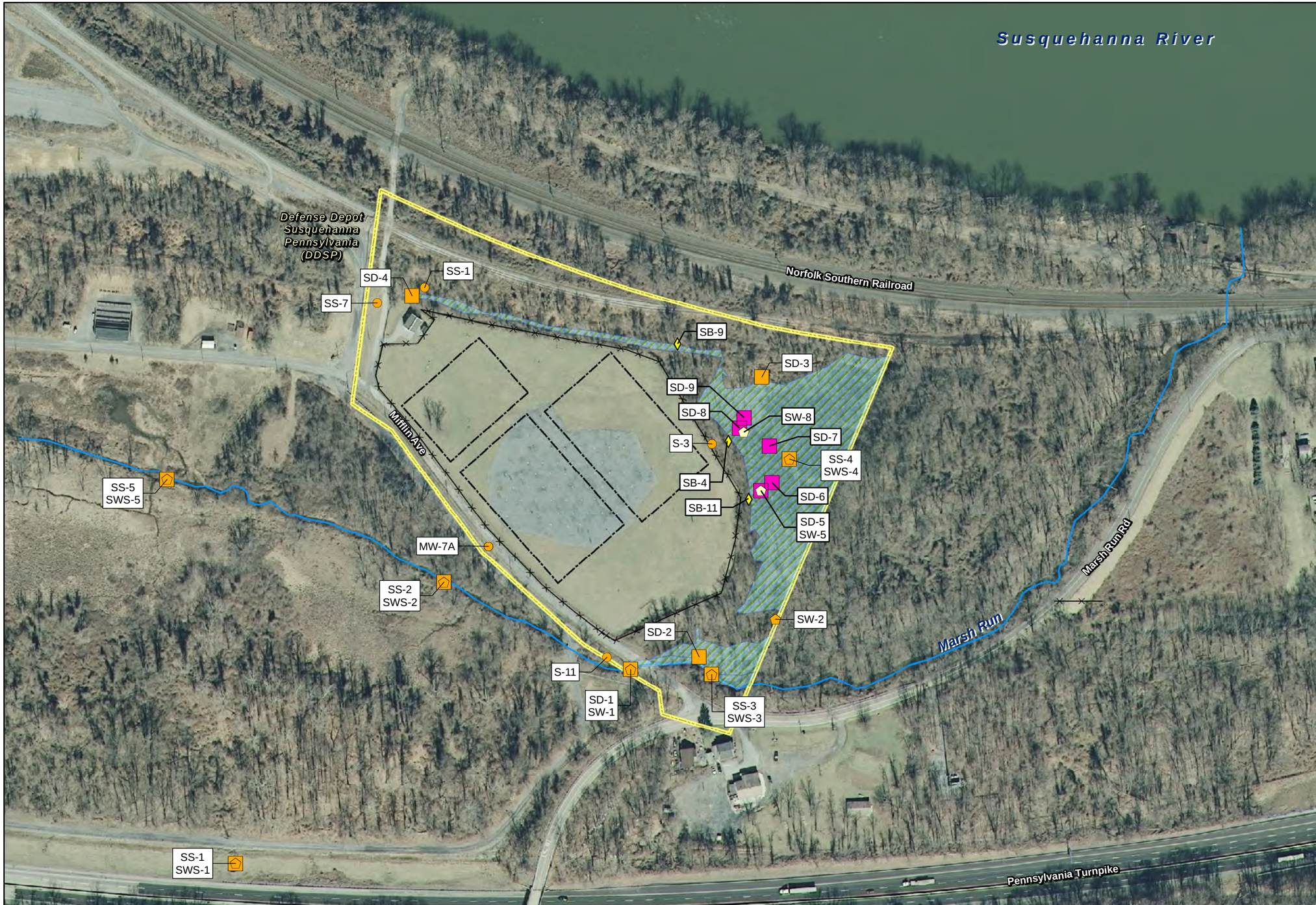
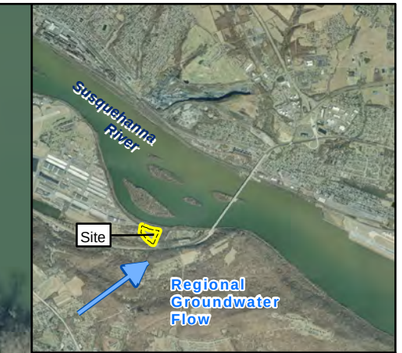




Legend

- Delineation Soil Sample Location (2011)
- Historical Surface Soil Sample Location used in Ecological Risk Assessment
- Historical Sediment Sample Location
- Historical Surface Water Sample Location
- Wetland Soil (Sediment) Sample Location (2011)
- Wetland Surface Water Sample Location (2011)
- Fence
- Stream
- Formerly Used Defense Site (FUDS) Boundary
- Proposed Soccer Fields
- Wetlands Within FUDS Boundary

Note:
Sample locations approximate, georeferenced data not available.

Aerial Photograph Source:
PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 2008

Marsh Run Park FUDS

Fairview Township, New Cumberland, Pennsylvania
FUDS Project No. C03PA040301

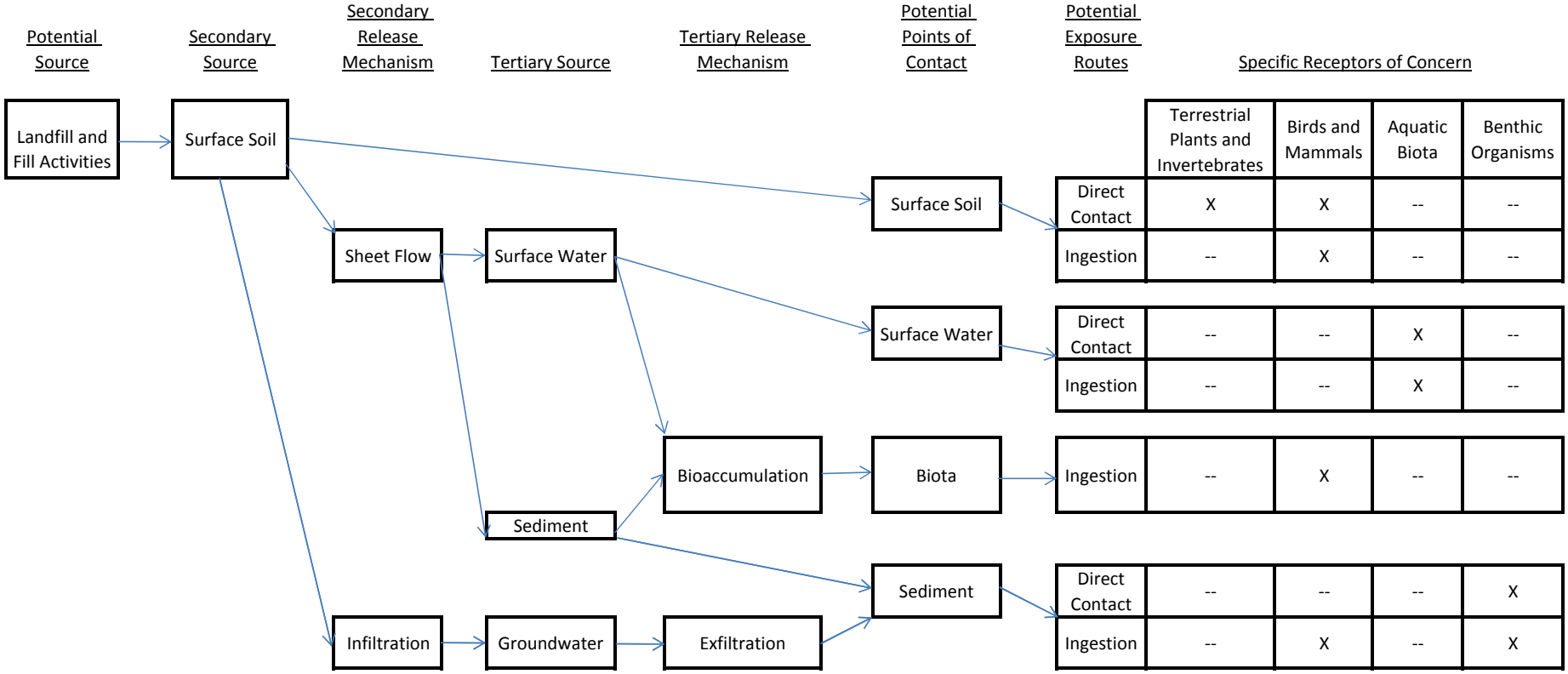
Project Number: 6233003

Date: May 2012

0 100 200
Feet
1 inch = 200 feet

Figure 1
Surface Soil, Surface Water, and Sediment Sampling Locations Included in the Ecological Evaluation

Path: J:\EA\projects\6233003\Mxd\RevisionsSAR\EcologicalEvaluation.mxd



X = Exposure Pathway Complete
-- = Exposure Pathway Incomplete

Figure 2. Ecological Conceptual Site Model for Marsh Run Park

TABLE 1 COMPARISON OF DETECTED MARSH RUN OUTSIDE FENCE SOIL SAMPLES TO ECOLOGICAL SCREENING VALUES

Loction ID:			sys_loc_code	MW-7A	S-3	S-11	SB-4	SB-9	SB-11	SS-1	SS-7	
Date:			sample_date	1/1/1989	6/23/1988	6/23/1988	6/2/2011	6/2/2011	6/2/2011	5/25/1988	5/25/1988	
Sample Name:				MW-7A S-1	S3	S11	SB-4-0-0.5	SB-9-0-0.5	SB-11-0-0.5	SS1	SS7	Maximum Detect
Depth Interval:				0-2 ft	0-2 ft	0-2 ft	0-0.5 ft	0-0.5 ft	0-0.5 ft	0-2 ft	0-2 ft	
Analyte	Ecological Screening Value[1]	Receptor	Unit									
Metals												
Aluminum	pH >5.5		mg/kg	14,100	NS	NS	NS	NS	NS	NS	NS	14100
Arsenic	18	Plants	mg/kg	6.2	2.4	0.57	NS	NS	2.5 J	4.23	4.19	6.2
Barium	330	Inverts	mg/kg	106	NS	NS	NS	NS	NS	NS	NS	106
Cadmium	0.77	Avian	mg/kg	U	**5.6**	**3.6**	NS	NS	NS	< 1 U	< 1 U	**5.6**
Calcium	NSV		mg/kg	2,170	NS	NS	NS	NS	NS	NS	NS	2170
Chromium	26	Avian	mg/kg	16.9	**33**	8.7	NS	NS	NS	9.03	14.8	**33**
Copper	28	Avian	mg/kg	U	**797**	12	NS	NS	NS	10.9	9.38	**797**
Iron	pH >5.5		mg/kg	22,200	NS	NS	NS	NS	NS	NS	NS	22200
Lead	11	Avian	mg/kg	**26.7**	**1,080**	**55**	**627 K**	**27.2 K**	**14.5 K**	10.8	**15.3**	**1080**
Magnesium	NSV		mg/kg	2,370	NS	NS	NS	NS	NS	NS	NS	2370
Manganese	220	Plants	mg/kg	**1,130**	NS	NS	NS	NS	NS	NS	NS	**1130**
Mercury	0.1[2]		mg/kg	U	0.07	0.07	NS	NS	NS	**0.34**	**0.13**	**0.34**
Nickel	38	Plants	mg/kg	13.2	13	12	NS	NS	NS	10.3	10.8	13.2
Potassium	NSV		mg/kg	655	NS	NS	NS	NS	NS	NS	NS	655
Selenium	0.52	Plants	mg/kg	0.21 B	**3.8**	**0.81**	NS	NS	NS	< 1 U	0.16	**3.8**
Silicon	NSV		mg/kg	674	NS	NS	NS	NS	NS	NS	NS	674
Silver	4.2	Avian	mg/kg	U	**5.6**	< 0.5 U	NS	NS	NS	< 2 U	< 2 U	**5.6**
Sodium	NSV		mg/kg	285 B	NS	NS	NS	NS	NS	NS	NS	285
Thallium	0.057[2]		mg/kg	U	**13**	**17**	< 2.3 U	< 2.3 U	NS	< 2 U	< 2 U	**17**
Vanadium	1.59[2]		mg/kg	**28.4**	NS	NS	NS	NS	NS	NS	NS	**28.4**
Zinc	16	Avian	mg/kg	**72.8**	**1,510**	**75**	NS	NS	NS	**36.7**	**39.9**	**1510**
Semivolatile Organic Compounds												
Bis(2-ethylhexyl) phthalate	NSV		mg/kg	U	U	U	NS	NS	NS	< 0.33 U	1.89	1.89
Diethylphthalate	NSV		mg/kg	U	U	U	NS	NS	NS	0.1	< 0.33 U	0.1
Di-n-butyl phthalate	NSV		mg/kg	U	U	U	NS	NS	NS	0.56	0.99	0.99

TABLE 1 COMPARISON OF DETECTED MARSH RUN OUTSIDE FENCE SOIL SAMPLES TO ECOLOGICAL SCREENING VALUES

Loction ID:			sys_loc_code	MW-7A	S-3	S-11	SB-4	SB-9	SB-11	SS-1	SS-7	
Date:			sample_date	1/1/1989	6/23/1988	6/23/1988	6/2/2011	6/2/2011	6/2/2011	5/25/1988	5/25/1988	
Sample Name:				MW-7A S-1	S3	S11	SB-4-0-0.5	SB-9-0-0.5	SB-11-0-0.5	SS1	SS7	Maximum Detect
Depth Interval:				0-2 ft	0-2 ft	0-2 ft	0-0.5 ft	0-0.5 ft	0-0.5 ft	0-2 ft	0-2 ft	
Analyte	Ecological Screening Value[1]	Receptor	Unit									
Low MW PAHs												
2-methylnaphthalene	NSV	Use Total	mg/kg	< 1.2 U	0.22	< 0.33 U	NS	NS	NS	< 0.33 U	< 0.33 U	0.22
Acenaphthene	NSV	Use Total	mg/kg	< 1.2 U	0.92	< 0.33 U	49	< 0.043 U	0.0491 J	< 0.33 U	< 0.33 U	49
Anthracene	NSV	Use Total	mg/kg	< 1.2 U	U	U	147	0.0422 J	0.138 J	< 0.33 U	< 0.33 U	147
Fluorene	NSV	Use Total	mg/kg	< 1.2 U	U	U	72.9	< 0.043 U	0.0523 J	< 0.33 U	< 0.33 U	72.9
Naphthalene	NSV	Use Total	mg/kg	< 1.2 U	0.4	< 0.33 U	29.2	< 0.043 U	< 0.0349 U	< 0.33 U	< 0.33 U	29.2
Phenanthrene	NSV	Use Total	mg/kg	< 1.2 U	1.9	< 0.33 U	503	0.043 J	0.547	< 0.33 U	< 0.33 U	503
Total LM PAHs	29	Inverts	mg/kg	< 1.2 U	3.4	<0.33U	**801**	0.042	0.7864	<0.33 U	< 0.33 U	**801**
High MW PAHs												
Fluoranthene	NSV	Use Total	mg/kg	< 1.2 U	7.3	< 0.33 U	612	0.0627 J	0.773	< 0.33 U	< 0.33 U	612
Indeno[1,2,3-c,d]pyrene	NSV	Use Total	mg/kg	< 1.2 U	U	U	82.2	0.0308 J	0.205 J	< 0.33 U	< 0.33 U	82.2
Pyrene	NSV	Use Total	mg/kg	0.13 J	6.6	< 0.33 U	406	0.066 J	0.725	< 0.33 U	< 0.33 U	406
Chrysene	NSV	Use Total	mg/kg	< 1.2 U	4.6	< 0.33 U	227	0.0515 J	0.357	< 0.33 U	< 0.33 U	227
Dibenz[a,h]anthracene	NSV	Use Total	mg/kg	< 1.2 U	U	U	37.4	< 0.043 U	0.061 J	< 0.33 U	< 0.33 U	37.4
Benzo[a]anthracene	NSV	Use Total	mg/kg	< 1.2 U	U	U	244	0.0379 J	0.378	< 0.33 U	< 0.33 U	244
Benzo[a]pyrene	NSV	Use Total	mg/kg	< 1.2 U	U	U	206	0.0349 J	0.307	< 0.33 U	< 0.33 U	206
Benzo[b]fluoranthene	NSV	Use Total	mg/kg	< 1.2 U	8.3	< 0.33 U	161	0.0447 J	0.302	< 0.33 U	< 0.33 U	161
Benzo[k]fluoranthene	NSV	Use Total	mg/kg	< 1.2 U	7.3	< 0.33 U	182	0.0418 J	0.3	< 0.33 U	< 0.33 U	182
Total HM PAHs	1.1	Mammals	mg/kg	0.13	**34**	<0.33 U	**2158**	0.3703	**3.4**	<0.33 U	< 0.33 U	**2158**
Miscellaneous Parameters												
Total Petroleum Hydrocarbons	NSV		mg/kg	0.13 J	NS	NS	NS	NS	NS	NS	NS	0.13
Other												
Cyanide	NSV		mg/kg	0.1	1.75	0.45	NS	NS	NS	< 0.25 U	< 0.25 U	1.75

1. U.S. EPA EcoSSLs unless otherwise specified.
2. Lowest screening value for soil in Buchman (2008)

Shaded and **Bolded** results exceed screening value.

NSV = No screening value
NS = Not sampled
U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.
J = Analyte present. Reported value may not be accurate or precise.
K = Analyte present. Reported value may be biased high. Actual value is expected lower.
B = Not detected substantially above the level reported in laboratory or field blanks.
PAH = Polycyclic aromatic hydrocarbon
MW = Molecular weight
SSL = Soil screening level
U.S. EPA = United States Environmental Protection Agency
mg/kg = milligram per kilogram

TABLE 2 COMPARISON OF DETECTED MARSH RUN SEDIMENT SAMPLES TO ECOLOGICAL SCREENING VALUES

		Loction	Small Stream near entrance to site	Small outfall from fill exiting south of landfill	Marsh area east of landfill	Drainage culvert north of landfill	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Maximum Detect	95% UCLM (dry weight)
		Date:	Apr-87	Apr-87	Apr-87	Apr-87	1989	1989	1989	1989	1989	12/9/2011	12/9/2011	12/9/2011	12/9/2011	12/9/2011		
		Sample Name:	SD-1	SD-2	SD-3	SD-4	SS-1	SS-2	SS-3	SS-4	SS-5	SD-5	SD-6	SD-7	SD-8	SD-9 average		
Analyte	Freshwater Sediment Invertebrate Screening Values[1]	Unit																
Metals																		
Aluminum	NSV	mg/kg	5,540	6,440	8,090	5520	6,170	22,130	12,200	7,200	13,600	37,200	33,100	27,600	17,100	25,300	37,200	
Antimony	NSV	mg/kg	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.2 J	2.6 J	2.2 J	1.4 J	1.85 J	2.6	
Arsenic	9.79	mg/kg	U	6.6	10	7	**11.8**	**36.4**	**13.1**	**32.4**	7.6	8	8.6	**11.1**	7	**10**	**36.4**	
Barium	NSV	mg/kg	93	77	101	33	51.9	175	69.9	108	64.3	185	178	149	84	118	185	
Beryllium	NSV	mg/kg	0.61	0.81	1	0.35	0.32	1.1	0.49	0.66	0.59	1.1 J	1.1 J	0.89 J	0.64 J	0.89 J	1.1	
Cadmium	0.99	mg/kg	0.89	0.62	0.92	0.57	U	U	0.62	**1.5**	0.63	0.72	**1.4**	0.8	**1.6**	**2.25**	**2.25**	1.4
Calcium	NSV	mg/kg	5,110	2,080	2,460	1020	2,170	2,750	1,910	3,810	5,180	3,370	4,120	2,680	4,610	3,020	5,180	
Chromium	43.4	mg/kg	14	12	15	8.1	9.9	24.9	12	18.2	20.9	38.9	36.9	32.7	23.7	33.5	38.9	26.4
Cobalt	NSV	mg/kg	6.7	9.1	9.5	4.6	8.5	11.1	11.7	7.6	10.3	7	7.7	8	7.4	10.1	11.7	
Copper	31.6	mg/kg	19	9.5	13	9.6	U	U	U	U	16.3	23.6	24.8	16.8	20.5	23.8	24.8	21
Iron	NSV	mg/kg	17,000	15,600	18,200	13400	17,500	19,800	16,100	29,800	26,700	21,400	22,100	24,500	20,600	26,200	29,800	
Lead	35.8	mg/kg	33	9	**72**	12	U	U	U	**75.8**	21.5	**61**	**69.2**	**70.9**	**44.1**	**63.5**	**75.8**	62
Magnesium	NSV	mg/kg	1,830	1,720	1,740	1640	1,450	2,810	3,430	2,090	2,840	3,310	3,470	2,900	2,950	3,675	3,675	
Manganese	460[2]	mg/kg	**482**	**927**	**756**	400	372	175	175	300	**898**	189	195	211	**720**	**854**	**927**	658
Mercury	0.018	mg/kg	NS	NS	NS	NS	0.34	0.12	0.13	0.14	0.36	U	U	U	U	U	0.36	0.36 (max)
Nickel	22.7	mg/kg	11	11	14	11	8.2	18.6	17.2	15.9	14.5	18.3	19.9	17.9	17	21.7	21.7	
Potassium	NSV	mg/kg	U	U	U	U	408	746	622	922	991	4,610	3,540	3,110	2,970	4,720	4,720	
Selenium	NSV	mg/kg	U	U	U	U	U	0.37	U	0.84	U	U	U	U	U	U	0.84	3.8
Silicon	NSV	mg/kg	NS	NS	NS	NS	999	1,430	962	1,170	32.7	NS	NS	NS	NS	NS	1430	
Silver	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	U	U	U	U	2 (DL)
Thallium	NSV	mg/kg	U	U	26	U	U	U	U	U	U	U	U	U	U	U	26	26 (max)
Vanadium	NSV	mg/kg	22	22	26	8.2	26.3	42.8	22.6	33	25.9	60.1	56.2	49.1	31.1	44.3	60.1	40
Zinc	121	mg/kg	91	78	101	44	U	U	U	U	59.4	**192**	**188**	**185**	**157**	**205.5**	**205.5**	166
Other																		
Cyanide	NSV	mg/kg	NS	NS	NS	NS	U	0.14	U	0.34	0.2	NS	NS	NS	NS	NS	0.34	
Total Petroleum Hydrocarbons	NSV	mg/kg	NS	NS	NS	NS	U	116	U	U	150	NS	NS	NS	NS	NS	150	
Semivolatile Organic Compounds																		
2,4-dinitrotoluene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	0.62	U	U	0.62	
2,6-dinitrotoluene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	0.76	U	U	0.76	
Bis(2-ethylhexyl) phthalate	0.75[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	0.16 J	0.03 J	U	0.03 J	0.12J	0.21 J	0.21	
Carbazole	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	0.02 J	0.03 J	0.03 J	0.08 J	0.13 J	0.13	
Diethylphthalate	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	0.15 J	U	U	U	U	U	0.15	
Di-n-butylphthalate	0.11[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.27 J**	U	U	U	U	U	**0.27**	
Isophorone	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	1.12	U	U	1.12	
mp-Cresol	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	U	0.20 J	0.69	0.69	
N-nitrosodi-n-propylamine	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	0.5	U	U	0.5	
N-nitrosodiphenylamine	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	0.05	U	U	0.05	

TABLE 2 COMPARISON OF DETECTED MARSH RUN SEDIMENT SAMPLES TO ECOLOGICAL SCREENING VALUES

		Loction	Small Stream near entrance to site	Small outfall from fill exiting south of landfill	Marsh area east of landfill	Drainage culvert north of landfill	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Maximum Detect	95% UCLM (dry weight)
		Date:	Apr-87	Apr-87	Apr-87	Apr-87	1989	1989	1989	1989	1989	12/9/2011	12/9/2011	12/9/2011	12/9/2011	12/9/2011		
		Sample Name:	SD-1	SD-2	SD-3	SD-4	SS-1	SS-2	SS-3	SS-4	SS-5	SD-5	SD-6	SD-7	SD-8	SD-9 average		
Analyte	Freshwater Sediment Invertebrate Screening Values[1]	Unit																
Polycyclic Aromatic Hydrocarbons																		
2-methylnaphthalene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	0.15 J	0.14 J	0.18 J	0.37 J	0.39 J	0.64 J	0.64	
Acenaphthene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	U	0.36 J	0.08 J	0.08	
Acenaphthylene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	0.03 J	0.04 J	0.04 J	0.08 J	0.11 J	0.11	
Anthracene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	0.04 J	0.04 J	0.05 J	0.12 J	0.21 J	0.21	
Dibenz[a,h]anthracene	0.033	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	U	**0.08 J**	**0.16 J**	**0.16**	
Dibenzofuran	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	U	U	U	U	0.03 J	0.06 J	0.06	
Phenanthrene	0.042[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.57 J**	**0.18 J**	**0.18 J**	**0.24 J**	**0.51 J**	**0.91 J**	**0.91**	
Fluoranthene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	0.78 J	0.44	0.44 J	0.61	1.26	1.95	1.95	
Fluorene	0.077	mg/kg	NS	NS	NS	NS	U	U	U	U	U	0.01 J	U	0.02 J	0.04 J	**0.1 J**	**0.1**	
Indeno[1,2,3-c,d]pyrene	0.017[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.23 J**	**0.10 J**	**0.10 J**	**0.12 J**	**0.24 J**	**0.50**	**0.50**	
Pyrene	0.044[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.86 J**	**0.36 J**	**0.36 J**	**0.51**	**1.07**	**1.70**	**1.70**	
Chrysene	0.027[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.59 J**	**0.26 J**	**0.27 J**	**0.35 J**	**0.71**	**1.14**	**1.14**	
Benzo[a]anthracene	0.108	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.43 J**	**0.19 J**	**0.18 J**	**0.25 J**	**0.58**	**0.95**	**0.95**	
Benzo[a]pyrene	0.15	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.48 J**	**0.22 J**	**0.23 J**	**0.29 J**	**0.66**	**1.04**	**1.04**	
Benzo[b]fluoranthene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	0.31 J	0.35 J	0.39 J	0.52	1.08	1.70	1.70	
Benzo[k]fluoranthene	0.027[2]	mg/kg	NS	NS	NS	NS	U	U	U	U	**0.37 J**	**0.15 J**	**0.15 J**	**0.51**	**0.47**	**0.62**	**0.62**	
Benzo[g,h,i]perylene	NSV	mg/kg	NS	NS	NS	NS	U	U	U	U	0.28 J	0.10 J	0.10 J	0.12 J	0.23 J	0.55	0.55	
Naphthalene	0.176	mg/kg	NS	NS	NS	NS	U	U	U	U	NS	U	U	U	U	0.05 J	0.05	
Total PAHs	1.61	mg/kg	NS	NS	NS	NS	U	U	U	U	**5.05**	**2.57**	**2.66**	**4.00**	**7.91**	**12.47**	**13.18**	8.9
Pesticides																		
4,4'-DDD	0.00488	mg/kg	NS	NS	NS	NS	U	U	U	**0.12**	U	NS	NS	NS	NS	NS	**0.12**	
4,4'-DDE	0.00316	mg/kg	NS	NS	NS	NS	U	U	U	**0.62**	U	NS	NS	NS	NS	NS	**0.62**	
4,4'-DDT	0.00416	mg/kg	NS	NS	NS	NS	U	U	U	**0.3**	U	NS	NS	NS	NS	NS	**0.3**	
Total DDT	0.0053	mg/kg	NS	NS	NS	NS	U	U	U	**1.04**	U	NS	NS	NS	NS	NS	**1.04**	

1. Consensus based screening value from MacDonald et.al. (2000)
2. Lowest screening value for freshwater sediment in Buchman (2008)

Shaded and **Bolded** results exceed screening value.

NSV = No screening value

NS = Not sampled

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

J = Analyte present. Reported value may not be accurate or precise.

PAH = Polycyclic aromatic hydrocarbon

mg/kg = milligram per kilogram

TABLE 3 COMPARISON OF AQUATIC SCREENING VALUES TO DETECTED SURFACE WATER CONCENTRATIONS

		Location:	Inlet of culvert Under Mifflin Avenue	Outlet of Creek to Marsh East of Landfill	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Maximum Detect
		Date:	1987	1987	1989	1989	1989	1989	1989	12/9/2011	12/9/2011	
		Sample Name:	SW-1	SW-2	SWS-1	SWS-2	SWS-3	SWS-4	SWS-5	SW-5	SW-8 average	
Analyte	Aquatic Screening Value[1]	Unit										
Metals												
Aluminum	NSV	µg/L	246	140	354	U	162	1,410	12,000	270	180	12000
Arsenic	NSV	µg/L	U	U	U	U	U	U	U	U	1.4 J	14
Barium	NSV	µg/L	70	29	43.8	57.6	61.3	10.2	215	33	39	215
Boron	NSV	µg/L	NS	NS	U	71	U	U	161	NS	NS	161
Calcium	NSV	µg/L	41,400	23,600	43,900	75,400	75,600	51,000	67,300	520	0.47	75600
Chromium	140[2]	µg/L	U	U	U	U	U	U	23.2	U	U	23.2
Copper	17.4[2]	µg/L	2.8	15	U	U	U	U	**23.7**	3.0 J	2.95 J	**23.7**
Iron	NSV	µg/L	1,010	1,140	345	655	900	1,610	22,800	460	3,350	22800
Lead	5.8[2]	µg/L	U	**39**	U	U	U	U	**53.5**	U	1.7 J	**53.5**
Magnesium	NSV	µg/L	8,030	4,010	8,510	10,900	11,100	7,600	12,100	9,100	11,350	12100
Manganese	NSV	µg/L	138	216	U	204	225	180	1,040	30	1,200	1,200
Mercury	0.77	µg/L	U	U	U	**2.1**	U	0.51	U	U	U	**2.1**
Potassium	NSV	µg/L	U	U	4,710	2,390	2,480	3,120	2,680	2,100	2,700	4710
Silicon	NSV	µg/L	NS	NS	9,670	4,940	5,570	4,730	17,700	NS	NS	17700
Sodium	NSV	µg/L	41,900	19,100	14,600	54,700	54,500	34,400	35,400	3,700	7,900	54700
Vanadium	NSV	µg/L	U	U	U	U	U	U	27.2	1.2 J	1.3 J	27.2
Zinc	229[2]	µg/L	U	51	U	U	U	U	170	9.4	11.50	170
Hardness	NSV	µg/L	U	U	U	U	U	U	U	167	186.50	186.5
VOCs												
1,1,2,2-Tetrachloroethane	210	µg/L	NS	NS	U	U	U	U	2 J	NS	NS	2
Trichloroethylene	450	µg/L	NS	NS	U	7	6	U	4J	NS	NS	4
Pesticides												
4,4'-DDD	0.001	µg/L	NS	NS	U	U	U	U	0.00024	NS	NS	0.00024

TABLE 3 COMPARISON OF AQUATIC SCREENING VALUES TO DETECTED SURFACE WATER CONCENTRATIONS

		Location:	Inlet of culvert Under Mifflin Avenue	Outlet of Creek to Marsh East of Landfill	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Marsh Run	Maximum Detect
		Date:	1987	1987	1989	1989	1989	1989	1989	12/9/2011	12/9/2011	
		Sample Name:	SW-1	SW-2	SWS-1	SWS-2	SWS-3	SWS-4	SWS-5	SW-5	SW-8 average	
Analyte	Aquatic Screening Value[1]	Unit										
PAHs												
Anthracene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.02 J	0.02
Benzo[a]anthracene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.06	0.06
Benzo[a]pyrene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.06	0.06
Benzo[b]fluoranthene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.1	0.1
Benzo[g,h,i]perylene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.04 J	0.04
Benzo[k]fluoranthene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.04 J	0.04
Chrysene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.06	0.06
Fluoranthene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	0.02 J	0.12	0.12
Indeno[1,2,3-c,d]pyrene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.03 J	0.03
Naphthalene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	0.04 J	0.1	0.1
Phenanthrene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	U	0.06	0.06
Pyrene	NSV	µg/L	NS	NS	NS	NS	NS	NS	NS	0.02 J	0.11	0.11

1. PA 2009 Chronic Water Quality Criteria based on dissolved concentration except where noted.

2. Calculated based on the hardness at sample SWS-5 (218 mg/L as CaCO3)

Shaded and **Bolded** results exceed screening value.

NSV = No screening value

NS = Not sampled

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

J = Analyte present. Reported value may not be accurate or precise.

VOC = Volatile organic compound

PAH = Polycyclic aromatic hydrocarbon

µg/L = micrograms per liter

TABLE 4 FOOD-WEB EXPOSURE FACTORS

Exposure Factor	American Robin	Short-Tailed Shrew
Body Weight (kg)	0.082 (U.S. EPA 1993) Average for adult, both sexes, all seasons, NY	0.017 (U.S. EPA 1993) Adult average, summer, fall; NH, PA
Food Ingestion Rate (g/g/day)	0.82 (U.S. EPA 2003; Nagy 1987) Allometrically scaled to body weight	0.56 (U.S. EPA 1993) Average for breeding adults, OH, WI
Incidental Soil Ingestion Rate (g/g/day)	0.085 (U.S. EPA 1993) Based on 10.4% soil in diet of American woodcock	0.0728 (U.S. EPA 1993)
Home Range (acres)	0.4 (U.S. EPA 1993) Foraging range of adults feeding nestlings, Ontario	0.2 (U.S. EPA 1993) Mid-point between high and low prey density ranges, NY
Dietary Composition	62% fruit 38% invertebrates (U.S. EPA 1993) Eastern U.S.	80% invertebrates 20% vegetation (U.S. EPA 1993)

kg = kilogram
g/g/day = gram per gram of body weight per day
U.S. EPA = United States Environmental Protection Agency
NH = New Hampshire
PA = Pennsylvania
OH = Ohio
WI = Wisconsin
NY = New York

TABLE 5 BIOACCUMULATION FACTORS FOR FOOD-WEB EXPOSURE

Analyte	Invertebrate Bioaccumulation Factor		Plant Bioaccumulation Factor	
	BAF (dw)	Source	BAF (dw)	Source
Metals				
Cadmium	Table 6	-----	Table 6	-----
Chromium	0.31	Sample et al. 1999	0.041	Bechtel 1998
Copper	Table 6	-----	Table 6	-----
Lead	Table 6	-----	Table 6	-----
Manganese	Table 6	-----	0.0792	Bechtel 1998
Mercury	Table 6	-----	Table 6	-----
Selenium	Table 6	-----	Table 6	-----
Silver	1	default	1	default
Thallium	1	default	0.004	Bechtel 1998
Vanadium	1	default	0.00485	Bechtel 1998
Zinc	Table 6	-----	Table 6	-----
PAHs				
LPAH	0.21 (a)	Beyer 1990	0.042 (b)	Travis & Arms 1988
HPAH	0.21 (a)	Beyer 1990	0.042 (b)	Travis & Arms 1988

(a) mean BAF for 12 PAHs calculated from data in Beyer (1990)

(b) based on geometric mean log Kow for all HPAHs applied in the equation of Travis and Arms (1988)

Note: When no BAF was available from the literature, a default BAF of 1.0 was used

BAF = Bioaccumulation factor

dw = dry weight

PAH = Polycyclic aromatic hydrocarbon

LPAH = Low molecular weight PAH

HPAH = High molecular weight PAH

TABLE 6 BIOACCUMULATION REGRESSION COEFFICIENTS

COPC	Soil Invertebrates[1]		Plants[2]	
	B_0	B_1	B_0	B_1
Cadmium	2.11	0.79	-0.476	0.546
Chromium	NA	NA	NA	NA
Copper	1.67	0.26	0.669	0.394
Lead	-0.21	0.81	-1.328	0.561
Manganese	-0.80	0.68	NA	NA
Mercury	-0.68	0.12	-0.996	0.544
Selenium	-0.075	0.73	-0.678	1.104
Silver	NA	NA	NA	NA
Thallium	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA
Zinc	4.44	0.33	1.575	0.555
LPAH	NA	NA	NA	NA
HPAH	NA	NA	NA	NA

Regression Equation is (ln [food]) = $B_0 + B_1$(ln [soil]) where the [soil] and [food] are in mg/kg dry weight.

COPC = Constituents of potential concern
NA = Not applicable (poor regression fit, or not analyzed)
mg/kg = milligrams per kilogram
LPAH = Low molecular weight polycyclic aromatic hydrocarbon
HPAH = High molecular weight polycyclic aromatic hydrocarbon

(1) Sample et al 1999
(2) Bechtel 1998

TABLE 7 TOXICITY REFERENCE VALUES (TRVs)

Analyte	Short-tailed shrew		American robin		Source		Notes
	NOAEL*	LOAEL*	NOAEL*	LOAEL*	Mammal	Avian	
Cadmium	0.77	7.7	1.47	7.8	1	1	D
Chromium	2.4	35.1	2.6	15.6	10	10	D
Copper	5.6	56	4.05	40.5	2	2	A, B
Lead	4.7	47	1.63	16.3	3	3	A, B
Manganese	51.5	139	179	269	11	11	D
Mercury	15.7	157	0.45	0.9	4	4	A
Selenium	0.143	1.43	0.29	2.9	5	5	A, B
Silver	6.02	60.2	2.02	20.2	6	6	C
Thallium	0.016	0.164	0.42	4.2	4	4	A
Vanadium	4.16	41.6	0.344	3.44	7	7	A, B
Zinc	75.4	292.1	66.1	171	8	8	D
High Molecular Weight PAHs	0.615	6.15	2.0	20	9	9	A, B
Low Molecular Weight PAHs	65.6	656	1653	16530	9	9	A

*All values are measured in units of milligrams per kilogram of body weight per day.

Sources:
(1) U.S. EPA 2005a
(2) U.S. EPA 2007a
(3) U.S. EPA 2005b
(4) Sample *et al* 1996
(5) U.S. EPA 2007b
(6) U.S. EPA 2006
(7) U.S. EPA 2005c
(8) U.S. EPA 2007c
(9) U.S. EPA 2007d
(10) U.S.EPA 2008
(11) U.S. EPA 2007e

Notes:
(A) Mammal LOAEL approximated as 10 X NOAEL
(B) Avian LOAEL approximated as 10 X NOAEL
(C) Insufficient NOAEL data to directly calculate an NOAEL; the lowest LOAEL for reproduction or growth endpoint was divided by 10 to approximate the NOAEL.
(D) LOAEL calculated as geometric mean of available Eco-SSL LOAEL values.

NOAEL = No observed adverse effect level
LOAEL = Lowest observed adverse effect level
PAH = Polycyclic aromatic hydrocarbon
SSL = Soil screening level
U.S. EPA = United States Environmental Protection Agency

TABLE 8 FOOD-WEB EXPOSURE MODEL FOR THE AMERICAN ROBIN BASED ON MAXIMUM SOIL CONCENTRATION

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Plant Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	4.5	5.21	0.24	2.13	1.47	1.40	7.8	0.27
Chromium	26.5	1.62	0.20	2.86	2.6	1.10	15.6	0.18
Copper	641	4.98	4.07	58.09	4.05	14.34	40.5	1.43
Lead	868	36.09	2.00	86.07	1.6	53.79	16.3	5.28
Manganese	909	8.61	13.42	86.73	179	0.48	269	0.32
Mercury	0.27	0.07	0.03	0.06	0.45	0.14	0.9	0.07
Selenium	3.1	0.39	0.33	0.55	0.29	1.90	2.9	0.19
Silver	4.5	1.83	0.84	1.38	2.02	0.68	20.2	0.07
Thallium	13.7	2.72	0.01	2.01	0.42	4.80	4.2	0.48
Vanadium	22.8	4.54	0.02	3.37	0.344	9.79	3.44	0.98
Zinc	1214	151.01	42.12	171.66	66.1	2.60	171	1.00
Total HPAHs	1735	72.51	13.51	176.94	2	88.47	20	8.85
Total LPAHs	644	26.91	25.91	89.65	1653	0.05	16530	0.01

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

TABLE 9 FOOD-WEB EXPOSURE MODEL FOR THE SHREW BASED ON SOIL MAXIMUM CONCENTRATION

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	4.5	5.21	3.25	0.77	4.22	7.7	0.42
Chromium	26.5	1.62	2.84	2.4	1.18	35	0.08
Copper	641	5	49	5.6	8.8	56	0.88
Lead	868	36	83	4.7	17.8	47	1.8
Manganese	909	9	71	51.5	1.4	139	0.5
Mercury	0.3	0.07	0.06	15.7	0.00	157	0.00
Selenium	3	0.39	0.44	0.143	3.1	1.43	0.31
Silver	5	1.83	1.35	6.02	0.22	60.2	0.02
Thallium	14	2.72	2.52	0.016	157	0.164	15
Vanadium	23	4.5	4.2	4.2	1.0	41.6	0.1
Zinc	1214	151.0	172.9	75.4	2.3	292.1	0.6
Total HPAHs	1735	72.51	166.92	0.615	271	6.15	27
Total LPAHs	644	26.9	62.0	65.6	0.9	656.0	0.1

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

TABLE 10 FOOD-WEB EXPOSURE MODEL FOR THE AMERICAN ROBIN SOIL MINUS S-3 AND SB-4

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Plant Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	2.9	3.67	0.19	1.48	1.47	1.0	7.8	0.19
Chromium	13.6	0.83	0.10	1.47	2.6	0.6	15.6	0.09
Copper	9.65	1.65	0.78	1.73	4.05	0.4	40.5	0.04
Lead	44.2	3.27	0.38	4.97	1.6	3.10	16.3	0.30
Manganese	909	8.61	13.4	86.7	179	0.5	269	0.32
Mercury	0.27	0.07	0.03	0.06	0.45	0.14	0.9	0.07
Selenium	0.7	0.13	0.06	0.13	0.29	0.4	2.9	0.04
Silver	1.6	0.65	0.30	0.49	2.02	0.2	20.2	0.02
Thallium	13.7	2.72	0.01	2.01	0.42	4.80	4.2	0.48
Vanadium	22.8	4.54	0.02	3.37	0.344	9.79	3.44	0.98
Zinc	58.5	55.9	7.8	26.4	66.1	0.40	171	0.15
Total HPAHs	2.7	0.11	0.02	0.28	2	0.14	20	0.01
Total LPAHs	0.64	26.9	0.03	8.45	1653	0.01	16530	0.0005

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

TABLE 11 FOOD-WEB EXPOSURE MODEL FOR THE SHREW BASED ON SOIL MINUS S-3 AND SB-4

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	2.9	3.67	2.27	0.77	2.94	7.7	0.29
Chromium	13.6	0.83	1.45	2.4	0.61	35.1	0.04
Copper	10	1.65	1.62	5.6	0.29	56	0.03
Lead	44	3.27	5.05	4.7	1.07	47	0.11
Manganese	909	8.61	70.96	51.5	1.38	139	0.51
Mercury	0.3	0.07	0.06	15.7	0.004	157	0.0004
Selenium	1	0.13	0.12	0.143	0.83	1.43	0.08
Silver	2	0.65	0.48	6.02	0.08	60.2	0.01
Vanadium	23	4.54	4.21	4.16	1.01	41.6	0.10
Zinc	59	55.86	35.54	75.4	0.47	292.1	0.12
Total HPAHs	3	0.11	0.26	0.615	0.43	6.15	0.04
Thallium	14	2.72	2.52	0.016	157.39	0.164	15.36
Total LPAHs	1	26.91	15.12	65.6	0.23	656	0.02

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

TABLE 12 FOOD-WEB EXPOSURE MODEL FOR THE AMERICAN ROBIN BASED ON SEDIMENT 95UCLM

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Plant Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	1.1	1.73	0.11	0.69	1.47	0.47	7.8	0.09
Chromium	21.2	1.29	0.16	2.29	2.6	0.88	15.6	0.15
Copper	16.88	1.91	0.97	2.52	4.05	0.62	40.5	0.06
Lead	49.8	3.60	0.40	5.56	1.6	3.48	16.3	0.34
Manganese	529.0	5.95	7.82	50.80	179	0.28	269	0.19
Mercury	0.3	0.07	0.03	0.06	0.45	0.14	0.9	0.07
Selenium	3	0.39	0.33	0.55	0.29	1.90	2.9	0.19
Silver	2	0.65	0.30	0.49	2.02	0.24	20.2	0.02
Thallium	20.9	4.16	0.02	3.08	0.42	7.34	4.2	0.73
Vanadium	32.2	6.4	0.0	4.7	0.3	13.8	3.4	1.4
Zinc	133.5	73.2	12.4	40.4	66.1	0.6	171.0	0.2
Total HPAHs	7.2	0.3	0.1	0.7	2.0	0.4	20.0	0.0
Total LPAHs	7.2	26.9	0.3	9.1	1653.0	0.0	16530.0	0.0

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

95UCLM = 95% upper confidence limit of the mean

*Separate HPAH and LPAH concentrations have not been calculated. Rather the total PAH concentration (Sum of HPAH and LPAH-8.9 mg/kg dw, 7.2 mg/kg ww) has been used as a conservative surrogate for both HPAH and LPAH in the food-webs.

TABLE 13 FOOD-WEB EXPOSURE MODEL FOR THE SHREW BASED ON SEDIMENT 95UCLM

Ecological Contaminant of Concern	Soil Concentration (mg/kg) (ww)	Invertebrate Concentration (mg/kg) (ww)	Dose (mg/kg/day)	NOAEL TRV (mg/kg/day)	NOAEL HQ	LOAEL TRV (mg/kg/day)	LOAEL HQ
Cadmium	1.1	1.7	1.1	0.77	1.4	7.7	0.14
Chromium	21.2	1.3	2.3	2.4	0.95	35.1	0.06
Copper	17	2	2	5.6	0.4	56	0.04
Lead	50	4	6	4.7	1.2	47	0.1
Manganese	5.29E+02	5.95E+00	4.18E+01	51.5	0.81	139	0.30
Mercury	0.3	0.07	0.06	15.7	0.00	157	0.00
Selenium	3	0.39	0.44	0.143	3.1	1.43	0.31
Silver	2	0.65	0.48	6.02	0.08	60.2	0.01
Thallium	21	4.16	3.85	0.016	241	0.164	23
Vanadium	32	6.4	5.9	4.2	1.4	41.6	0.1
Zinc	133	73.2	50.7	75.4	0.7	292.1	0.2
Total HPAHs	7	0.30	0.69	0.615	1.1	6.15	0.1
Total LPAHs	7	26.9	15.6	65.6	0.2	656.0	0.0

Shaded cells identify HQs ≥ 1.0

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

TRV = Toxicity reference value

mg/kg = milligram per kilogram

mg/kg/day = milligram per kilogram of body weight per day

HPAH = High molecular weight polycyclic aromatic hydrocarbon

LPAH = Low molecular weight polycyclic aromatic hydrocarbon

HQ = Hazard quotient

ww = wet weight

95UCLM = 95% upper confidence limit of the mean

*Separate HPAH and LPAH concentrations have not been calculated. Rather the total PAH concentration (Sum of HPAH and LPAH-8.9 mg/kg dw, 7.2 mg/kg ww) has been used as a conservative surrogate for both HPAH and LPAH in the food-webs.