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Pharmacia LLC and Solutia Inc.

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek

Anniston PCB Site, Anniston, Alabama

December 2013 Revision 2

Tables

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ACDNR	Alabama Department of Conservation and Natural Resources
AE	assessment endpoint
AHR	Arylhydrocarbon Receptor
ASTM	ASTM International
BBL	Blasland, Bouck & Lee, Inc
BAF	bioaccumulation factor
BERA	Baseline Ecological Risk Assessment
BSA	biological sampling area
BSAFs	biota-sediment accumulation factors
BW	body weight
CD	Consent Decree
COPC	constituent of potential concern
CSM	conceptual site model
d	day
DLC	dioxin-like compounds
DL-PCBs	dioxin-like polychlorinated biphenyls
DMI	dry matter ingestion
dw	dry weight
EcoSSL	Ecological Soil Screening Level
EDR	ecologically distinct reaches
EPC	exposure point concentration
ERA	ecological risk assessment
FIR	food ingestion rate
FS	Feasibility Study
g	gram
HQ	hazard quotient
KDWP	Kansas Department of Wildlife and Parks

KPM	Kansas Parks Method
kg	kilogram
LOAEL	lowest observed adverse effect level
ME	measurement endpoint
MENVIQ	Environment Canada and Ministere de l'Envionnement du Quebec
mg/kg	milligrams per kilogram
mg/kg BW-d	milligrams/kilogram body weight per day
NOAEL	no observed adverse effect level
OC	organic carbon
OU	Operable Unit
p	probability of a type 1 error
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PCD	partial consent decree
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
PEC	probable effects concentration
PEL	probable effects level
P/S	Pharmacia LLC and Solutia Inc.
PSCS	Preliminary Site Characterization Summary
PSCSR	Preliminary Site Characterization Summary Report
RBP	Rapid Bioassessment Protocol
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RQ	risk question
SERA	Streamlined Ecological Risk Assessment
SLERA	Screening-Level Ecological Risk Assessment

SQG	Sediment Quality Guideline
SSRBC	site-specific risk-based concentration
SVOCs	semivolatile organic compounds
tPCB	total polychlorinated biphenyls
$tPCB_A$	total polychlorinated bipenyls measured as Aroclors
$tPCB_H$	total polychlorinated bipenyls measured as homologs
TCL	target compound list
TEC	threshold effect concentration
TEFs	toxic equivalency factors
TEL	threshold effects level
TEQ	toxic equivalency
TOC	total organic carbon
TRV	toxicity reference value
TSS	total suspended solids
TWRA	Tennessee Wildlife Resources Agency
USEPA	U.S. Environmental Protection Agency
VOCs	volatile organic compounds
UCL	95% upper confidence limit
µg/L	micrograms per liter

1. Introduction

The Anniston Polychlorinated Biphenyl (PCB) Site (the Site) is located in portions of Calhoun and Talladega counties in the north-central part of Alabama, near the City of Anniston. The Site has been investigated for the past 20 years based on the presence of PCBs and other chemical constituents that might occur in various Site media. Geographically extensive, the Site encompasses the Solutia Inc. (formerly Monsanto) Anniston Plant (the plant) and grounds, residential and non-residential properties, and stretches of both Choccolocco Creek and Snow Creek and their floodplains. The Anniston PCB Site is not on the Superfund National Priorities List, but is being addressed through the Superfund Alternative Approach. Because it is large and varied, it was divided into four operable units (OUs) to facilitate parallel evaluation efforts in the different areas and to streamline closure in specific locations, as appropriate (Figure 1-1). The OU-1/OU-2 Area generally consists of both residential and non-residential properties within the Site upstream of Highway 78, up to and surrounding the On-Facility Area (OU-3). OU-4 includes Choccolocco Creek and its floodplain downstream to Lake Logan Martin, the lower end of Snow Creek and its floodplain downstream of Highway 78 to the confluence of Snow and Choccolocco Creeks, and the backwater area of Choccolocco Creek upstream of the Snow Creek confluence. A decision on what investigations may be required beyond Choccolocco Creek will be made after data from the OU-4 Remedial Investigation (RI), and any other studies that may become available, are reviewed (Blasland, Bouck & Lee, Inc [BBL] 2004). This *Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek* (SERA) evaluates the OU-1/OU-2 portion of Snow Creek, which generally includes the area of the Snow Creek drainage upstream of U.S. Highway 78, up to the confluence with the 11th Street Drainage Ditch.

The OU-1/OU-2 portion of Snow Creek comprises highly developed and disturbed land uses. Residential, light industrial, commercial, and industrial activities occupy the majority of land in this area. In many cases, the disturbance runs well into the riparian corridor and even reaches the creek bank. The clear differences between the highly urbanized environment of Snow Creek in OU-1/OU-2 and the more natural, less disturbed lower reaches of the creek was part of the rationale for locating the dividing line between OU-1/OU-2 and OU-4 at Highway 78.

Potential ecological risks for OU-1/OU-2 were initially evaluated in the *Screening Level Ecological Risk Assessment for Operable Units 1, 2, and 3* (SLERA; BBL 2005). The U.S. Environmental Protection Agency (USEPA) approved the SLERA with the exception of the OU-1/OU-2 portion of Snow Creek. The approval acknowledged the low quality and fragmented nature of terrestrial habitat in OU-1/OU-2 and the need to more quantitatively evaluate ecological risks in Snow Creek. The plan moving forward from this approval was to include the OU-1/OU-2 portion of Snow Creek in the baseline ecological risk assessment (BERA) for OU-4. Based on the large amount of technical information that has been developed for the OU-4 BERA, and the planned near-term schedule for completing the remedial investigation and feasibility study (RI/FS) for OU-1/OU-2, Pharmacia LLC and Solutia Inc. (together Pharmacia LLC and Solutia Inc. are referred to as P/S) requested that the ecological risk assessment (ERA) for the OU-1/OU-2 portion of Snow Creek (the OU-1/OU-2 site area) proceed in advance of the OU-4 BERA. This request was presented in a letter dated November 14, 2012 (Solutia Inc. 2012) and was approved by USEPA in a letter dated November 16, 2012 (USEPA 2012). The concept for ERA of the OU-1/OU-2 portions of Upper Snow Creek was that a streamlined ecological assessment would be appropriate, acknowledging that, in application, the highly disturbed nature of Upper Snow Creek rendered habitat, human activity, water quality, and general disturbance as critical constraints. This SERA is being submitted concurrently with the RI Report for OU-1/OU-2 (ENVIRON 2013). This SERA fulfills the commitment made by P/S, who are signatory parties to the August 4, 2003 Partial Consent Decree (CD) for the Site (USEPA 2002), to provide an RI Report that summarizes the risk assessments for OU-1/OU-2, among other requirements.

This SERA is focused on key ecological receptors that may reside or forage within the aquatic habitat in the OU-1/OU-2 portion of Snow Creek (Figure 1-2). As noted above, the USEPA previously approved the terrestrial component of a SLERA for OU-1/OU-2 (BBL 2005), which found that terrestrial exposure pathways in OU-1/OU-2 are limited by poor habitat quality. The SLERA indicated that the habitat in this portion of Snow Creek is dominated by mowed and maintained lands with little habitat quality, impervious surfaces, and transportation infrastructure, and development pressure is strong, which will likely lead to even more fragmented and disturbed ecological habitat with the passage of time. Thus exposure to terrestrial receptors and potential risk is expected to be within an acceptable level and is not quantitatively evaluated in this SERA.

1.1 OU-1/OU-2 Streamlined Risk Assessment Process

The purpose of this SERA is to evaluate the likelihood that adverse ecological effects are occurring or may occur for local receptor populations as a result of exposure to constituents of potential concern (COPC) in the OU-1/OU-2 portion of Snow Creek. As described in the SLERA (BBL 2005) and the Preliminary Site Characterization Summary Document (PSCS; ARCADIS 2009), exposure pathways to terrestrial receptors in this area are limited by the low quality fragmented terrestrial habitat. Thus, this SERA does not evaluate the floodplain or terrestrial areas of the OU-1/OU-2 portion of Snow Creek, and focuses on receptors that may be exposed to the aquatic (instream) portion of Snow Creek. Because of the similarly fragmented/degraded nature of the aquatic habitat within the OU-1/OU-2 portion of Snow Creek, the potential for ecological risks in this OU are most appropriately evaluated through a streamlined assessment. The specific ways in which this assessment is streamlined are described in more detail in Section 2.

This SERA follows the process outlined in the USEPA Superfund Guidance for Ecological Risk Assessment (USEPA 1997). The SLERA (BBL 2005) that was completed for OU-1/OU-2 in 2007 includes Steps 1 and 2 in the USEPA's eight-step process (e.g., Step 1 – Screening Level Problem Formulation and Effects Evaluation and Step 2 – Preliminary Exposure Estimates and Risk Calculations). This SERA begins with Step 3 – Baseline Problem Formulation. The problem formulation (described in Section 2) includes the refinement of the OU-1/OU-2-specific aquatic ecological conceptual site model (CSM), and identification of assessment endpoints (AEs), measurement endpoints (MEs), and representative receptors that will be evaluated. The Data Quality Objective portion of Step 4 (Study Design and Data Quality Objective Process) is addressed in Section 3. Study Design (Step 4) and field verification of sampling design (Step 5) were not conducted for this SERA because additional sampling was not required. Exposure and Effects Assessments (Step 6) to estimate potential exposure to the identified representative receptors and to identify appropriate toxicity and/or effects data are included in Sections 4 and 5, respectively. Finally, the Risk Characterization (Step 7) combines the exposure and effects components to calculate site-specific risk-based concentrations (SSRBCs) for each of the receptors evaluated. These SSRBCs are compared to the available sediment data for OU-1/OU-2 to evaluate possible risk. The risk characterization also includes a detailed description of habitat in OU-1/OU-2 and an uncertainty analysis. Following these elements, a risk summary is provided based on the complete interpretation of all lines of evidence.

1.2 Document Organization

The remainder of this OU-1/OU-2 SERA includes the following sections:

- Section 2 – Problem Formulation
- Section 3 – Data Evaluation

- Section 4 – Exposure Assessment
- Section 5 – Effects Assessment
- Section 6 – Risk Characterization
- Section 7 – References

Specific details regarding development of bioaccumulation factors (BAFs) used in the exposure assessment (Section 4) are included in Appendix A. Additional supporting information for the effects assessment (Section 5) on the development of Site-specific PCB sediment benchmarks and selection of toxicity benchmarks and toxicity reference values (TRVs) for PCBs and other COPCs is provided in Appendices B and C, respectively. The methods and exposure/effects inputs for the assessment of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs) and dioxin-like PCBs (DL-PCBs) are provided in Appendix D.

2. Problem Formulation

Problem formulation defines the goals and establishes the scope and focus of an ecological risk assessment. The problem formulation for this SERA includes an overview of the ecological setting, selection of COPCs, the aquatic ecological CSM, the selection of AEs and MEs, and the identification of representative receptors. Each of these elements is discussed below.

2.1 Ecological Setting

The ecological setting of the non-residential, residential, and industrial properties in OU-1/OU-2 has been investigated by risk assessors and ecologists on four occasions: October of 2001, May of 2002, October of 2003, and June of 2005. The 2001, 2002, and 2003 work was used to inform the detailed quantitative and qualitative survey work that was conducted in 2005 to support the SLERA (BBL 2005). The methods and results of the 2005 survey are summarized in this SERA, along with details of the area from previous work.

2.1.1 Land Use Classifications

Several classifications of land use in OU-1/OU-2 were surveyed as potential habitat for wildlife. The findings, taken from the SLERA (BBL 2005), are described below.

Residential. Most of the habitat available to ecological species in these areas is limited to maintained lawns with sparse and arranged ornamental (and often exotic/“non-native”) trees and shrubs. Impervious layers, as represented by paved driveways, rooftops, streets, or large parking areas, are present throughout the residential communities and provide little, if any, significant habitat. Mowed lawns of some residential properties are maintained right up to the edge of Snow Creek. In these cases, there is little habitat in the form of cover or forage for terrestrial wildlife. In other locations where residential properties do not border the creek, riparian habitat along the top of the creek bank (although typically narrow) provides some habitat for species of songbirds and “urban” wildlife (e.g., raccoons). However, these areas are somewhat isolated by surrounding dense, residential communities (and other land uses), and therefore access is likely constrained.

Habitats associated with residential communities are most dominant in sections of OU-1/OU-2 immediately north and south of Route 202 and to the west of Route 21 in

Anniston (Figure 2-1). Several other residential communities are present along the west side of Noble Street and on Main Street in Oxford.

Industrial. Land use in industrial areas is dominated by the presence of commercial buildings, manufacturing facilities, junkyards, parking areas, railroad tracks, and areas with impervious cover (usually greater than 80%), or if not impervious, groundcover disturbed by maintenance, excavation, or debris. Potential habitats are primarily disturbed or abandoned fields, patches of urban scrub/shrub forest, or maintained lawns with sparse ornamental trees and shrubs. Little or no wildlife were observed at locations throughout industrial areas during surveys.

Commercial. Land use in commercial areas is dominated by retail structures, single stores, strip malls, associated parking areas, landscaping, stormwater facilities, and areas with an impervious cover (usually greater than 80%). Potential habitats consist of maintained lawns, and sparse ornamental trees and shrubs. Little or no wildlife were observed in these areas.

Recreational/School. Land use in these areas is dominated by playgrounds, ball fields, and large areas of maintained and manicured lawns (nearly 100% cover). Functional ecological habitats are confined to less regularly maintained fields where songbirds typical of urban environments were observed foraging.

Transportation Infrastructure. Non-residential areas (primarily associated with transportation infrastructure, including roadways and railroad beds) are found throughout OU-1/OU-2. Main roads and the active railway through Anniston are used heavily by motorists and trains, respectively. In fact, it is this high density transportation infrastructure that limits the abundance and quality of terrestrial habitat by creating small, isolated patches of field or forested habitat.

2.1.2 Terrestrial Habitat Summary

Both residential and non-residential land uses have altered the floodplain of Snow Creek. Over time, there have been many alterations to the creek itself, and significant development of residential and non-residential properties within the floodplain have altered topography and floodplain boundaries. The extensive developed land areas have consumed much of the contiguous habitat that was in place before the development of Anniston and Oxford. What are left are only small, isolated patches of disturbed land that have limited capacity to support wildlife communities. Many of the terrestrial habitats provided by trees and shrubs (including a high proportion of non-native species) are confined to the steep altered edge of Snow Creek. Here, habitats are provided by mimosa (*Albizia julibrissin*), sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), slippery elm (*Ulmus fulva*), privet (*Ligustrum vulgare*), white aster (*Aster vimineus*), and evening primrose (*Oenothera biennis*). These habitats are disturbed by pruning. Other locations where trees and shrubs are present are in small, undeveloped areas that border residential, commercial, or industrial properties near the railroad tracks that run adjacent to and across Snow Creek (Figure 2-1). Major species in these habitats include mimosa, multiflora rose (*Rosa multiflora*), tree-of-heaven (*Ailanthus altissima*), and kudzu (*Pueraria montana*). These are invasive forms that have colonized the disturbed habitats in this area. Additional quantitative terrestrial habitat survey work was conducted in 2005 and is summarized below.

2.1.3 Quantitative Terrestrial and Aquatic Habitat Survey Summary

In addition to these observations, the 2005 survey included two quantitative approaches for evaluating the habitat quality in and along Snow Creek where aquatic and riparian (creek bank) habitats are the primary habitat types. The USEPA *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (RBP) (Barbour et al. 1999) was used to evaluate aquatic habitat within Snow Creek. The method scores a number of stream parameters from 0 to 20 with a total possible score for ideal stream habitat of 200. The terrestrial environment (primarily the riparian corridor along Snow Creek) was assessed using the Kansas Department of Wildlife and Parks (KDWP) method for the quantitative evaluation of terrestrial wildlife habitat quality (KDWP 2004). The Kansas Parks Method (KPM) is a terrestrial analog of that used in the RBP. The method is used to assign a value from 0.0 to 10.0 (a KP Value Score) to represent the quality of an evaluated habitat compared to an optimum habitat, which is represented by a score of 10.

Five survey locations were selected along Snow Creek: one upstream of the confluence with the 11th Street Drainage Ditch, and four within the OU-1/OU-2 portion of Snow Creek (Figure 2-1). Work done prior to 2005 indicated that habitat components of OU-1/OU-2 are isolated patches in intensely developed, urbanized, and managed landscapes. Much of the terrestrial habitat that exists at the OU-1/OU-2 portion of Snow Creek is confined to narrow (and sometimes fragmented) bands of habitat along Snow Creek that are surrounded by a well-established urban setting of commercial, industrial, and residential land uses.

Within the creek, there are a number of areas containing concrete sluiceways in upstream reaches of Snow Creek (Figure 2-1) that have eliminated bank habitat, substrate, and a functional floodplain. Land is developed immediately along the creek in these areas (Figure 2-1). There are some areas of Snow Creek where small pools, riffles, and runs may provide limited habitat for aquatic organisms; however, these areas are limited in size relative to the overall length of the creek. Based on information on limited aquatic habitat and reconnaissance work done for the 2005 survey work, the five survey locations were selected to be biased toward the highest quality habitat locations. The results of the RBP and the KPM are summarized in Tables 2-1 and 2-2, respectively. As shown on these tables, the quality of the riparian corridor habitat is considered poor, and the creek habitat is considered fair.

In addition to the RBP and KPM, plant, macroinvertebrate, fish, and wildlife species observations were made during the 2005 biological survey work. With the exception of Station 1 (the upstream station), no aquatic vegetation was observed in any of the survey locations. However, some aquatic plants were observed during previous survey work. The benthic macroinvertebrate survey showed the greatest diversity and abundance of species was found in Stations 1 and 2 with lower values by comparison in Stations 3, 4, and 5. The fish observed primarily consisted of small minnow-like fish such as mosquitofish (*Gambusia holbrooki*) and stonerollers (*Campostoma oligolepis*). Station 4 had the highest number of fish and the highest diversity of species found with eight taxa and 177 fish. The wildlife species (including birds, mammals, reptiles, amphibians, and crustaceans) that were observed during the 2005 survey and in previous survey work are summarized in Table 2-3. Eleven bird species were observed feeding or foraging within at least one of the survey areas in 2005, and nine others were seen resting or identified by call. The tree swallow (*Tachycineta bicolor*) was the only bird species observed nesting in the area. Only two mammal species were observed, and four mammals were identified based on tracks. The muskrat (*Ondatra zibethica*) was the only mammal for which a den, hut, or burrow was observed. Several frog species were heard calling, but the American toad (*Bufo americanus*) and the Southern two-lined salamander (*Eurycea cirrigera*) were the only amphibians observed. Two turtles and two snakes were observed and/or seen foraging. These observations of habitat quality and species presence are used to support the selection of AEs and representative receptors below.

2.2 COPC Selection

A total of 28 constituents were identified in the Partial Consent Decree (PCD) for the Site (USEPA 2002), and these 28 constituents were evaluated in the SLERA (BBL 2005). The SLERA compared maximum sediment concentrations to conservative ecological screening values and did not eliminate any constituents from further consideration. Note that no screening values were available for 17 of the 28 constituents on the list. In 2005, USEPA clarified a desire for future investigations at the Site to include limited analyses (10% of the samples) for a “wider list of constituents” (USEPA 2005a), which included target compound list (TCL) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), PCDD/PCDFs, and target analyte list (TAL) inorganics, in addition to the chemicals included in the PCD list. The RI Report for OU-1/OU-2 includes an evaluation of the wider list of constituents by comparing constituent concentrations to a range of available screening criteria and background datasets, considering frequency and magnitude of any exceedances and considering the distribution of concentrations relative to the Facility (OU-3). The results of this evaluation support PCBs as the primary risk driver for OU-1/OU-2. In further evaluation conducted by USEPA, (which considered background concentrations, bioaccumulation and USEPA Region 4 sediment screening values), eight other constituents, in addition to PCBs, were identified as possibly indicating risk (regardless of whether Site-related), and these constituents were carried forward for evaluation in this SERA. The COPCs evaluated in this SERA are PCBs, barium, chromium, cobalt, lead, manganese, mercury, nickel, vanadium, and PCDDs/PCDFs and DL-PCBs[1].

2.3 Conceptual Site Model

The USEPA guidance on conducting ecological risk assessments defines exposure pathways as “the paths of stressors from the source(s) to the receptors” (USEPA 1998). The USEPA (1997) describes a complete exposure pathway in terms of four components:

1. A source and mechanism of chemical release

2. A relevant transport medium

3. A receptor at a point of potential exposure to the affected medium

4. A route of uptake at the exposure point

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[1] The detailed evaluation of PCDDs/PCDFs and DL-PCBs is presented in Appendix D to this SERA. The general approach for evaluation is consistent with the approaches used herein. The relevant details and findings are presented throughout the SERA, and a summary of the risk findings is included in the conclusions of this report.

If any one of these four components is not present, a potential exposure pathway is considered incomplete and is not evaluated further in a risk assessment. If all four components are present, a pathway is considered complete. As described previously in the ecological setting, and in more detail in the SLERA (BBL 2005), terrestrial exposure pathways are expected to be minimal due to the limited and poor quality terrestrial habitat. Thus, this SERA is focused on the aquatic food chain. The complete pathways identified for the aquatic food chain are shown in Figure 2-2 and were based on area-specific observations (see Section 2.1) as well as consideration of the available prey-base within the OU-1/OU-2 portion of Snow Creek. This figure illustrates the constituent sources (COPCs in Snow Creek sediment), release mechanisms, exposure media, exposure pathways, exposure routes, and ecological receptors potentially present within the Snow Creek portion of OU-1/OU-2.

Complete exposure pathways can be further delineated into those expected to have more significant exposure potential (primary exposure pathways), those that are complete but are expected to be minimal compared to the identified primary exposure pathways (secondary exposure pathways), and those expected to be insignificant due to minimal or unappreciable exposure potential (*de minimus* exposure pathways). For aquatic-feeding receptors, the potential exposure routes are direct contact with the COPC in water or sediment and ingestion of food. The particular COPCs at this site are relatively insoluble in water and tend to adhere tightly to sediments. Thus the bioaccumulation models used in the risk assessment compared concentrations in prey tissues to concentrations in the sediment. Because direct exposure of wildlife to PCBs in surface water is expected to be minimal, compared to exposure through bioaccumulation in the food web, ingestion of surface water is considered a secondary pathway for birds and mammals feeding in Snow Creek. The benthic invertebrate community, and aquatic organisms may be directly exposed to COPCs in sediments and surface water. Potential risk to populations and communities of aquatic organisms through direct exposure to surface water is evaluated in Section 3.2 through comparison of available surface water data to national recommended water quality criteria for protection of aquatic life. In this SERA, only the primary pathways that are expected to be prevalent and to represent the high end of possible exposure are evaluated quantitatively. Specifically, there is a limited fish community present within the OU-1/OU-2 portion of Snow Creek (i.e., primarily small minnow-like fish such as mosquitofish and stonerollers) and the exposure pathway between sediment and fish is considered to be a secondary pathway. Likewise, fish eating upper trophic-level receptors are not expected to have a high probability of exposure based on the limited availability of prey fish and this pathway is also considered secondary in this assessment. In addition, reptiles and amphibians have been observed within the OU-

1/OU-2 portion of Snow Creek. However, because observations were limited and sufficient toxicity data for reptiles and amphibians are not readily available, this pathway is also not quantitatively evaluated. The primary pathways that have the highest potential for exposure are quantitatively evaluated in this SERA and are shown on Figure 2-2. Because the aquatic habitat within the OU-1/OU-2 portion of Snow Creek is generally degraded or of poor quality, it is unlikely that there would be a sufficient prey-base to support local populations of receptors. Rather, the OU-1/OU-2 portion of Snow Creek would more likely support transient exposure (e.g., to seasonal or migratory birds such as the spotted sandpiper), or wide ranging opportunistic receptors (e.g., the raccoon). Thus, the evaluation of the primary pathways shown on Figure 2-2 is expected to be conservative and protective of the secondary or less significant, pathways that were identified as complete but that will not be quantitatively evaluated herein.

For the aquatic habitats within OU-1/OU-2, complete pathways that are identified as significant and will be quantitatively evaluated are:

- Sediments and benthic invertebrates
- Sediments/contaminated prey and herbivorous, invertivorous, and omnivorous birds and mammals

2.4 Assessment Endpoints

AEs are formal expressions of the actual environmental value to be protected from risk (Suter et al. 1993) and are typically tied directly to specific ecological values needing protection. Furthermore, AEs provide a clear, logical connection between regulatory policy goals and ecotoxicological investigations.

The AEs for Snow Creek identified for evaluation in this SERA are based on the complete and significant exposure pathways identified in the CSM (Section 2.3). Consistent with Principle No. 1 of the USEPA's Office of Solid Waste and Emergency Response Directive "Ecological Risk Assessment and Risk Management Principles for Superfund Sites" (USEPA 1999), which states that, "Superfund's goal is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota," each AE is intended to protect the local populations of the identified resources.

2.4.1 Survival, Growth, and Reproduction of Benthic Communities

Benthic invertebrates (e.g., amphipods; larval stages of midges, stone flies, and true flies) are valued components of the aquatic ecosystem because they sustain many elements of the food chain (other invertebrates, fish, birds, and mammals) and contribute to nutrient cycling. In addition, they live, feed, and reproduce in/on sediments where COPC concentrations may be higher than in other media. In fact, direct contact with sediments represents the primary exposure route of benthic invertebrates to sediment-bound chemicals. Therefore, the protection of the benthic invertebrate community in OU-1/OU-2 is an AE.

2.4.2 Survival, Growth and Reproduction of Aquatic Feeding Birds

Birds are valued components of an ecosystem, and they are consumers at various levels in the foodweb. As such, they may be exposed to COPCs through direct ingestion of sediment and sediment-associated prey. Herbivorous, insectivorous, omnivorous, and invertivorous birds have been observed at the OU-1/OU-2 portion of Snow Creek and could be exposed to the identified COPCs through the food chain.

2.4.3 Survival, Growth and Reproduction of Aquatic Feeding Mammals

Mammals play diverse roles in aquatic and terrestrial foodwebs and are potentially exposed to COPCs by various routes. As such, they may be exposed to COPCs through direct ingestion of sediment and sediment-associated prey.

2.5 Representative Receptors

Because it is not feasible to evaluate all possible species of birds and mammals, specific surrogate, or representative, species were selected to represent the AEs for birds and mammals. Specifically, representative receptors were chosen to represent a range of feeding guilds including herbivores, insectivores, omnivores, and invertivores. As discussed above, piscivorous receptors are not evaluated due to the ephemeral nature of areas of the creek and the low number of fish present. Observations of prey types present within the OU-1/OU-2 portion of Snow Creek (e.g., aquatic vegetation and benthic invertebrates, and limited availability of prey fish), from previous ecological survey work were used to determine which bird and mammal feeding guilds are likely to have the highest potential exposure. Each of these guilds was selected to represent the high end of exposures for the range of COPCs being evaluated. To select representative species, observations from Site surveys and input from the USEPA were used to identify the following representative bird and mammal species for the identified AEs and feeding guilds:

- The mallard (*Anas platyrhynchos*) was selected to represent aquatic feeding herbivorous birds.
- The tree swallow (*Tachycineta bicolor*) was selected to evaluate insectivorous birds.
- The pied-billed grebe (*Podilymbus podiceps*) was selected to evaluate aquatic omnivorous birds.
- The spotted sandpiper (*Actitis macularius*) was selected to represent aquatic ground-feeding insectivorous/invertivorous birds.
- The muskrat (*Ondatra zibethicus*) was selected to evaluate semi-aquatic herbivorous mammals.
- The little brown bat (*Myotis lucifugus*) was selected to represent aerial feeding insectivorous mammals.
- The raccoon (*Procyon lotor*) was selected to represent omnivorous mammals.

The tree swallow, muskrat, and bat[2] have been observed within the OU-1/OU-2 portion of Snow Creek (BBL 2005). While not observed during the survey, the mallard and raccoon have been observed incidentally during other Site activities. The sandpiper and grebe are evaluated as a reasonably likely exposure scenario based on their dietary preferences and the prey types present.

2.6 Measurement Endpoints and Risk Questions

The AEs established for OU-1/OU-2 cannot be directly measured; therefore, MEs related to each AE were defined based on specific risk questions (RQ) for each AE. MEs are quantitative expressions of observable or measureable changes that are used to evaluate the effects of chemical stressors on the receptor species AEs (USEPA

[2] While the little brown bat was not observed on the site, another similar bat species (*Microchiroptera* sp.) was observed.

1997). The MEs are then used to make inferences about the potential effects to the AEs. For this streamlined assessment, MEs were selected to represent the most likely exposure scenario.

AE 1: Survival, growth and reproduction of benthic communities

RQ: Are the levels of COPCs in whole sediments from OU-1/OU-2 greater than benchmarks or risk-based concentrations protective of survival, growth, or reproduction of aquatic invertebrates?

- ME: Compare sediment toxicity benchmarks or values for benthic community to measured COPC concentrations in sediment

AEs 2 and 3: Survival, growth, and reproduction of aquatic feeding birds (AE 2) and mammals (AE 3)

RQ: Do modeled daily dietary doses of COPCs for aquatic-dependent birds and mammals (including herbivorous, invertivorous, insectivorous and omnivorous birds, and herbivorous and omnivorous mammals) from consumption of/exposure to food and sediment from OU-1/OU-2 exceed the TRVs for survival, growth, or reproduction of birds and mammals?

- ME: Compare measured concentrations of COPCs in sediment to SSRBCs for birds and mammals for each COPC

SSRBCs for birds and mammals are calculated using a dietary foodweb model for each respective species and a TRV protective of survival or growth in birds or mammals (e.g., no-observable-adverse-effects levels [NOAELs] and lowest-observed-adverse-effects levels [LOAELs], as available). Specific details of the SSRBC calculations and input parameters are provided in Sections 4 (receptor exposure inputs) and 5 (TRVs).

3. Data Evaluation

Data inputs needed in this SERA to evaluate the AEs and MEs identified in Section 2 include surface sediment COPC concentrations for estimating exposure to the benthic community and both sediment and biotic prey tissue for estimating dietary exposure for upper trophic-level receptors. In addition, surface water data are available and were considered for inclusion in this assessment. Because the surface water data have a high level of associated uncertainty, as discussed further in Section 3.2, and because exposure pathways between receptors and surface water are considered secondary, these data are not included in the quantitative evaluation of upper trophic level receptors herein but are summarized and discussed in Section 3.2 below. The following sections describe the available data that were considered for use in this OU-1/OU-2 SERA. For PCBs, data are presented as total PCBs based on the sum of detected Aroclors or detected homologs. If one or more Aroclor or homolog group was detected, the non-detected values for other Aroclor or homologs were not added to the total reported concentrations. If no Aroclors or homologs were detected, the highest reporting limit for either a single Aroclor or homolog group was used for reporting purposes.

3.1 Sediment Dataset for the OU-1/OU-2 Portion of Snow Creek

Surface sediment data used in preparing this OU-1/OU-2 SERA include 43 discrete samples analyzed for total PCBs as the sum of Aroclors (Figures 3-1a and b) and 12 discrete samples analyzed for metals (Figure 3-2) that are located within the site area for this SERA. There are 12 samples upstream of the OU-1/OU-2 portion of Snow Creek that are considered along with the data within the SERA site area (Figures 3-1a and 3-2). These data were from three data sources as described below:

1. The Resource Conservation and Recovery Act (RCRA) Program conducted in 1999

2. RI/FS Program conducted in 2006

3. Data collected by the USEPA

For the RCRA Program, 34[3] cores and one duplicate were collected in this area and analyzed for total PCBs (tPCBs) as Aroclors and total organic carbon (TOC). In addition, three samples and one duplicate were analyzed for the 11 metals identified in the PCD, including the eight metals identified as COPCs for this SERA. The RCRA data are described in detail in the Conceptual Site Model Report (BBL 2003).

As a part of the data collected to support the RI/FS, three additional cores were collected from areas identified during the RCRA program as containing low, medium, and high sediment PCB concentrations. These three samples and one duplicate were analyzed for PCBs, TOC, and a wider list of analytes, including PCDDs/PCDFs and the eight metals being evaluated as COPCs in this SERA. The sample and duplicate collected from the high sediment deposit (S-High-1) was not included in the SERA dataset because it was collected from a depth of 0 to 18 inches and was not considered applicable for ecological exposures. The RI/FS data are described in detail in the PSCS (ARCADIS 2007b).

In addition to the RCRA and the RI/FS data, USEPA collected a variety of soil and sediment samples from residential and non-residential properties to characterize the nature and extent of PCBs in the Anniston Area. These investigations were primarily conducted in 2000 and 2001. For these data collection activities, seven additional sediment samples collected from the OU-1/OU-2 portion of Snow Creek by USEPA were identified. PCBs as Aroclors and metals were analyzed in theses samples. While these samples were not collected under specific sampling plans, they are considered valid and applicable data and are included herein for completeness.

For the purposes of this SERA, all duplicates were averaged and evaluated as a single result. A summary of the available PCB and metals data is provided in Table 3-1, and sample locations and results are shown in Figures 3-1a, 3-1b, and 3-2. These figures also present the sample data for PCBs and metals that are upstream of the 11th street ditch. These samples are shown in green boxes on Figures 3-1a and 3-2. PCDDs/PCDFs and DL-PCBs were evaluated separately, and the data are discussed in Appendix D.

The surface sediment samples used for this SERA were generally collected from a depth of 0 to 2 inches. However in some cases, sediment cores of differing depths

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[3] In two cases, multiple sediment samples were collected from a single sediment deposit (e.g., S-2-06a, b and c and S-5-14 a and b). These samples are separated by short distances so appear as one point on Figures 3-1a and 3-1b but were discreet samples and are treated as such in the SERA.

were taken for sediment characterization. For example, the medium PCB concentration sample location result was collected from the 0 to 8 inch horizon and the PCB result for the targeted low PCB concentration sample location was collected from the 0 to 6 inch interval. The collection interval for each sample location was the total thickness of sediment present at that location. These samples may not represent the precise exposure interval but were included for completeness and conservatism. As described above, the sample collected from a depth of 0-18 inches was not included in the dataset.

3.2 Surface Water Data

The available whole water surface water data collected as a part of the RI/FS sampling reflect samples collected from the upstream end of OU-4 (Oxford Lake Park) and are considered representative of conditions in the downstream end of OU-1/OU-2 (Table 3-2). These samples were collected during three separate high flow events and characterize the surface water conditions for PCBs and metals during these events. In addition to these data, surface water data were collected during the RCRA program and are included as part of the OU-1/OU-2 RI dataset. These samples were collected from four general locations along Snow Creek and were designed to reflect surface flow conditions in two general areas of Snow Creek. The two upstream sample collection locations were selected to quantify PCB inputs from Snow Creek drainage areas located upstream of the 11th Street Ditch-Snow Creek confluence during base flow conditions. The Snow Street and Oxford Park sample collection locations were selected to be representative of conditions at the downstream end of Snow Creek prior to its confluence with Choccolocco Creek. These samples were collected to characterize the movement of PCBs and total suspended solids (TSS) during periods of base and high flow. The data include particulate PCB and TSS measurement concentrations for multiple base and high flow events (Table 3-3). The whole water and modeled surface water data from both the high and base flow sampling events are presented in Tables 3-2 and 3-3, respectively.

As indicated in Table 3-2, PCB Aroclors were not detected (at a reporting limit of approximately 0.5 micrograms per liter [µg/L]) in any of the whole water samples. Total PCBs as the sum of homolog groups were also determined using a more sensitive method than the 8082 Aroclor method and the data ranged from 0.2 µg/L to 0.6 µg/L. While PCBs were present at concentrations above the chronic water quality criterion during high flow conditions (Table 3-2), this criterion was only exceeded in three of six samples that were collected at the downstream end of OU-1/OU-2 during base flow conditions. This is relevant in assessing surface water conditions for Snow Creek in that base flow conditions are typically present 90% of the time. The average calculated water PCB concentrations from samples collected from Snow Creek upstream of the 11th Street Ditch confluence during base flow conditions are a factor of 10 higher than average concentrations for samples collected at the downstream end of OU-1/OU-2. The two upstream surface water sample collection locations (at 14th and 16th Streets) are located approximately 2,000 feet and 3,000 feet upstream of the Snow Creek and 11 Street Ditch, respectively.

For metals, lead exceeded the chronic criteria in one event and both chromium and lead exceeded acute and chronic criteria in one event. The surface water data were previously presented in the Preliminary Site Characterization Summary Report for OU-1/OU-2 dated December 2007 (OU-1/OU-2 PSCSR, ARCADIS 2007).

Based on data collected during the RCRA program, the high flow data are short-term in nature and not appropriate for evaluating long-term exposures to creek water. The surface water data also indicate that during base-flow conditions, PCB contributions from Snow Creek are low and PCB transport under high flow conditions is greater than during base-flow conditions.

Even with this potential bias, only three of six of the calculated values exceeded the surface water criteria for PCBs of 0.014 µg/L under base flow conditions.

3.3 Biota Data

Based on the range of ecological receptors identified for foodweb evaluation, COPC data representing tissues of aquatic plants, emergent aquatic insects, benthic invertebrates (including crayfish, mollusks), and amphibians/reptiles are needed. Because biota data have not been collected within the OU-1/OU-2 portion of Snow Creek, sediment and biotic tissue data available from the biological sampling conducted for OU-4 were used to develop uptake models for estimating prey tissue concentrations.

The available data were collected from three ecologically distinct reaches (EDRs). The upper, middle, and lower reaches were identified within OU-4 based on habitat surveys conducted in the Phase I Ecological Survey (ARCADIS BBL 2007). Three aquatic biological sampling areas (BSAs) were identified within each of the three EDRs for a total of nine aquatic BSAs within OU-4. Samples were also collected from three aquatic reference locations. In general, biotic tissue samples were not precisely co-located with specific sediment samples.

Sediment and biotic tissue data were analyzed for PCBs and mercury in all of the BSAs and reference locations. Sediment data were also analyzed for TOC and percent fines and tissue data were analyzed for lipid and percent solids (see Appendix A). In general, six sediment samples and three composite tissue samples of each type were collected from each BSA and reference area and analyzed for PCBs and mercury. Consistent with the agreed upon sampling approach, metals were analyzed in a subset of the samples collected. Specifically, metals were analyzed in sediment samples from six BSAs and two reference locations. For tissue, metals were analyzed in two to three BSA samples and one reference sample for each tissue type. The data are described below. Tables 3-4 through 3-6 summarize the available PCB, mercury, and other metals data, respectively, for each BSA. In addition to the BSA sediment data, some of the historical sediment samples fell within a reasonably close proximity to the BSAs. These sediment samples were included in the sediment dataset for the respective BSA. These samples are also included in Tables 3-4 through 3-6. Additional detail regarding data handling for calculation of uptake factors can be found in Section 4.3.1 and Appendix A.

Efforts were made to collect all biotic tissues in each of the three habitat types that were targeted (i.e., emergent vegetation, riffle, and run). However, specific tissue types were not always found in each habitat. Exceptions and specific tissue types collected are noted below. Aquatic plants, emergent insects, and benthic invertebrates were collected in all BSAs and reference areas. Aquatic plants collected consisted primarily of the stems and leaves of alligator weed. Emergent insects primarily consisted of crane flies, damselflies, and dragonflies. Benthic invertebrate samples consisted of odonata larvae. Crayfish and mollusks were collected in all nine BSAs and three reference areas but were not found in all habitat types. One to three composite samples were collected opportunistically in either emergent vegetation, riffle, or run habitats in each area. Snakes and frogs were collected opportunistically as samples were not found in all areas and habitat types. Species of frogs collected include southern leopard frogs (*Thobates sphenocephalus*), bullfrogs (*Rana catesbeiana*), bronze or green frogs (*Rana clamitans*), and northern cricket frogs (*Acris crepitans*). Snake species collected include midland water snake (*Nerodia sipedon*), queen snake (*Regina septemvittata*), cottonmouth (*Agkistrodon piscivorus*), and yellow-bellied water snake (*Nerodia erythrogaster*).

4. Exposure Assessment

This section describes the underlying assumptions used to estimate exposure to each of the AEs. Benthic invertebrates are evaluated based on direct contact with sediment. Upper trophic-level receptors (Birds and Mammals) are evaluated based on modeled dietary food chain exposure. Both sediment and food chain exposure estimates are described below.

4.1 Sediment Exposure Estimates

In general, to evaluate relevant ecological exposures, the surface sediment data from 0 to 2 inches were used, although in some cases deeper depths were also included. This depth interval encompasses the biologically active zone where the majority of the contact between ecological receptors, their prey, and sediment is likely to occur. Individual sample concentrations were used to estimate receptor exposure to COPCs. Exposure estimates for PCDDs/PCDFs and DL-PCBs are based on individual sample toxic equivalency (TEQ) concentrations. TEQs were calculated for avian and mammalian receptors using dioxin toxic equivalency factors (TEFs) from USEPA (2008) and Van den Berg (2006), respectively, and are described in more detail in Appendix D. In addition to individual sample point exposure estimates, for PCBs and metals the 95% upper confidence limit (UCL) on the mean was calculated using ProUCL (v. 4.1.01; USEPA 2011). Duplicates were averaged before including those values in Pro UCL. Non-detects were included using the reporting limit to calculate the 95% UCL concentration. The 95% UCL recommended by Pro UCL was selected. Figures 3-1a, 3-1b, and 3-2 show individual surface sediment concentrations for PCBs and metals. Summary statistics for the available data for PCBs and metals are provided in Table 3-1. The data and summary statistics for PCDD/PCDFs and DL-PCBs are provided in Appendix D.

4.2 Exposure Units

The four miles of creek being evaluated in this SERA have not been explicitly divided into exposure units. Rather, the measured COPC concentrations in each individual sample location were compared to the range of benchmarks/toxicity values identified and the SSRBCs that were calculated. The potential impact of a particular sample location result on receptors and receptor populations is discussed in the risk characterization section.

4.3 Dietary Exposure Model

As described previously, exposure to birds and mammals is evaluated in this SERA using a dietary exposure estimate. Dietary exposure in the form of a daily dose is estimated using methods that are consistent with USEPA guidance (1997). A daily intake represents an estimate of a constituent dose that a receptor might receive per day and was calculated by summing all intakes for complete and significant exposure pathways (i.e., dietary and incidental floodplain soil ingestion) for each wildlife receptor. The dietary dose model employed for the OU-1/OU-2 SERA follows the form:

Equation 1: $$ADD_{pot} = \sum_{k=1}^{n} (C_k * DF_k * NIR) + (NIR * EPC_{sed} * DF_{sed}) * SUF$$

Where:

ADD_{pot}	=	Potential average daily dose (milligrams/kilogram body weight per day [mg/kg BW-d])
n	=	Number of food types
C_k	=	EPC for the kth food type (mg/kg, dry weight [dw])
DF_k	=	Dietary fraction of intake of the kth food type (range 0 to 1.0)
NIR	=	Normalized ingestion rate (dw of food ingested per kilogram of BW-d [kg dw/kg BW-d])
EPC_{sed}	=	Exposure Point Concentration in sediment (mg/kg, dw)
DF_{sed}	=	Dietary fraction of sediment ingested (range 0 to 1.0)
SUF	=	Site use factor (assumed to be 100%)

4.3.1 Prey Tissue Concentration Estimates

Because prey tissue was not measured in OU-1/OU-2, the exposure point concentration (EPC) for prey tissue (C_k) was modeled using a BAF along with the sediment EPC (EPC_{sed}). As discussed in Section 3.3, the biotic data collected within OU-4 were used to develop uptake models or BAFs. Additional discussion of the specific data available for BAFs is provided in Section 3.3 and Appendix A. The BAFs for PCBs were also used as the surrogates for PCDD/PCDFs as described in Appendix D.

The bioaccumulation model represents the relationship between the sediment and the measured prey tissue concentration. It is expressed either as a function based on regression analysis of exposed sediment concentrations and biotic tissue concentrations (e.g., for a linear model, tissue concentration [y] = slope [m] of the line x soil concentration [x] + the y intercept [b]), or as a simple ratio.

For example:

Equation 2: $$BAF = \frac{C_{\text{benthic invertebrate}}\,(\text{mg/kg - dw})}{C_{\text{sediment}}\,(\text{mg/kg - dw})}$$

Thus,

$$C_{\text{benthic invertebrate}} = BAF_{\text{benthic invertebrate}} \times C_{\text{sediment}}$$

For this SERA, the ingestion rates for the identified receptors are based on dry weight estimates (see Section 4.4.3). As such, it was necessary to estimate prey tissue concentrations in dry weight. For biotic tissues, the COPC concentrations are reported from the laboratory as wet weight. The fraction of solids in each sample was also measured. Thus the fraction of solids was used to calculate a dry weight concentration from each reported wet weight tissue concentration (concentration as mg/kg wet weight/fraction solids – see Appendix A). Available sediment and biotic tissue data were evaluated in detail to determine if significant predictive relationships existed between sediment and various tissue types. For PCBs, possible correlations were evaluated based on sediment measured as Aroclors and homologs on a dry weight, organic carbon normalized and fines normalized basis compared to biotic tissues measured as Aroclors or homologs on a dry weight, wet weight, and lipid normalized basis. For mercury, possible correlations were evaluated based on sediment dry weight and fines normalized and tissue on a wet weight and dry weight basis.

For PCBs, a significant (i.e., $r^2 > 0.3$ and $p < 0.1$) positive relationship was found between PCB measured as Aroclor in sediment normalized to percent fines and benthic invertebrate tissue on a wet weight basis. No positive and significant relationships were identified for other tissue types. For mercury, a significant positive relationship was found between sediment normalized to fines and wet weight and dry weight tissue concentrations for frogs. Because no other significant relationships between fines normalized sediment and biotic tissue was identified and fines were not correlated with PCB or mercury concentrations, this regression was not selected for use in this SERA. Appendix A provides a detailed description of the correlation analyses conducted. As no other significant relationships were identified, tissue concentrations were estimated in this SERA based on ratios (Appendix A). The BAFs selected for use in this SERA are summarized in Table 4-1 and plotted relative to the OU-4 measured tissue data in Figures 4-1 and 4-2 for PCBs and mercury, respectively. As shown on these graphs, the selected median BAFs generally provide a good estimation of central tendency and are not highly influenced by non-detected tissue concentrations (shown as open symbols on figures). An evaluation of the implications and uncertainty associated with the use of a ratio BAF rather than the regression for benthic invertebrates discussed above is provided in Section 6.3.2.

In addition to the field data, laboratory bioaccumulation data for PCBs are available based on bioaccumulation testing done with benthic invertebrates (*lumbriculus verigatus*) with OU-4 and reference sediments. Specific details of the analyses and methods employed during laboratory bioaccumulation testing as well as the data are presented in draft form in Ingersoll et al (in review). These data were evaluated for correlation between sediment and tissue concentrations (Appendix A), and significant fits were found between sediment and tissue on a wet weight/dry weight basis as well as on a lipid and organic carbon normalized basis. As such, regression based on wet weight tissue and dry weight sediment was selected for use as a secondary assessment for this component of the diet of the receptors evaluated. This alternative laboratory-based scenario is also discussed with the scenario based on the field data in Section 6.

4.4 Exposure Parameters

For wildlife receptors, exposure parameters such as dietary composition, body weight (BW), and food ingestion rates (FIRs) are defined and summarized in Tables 4-2 and 4-3. In this section, exposure and intake assumptions are defined on the basis of available literature information and best professional judgment using the USEPA's Wildlife Exposure Factor Handbook (USEPA 1993) and other sources as necessary and appropriate.

4.4.1 Body Weight

BW values for spotted sandpiper and raccoon were obtained from the USEPA (1993), determined by the average weights for adult males and females. The BW for the little brown bat was taken from the Nagy (2001) publication in which the FIR for the little brown bat was derived. BWs for mallard, tree swallow, pied-billed grebe, and muskrat were derived from literature, averaging values where appropriate. Mallard BW was an average of three surveys of North American non-breeding adult birds (males and females averaged) (Drilling et al. 2002). Robertson et al. (1992) report a mean BW of 21 grams (g) for adult tree swallows in Ontario. BW for pied-billed grebe was the average of males and females reported in Muller and Storer (1999). Muskrat BW was the average of the BW range provided in Reid (2006).

4.4.2 Dietary Composition

The composition of the diet (FR_k) for mammals and birds, expressed as a fraction of the total diet, was generally developed based on diets provided in the Wildlife Exposure Factor Handbook (USEPA 1993). When diet for a specific species was unavailable, diet composition was based on life history information found in the peer-reviewed literature. Because the OU-1/OU-2 area does not support a significant forage fish community, the diets of species that normally eat fish (raccoon and pied-billed grebe) were adjusted such that the entire diet could consist of prey items found within OU-1/OU-2.

The mallard, a dabbling duck, was evaluated as an herbivorous receptor. Mallard diets show geographic and seasonal variation, but a study in Louisiana cited by the USEPA (1993) showed that mallards can have an entirely herbivorous diet. It was also assumed that mallards would incidentally ingest small numbers of benthic invertebrates and mollusks. A sediment ingestion rate of 6.0% was taken from an average of Beyer et al. (1994) (n=88 samples) and Connor (1993). An alternative dietary scenario based on an omnivorous diet for mallards is also included in the uncertainty analysis in Section 6.3.1.

The tree swallow and little brown bat are aerial insectivores that primarily consume emergent and flying insects in flight near or occasionally off the surface of water (Robertson et al. 1992; Belwood and Fenton 1976, as cited in Sample and Suter 1994). Thus, both the tree swallow and little brown bat diet are assumed to consist of 100% emergent insects. Because of their aerial foraging habits, sediment ingestion was assumed to be negligible for both tree swallow and little brown bat.

The spotted sandpiper is a small shorebird that frequents shorelines, shallow water (1 to 3 inches), and upland areas adjacent to water bodies. Oring et al. (1997) reported that spotted sandpipers are opportunistic and consume a wide variety of invertebrate prey occurring in these transitional areas. Therefore, a diet consisting of 50% emergent and flying insects and 50% benthic invertebrates was deemed an appropriate diet composition for spotted sandpiper. Sediment ingestion rate was an average of FIRs for four closely related species with similar foraging habits (stilt sandpiper, semi-palmated sandpiper, least sandpiper, and western sandpiper) (Beyer et al. 1994) and was, therefore, considered to be representative of the spotted sandpiper.

The pied-billed grebe is a small aquatic diving bird that was chosen as an avian omnivore receptor because of its varied diet. The diet described by Wetmore (1924, as cited in Muller and Storer (1999) was used for the pied-billed grebe's diet composition. However, Wetmore (1924, as cited in Muller and Storer 1999) included a 20% fish component. Because fish are not likely to present in OU-1/OU-2 in sufficient quantity to constitute a significant dietary item for birds, the grebe's diet was adjusted based on professional judgment to include a reptile/amphibian (Muller and Storer 1999 include amphibians in a list of prey items) and an aquatic vegetation component. No sediment ingestion rates were available for the pied-billed grebe. The mallard was chosen as a surrogate for sediment ingestion rate because it shares similar foraging habits as the pied-billed grebe.

The muskrat is a large rodent that primarily consumes aquatic emergent plants including cattails, rushes, grasses, and seeds (USEPA 1993; Reid 2006). It was, therefore, chosen as a mammalian herbivorous receptor. The muskrat diet was based on the USEPA (1993), however, in stream and river habitats, muskrat diet can include mollusks (Neves and Odom 1989). Thus, an alternative dietary composition for the muskrat is evaluated in the uncertainty analysis in Section 6.3.1. A sediment ingestion rate for muskrats was not available; therefore, the sediment ingestion rate for the raccoon (Beyer et al. 1994) was used as surrogate based on the similarity of foraging habits.

The raccoon is an opportunistic omnivore with a diet that varies widely geographically and seasonally. They often forage along streams for a variety of aquatic and terrestrial plant and animal food items (Reid 2006). Diet composition was adapted from the USEPA (1993) using professional judgment based on food items available at OU-1/OU-2. Beyer et al. (1994) provide an average sediment ingestion rate of 9.4% based on four studies.

4.4.3 Ingestion Rates

For consistency across receptors and dietary components, ingestion rates for all receptors are based on allometric equations developed by Nagy (2001) that estimate intake based on metabolic need of specific species, taxon, or feeding guilds. Total

FIRs for birds and mammals expressed in kg/kg BW-d dw were calculated as a function of body mass, using the appropriate allometric equations. For the little brown bat, Nagy (2001) calculated a dry matter ingestion (DMI) rate of 1.6 grams per day (g/d), which was BW normalized to 0.178 kg/kg BW-day dw, based on a 9 g bat. For the muskrat, FIR was based on a taxon-specific (rodentia) regression coefficient. No appropriate species DMI or taxon-specific ingestion rates were deemed appropriate for mallard, tree swallow, spotted sandpiper, pied-billed grebe, or raccoon. For the mallard, information available in the literature was available to develop an FIR. Specifically, a mean value from Chukwudebe et al. (1998) was selected and converted to dry weight using an assumption of 12% moisture in the diet (Amici et al. 1997; Gold Coin Feed Inc.) and the mallard body weight of 1.2 kg discussed above. For the remaining species, general regression coefficients were used: avian insectivore for tree swallow and spotted sandpiper, avian omnivore for pied-billed grebe, and mammalian omnivore for raccoon (Nagy 2001).

5. Effects Assessment

The effects assessment describes the selection and development of the toxicity benchmarks and TRVs used to calculate site-specific risk-based concentrations for benthic invertebrates, birds, and mammals.

5.1 Benthic Community Toxicity Benchmarks and Values

For the benthic community, a sediment-based toxicity benchmark for PCBs was developed based on Site-specific bioassays that were conducted within OU-4. This benchmark and its development are summarized below and in more detail in Appendix B. For metals, benchmarks were selected from the consensus-based sediment quality guidelines developed by MacDonald et al. (2000b). These threshold effect concentrations (TECs) and probable effect concentrations (PECs) are used as screening levels to identify the potential for toxic effects and are summarized in Table 5-1.

5.1.1 Sediment PCB Site-Specific Toxicity Values

Although toxicity tests were not conducted with sediments from OU-1/OU-2, a series of toxicity tests was conducted with sediments collected from OU-4 as part of a BERA being prepared for that OU. Because PCBs were the dominant toxicant in the OU-4 sediments (see below and Appendix B), concentration-response relationships determined from the results of the OU-4 sediment-toxicity tests can be used to predict the toxicity of PCBs in the OU-1/OU-2 sediments.

The 32 sediments samples (a total of 26 sediment samples from six different locations in OU-4, and six reference sediment samples from Choccolocco Creek approximately 3 kilometers upstream of OU-4) collected for toxicity testing collectively spanned a wide range of combinations of tPCBs and organic carbon (OC) concentrations, instead of randomly sampling the OU-4 sediments. The six targeted bins of OC-normalized PCB concentrations (expressed as mg tPCB/kg OC) were: <100; 100-500; 501-1,000; 1,001-5,000; 5,001-10,000; and >10,000. The purpose of the toxicity tests was to develop concentration-response relationships for the various *H. azteca* and *C. dilutus* endpoints, not to determine which specific sediments across the Site (including OU-1/OU-2 and/or OU-4) were toxic. The sediments selected for the toxicity testing program were not randomly chosen, but instead, were collected from a few targeted locations to provide a wide range of combinations of PCB and OC concentrations were tested. For those reasons, it is not appropriate to compare the test sediments to the reference condition, but the toxicity test results will be used as intended to identify a range of concentration-based toxicity thresholds.

Chronic toxicity tests were conducted on 31 different sediments (20 sediment samples from OU-4, six reference sediment samples, and duplicate tests for five of the 20 OU-4 sediments were tested in each of the two cycles of toxicity tests, resulting in a total of 27 toxicity tests conducted with non-control sediments). The toxicity tests were conducted by the U.S. Geological Survey's Columbia Environmental Research Center in Columbia, Missouri, and the U.S. Army Corps of Engineers' Engineer Research and Development Center in Vicksburg, Mississippi (ARCADIS 2010). Because of the large number of tests and associated logistical requirements, the tests were conducted in two separate testing cycles that were started during the week of November 1, 2010, and during the week of January 17, 2011.

Test organisms included a freshwater amphipod (*Hyalella azteca*; 42-d tests) and midge (*Chironomus dilutus*; up to 54-d tests). The sediment toxicity tests were conducted according to standard procedures specified in USEPA (2000) and American Society for Testing and Materials (ASTM) International (2012). Twelve survival, growth, and reproduction endpoints were measured in the *C. dilutus* tests; and 11 survival, growth, and reproduction endpoints were measured in the *H. azteca* tests (Appendix B, Table B-1). The sediments were analyzed for six grain-size categories, moisture content, loss on ignition, concentrations of OC, 23 major and trace elements (including the 16 metals and metalloids on the USEPA Target Analyte List), acid volatile sulfide, five simultaneously extracted metals, nine PCB Aroclors, 13 PCB congeners, 10 PCB homolog groups, one biphenyl, 46 parent and alkylated polycyclic aromatic hydrocarbons, 21 organochlorine pesticides, and 17 PCDD/PCDF congeners. Additionally, during the toxicity tests, porewaters were analyzed for pH; conductivity; alkalinity; hardness; and concentrations of ammonia, hydrogen sulfide, dissolved OC, four inorganic anions, and 61 major and trace elements. Specific details of the analyses and methods employed during the testing program and the sediment toxicity and laboratory bioaccumulation testing data are presented in draft form in Ingersoll et al (in review).

Concentrations of metals, PAHs, and organochlorine pesticides were generally lower than "consensus-based" PECs published by MacDonald et al. (2000b). Therefore, those COPCs are not likely to have contributed significantly (relative to PCBs) to toxicity in OU-4 sediments, leaving PCBs as the likely dominant contaminant. Therefore, the remainder of this discussion about OU-4 sediment toxicity tests focuses only on PCBs.

Because the chronic toxicity tests for each species were conducted in three separate batches (at different times and/or in different labs) and the control responses sometimes differed considerably among those batches (Appendix B, Table B-2), the response measured for each endpoint for each species was normalized to the average response measured for that endpoint in the control sediment tested concurrently with that batch of sediments. Therefore, the response for each endpoint in each sediment was expressed as a percentage of the control response; and thus, control-normalized responses greater than 100% sometimes occurred in reference and/or Site sediments.

After control normalization, each endpoint response was regressed against tPCB concentration using a logistic equation to produce a sigmoid concentration-response relationship. Regression equations were determined separately for dw-normalized tPCB Aroclor ($tPCB_A$) concentration and for OC-normalized $tPCB_A$ concentration to develop two concentration-response relationships for each endpoint. The dw-normalized and OC-normalized $tPCB_A$ concentrations were chosen as the predictors for the concentration-response relationships because sediments at OU-4 had been previously characterized in terms of their $tPCB_A$ concentrations instead of their tPCB homolog ($tPCB_H$) concentrations, thus necessitating development of toxicity-predictor equations based on $tPCB_A$ concentrations for use in remediation decisions.

To determine background toxicity, a reference envelope was calculated for each endpoint using the control-normalized responses of the six reference sites. The "bottom" of that response envelope was defined as the lowest control-normalized response percentage observed in the six reference sediments, and 10, 20, and 50% effect concentrations (EC10*, EC20*, and EC50* values, relative to the "bottom" of the reference envelope) were calculated from the PCB-response regressions for each survival, growth, and reproduction endpoint. By this definition, the EC0* value is the regression-predicted concentration at the "bottom" of the reference envelope. Then, TECs of PCBs were calculated from the concentration-response relationships. The "bottom" of the response envelope was defined as the lowest response percentage instead of as the 5^{th} percentile of the reference-sediment response percentages because only six reference sediments were tested, thus leaving high uncertainty about the true numerical value of the 5^{th} percentile reference response.

Toxicity values were developed for the EC0*, EC10*, and EC20* values. The ultimate selection of sediment cleanup levels by the USEPA may in part be based on this range of effect levels and might consider the variability in the responses among the two cycles of testing and the test acceptability criteria for control mortality.

The most sensitive endpoints for *H. azteca* related to reproduction (the lowest EC0*, EC10*, and EC20* values [i.e., 0, 10, and 20%-impairment beyond the “bottom” of the reference envelope]) were 1.38 (the EC0*), 2.58 (the EC10*), and 4.43 (the EC20*) mg $tPCB_A$/kg dw of sediment for 42-d young/female normalized to 42-d survival (Appendix B, Table B-1). The most sensitive endpoints for *C. dilutus* were related to emergence (the lowest EC0*, EC10*, and EC20* values were 2.04 [the EC0*], 6.80 [the EC10*], and 14.3 [the EC20*] mg $tPCB_A$/kg dw of sediment, for percent emergence of the pupae from their cocoons; Appendix B, Table B-1). The adult biomass endpoint for *C. dilutus* that was reported by the laboratories is not included in this analysis because it was based on estimated instead of measured weights of adult *C. dilutus*, thus making that endpoint highly uncertain.

Based on this analysis, a range of toxicity values are considered. Specifically, the EC0* (1.38 mg/kg) and EC20* (4.43 mg/kg) toxicity values for the most sensitive endpoint and species from the site-specific toxicity testing will be compared to Site PCB data in Section 6.

5.2 Avian and Mammalian TRVs

Following USEPA guidance (1997), dietary TRVs for birds and mammals were developed based on endpoints that could result in population-level impacts such as survival, reproduction, development, and growth. Both NOAEL and LOAEL TRVs were selected. For PCBs and mercury, available peer-reviewed toxicity data were reviewed to develop avian and mammalian TRVs. For the remaining seven metals, TRVs were selected primarily from the datasets compiled for development of USEPA Ecological Soil Screening Levels (EcoSSLs; USEPA 2005 and 2007). The development of avian and mammalian TRVs for PCBs and metals is summarized below and discussed in detail in Appendix C. The TRVs for PCBs and metals used in this SERA are summarized in Table 5-2. The development of the TRVs for dioxin-like compounds (PCDD/PCDF and DL-PCBs) is described in Appendix D.

5.2.1 Avian TRVs

Available toxicity data for all species were considered initially. However, specifically for PCBs, based on all of the avian toxicity data reviewed, studies conducted with domestic chickens (*Gallus domesticus*) appear to represent the high end of the sensitivity range for PCB toxicity. A significant body of research has been conducted regarding avian sensitivity to aryl hydrocarbon receptor (AHR)-mediated effects of dioxin-like compounds (DLCs). AHR-mediated effects are the primary mechanism of toxicity for PCBs in vertebrate species (Okey 2007). While non-AHR-mediated effects can occur, they are thought to occur at much higher concentrations than AHR-mediated effects (Giesy and Kannan 1998). Based on this research, two sets of TRVs were developed for PCBs. One represents the high end of the range of sensitivity and the second represents the mid-range of sensitivity for avian species. Additional detail on this AHR-related research and the development of the two sets of TRVs is provided in Appendix C.

Unlike PCBs, chickens do not appear to be more sensitive to mercury (Heinz et al. 2009) than other wild avian species. As such, one set of TRVs was developed for mercury and was considered applicable to all avian species evaluated. The TRVs for mercury were selected based on review of the underlying dataset for the Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife (USEPA 1995) as well as more recent literature. A detailed description of the selection of avian mercury TRVs is provided in Appendix C.

For six of the remaining seven metals (barium, chromium, cobalt, lead, manganese, nickel, and vanadium), TRVs were obtained from the dataset used to develop USEPA EcoSSLs (USEPA 2005 and 2007). Specifically, avian NOAELs were provided in the EcoSSL documents and are used herein. LOAELs were not selected for the purposes of the development of EcoSSLs. However, the toxicity dataset was reviewed and a relevant LOAEL was selected for each metal based on this dataset. This selection of LOAELs is described in more detail in Appendix C. For barium, bird low and high TRVs were obtained from Oak Ridge National Laboratory (Sample et al. 1996).

5.2.2 Mammalian TRVs

The toxicity data were reviewed and mink appear to be uniquely sensitive to PCBs. Because mink are not a receptor of concern for this SERA, the toxicity data considered in development of TRVs for small mammals does not include toxicity studies conducted with mink. The mammalian PCB TRVs selected represent the lowest toxicity thresholds for relevant endpoints and non-mink species found in the literature. For mercury, as for birds, the Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife (USEPA 1995) was reviewed along with other studies from the peer reviewed literature. For the remaining seven metals (barium, chromium, cobalt, lead, manganese, nickel, and vanadium), TRVs were obtained from the dataset used to develop USEPA EcoSSLs (USEPA 2005 and 2007) as described above for birds and in Appendix C.

6. OU-1/OU-2 Risk Characterization

The risk characterization for this SERA is based on comparison of receptor-specific benchmarks/toxicity values or SSRBCs (calculation described below in Section 6.1) to measured COPC concentrations in sediments within the OU-1/OU-2 portion of Snow Creek. While the exceedance of toxicity value or SSRBC at an individual sample point does not necessarily indicate potential risk to a receptor or a local population of receptors, this initial comparison is considered along with OU-1/OU-2- and receptor-specific habitat information to formulate conclusions about risk to the identified receptors.

The first part of the risk characterization is the risk description (Section 6.1), which provides the quantitative results of the toxicity value and SSRBC comparisons. The second part is the habitat evaluation (Section 6.2), which provides a discussion of some of the key habitat and prey needs of each receptor relative to what has been observed or is expected within the SERA site area. Section 6.3 discusses key uncertainties that affect risk estimations, and risk conclusions are presented in Section 6.4.

6.1 Risk Description

This section describes the results of the quantitative risk estimates for each AE. The AEs and associated representative receptors evaluated include:

- Survival, growth, and reproduction of benthic communities
- Survival, growth, and reproduction of aquatic feeding birds (mallard, tree swallow, pied-billed grebe, and spotted sandpiper)
- Survival, growth, and reproduction of aquatic feeding mammals (muskrat, little brown bat, and raccoon)

The results of this SERA do not attempt to provide a quantitative assessment of how the magnitude and spatial extent of potential adverse effects could affect local populations. This issue along with the other identified uncertainties will be considered as part of the risk management activities of the FS process.

6.1.1 Site-Specific Risk-Based Concentration Calculation

Site-specific risk-based concentrations were calculated for each avian and mammalian receptor to facilitate the evaluation of the magnitude and spatial extent of potential risk. The SSRBC calculations for each receptor and COPC are shown in Tables 6-1 and 6-2 for avian and mammalian receptors respectively. The approach and methods for calculating the TEQ-based SSRBCs are provided in Appendix D. The development of the SSRBC for benthic invertebrates for PCBs is discussed in Section 5.2 and Appendix B. The SSRBC calculation for birds and mammals uses the dose equation described in Section 4.3. The dose is set equal to the TRV, and the equation is rearranged to solve for $C_{sediment}$. Specifically, the SSRBC calculation is shown in Equation 3:

Equation 3: $$SSRBC = \frac{TRV}{\sum_{k=1}^{n} (BAF_k * DF_k * NIR) + (NIR * DF_{sed})}$$

Where:

SSRBC	=	Site-specific risk-based concentration (Table 6-3)
TRV	=	Dietary TRV for avian- or mammalian-specified receptor (Table 5-2)
BAF	=	BAF of the kth food type (see Table 4-1)
DF_k	=	Dietary fraction of intake of the kth food type or sediment (Tables 4-2 and 4-3)
NIR	=	Normalized dw ingestion rate (Table 4-2 and 4-3)
n	=	Number of food types

6.1.2 Interpretation of SSRBC Comparisons

Because the SSRBCs are calculated based on the dose being equal to a protective toxicity threshold (i.e., the NOAEL or LOAEL TRV), a sediment concentration that is less than or equal to the specified NOAEL SSRBC is considered to indicate no unacceptable risk. This determination is based on the compounded conservative assumptions used in the exposure model (e.g., high estimates for exposure parameters such as ingestion rate and assumption of 100% site use) and the conservative nature of the NOAEL TRVs. Specifically, the NOAEL is a level at which no adverse effects have been observed in toxicity studies. The NOAELs selected are generally the highest NOAEL that is below the lowest LOAEL from the body of toxicity literature evaluated (see Appendix C). Thus, when hazard quotients (HQs) based on NOAELs are less than 1.0, the likelihood of adverse effects occurring at these concentrations is considered *de minimus*[4], and no unacceptable risk is expected. When the NOAEL HQs are greater than 1.0 but the LOAEL HQs are less than 1.0, ecologically significant adverse effects to that receptor are also uncertain, as concentrations have not reached the threshold at which effects are observed. However, there is uncertainty associated with defining the true toxicity threshold, so adverse effects are considered possible in this case, and the results are reviewed in the context of other supporting information. Likewise, a LOAEL TRV-based HQ greater than 1.0 indicates potential for adverse effects, and both the NOAEL- and LOAEL-based HQs and their associated uncertainties are evaluated with other supporting information.

6.1.3 Benchmark/Toxicity Value and SSRBC Comparisons

The benchmark/toxicity values and SSRBCs for PCBs and metals are summarized in Table 6-3, and the percent of individual sample points exceeding these values are shown in Table 6-4. The 95% UCL EPCs were also compared to each benchmark/toxicity value and SSRBC, and exceedances are shown in blue highlighted cells in Table 6-4. Note that the data used to calculate the 95% UCL EPCs were collected using sampling designs that focused on the upstream areas near the confluence of the 11th Street Ditch and Snow Creek and the culverts that convey Snow Creek flow under Highway 202. These locations were selected for sampling during multiple programs based on the potential for high PCB concentrations to be present. The elevated PCB concentrations in this portion of the creek reflect proximity to the Facility via surface water flow from the 11th Street Ditch and that the Highway 202 culverts tend to retain sediment (i.e., are generally depositional areas). Based on these factors, the estimated UCL of the mean for the OU-1/OU-2 portion of Snow Creek as a whole, is biased high. Given this bias, it is important to compare the measured concentrations in individual sample results to the benchmarks/toxicity values and SSRBCs, especially downstream of the highway 202 culverts.

The SSRBC comparisons with TEQ are provided in Appendix D. For sample location S-LOW-1, the TEQ concentrations in OU-1/OU-2 sediments (inclusive of

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[4] *De minimus* risk is defined as negligible or not of societal concern (National Library of Medicine Toxicology Glossary - Risk De minimis Retrieved on August 11, 2011).

PCDDs/PCDFs and DL-PCBs) are below the lowest TEQ-based SSRBC for birds or mammals (i.e., based on NOAEL for the tree swallow and little brown bat respectively), except for those cases where one half the sample reporting limit is used as a substitute for non-detected values are used in the TEQ calculation.

For sample S-MED-1, the SSRBC value was exceeded by a factor of approximately 2 for the little brown bat expect for where one half of the reporting limit was used for non-detected PCB congener concentration values. When one half of the reporting limit was used for the non-detect PCB concentration values, the mammalian TEQ (inclusive of PCDDs/PCDFs and DL-PCBs) exceeded the SSRBC for the little brown, the muskrat and the raccoon. Likewise, for birds, the calculated TEQ value (inclusive of PCDDs/PCDFs and DL-PCBs) for sample S-MED-1 exceeded the SSRBC for the tree swallow but not the duck, sandpiper or grebe.

The impact of including non-detected PCB congeners in the TEQ estimate at one half of the reporting limit is illustrated for sample S-MED-1 where the estimated concentration of a single congener (PCB 126) at one half the reporting limit accounts for 75 percent of the estimated TEQ for mammals. The TEQ exceedances noted above are also in driven in part by the PCB emergent insect BAF that was used as a surrogate for PCDD/PCDFs in the TEQ SSRBC calculations (Appendix D). The uncertainties associated with this BAF are discussed in Section 6.3.2 of this OU-1/OU-2 SERA.

For benthic invertebrates, the 95% UCL concentration for PCBs exceeded the EC0* and the EC20* for the most sensitive endpoint and species tested in the site specific toxicity tests (i.e*., H. Azteca* 42-d young/female normalized to 42-d survival), with 47 and 74 percent of samples exceeding these values respectively. By comparison, using non-site-specific screening values (i.e., TECs and PECs – Table 5-1), the 95% UCL as well as all but two individual sample points exceed these values. For metals, no SSRBCs were developed. As such, other available, non-site-specific screening benchmark values (primarily TECs and PECs) are used for this comparison. For cobalt, only a single sample exceeded the TEC value, thus risk to benthic invertebrates from cobalt is considered *de minimus*. The 95% UCL concentrations did not exceed the PEC for mercury, and only 1 individual sample (S-2-03a) exceeded this value. Similarly, for lead, the 95% UCL slightly exceeded the PEC, but only one individual sample (CA-25-EPA-43166-2503) exceeded this value. Based on this comparison, risk to benthic invertebrate communities from lead is expected to be low. The 95% UCL concentrations of chromium and nickel as well as 25 to 33% of individual sample points exceeded the PEC values. Thus, risk to benthic invertebrate communities from these

COPCs is possible. For barium, manganese, and vanadium, no benchmarks, toxicity values or SSRBCs are available and risk to benthic invertebrate communities from these COPCs is uncertain.

For birds, the 95% UCL concentration is below the SSRBC for cobalt (Table 6-4). Likewise, there were infrequent or no individual sample points exceeding SSRBCs (either 0 or 1 out of 12 samples depending on the species), indicating risk to birds from cobalt is *de minimus*. Similarly, possible risk to birds from barium appears to be minimal as the 95% UCL concentration is below the LOAEL SSRBC and only 1 individual sample exceeded this value (s-med-1). For the remaining COPCs, 95% UCL concentrations exceed NOAEL and LOAEL SSRBCs for at least one of the avian representative receptors. The tree swallow and spotted sandpiper indicated the highest possible risk for PCBs and chromium. The sandpiper indicated the highest possible risk for four of the remaining COPCs (lead, manganese, mercury, and vanadium), and the tree swallow indicated the highest possible risk from nickel. Risk from PCBs to high sensitivity avian species appears to be highest followed by risk to insectivorous birds from chromium (represented by the tree swallow) and invertivorous birds (represented by the sandpiper) from manganese and lead. Risk to avian species from mercury and nickel appears to be low with 95% UCL concentrations only slightly exceeding LOAEL SSRBCs for the tree swallow and sandpiper and infrequent individual sample point exceedances (0-3 samples).

In addition to the SSRBC comparisons based on the field bioaccumulation data described above, for PCBs, a second scenario was evaluated. In this scenario, the laboratory bioaccumulation study results were used to estimate PCB uptake into benthic invertebrate tissue. The regression analysis of the laboratory data is provided in Appendix A. The laboratory study predicted substantially higher PCB uptake into benthic invertebrates compared to the field data. Thus the resulting SSRBCs were lower. Using the laboratory uptake estimate, all samples exceeded both NOAEL and LOAEL SSRBCs for the sandpiper (i.e., the receptor with the highest proportion of benthic invertebrates in the diet). Table 6-5 presents the alternative SSRBCs as well as the percent of samples that exceed each value.

For mammals, 95% UCL concentrations are below SSRBCs for barium, cobalt, mercury, and vanadium (Table 6-4). Likewise, there were infrequent or no individual sample points exceeding SSRBCs (either 0 or 1 out of 12 samples depending on the species), indicating risk to mammals from these COPCs is *de minimus*. The 95% UCL concentrations exceed NOAEL and LOAEL SSRBCs for PCBs, chromium, manganese, and nickel. The 95% UCL concentration for lead does not exceed the

LOAEL SSRBC. For lead, the muskrat indicates possible risk, but only a single sample exceeds the NOAEL or LOAEL SSRBCs (CA-25-EPA-43166-2503). Thus risk from lead to mammals is considered *de minimus*. The bat indicates the highest possible risk from exposure to chromium, nickel, and PCBs with all concentrations of chromium, 88% of PCB concentrations and 42% of nickel concentrations exceeding LOAEL SSRBCs. The muskrat indicates the highest possible risk from manganese with 100% of the samples exceeding the LOAEL SSRBC.

6.2 Habitat Quality for Receptor Species

In interpreting the individual exceedances of SSRBCs and what that may mean to the AEs being evaluated in this SERA (i.e., protection of local communities or populations), it is important to understand the habitat quality within the SERA site area. The habitat quality has a large influence on the numbers and types of receptors that may be present. The habitat and prey needs of each of the receptors evaluated in this SERA are discussed below so that the comparisons to SSRBCs can be interpreted in this context. The receptor species evaluated for risk to PCBs and metals in this OU-1/OU-2 SERA include the mallard, tree swallow, spotted sandpiper, pied-billed grebe, muskrat, little brown bat, and raccoon. The habitat quality was evaluated for each of these species on Snow Creek to determine if many individuals of each species (and guild they represent) are likely to be exposed to COPCs in sediment.

6.2.1 Mallard

The mallard, a dabbling duck, is a winter resident in the area that likely forages on Snow Creek (Drilling et al. 2002). This species is mainly an herbivore in the winter and has a high tolerance for humans and urban areas. It can feed in nearby agricultural areas as well as on vegetation in the creek. Fragmented habitat in an urban area is not optimum for this species, but this species and possibly other herbivorous dabbling duck species wintering in the area may be more exposed than many of the other bird species.

6.2.2 Tree Swallow

The tree swallow has been observed foraging and nesting near Snow Creek (Section 2.1; Table 2-3). The tree swallow forages on aerial insects, including aquatic species hatching from the creek, and nests in cavities in trees, stumps, or rocks (Winkler et al. 2011). In such an urban area with fragments of narrow corridors of trees along the creek and a low habitat quality index (Modified KP of 1 to 3.75 in northern reach and 3 to 5 in southern reach of creek, where optimum score is 10; see Table 2-2), natural cavities are more limited than in non-urban forests. Density of tree swallows and the receptor group they represent are expected to be low, but some individuals establishing territories in the area may be exposed, particularly in the southern section where habitat quality is higher.

6.2.3 Spotted Sandpiper

The spotted sandpiper does not breed or winter on Snow Creek, according to the geographic range map in Oring et al. (1997). It migrates through the area, but the urbanized Snow Creek is not likely to be a highly desirable stopover point because more attractive, undeveloped water bodies are nearby. This bird forages mostly in open habitat and prefers sandy or firm substrates, such as sandbars in creeks. Such sandbars are more common in the northern-most half mile and southern-most mile of the creek. Between these areas there are few sediment deposits (BBL 2003). While the sandpiper may be a transient visitor to this area, it is unlikely that there is substantial exposure to COPCs in Snow Creek for this invertivorous species or the receptor group it represents that feed on sandbars and requires open, non-mowed habitat for nesting.

6.2.4 Pied-Billed Grebe

The pied-billed grebe, a diving bird, can be a year-round resident or migrant from the north wintering in the region but requires specialized habitat typically on lakes and ponds. If using riparian areas, the pied-billed grebe requires non-moving, open water to forage and breed such *as* still bays and sloughs at least 0.2 hectare in size (Muller and Storer 1999). The bird requires emergent wetland vegetation for nesting in water depths of 0.8 meter. Such open, non-flowing habitat is very limited on Snow Creek. Likely, pied-billed grebes and diving ducks that would feed on the creek’s invertebrates are rare in the area and, thus, little exposed. Pied-billed grebes and ducks were not observed during the field surveys conducted (see Table 2-3).

6.2.5 Muskrat

Muskrats have been observed foraging and denning on Snow Creek (BBL 2005). This semi-aquatic species is primarily herbivorous and prefers waters with dense emergent vegetation neighbored by upland herbaceous vegetation or agricultural fields (Allen and Hoffman 1984). It feeds on aquatic plants and agricultural crops, if crops are in its home range. Lodges (conical vegetation structures) and dens (bank burrows) are built within a few feet of still or slow-flowing surface waters, in depths of 0.6 to 1.3 feet. Availability of steep enough dirt banks for dens or plants to build lodges in the water are more limited on an urban creek with fragmented vegetation patches and disturbed (sometimes concrete) banks than less developed creeks. Some individuals of muskrats may be exposed.

6.2.6 Little Brown Bat

The little brown bat forages at dusk on aerial insects, following a flight path over water (Alabama Department of Conservation and Natural Resources [ADCNR] 2013) and potentially could forage along Snow Creek. They feed mostly on the insect orders Diptera, Lepidoptera, Coleoptera, Trichoptera, Ephemeroptera, and Neuroptera in proportion to availability of these orders (Kunz and Reichard 2010). Overall, insect production is low within the OU-1/OU-2 portion of Snow Creek (compared to OU-4), particularly in the southern half of the creek and low in some of the aquatic orders at many of the stations sampled (Ephemeroptera, Trichoptera, Neuroptera; SLERA Tables 10-14 [BBL 2005]). Low insect production not only lowers the density of bats that can be supported, but also decreases attraction of bats to the creek because they focus on areas with high insect concentrations (Kunz et al. 2011). The high percentage of the urban creek that supports little sediment or aquatic habitat (Figure 2-1) probably accounts for much of the low production of insects.

Other habitat requirements of the little brown bat include: (1) caves for hibernating, which can be up to 200 miles from their summer foraging area; (2) maternity roosts, which support hundreds of females and are typically in warm dark places such as attics barns, or tree cavities; and (3) roosts for non-reproductive females and males, which are typically in tree cavities, underneath rocks, in piles of wood, crevices, human structures, and occasionally caves. None of these features are likely to be limiting for bats inhabiting the Snow Creek area. However, although possible, it is highly unlikely little brown bats are foraging along Snow Creek because this species is rare in Alabama (ADCNR 2013). Extensive netting and cave surveys throughout Alabama in the past 15 years have yielded no observations, and it was rare in caves in Alabama in 1965 (Kunz and Reichard 2010). Alabama is south of the core geographic range of this species. However, other bat species represented in the guild of the little brown bat (e.g. eastern pipistrelle and big brown bat) are common in Alabama, though probably still uncommon on a creek with low insect production. Thus, exposure of bats to COPCs in OU-1/OU-2 sediments is likely limited.

6.2.7 Raccoon

Raccoons are nocturnal and dormant in dens during the day. Although not observed during field surveys in the day, they may be present on Snow Creek. Raccoons are omnivorous and opportunistic feeders and well adapted to life in urban as well as more natural settings (SIBR 2013) if a permanent water source is nearby. Foraging habitat includes riparian and other wetlands, forest, and shrub cover (SIBR 2013). Raccoons are commonly found along waterways (Tennessee Wildlife Resources Agency [TWRA] 2013). Raccoons may be attracted to urban/suburban areas where scavenging opportunities and cover are abundant. Raccoons have daily nest sites, often used in mild weather, but will also den in tree cavities, snags, logs, rocks, abandoned buildings, or dense vegetation. Individual raccoons living along Snow Creek may be exposed.

6.2.8 Habitat Summary

Based on the habitat analysis provided above, it is unlikely that avian or mammalian exposures within the OU-1/OU-2 portion of Snow Creek could result in population-level effects, simply due to the low numbers of individuals likely present or feeding significantly in this area. Of the receptors considered in this SERA, individual mallards, tree swallows, muskrats, and raccoons are considered to have the highest probability of exposure. These findings are considered below in the discussion of the comparison to SSRBCs for each AE.

6.3 Uncertainty Analysis

There are a number of uncertainties that affect risk predictions in this SERA. This section focuses on those uncertainties that may result in significant over- or underestimation of possible risk. These sources of uncertainty are generally associated with receptor exposure assumptions, BAFs, TRVs, and benchmarks. Specific uncertainties and how they may result in over- or underestimation or risk are discussed below.

6.3.1 Exposure Assumptions

Exposure assumptions with the greatest uncertainty are associated with receptor site use (i.e., are the receptors present for a significant amount of time and is the prey base sufficient to support their long-term dietary needs) and receptor exposure models. Each of these is discussed in the following sections.

6.3.1.1 Habitat Quality/Food Availability

As discussed in Section 2.1, the quality of the habitat in this urbanized portion of Snow Creek is not optimal for ecological receptors. The detailed discussion of receptor habitat use provided above demonstrates that the evaluation of each of the receptors in this SERA with the assumption of 100% site use likely overstates exposure. However, it is acknowledged that the OU-1/OU-2 portion of Snow Creek is adjacent to more optimal habitat within OU-4. As such, the overall exposure to ecological receptors that may have exposure from both areas is unknown. It is anticipated that the OU-4 BERA will fully evaluate ecological receptor exposure in these downstream areas.

6.3.1.2 Receptor Use

Most of the receptors that are assumed in this SERA to be using the OU-1/OU-2 site area continuously (i.e., 100% site use) are likely transient and are not expected to spend 100% of their time in the site area. For example, the federally endangered gray bat (*Myotis grisescens*) could potentially forage in Snow Creek. It requires continuous cover while foraging and while traveling to and from its foraging habitats. Tree and shrub canopy is probably limited for most areas of Snow Creek; therefore, it may be a transient receptor within the OU-1/OU-2 portion of Snow Creek. Likewise, as discussed above, the sandpiper is migratory and would be expected to use the OU-1/OU-2 site area only as a stop-over. Because the habitat and the prey base within the site area is limited and other more optimal water bodies are nearby, it is unlikely that this and other invertivores species would preferentially use the OU-1/OU-2 portion of Snow Creek.

6.3.1.3 Receptor Exposure Inputs

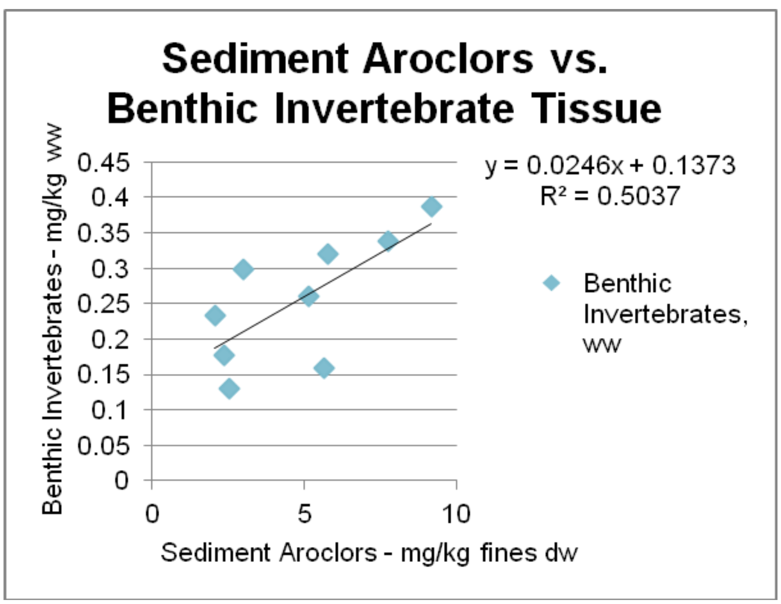
For avian and mammalian receptors, exposure is estimated using a dietary exposure model. This model uses generic assumptions for FIR, BW, and dietary composition. Each of these can affect the resulting SSRBC that is calculated. All elements were selected to be conservatively representative of the species evaluated and could over or under estimate potential exposure. In selecting representative receptors, the mallard and the muskrat were selected to represent the herbivorous feeding guild. However, considering the lack of substantial aquatic vegetation present within the OU-1/OU-2 site area, alternative diets are considered for these receptors. Specifically, alternative dose estimates were calculated for the mallard and the muskrat, assuming an omnivorous diet. All other elements of the exposure model remained the same as those described in Sections 4.3 and 4.4. For this alternative analysis, the mallard dietary composition was based on breeding mallards diet that was available from the USEPA Wildlife Exposure Factors Handbook (USEPA 1983). Adjusting this diet slightly to be consistent with prey tissue estimates available for the OU-1/OU-2 portion of Snow Creek, the breeding diet of the mallard is assumed to consist of 26% aquatic emergent insects, 25% mollusks, 15% crayfish, and 34% plants. Likewise, muskrats have been observed to opportunistically adjust their diets when aquatic vegetation is not prevalent (Neeves and Odom 1989). While this study does not provide a specific percent of mollusks in the diet of muskrats, it does indicate that muskrats in streams and canals can adopt an omnivorous diet which may include Asiatic clams if abundant. To evaluate this possibility, a muskrat diet of 20% mollusks, 5% benthic invertebrates, and 75% aquatic vegetation was evaluated.

The results of using these alternative diets indicate that for PCBs, chromium, and nickel, SSRBCs would be lower (between approximately 50% for PCBs and 30% for chromium). For barium and manganese, SSRBCs would be higher based on these alternative assumptions (15% and 100%, respectively). Table 6-6 summarizes these alternative SSRBCs in comparison to the values calculated using the assumptions discussed in Section 4 of this SERA (i.e., the herbivorous dietary scenario). The primary reason for the large change in SSRBCs is based on the influence of the tissue specific BAFs employed. For example, the plant BAF for manganese is 4.4 and the mollusk BAF for manganese is 1.1 (Table 4-1). Because the relative proportion of mollusk in the mallard diet went up and the plant proportion went down, the overall result was that a lower exposure would be indicated, making a higher SSRBC protective of mallards based on this diet. Similarly, for PCBs, the plant BAF is 0.42 compared to the mollusk BAF of 6.5. The higher proportion of mollusk in the diet relative to plants results in a higher estimate of exposure and a lower SSRBC for protection of mallards eating an omnivorous diet. Uncertainty associated with BAFs is evaluated below and in Appendix A.

6.3.2 Bioaccumulation Factors

Because specific biological data were not available for OU-1/OU-2 and, therefore, prey tissue concentrations were not measured in OU-1/OU-2, it was necessary to model prey tissue concentrations using an uptake model based on biological data collected in OU-4. The BAF is used to estimate prey tissue concentrations that may be consumed by the representative birds and mammals evaluated in this SERA. Specifically, the BAF represents the relationship between abiotic media (in this case sediment) and various prey tissues (e.g., plants, benthic invertebrates, etc). For PCBs and mercury, the model was based on a large dataset collected within OU-4. While having this large dataset may decrease some of the uncertainty associated with the model, a good deal of uncertainty remains because predictive relationships were generally not found between sediment and prey tissue for either constituent. A detailed correlation analysis was conducted with the dataset for PCBs and mercury (Appendix A). This analysis resulted in significant relationships between fines normalized sediment and PCBs in benthic invertebrates and mercury in frogs on a wet weight basis. As discussed in Section 4.3.1, none of the other tissue types being consumed by receptors showed a positive correlation with fines normalized PCB or mercury concentrations in sediment. In addition, percent fines in sediment did not correlate well with PCB or mercury concentrations in sediment. Thus, it was not possible to estimate a concentration for any other tissue type based on fines normalized sediment. Because no other element of the diet is based on percent fines and because the calculation of an SSRBC requires a static assumption about the percent of fines in sediment, it was not feasible to incorporate these fines normalized relationship into the overall dose estimation for SSRBC calculation. To evaluate this uncertainty, an SSRBC was calculated using the benthic invertebrate PCB regression shown below.

Figure 6-1. Regression Analysis of Fines Normalized tPCB Concentrations in Sediment and Field Collected Benthic Invertebrate Tissue



To use this relationship in the dose model, it was necessary to convert the fines normalized sediment concentration into a dry weight PCB concentration using the average percent fines for all BSA data of 36.4%. It was also necessary to convert the estimate tissue to a dry weight value to be consistent with the dry weight ingestion rate used in the dose model. The average percent solids of 18.5% (83.5% moisture) was used for this purpose. The resulting SSRBC based on this static assumption for fines would be increased by approximately 25% based on the sandpiper (i.e., the receptor with the highest proportion of benthic invertebrates in the diet). Specifically, the SSRBC based on the median BAF of 0.92 for benthic invertebrates results in a LOAEL SSRBC of 8.1 mg/kg dw sediment and the SSRBC calculated using the regression equation and assumptions shown above results in an SSRBC of 10.8 mg/kg dw.

Based on the lack of a usable correlation discussed above, a ratio estimator that represents the central tendency of the dataset was selected. Because individual samples of the various prey tissues were not co-located with individual sediment locations, mean sediment and tissue concentrations were calculated for each BSA to maintain some degree of co-occurrence. Field notes were reviewed to determine if specific tissue collection locations could be estimated. While general collection areas were identified, specific tissue samples could not be associated with the individual collection locations, so additional analysis of spatial correlation was not conducted. The ratio of means for each BSA was calculated and, consistent with the approach used for BAF selection in the EcoSSL Guidance (USEPA 2005), the median BAF was selected as the most appropriate estimate of central tendency for the range of BAFs. To further evaluate the predictiveness of these BAFs, figures 4-1 and 4-2 present the individual tissue concentrations for each BSA relative to the mean sediment concentration for that BSA. The BAF line (in green) is plotted to demonstrate how predicted concentrations relate to measured tissue concentrations. Non-detected values are shown as open symbols and as shown on these figures, the non-detects do not appear to result in BAFs that underestimate central tendency. As shown on these figures, the median BAF generally results in a good prediction of the central tendency of the measured tissue concentrations. One exception appears to be for PCBs in emergent insects. In this case, crane flies in two BSAs (EUA-02 and EUA-03) contained substantially higher PCB concentrations than those collected at EMA-02 (craneflies plotted as squares on Figure 4-1) and damselflies collected in other BSAs. The selected BAF for emergent insects may underestimate uptake for crane flies.

To better understand this uncertainty and the disparity between concentrations, natural history of the orders collected were reviewed. There are thousands of species of crane flies, dragonflies, and damselflies, but in general, crane flies primarily feed on vegetation and algal and microscopic organisms low in the food chain. They can also feed and reside in both aquatic and terrestrial environments. This is in contrast to odonates, which are mainly predaceous and prey upon various trophic levels within the food chain throughout their nymph development stage and on insects in their adult stage. This information is not consistent with the observed concentrations, as species feeding lower in the foodchain (e.g., on plant matter) would not be expected to be exposed to higher PCB concentrations than species that are predators. Because some species of crane flies can be terrestrial, a possible connection between the crane flies and the riparian soil adjacent to EUA-02 and EUA-03 was considered. Calculating a mean soil concentration and comparing that to the tissue concentrations in these areas results in BAFs that are more consistent with what was observed in other samples, but the BAFs are still relatively high (e.g., 1.4 and 1.8 for crane flies only compared to 0.3 to 0.8 for mixed species). Based on the feeding strategy for crane flies, it would seem unlikely that the sediment in EUA-02 and EUA-03 is the source of the elevated PCB concentrations measured. Comparing the crane fly results to those observed at another PCB River site (i.e., the Kalamazoo River), indicates that the BAFs for dipteran species are very consistent with the BAFs observed for mixed species in this OU-1/OU-2 SERA (e.g., on a wet weight basis, mean OU-4 BAF = 0.17 and mean Kalamazoo BAF for all emergent insects = 0.18). This further supports that the six crane fly samples collected within EUA-02 and EUA-03 may not be appropriately representative of aquatic emergent insects. However, the selected BAF is intended to represent uptake across a range of insects and it is recognized that upper trophic level receptors do not differentiate between aquatic and terrestrial insects when feeding. Given that the crane fly PCB data are uncertain, the selected BAF may over- or underestimate potential uptake for these species..

To further evaluate the predicted median BAFs based on the OU-4 data, BAFs available for two other PCB sites were considered. For the Kalamazoo River (Kay et al. 2005) and the Housatonic River (ARCADIS 2008) biota-sediment accumulation factors (BSAFs) were available for several of the biotic tissues considered in this SERA. Specifically crayfish BSAFs were available from both sources and are used here for comparison. For the Kalamazoo calculated BSAFs were based on the geometric mean of lipid-normalized wet weight biota total PCBs to the geometric mean of OC-normalized dry weight sediment total PCBs. For the Housatonic River, BSAFs were based on averaged OC-normalized PCBs in river sediment by sediment mile and co-located lipid normalized crayfish tissue concentrations. The higher of the median or geometric mean of the individual BSAFs was used, and in the case of crayfish, the geometric mean of the individual BSAF was used. The Kalamazoo River data resulted in a crayfish BSAF of 0.429 kg organic carbon (oc)/kg lipid (Kay et al., 2005) and the Housatonic River data resulted in a crayfish BSAF of 0.56 kg oc/kg lipid for Reach 5A/5B and a crayfish BSAF of 1.23 kg oc/kg lipid for Reach 5C/5D/6 (ARCADIS 2008).

The crayfish BSAF in the SERA is calculated as 0.31 kg oc/kg lipid based on the median BSAF of the tissue to sediment ratios (Table A-9 in Appendix A).

It is important to note that no predictive relationships were found between tissue and sediment for either the Housatonic River or the Kalamazoo River datasets and both values are based on selecting a predictor of central tendency. This comparison indicates that the Site-specific values developed for this SERA are generally in the range of those observed for other sites and are preferred because they are based on Site-specific data. While there is some uncertainty regarding the application of data collected from OU-4 to OU-1/OU-2, this uncertainty is considered relatively small compared to application of non-site specific factors. Because BAFs are used in conjunction with a number of other conservative (tending to overestimate) assumptions (i.e., ingestion rates, sediment estimates, site use, and TRVs), the use of median BAFs is not expected to result in overall underestimation of exposure.

Additional uncertainty results from the fact that sediment data from individual BSAs were measured as sum of Aroclors, and some tissue was measured as the sum of homologs (i.e., plants, benthic invertebrates, emergent insects, reptiles, and amphibians). This mixing of Aroclor and homolog data adds some uncertainty to the BAFs and the resulting SSRBCs. Because measured homolog tissue concentrations are generally higher than those measured as Aroclors (i.e., Site specific benthic invertebrate data indicate that homologs overestimate Aroclor concentrations by a factor of 2 to 4), tissues measured as homologs are expected to overestimate uptake compared to Aroclors. Because the BAFs are used to calculate safe sediment concentrations and the sediment concentrations are based on Aroclors, the resulting SSRBCs are likely to be biased low when based on homolog data.

As discussed in Section 4.3.1, bioaccumulation for benthic invertebrates was also measured in a laboratory study conducted with OU-4 and reference sediment and *lumbriculus verigatus.* The resulting laboratory study predicts uptake of PCBs from sediment at approximately 26 times that of what was observed based on the field collected invertebrates. The specific reasons for the differences in the laboratory and field estimates may result from differences in sediment composition, but the field data were evaluated based on organic carbon and fines normalized sediment and neither of these factors substantially changed the general uptake estimates. Another factor that may influence differences is the fact that the field and laboratory data are based on different species. The worms used in the laboratory analysis are generally adult forms, are infauna and live and feed primarily in the sediment matrix. The field collected invertebrates (odonates) are larval form and live on the surface of the sediment during this life stage and likely have lesser exposure than worms. A benthic feeding receptor likely eats some combination of a variety of invertebrates so the use of this lab-based uptake relationship may over estimate exposure as its use assumes all invertebrates consumed are worms.

6.3.3 Toxicity Benchmarks and Reference Values

The toxicity benchmarks and TRVs used in this SERA to identify possible risk to each AE represent one of the largest sources of uncertainty in the SERA. In all cases, the benchmarks and TRVs are selected to be conservative estimators of a toxicity threshold so that the possibility of underestimating risk is minimized. The specific uncertainties for these values are discussed below.

6.3.3.1 PCB Sediment Toxicity Values

Uncertainty in the sediment-toxicity values (EC0*, EC10*, EC20*, and EC50* values) has five components: (1) whether the reference sediments collected in areas that are located upstream of the Site reflect background chemical constituents that are not associated with P/S (i.e. urban runoff from the Snow Creek watershed); (2) whether the lowest measured reference-sediment response for a given toxicity endpoint adequately represents the lowest response that would be caused by a reference sediment; (3) variability in the calculated EC0*, EC10*, EC20*, and EC50* values; (4) inherent variability in results of toxicity tests; and (5) potential variability between batches of toxicity tests conducted at different times and in different laboratories a considerable length of time after the sediments were collected from OU-4. These five potential sources of uncertainty are discussed below.

Regarding the first uncertainty, the six reference sediments collected from Choccolocco Creek approximately 3 kilometers upstream of its confluence with Snow Creek came from an agricultural area that does not receive urban inputs. Therefore, the reference sediments do not have physical-chemical characteristics of an urban-influenced stream (Snow Creek) and might underestimate the toxicity caused by chemicals that originated from non-Site sources, thus, overestimating the toxicity caused by inputs originating from the Site.

Regarding the second uncertainty, only six reference sediments might not adequately represent the entire range of potential reference-sediment responses, even if the reference sediments contained appropriate background chemicals and toxicity from non-Site sources. Therefore, the lowest reference-sediment response for a given toxicity endpoint might not be representative of the “true” lower limit of the reference values, contributing to a potential underestimate or overestimate of the toxicity caused by inputs originating from the Site.

Regarding the third uncertainty, there is variability in the responses of the OU-4 sediments around the central-tendency concentration-response curves for each endpoint (see Figures B-3 and B-4 in Appendix B). Furthermore, there is variability in the toxicity responses for repeated testing of a given sediment (see Appendix B and below). Therefore, there is statistical uncertainty in the EC0*, EC10*, EC20*, and EC50* values listed in Table B-1 (Appendix B).

Regarding the fourth uncertainty, results of sediment toxicity tests can be highly variable for some endpoints, even when conducted in the highly-skilled laboratories that conducted the tests with OU-4 sediments (Appendix B). For example, the OU-4 tests were conducted in three batches, each with its own control sediment (but the same sediment was used as a control in all three batches). The variation among the three control responses for the 23 endpoints ranged from 1.3% to 137% of the mean of the three results (Appendix B). In general, survival and hatch-percentage endpoints varied by relatively small percentages (1.3 to 4.4%), growth endpoints varied by intermediate percentages (18 to 80%), and reproduction endpoints varied by intermediate to large percentages (25 to 137%). Given this sometimes large variability in control responses for a toxicity endpoint, large variability can also be expected in responses of organisms exposed to OU-4 sediments. For example, for the one OU-4 sediment that was repeat-tested two months apart in the same laboratory, the difference in control-normalized response for the 12 endpoints ranged from 0.2% to 74% of the mean of the two results. Six (50%) of those endpoints had differences that were less than 20% of the mean control-normalized response, and five (42%) had differences between 20 and 50% of the mean control-normalized response. The median difference was 22.4%. Therefore, when comparing any one response percentage to a specified threshold for significant effects (e.g., an EC0*, EC10*, EC20*, or EC50*), it should be recognized that the “true” toxicity of that sediment might be accurately estimated, considerably underestimated, or considerably overestimated by the result from a single toxicity test. In contrast, the regression-based predictions of PCB concentrations that cause a specified percentage response are central-tendency estimates that tend to “average-out” that variability, making the regression-based predictions of effect percentages less uncertain than the results from any single sediment toxicity test.

Regarding the fifth uncertainty, the OU-4 sediments used in the toxicity tests were collected in August 2010 but were not tested until November 2010 (the first cycle of testing) or January 2011 (the second cycle of testing). Those intervening periods exceeded the maximum eight-week hold time recommended by USEPA (2000) before sediment toxicity tests should be started. During storage, the chemical characteristics of the sediments might have changed, thus altering the concentrations and/or bioavailability of the PCBs and other potential contributors to toxicity. However, those delays were decided to be necessary: (1) to provide time for chemical analyses of the sediments, so informed decisions could be made about which sediments to test in which batch, and (2) because the two contracted laboratories did not have enough capacity to conduct all the toxicity tests in one batch (i.e., a minimum two-month interval was needed between batches to allow the C. *dilutus* tests in the first batch to be completed before starting the second batch of tests). The extended hold times were deemed acceptable because the primary goal of the testing was to develop generic concentration-response relationships of toxicity *versus* PCB concentration (for extrapolation to all OU-4 sediments not only those sediments that were tested) and was not to specifically characterize the “true” toxicity of any given OU-4 sediment. Therefore, although changes in the chemistry of sediments that are stored beyond the eight-week hold time can contribute to interpretation uncertainties, the uncertainty is less when the results of the toxicity tests are used to develop concentration-response relationships (as in this application) than when they are used to decide whether a specific sediment is toxic when tested after its hold time has been exceeded (which was not the purpose of these toxicity tests).

6.3.3.2 TECs and PECs

Consensus-based sediment guidelines were evaluated by MacDonald et al. (2000a,b) to determine if they would be effective tools for predicting sediment quality benchmarks in freshwater ecosystems. The TEC is defined as the concentration below which adverse effects are not expected to occur, and the PEC is the concentration above which adverse effects are expected to occur. These levels were derived using an averaging approach based on similar thresholds from the following published sources:

- Effects-Level SQGs (threshold effects levels [TELs] and probable effects levels [PELs]; Smith et al. 1996)
- *Hyalella azteca* Effects-Level SQGs (TEL-HA28 and PEL-HA28; Ingersoll et al. 1996 and USEPA 1996)
- Effects-Range SQGs (effects range low and effect range median; Long and Morgan 1991)

- Screening-Level Concentration SQGs (lowest effect levels and severe effect levels; Persaud et al. 1993)
- Sediment Quality Advisory Level SQGs (minimum effect thresholds, toxic effect thresholds, effects concentration and EC, MENVIQ; Environment Canada and Ministere de l'Envionnement du Quebec 1992)

Based on the evaluation criteria, TECs and PECs for most of the individual chemicals and mixtures were considered reliable as predictive tools (i.e., predictive ability was greater than 75%). This reliability was associated with the narrative intent of TECs and PECs (i.e., sediment samples were predicted not to be toxic if the measured concentration of a chemical was less than its corresponding TEC and, similarly, sediment samples were predicted to be toxic if the measured concentration of a chemical was greater than its corresponding PEC). However, MacDonald et al. (2000b) acknowledged that sediment samples with concentrations of a chemical that lie between its corresponding TEC and PEC values could not be predicted as being not toxic or toxic. Thus, the true toxicity threshold (i.e., no observed effect concentration) theoretically lies between the TEC and PEC.

There is significant uncertainty inherent in all of the approaches developed based on empirical data relationships and, consequently, compound-specific values can vary by several orders of magnitude depending on the intent of their use and the derivation procedure (MacDonald et al. 2000b; Smith et al. 1996). Empirical approaches may not reflect contaminant-specific response thresholds (due to un-addressed co-contaminant and chemical mixture issues), and they do not incorporate site-specific factors that influence bioavailability (MacDonald et al. 2000a,b; DiToro et al. 1991). For these reasons, these screening values are likely to overestimate toxicity, as demonstrated specifically with Anniston OU-4 sediments in Appendix B.

6.3.3.3 Avian TRVs

As discussed in Section 5, one of the primary uncertainties associated with avian PCB TRVs is determining if identified receptors might be highly sensitive to PCBs (i.e., chicken-like). For avian receptors, a large number of the available toxicity studies have been conducted using the domestic chicken and other species as the test species. Based on review of the data, the chicken appears to be substantially more sensitive to PCBs than all of the other avian species tested. As such, TRVs based on domestic chicken studies were developed to represent the high end of the range of sensitivity for all potential species. A second set of TRVs were developed to represent the mid-range of sensitivity. Recent research conducted by Dr. Kennedy at the University of

Ottawa indicates that the vast majority of wild species are not expected to be chicken-like in their sensitivity to PCBs (Farmahin et al 2012). Specifically, genetic sequence of the AHR for the spotted sandpiper, the tree swallow, and the mallard have been determined and all three species were found to be have moderate or low sensitivity to DLCs. The pied-billed grebe has not been tested, but seven duck species have been tested and all had either moderate or low sensitivity. Additional detail regarding Dr. Kennedy's research and species sensitivity to PCBs is provided in Section 5.2 and Appendix C. Thus, the mid-range sensitivity TRVs are expected to be more representative of wild birds found along the OU-1/OU-2 site area.

For development of the high-sensitivity (i.e., chicken) tPCB TRVs, a total of seven studies were evaluated. Based on the available data, the lowest LOAEL of 0.13 mg/kg-d for reduced hatchability in chickens, reported by Lillie et al. (1974) was selected. While the relevance of this endpoint to population level effects is uncertain, the LOAEL was selected for conservatism. No NOAEL was measured in this study, thus the NOAEL was extrapolated by dividing the selected LOAEL by a factor of 3. The extrapolated NOAEL of 0.043 mg/kg/day is lower than the observed NOAEL from Scott 1977 of 0.065 mg/kg/day and indicates that an extrapolation factor of 3 is conservative. These values are the lowest values from the available literature and are, therefore, likely to be conservative TRV values.

A total of nine studies were evaluated to develop mid-range sensitivity (i.e., non-chicken) tPCB TRVs. Based on the available data, the lowest LOAEL of 1.4 mg/kg-d for reduced egg production in mourning doves (Koval et al. 1987) was selected for a representative low-effect threshold for the mid-range of sensitivity. While this study was not designed to measure this endpoint and did not provide statistical evaluation of egg production, this value is similar to other observed LOAELs (e.g., study with ring-necked pheasants by Dahlgren et al. 1972: LOAEL 1.8 mg/kg) and was selected for conservatism. Because only a single unbounded NOAEL below this LOAEL was available in the literature (McLane and Hughes 1980 – 0.41 mg/kg/day), the NOAEL TRV of 0.47 mg/kg/day was extrapolated by dividing this LOAEL by a factor of three. While this may create some uncertainty surrounding the exact no-effect threshold level, this is not anticipated to underestimate risk to moderate or low sensitivity avian species because the selected NOAEL is bounded closely by the observed NOAEL and by TRVs developed for the more sensitive chicken species. Therefore, these mid-range sensitivity TRVs, including the extrapolated NOAEL, are expected to be conservative, and any uncertainty should overestimate risks to moderate or low sensitivity avian species considered in this OU-1/OU-2 SERA.

For mercury, the primary uncertainty associated with the selected TRVs is the fact that the selected values are based on studies in which exposure was solely to methylmercury. This likely over estimates potential toxicity to identified receptors as the complete dose would not be expected to consist of methylmercury (e.g., the portion coming from incidental sediment ingestion).

6.3.3.4 Mammalian TRVs

For PCBs, a total of ten studies was evaluated to develop the TRV values for small mammals. Based on the available data, the lowest LOAEL of 0.68 mg/kg-d based on reduced mouse birth and weaning weight and reduced number weaned per month (McCoy et al. 1995) was selected as the representative low-effect threshold. Only one bounded NOAEL and LOAEL value was available; however, the NOAEL was higher than the TRV selected for the LOAEL. Therefore, a NOAEL TRV threshold was extrapolated by dividing this LOAEL by a factor of three. While this may create some uncertainty surrounding the exact no-effect threshold level, this is not anticipated to underestimate risk to small mammalian species, as this value is well below the other NOAEL values in the small mammal toxicity dataset considered.

For mercury, as discussed above for birds, the primary uncertainty associated with the selected TRVs is the fact that the selected values are based on studies in which exposure was solely to methylmercury.

6.4 Risk Findings

The findings of the risk assessment for the OU-1/OU-2 portion of Snow Creek are presented below and consider the habitat quality/connectivity and well as key uncertainties associated with the SSRBC calculations and comparisons.

6.4.1 Survival, Growth, and Reproduction of Benthic Invertebrate Communities

For PCBs, the comparison of the EC0* toxicity values (i.e., the EC0* result for the most sensitive endpoint and species from the site-specific toxicity testing) to sediment concentrations shows that 74% of the sample locations exceed this value (Table 6-4), while 47% exceeded the EC20* (i.e., the EC20* result for the most sensitive endpoint and species from the site-specific toxicity testing). Concentrations are generally higher in the upstream portion of the creek, near the confluence of the 11^{th} Street Drainage Ditch and the culverts at the Highway 202 underpass. Downstream of Highway 202, where habitat is even more fragmented, there are only five exceedances of the EC20* toxicity value.

For metals, a number of sample locations exceeded both low and high benchmarks (Table 6-4). It is important to note that metal concentrations upstream of the 11th Street Drainage Ditch confluence with Snow Creek, and hence upstream of runoff from the plant (OU-3), also exceed benchmarks. In many cases, these upstream concentrations are higher than concentrations downstream of the 11th Street Drainage Ditch. As with PCBs, some of the highest metal concentrations are associated with samples collected in or near the culverts at the Highway 202 underpass (Figures 3-1a, 3-1b, and 3-2). This finding is more likely related to the sediment trap aspects of the culverts than a relationship between PCBs and the other constituents that could otherwise be inferred.

6.4.2 Protection of Local Populations of Aquatic Feeding Birds

For PCBs, the spotted sandpiper and the tree swallow indicate the highest potential for risk (i.e., had the lowest SSRBCs), followed by the pied-billed grebe and the mallard. Assuming an omnivorous diet for the mallard (Section 6.3.1.3), the mallard also indicates a similar level of risk to the sandpiper and tree swallow. Table 6-4 summarizes the number of samples that exceeded each SSRBC. The spotted sandpiper and the tree swallow are moderately sensitive species based on AHR genetic sequences (see Section 5.2). As such, the mid-range sensitivity SSRBCs apply for these species. The LOAEL SSRBCs are 1.5 and mg/kg and 3.1 mg/kg, respectively, for the tree swallow and the sandpiper. Most of the sediment samples exceed the SSRBC for the tree swallow and a little over half exceed the SSRBC for the sandpiper. The SSRBC exceedances for the sandpiper are generally near the confluence of the 11th Street Drainage Ditch and Snow Creek and the culverts at the Highway 202 underpass. There are eight exceedances of the LOAEL SSRBC downstream of the Highway 202 underpass (Figure 3-1b). The mallard and the grebe are also expected to be mid-range or low sensitivity species. The LOAEL SSRBs for these species are not exceeded downstream of the Highway 202 underpass. For any high sensitivity avian species that may be present within the OU-1/OU-2 portion of Snow Creek, the majority of samples exceed both NOAEL and LOAEL SSRBCs indicating risk from PCBs to these potential receptors if site use is high.

For metals, LOAEL SSRBCs are primarily exceeded near the confluence of the 11th Street Drainage Ditch and Snow Creek and the culverts at the Highway 202 underpass. However, three samples collected by USEPA within an industrial area of the OU-1/OU-2 site area indicate concentrations of several metals greater than the most conservative SSRBCs. Specifically, sample CA-25-EPA-43166-2503 contains the highest lead concentration by 5 to 10 fold and relatively high concentrations of barium, chromium, manganese and nickel. Based on the relatively low concentration of PCBs detected in this sample (0.75 mg/kg), the Site contribution to this sample is uncertain. In addition, with the exception of mercury, metals concentrations upstream of the Site are similar or greater than many concentrations measured within the OU-1/OU-2 site area and also exceed SSRBCs.

As described in Appendix D, TEQ for PCDD/DFs exceeded SSRBCs only when the full reporting limit was include for non-detected PCDD/DF congeners and these exceedances were less than a factor of 2. Total TEQ concentrations (inclusive of PCDD/DFs and DL-PCBs) in one of the two PCDD/DF samples (S-MED-1) exceeded SSRBCs for the tree swallow[5], which was assumed to consume 100 percent emergent insects. The uncertainties associated with the emergent insect BAF and the use of one half reporting limit for non-detected PCB congeners are discussed in Section 6.3.2 and Appendix D, respectively.

6.4.3 Protection of Local Populations of Aquatic Feeding Mammals

For PCBs, the little brown bat indicated the highest potential for risk (i.e., had the lowest SSRBCs), followed by the muskrat, and lastly the raccoon. Assuming an omnivorous diet including mollusks for the muskrat, the SSRBCs are lower but still greater than those of the bat. Table 6-4 summarizes the number of samples that exceeded each SSRBC. The LOAEL SSRBCs are 1, 8, and 12 mg/kg respectively, for the bat, raccoon and muskrat. For the bat, most samples exceeded this SSRBC. For the muskrat and raccoon, as discussed above, the sediment samples that exceed these SSRBCs are generally near the confluence of the 11th Street Drainage Ditch and Snow Creek and the culverts at the Highway 202 underpass. There are three low magnitude exceedances of these SSRBCs downstream of the Highway 202 underpass (Figure 3-1b).

For barium, cobalt, mercury, and vanadium, no samples exceeded the LOAEL SSRBC for mammals. For lead, only one sample exceeded the LOAEL SSRBC. For

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[5] Both samples exceeded SSRBCs when one half the reporting limit was substituted for non-detected PCB congener concentrations. (See appendix D).

manganese and chromium, all OU-1/OU-2 site area samples exceeded the lowest LOAEL SSRBC for mammals, as did the majority of the samples upstream of the OU-1/OU-2 site area. As discussed above, this indicates that the sources of these metals may not be OU-1/OU-2 related.

TEQ for PCDD/DFs exceeded SSRBCs only when the full reporting limit was include for non-detected PCDD/DF congeners and these exceedances were less than a factor of 2. Total TEQ concentrations (inclusive of PCDD/DFs and DL-PCBs) in one of the two PCDD/DF samples (S-MED-1), exceeded SSRBCs for the little brown bat[5], which was assumed to consume 100 percent emergent insects. The uncertainties associated with the emergent insect BAF and the use of one half reporting limit for non-detected PCB congeners are discussed in Section 6.3.2 and Appendix D, respectively.

6.4.4 Summary

In summary, risk to benthic invertebrates from exposure to PCBs and some metals in localized areas within OU-1/OU-2 portion of Snow Creek (i.e., primarily near the confluence of the 11th Street Drainage Ditch and Snow Creek and the culverts at the Highway 202 underpass) is possible. Risk to populations of avian and mammalian species that may reside or forage within this area is unlikely because habitat constraints likely limit exposure to large numbers of receptors for extended periods of time. Some risk to individual birds is possible from exposure to PCBs, chromium, lead, manganese, mercury, nickel, vanadium, and total TEQ and some risk to individual mammals is possible from exposure to PCBs, chromium, manganese, nickel, and total TEQ. These risk estimates are considered conservative and likely overstate the potential for adverse effects on local populations of receptors in the OU-1/OU-2 site area.

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Tables

Table 2-1
Summary of Aquatic Habitat Assessment[1]
(conducted using USEPA Rapid Bioassessment Protocols)

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Habitat Parameters - Low Gradient Streams Reaches	Condition Category & Score[2] for Each Survey Location Optimal (20 - 16) --- Suboptimal (15 - 11) --- Marginal (10 - 6) --- Poor (5 - 0)				
	SC-STA-1	***SC-STA-2***	***SC-STA-3***	***SC-STA-4***	***SC-STA-5***
Epifaunal Substrate/Available Cover	8	11	17	12	17
Pool Substrate Characterization	14	8	7	8	4
Pool Variability	3	4	8	11	15
Sediment Deposition	14	12	17	14	17
Channel Flow Status	17	17	17	17	18
Channel Alteration	14	17	18	18	9
Channel Sinuosity	5	6	3	4	6
Bank Stability					
Right Bank (10 - 0)	9	9	7	10	10
Left Bank (10 - 0)	9	9	10	10	10
Vegetative Protection					
Right Bank (10 - 0)	9	9	7	10	9
Left Bank (10 - 0)	8	8	10	9	7
Riparian Vegetative Zone Width					
Right Bank (10 - 0)	6	6	1	5	2
Left Bank (10 - 0)	6	5	2	2	1
TOTAL SCORE	**122**	**121**	**124**	**130**	**125**

Footnotes:

[1]Habitat assessment conducted in 2005. A detailed description of methods and results is provided in BBL (2005).

[2]Protocol based on Barbour et al. (1999).

Acronyms and Abbreviations:

OU = Operable Unit
PCB = polychlorinated biphenyl
USEPA = U.S. Environmental Protection Agency

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BBL. 2005. *Screening Level Risk Assessment (SLERA) for Operable*

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Table 2-2
Summary of Terrestrial Habitat Assessment[1]
(conducted using Kansas Parks Method)

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Survey Location	Habitat Type	Evaluation Key	KP Optimum Habitat Score	KP Value Score (2)	Site-Specific Interspersion Factor (3)	Modified KP Value Score	Adjacent Habitat	Adjusted Habitat Quality Rating (4)
SC-1 East Bank	Mowed Field	Odd Area	10	3.0	-1.0	2.0	Residential development and a park	Poor
SC-1 West Bank	Mowed Field	Odd Area	10	2.5	-1.0	1.5	Residential homes and roads	Poor
SC-2 East Bank	Narrow (30-ft) riparian corridor	Odd Area	10	2.5	-1.0	1.5	Residential development	Poor
SC-2 West Bank	Narrow (30-ft) mowed field	Odd Area	10	2.0	-1.0	1.0	Residential development and road ditches	Poor
SC-3 East Bank	Narrow (20-ft) upland	Woodland	10	4.75	-1.0	3.75	Abandoned construction yard	Fair
SC-3 West Bank	Narrow (10-ft) riparian upland	Woodland	10	3.75	-1.0	2.75	Riprapped embankment of railroad ROW	Poor
SC-4 East Bank	Narrow (20-ft) steep slope	Odd Area	10	4.0	-1.0	3.0	15-ft wide mowed area adjacent to a parking lot	Poor
SC-4 West Bank	Junkyard	Woodland	10	5.25	-1.0	4.25	No access	Fair
SC-5 East Bank	Narrow (10-ft) railroad ROW	Woodland	10	4.5	-1.0	3.5	Railroad line	Fair
SC-5 West Bank	Narrow (10-ft) forest edge	Woodland	10	4.5	-1.0	3.5	Parking lot	Fair
OU-1/OU-2 Average				**3.8**		**2.9**		**Poor**

Footnotes:

[1] Habitat assessment was conducted in 2005. A detailed description of methods and results is provided in BBL (2005).

[2] The KP Value Score is the habitat quality score resulting from the characteristics of the highest quality habitats in the evaluation area.

[3] A site-specific interspersion factor was developed and applied to the KP Value score to account for the developed, urban nature of the land use bordering Snow Creek.

[4] The Adjusted Habitat Quality Rating is the qualitative ranking of habitat quality reflected by the Modified KP Value score. Scores that fall within established ranges in the KP Method are ranked as follows:

KP Value Score range	Rank
1.0 - 3.0	poor
3.1 - 5.5	fair
5.6 - 7.9	good
8.0 - 10.0	excellent

Acronyms and Abbreviations:

ft = foot/feet
KP = Kansas Parks
OU = Operable Unit
PCB = polychlorinated biphenyl
ROW = right of way

Reference:

BBL. 2005. Screening Level Risk Assessment (SLERA) for Operable Units 1, 2, and 3 of the Anniston PCB Site. Revision 1. December.

Table 2-3
Summary of Wildlife Observations in Snow Creek

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Common Name	Scientific Name	Observation Location[1]					
		SC-STA-1	*SC-STA-2*	*SC-STA-3*	*SC-STA-4*	*SC-STA-5*	*Previous Survey Observation*
Birds							
American robin	*Turdus migratorius*	CA	FE			CA	OB
Bank swallow	*Riparia riparia*						OB
Barn swallow	*Hirundo rustica*	FG	FG	FG		FE	
Belted kingfisher	*Megaceryle alcyon*		FL	FL			
Blue jay	*Cyanocitta cristata*	RS					OB
Brown thrasher	*Toxostoma rufum*			FG			
Carolina chickadee	*Poecile carolinensis*		FG				OB
Chimney swift	*Chaetura pelagica*	FG		FG			
Common grackle	*Quiscalus quiscula*	FE	FG		FL		OB
Cuckoo	*Cuculus* sp.						OB
Eastern bluebird	*Sialia sialis*						OB
European starling	*Sturnus vulgaris*	FE	FL	RS	FG	FL	OB
Gray catbird	*Dumetella carolinensis*		CA	CA			
Great blue heron	*Ardea herodias*						OB
House sparrow	*Passer domesticus*		RS			RS	
Mourning dove	*Zenaida macroura*		RS				OB
Northern mockingbird	*Mimus polyglottos*	CA	CA	CA	CA	CA	OB
Northern cardinal	*Cardinalis cardinalis*		CA	CA			OB
Phoebe	*Sayornis phoebe*		FG				
Red-tailed hawk	*Buteo jamaicensis*						
Red-winged blackbird	*Agelaius phoeniceus*	CA					
Rock pigeon	*Columba livia*		FL		FL		
Song sparrow	*Melospiza melodia*		CA				OB
Tree swallow	*Tachycineta bicolor*	FG	FG	NE			
White-breasted nuthatch	*Sitta carolinensis*						OB
Northern flicker (yellow-shafted)	*Colaptes auratus*	CA					

Table 2-3
Summary of Wildlife Observations in Snow Creek

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Common Name	Scientific Name	Observation Location[1]					
		SC-STA-1	*SC-STA-2*	*SC-STA-3*	*SC-STA-4*	*SC-STA-5*	*Previous Survey Observation*
Mammals							
Domestic cat	*Felis domestica*		TR				
Domestic dog	*Canis domestica*		TR				
Harvest mouse	*Reithrodontomys humulis*						
Muskrat	*Ondatra zibethica*	FG	DHB		TR		
Rat	*Rattus norvegicus*		TR	TR	TR		
Bat	*Microchiroptera* sp.	FL					
Herptiles							
Musk turtle	*Sternotherus odoratus*	FG					
Gulf Coast spiny softshell	*Apalone spinifera aspera*	FG			OB	OB	
Copperhead	*Agkistrodon contortix*				FG	RS	
Cottonmouth	*Agkistrodon piscivorus*	FG					
Amphibians							
American toad	*Bufo americanus*	OB					
Bull frog	*Rana catesbeiana*	CA					
Green frog	*Rana clamitans melanota*	CA					OB
Southern leopard frog	*Rana sphenocephala*	CA					
Southern two-lined salamander	*Eurycea cirrigera*				OB		
Crustaceans							
Crayfish	*Astacoidea* sp.	DHB	OB		OB	OB	

Acronyms and Abbreviations:
OU = Operable Unit
PCB = polychlorinated biphenyl

Wildlife Observation Codes:
CA = Calling
DHB = Den, Hut, Burrow
FE = Feeding
FG = Foraging
FL = Flight
NE = Nest
OB = Observed
RS = Resting/Perching
TR = Tracks

[1]Observations at Locations:
SC-STA-1 through SC-STA-5 were made during the 2005 Biological Survey. Previous observations were made during survey work conducted in 2001, 2002, and 2003. A detailed description of methods and results is provided in BBL (2005).

Reference:
BBL. 2005. Screening Level Risk Assessment (SLERA) for Operable Units 1, 2, and 3 of the Anniston PCB Site. Revision 1. December.

Table 3-1
Summary Statistics for Sediment Data[1]

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Sample Size	Minimum	Maximum	Mean	Median	Variance	Standard Deviation	95% UCL[2]	95% UCL Method
tPCB	43	0.66	60	8.9	4.0	134	12	12	95% Approximate Gamma UCL
Barium	12	52	577	163	102	23168	152	255	95% Approximate Gamma UCL
Chromium	12	28	670	130	51	34604	186	364	95% Chebyshev (Mean, Sd) UCL
Cobalt	12	2	89	19	13	546	23	33	95% Approximate Gamma UCL
Lead	12	15	510	92	53	18108	135	177	95% H-UCL
Manganese	12	340	4610	1661	1005	2169408	1473	2643	95% Approximate Gamma UCL
Mercury	12	0.013	2.2	0.40	0.20	0.37	0.61	0.82	95% Approximate Gamma UCL
Nickel	12	12	92	32	19	860	29	50	95% Approximate Gamma UCL
Vanadium	12	5.7	64	28	21	350	19	40	95% Approximate Gamma UCL

Acronyms and Abbreviations:
OU = Operable Unit
PCB = polychlorinated biphenyl
tPCB = total polychlorinated biphenyl
UCL = upper confidence limit
H-UCL = UCL based on Land's H-statistic
Sd = standard deviation

Footnotes:
[1] Soil depth of 0-2 inch interval was used when multiple depths were sampled.
[2] 95% UCL calculated using ProUCL Version 4.1.01.

Table 3-2
OU-1/OU-2 Investigation Whole Water Surface Water Data for Snow Creek

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Location ID		National Ambient Water Quality Criteria		Oxford Park					
Sample ID				S50048	S50049	S50050	S50051	S50052	S50053
Sample Date				3/16/2007	3/16/2007	6/8/2007	6/8/2007	6/20/2007	6/20/2007
Total Suspended Solids	Units	Acute	Chronic	310		64		496	
Barium	µg/L	NC	NC	92.9		25.6	24.1	201	
Chromium	µg/L	16	11	10.8		2	2.2	32.9	
Cobalt	µg/L	NC	NC	5		*1.9*	*1.9*	12.2	
Lead	µg/L	65	2.5	28.6		4.8	4.2	96.4	
Manganese	µg/L	NC	NC	640		72.8	68.5	2400	
Mercury	µg/L	1.4	0.77	0.15		*0.018*	*0.018*	0.43	
Nickel	µg/L	470	52	8.2		*2.4*	*2.4*	23.2	
Vanadium	µg/L	NC	NC	16.4		4.8	4.1	33.9	
Total Aroclor PCBs	µg/L	NC	0.014	*0.51*	*0.5*	*0.5*		*0.54*	
Total Homolog PCBs[1]	µg/L	NC	0.014	0.4	*0.59*	0.40		0.17	
2,3,7,8-TCDD[2]	pg/L	100,000	10	*0.57*	*0.57*	*0.59*		*0.84*	
WHO Dioxin TEQ[2]	pg/L	100,000	10	5.47	8.57	2.74		21.9	

Notes:
NC = no criterion available
na = not available
OU = operable unit
PCB = polychlorinated biphenyl
values in italics indicate non-detected results - value shown is the maximum reporting limit
pg/L = picograms per liter
PCDD/PCDF = polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran
TEQ = 2,3,7,8-TCDD Toxic Equivalents (TEQs are based on mammalian toxic equivalency factors [Vandenberg 2006])
WHO = World Health Organization.
µg/L = micrograms per liter
Water Quality Criteria for lead and nickel are hardness dependent. Values presented assume a hardness of 100 mg/l CaCO3.
[1] Total PCBs calculated 0 for non-detected homologs when at least one homolog was detected.
[2] Criteria for 2,3,7,8-TCDD and TEQ are taken from USEPA Region 4 Freshwater Screening Values for Hazardous Waste Sites (USEPA 2001). TEQs calculated by summing PCDD/PCDF congeners using 1/2 sample reporting limit for non-detected results
(blue) = exceeds acute (and chronic) criterion
(green) = exceeds chronic criterion

Table 3-3
Summary of RCRA Program Calculated Surface Water Data for Snow Creek

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Sampling Location	Flow Event Type	Date	Flow (cfs)	TSS (mg/L)	Particulate Total PCB (mg/kg)	Calculated Whole Water PCB (µg/L)
14th Street (Upstream)	Base	June 21,1999	0.02	66	11.7	0.772
16th Street (Upstream)		June 21,1999	1.2	52	0.9	0.045
Snow Street	Base	March 22-23, 1999	16	17	9.9	0.168
		May 3-4,1999	5.0	20	2.7	0.054
		May 26-27,1999	3.4	2.5*	1.0	0.002
		June 14,1999	2.6	2.5*	0.9	0.002
		September 27-28,1999	1.6	2.5*	0.2	0.000
		January 18,2000	2.9	2.5*	16.4	0.041
	High	April 27,1999	205	230	3.7	0.851
		April 27,1999	135	280	3.3	0.930
Oxford Park	High	January 19, 2002	480	270/290	5.2	1.196
		January 25, 2002	257	78/250	6.0	0.984
		February 6, 2002	221	41/35	5.9	0.224
		March 12, 2002	154	620	7.5	4.650
		March 30, 2002	224	400/390	2.8	1.086
		May 3, 2002	146	290/390	0.5	0.173
		June 4, 2002	133	480/350	1.7	0.685
		June 14, 2002	118	180/270	0.3	0.060
		July 10, 2002	206	220/230	5.4	1.215
		August 17, 2002	152	110/120	1.1	0.121
		August 28, 2002	154	270/280	4.1	1.130
		September 22, 2002	214	230/210	1.6	0.359
		September 25, 2002	214	100	6.3	0.630
		October 29, 2002	164	450/400	2.5	1.075
		October 29, 2002	162	150/140	3.6	0.515
		November 11, 2002	299	340/310	5.7	1.853
		November 15, 2002	172	170/160	5.0	0.825

Notes:
cfs = cubic feet per second
mg/L = milligrams per liter
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
OU = Operable Unit
Total PCB = total polychlorinated biphenyl calculated as the sum of PCB Aroclors, assuming 1/2 the sample reporting limit for non-detected results
RCRA = Resource Conservation and Recovery Act
TSS = Total Suspended Solids - Results for the Oxford Park location may include duplicate measurements from a single composite sample collected from the automated sampling unit.
Flows at Oxford Park were calculated from stage data.
The total PCB concentration was calculated as the sum of detected aroclors.
* - TSS was not detected above the 5 mg/L detection limit. The value 2.5 represents one half the detection limit.
[green] = exceeds chronic criterion of 0.014 µg/L

Table 3-4
Summary of PCB Sediment and Tissue Data Used for Bioaccumulation Factor Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	PCB Results (mg/kg dry weight)[1]							
			Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Lower	ELA-01	ELA-01-55	0.53	0.63	0.67	1.6	1.3	10	na	45
		ELA-01-56	0.26	0.37	0.96	0.90	0.83	11	na	35
		ELA-01-57	1.97	0.58	1.2	0.91	1.1	6.1	na	35
		ELA-01-58	2.65							
		ELA-01-59	0.82							
		ELA-01-60	2.37							
		HHFL-04	1.31							
	ELA-02	ELA-02-61	3.90	0.25	0.74	0.80	0.24	12	5.4	26
		ELA-02-62	2.37	0.036	0.83	0.81	0.51	8.4	5.3	na
		ELA-02-63	2.99	0.042	1.4	1.0	1.3	14	na	na
		ELA-02-64	3.17							
		ELA-02-65	1.19							
		ELA-02-66	1.10							
	ELA-03	ELA-03-67	4.20	0.33	0.71	0.74	0.68	11	na	30
		ELA-03-68	0.98	0.24	0.95	0.94	0.76	11	na	48
		ELA-03-69	2.04	0.042	1.2	0.61	0.87	12	na	55
		ELA-03-70	0.04							
		ELA-03-71	0.10							
		ELA-03-72	0.36							
Middle	EMA-01	EMA-01-01	1.22	0.041	0.31	1.6	2.6	4.9	2.4	122
		EMA-01-02	0.70	1.1	0.55	1.3	2.6	4.6	2.6	na
		EMA-01-03	1.14	0.39	0.69	1.2	na	6.3	na	na
		EMA-01-04	0.36							
		EMA-01-05	1.30							
		EMA-01-06	2.27							
		HHFL-05	0.23							
	EMA-02	EMA-02-07	2.37	1.7	0.68	2.0	2.1	7.3	3.4	19
		EMA-02-08	1.31	1.2	0.73	1.9	na	6.4	2.9	na
		EMA-02-09	5.15	0.054	0.58	1.9	0.89	6.2	na	na
		EMA-02-10	2.27							
		EMA-02-11	1.95							
		EMA-02-12	3.64							
		C-064-SED-1	0.11							
		C-065-SED-3	0.20							
	EMA-03	EMA-03-31	0.23	0.059	0.81	1.4	1.8	12	4.5	na
		EMA-03-32	0.02	0.44	0.80	2.0	1.5	10	3.1	na
		EMA-03-33	0.38	0.39	1.0	1.2	1.1	12	na	na
		EMA-03-34	0.69							
		EMA-03-35	3.90							
		EMA-03-36	1.51							
Upper	EUA-01	EUA-01-19	1.10	0.87	2.7	3.5	1.8	11	15	26
		EUA-01-20	3.08	0.41	0.36	0.96	3.2	6.3	18	na
		EUA-01-21	0.81	0.88	0.31	0.98	1.6	5.9	na	na
		EUA-01-22	1.96							
		EUA-01-23	0.35							
		EUA-01-24	2.83							
		C-001-SED-4	1.88							
	EUA-02	EUA-02-43	1.93	0.65	27	0.86	3.8	14	9.5	167
		EUA-02-44	0.40	0.67	23	2.9	3.3	17	2.5	na
		EUA-02-45	1.51	0.80	18	1.3	2.2	12	na	na
		EUA-02-46	0.26							
		EUA-02-47	1.63							
		EUA-02-48	0.87							
		C-005-SED-1	0.23							
		C-008-SED-2	0.34							
		C-008-SED-4	0.50							
		C-009-SED-1	2.13							
		C-010-SED-4	0.42							
	EUA-03	EUA-03-25	1.24	0.76	25	1.1	1.3	17	17	na
		EUA-03-26	1.45	1.2	23	2.3	na	15	38	na
		EUA-03-27	0.28	1.2	20	1.3	na	8.8	5.6	na
		EUA-03-28	0.36							
		EUA-03-29	2.35							
		EUA-03-30	0.42							
		C-017-SED-2	8.90							
		C-021-SED-4	1.22							

Table 3-4
Summary of PCB Sediment and Tissue Data Used for Bioaccumulation Factor Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	PCB Results (mg/kg dry weight)[1]							
			Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Reference	ERA-01	ERA-01-49	0.021	0.042	0.16	0.15	na	0.28	na	1.3
		ERA-01-50	0.027	0.040	0.16	0.12	na	0.27	na	1.2
		ERA-01-51	0.019	0.040	0.18	0.14	na	0.11	na	0.21
		ERA-01-52	0.020							
		ERA-01-53	0.024							
		ERA-01-54	0.037							
		ECO-REF-01	0.029							
	ERA-02	ERA-02-13	0.017	5.1	0.089	0.069	0.064	0.14	0.063	0.074
		ERA-02-14	0.036	0.037	0.09	0.13	0.051	0.15	0.14	na
		ERA-02-15	0.040	0.051	0.07	0.15	0.063	0.11	na	na
		ERA-02-16	0.024							
		ERA-02-17	0.021							
		ERA-02-18	0.022							
		ECO-REF-02	0.029							
	ERA-03	ERA-03-37	0.055	0.042	0.24	0.16	na	0.15	0.06	0.028
		ERA-03-38	0.030	0.039	0.17	0.18	na	0.14	na	4.5
		ERA-03-39	0.036	0.039	0.16	0.17	na	0.13	na	na
		ERA-03-40	0.020							
		ERA-03-41	0.021							
		ERA-03-42	0.047							
		ECO-REF-03	0.025							

General Notes:

Red text indicates value is shown at half the reporting limit.

Total PCB calculated as non-detect = 0 if one or more Aroclor or homolog detected; if all are non-detect then one-half the highest reporting limit for individual Aroclor or homolog shown in red.

Footnote:

[1] Sediment, crayfish tissue, and mollusk tissue concentrations were measured as aroclors while all other tissue concentrations were measured as homologues.

Acronyms and Abbreviations:

BSA = biological sampling area
EDR = ecologically distinct reach
mg/kg = milligrams per kilogram
na = no sample acquired in specified area
OU = Operable Unit
PCB = polychlorinated biphenyl

Table 3-5
Summary of Mercury Sediment and Tissue Data Used for Bioaccumulation Factor Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Mercury Results (mg/kg dry weight)							
			Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Lower	ELA-01	ELA-01-55	0.35	0.046	0.16	0.36	0.72	0.56	na	0.78
		ELA-01-56	0.19	0.052	0.21	0.36	0.26	0.80	na	1.1
		ELA-01-57	0.62	0.048	0.25	0.32	0.19	0.52	na	0.94
		ELA-01-58	0.69							
		ELA-01-59	6.30							
		ELA-01-60	0.58							
		HHFL-04	0.38							
	ELA-02	ELA-02-61	0.91	0.092	0.14	0.27	0.29	0.78	0.56	1.9
		ELA-02-62	0.75	0.069	0.19	0.58	0.20	0.85	0.32	na
		ELA-02-63	0.49	0.033	0.24	0.25	0.21	1.0	na	na
		ELA-02-64	0.27							
		ELA-02-65	0.52							
		ELA-02-66	0.59							
	ELA-03	ELA-03-67	1.60	0.073	0.08	0.26	0.11	0.73	na	2.1
		ELA-03-68	0.37	0.067	0.11	0.70	0.14	0.88	na	1.4
		ELA-03-69	0.43	0.060	0.17	0.34	0.14	0.78	na	0.42
		ELA-03-70	0.16							
		ELA-03-71	0.22							
		ELA-03-72	0.19							
Middle	EMA-01	EMA-01-01	0.43	0.063	0.15	0.22	0.19	0.17	0.67	0.54
		EMA-01-02	0.61	0.049	0.19	0.24	0.17	0.37	0.33	na
		EMA-01-03	0.73	0.081	0.32	0.32	na	0.14	na	na
		EMA-01-04	0.74							
		EMA-01-05	0.50							
		EMA-01-06	0.91							
		HHFL-05	0.51							
	EMA-02	EMA-02-07	0.65	0.069	0.077	0.44	0.21	0.27	0.33	1.7
		EMA-02-08	0.84	0.081	0.034	0.26	na	0.28	0.24	na
		EMA-02-09	1.10	0.38	0.038	0.23	0.14	0.33	na	na
		EMA-02-10	0.69							
		EMA-02-11	0.47							
		EMA-02-12	0.87							
	EMA-03	EMA-03-31	0.30	0.049	0.15	0.30	0.12	0.42	0.28	na
		EMA-03-32	0.43	0.047	0.13	0.41	0.14	0.37	0.37	na
		EMA-03-33	0.45	0.049	0.12	0.28	0.20	0.36	1.8	na
		EMA-03-34	0.51							
		EMA-03-35	0.81							
		EMA-03-36	0.75							
Upper	EUA-01	EUA-01-19	2.60	0.049	0.13	0.13	0.12	0.14	0.63	0.88
		EUA-01-20	0.83	0.040	0.10	0.19	0.13	0.14	1.0	na
		EUA-01-21	2.90	0.046	0.11	0.16	0.12	0.16	na	na
		EUA-01-22	0.30							
		EUA-01-23	0.78							
		EUA-01-24	0.75							
	EUA-02	EUA-02-43	0.47	0.075	0.27	0.13	0.80	0.26	0.12	0.61
		EUA-02-44	0.04	0.085	0.23	0.31	0.12	0.30	0.13	na
		EUA-02-45	0.32	0.065	0.30	0.19	0.14	0.25	na	na
		EUA-02-46	0.05							
		EUA-02-47	1.00							
		C-005-SED-2	0.65							
		EUA-02-48	1.30							
	EUA-03	EUA-03-25	1.30	0.088	0.42	0.18	0.19	0.32	0.73	na
		EUA-03-26	0.91	0.080	0.36	0.28	na	0.38	1.0	na
		EUA-03-27	0.27	0.11	0.32	0.15	na	0.22	0.86	na
		EUA-03-28	0.35							
		EUA-03-29	0.86							
		EUA-03-30	1.00							
	ERA-01	ERA-01-49	0.013	0.064	0.066	0.091	na	0.23	na	1.0
		ERA-01-50	0.024	0.034	0.047	0.072	na	0.20	na	0.52
		ERA-01-51	0.014	0.046	0.035	0.090	na	0.24	na	0.41
		ERA-01-52	0.015							

Table 3-5
Summary of Mercury Sediment and Tissue Data Used for Bioaccumulation Factor Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Mercury Results (mg/kg dry weight)							
			Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Reference		ERA-01-53	0.016							
		ERA-01-54	0.027							
		ECO-REF-01	0.01							
	ERA-02	ERA-02-13	0.012	0.038	0.068	0.10	0.06	0.70	0.11	0.50
		ERA-02-14	0.026	0.035	0.041	0.16	0.10	0.57	0.11	na
		ERA-02-15	0.034	0.041	0.048	0.20	0.09	0.68	na	na
		ERA-02-16	0.015							
		ERA-02-17	0.016							
		ERA-02-18	0.015							
		ECO-REF-02	0.022							
	ERA-03	ERA-03-37	0.11	0.036	0.17	0.075	na	0.29	0.11	0.32
		ERA-03-38	0.032	0.033	0.17	0.064	na	0.20	na	0.57
		ERA-03-39	0.041	0.033	0.25	0.070	na	0.17	na	na
		ERA-03-40	0.013							
		ERA-03-41	0.014							
		ERA-03-42	0.041							
		ECO-REF-03	0.016							

General Note:
Red text indicates value is shown at half the reporting limit.

Acronyms and Abbreviations:
BSA = biological sampling area
EDR = ecologically distinct reach
mg/kg = milligrams per kilogram
na = no sample acquired in specified area
OU = Operable Unit
PCB = polychlorinated biphenyl

Table 3-6
Summary of Metals Sediment and Tissue Data Used for Bioaccumulation Factor Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

	Measured Concentrations (mg/kg dry weight)						
Sample ID	**Barium**	**Chromium**	**Cobalt**	**Lead**	**Manganese**	**Nickel**	**Vanadium**
Sediment							
ELA-01	18.95	8.15	2.45	7.05	146	2.30	5.05
ELA-02	26.90	8.50	3.40	8.40	110	3.20	5.30
EMA-01	33.00	7.60	3.50	8.00	271	3.80	5.00
EMA-03	33.90	7.60	2.30	4.30	171	2.40	3.40
EUA-02	82.90	16.90	7.00	13.90	397	4.40	17.20
EUA-03	35.10	18.10	4.10	10.40	354	5.00	7.40
ERA-01	90.90	8.30	8.50	12.60	245	6.20	11.00
ERA-03	84.70	30.90	14.90	12.60	537	11.90	34.30
HHFL-04	14.30	13.60	3.90	9.20	86.30	3.40	7.60
HHFL-05	24.10	6.30	2.55	5.95	217	2.25	3.15
C-005-SED-2	47.50	20.80	10.50	10.20	519	9.20	9.40
ECO-REF-01	42.80	4.50	3.90	6.20	45	3.70	6.30
ECO-REF-02	110.00	8.20	8.10	11.60	442	6.40	11.40
ECO-REF-03	24.80	26.60	6.70	8.00	248	8.40	17.30
Average	47.85	13.29	5.84	9.17	271	5.18	10.27
Aquatic Plants							
ELA-01	66.24	0.18	0.45	1.78	1274	0.64	0.18
EMA-03	50.00	3.13	5.00	3.96	861	0.97	1.94
EUA-02	70.12	2.57	5.00	7.05	1012	0.18	1.49
ERA-03	118.26	4.57	5.02	1.92	1648	2.42	6.85
Average	76.16	2.61	3.87	3.68	1199	1.05	2.62
Ratio of Means BAF	**1.59**	**0.20**	**0.66**	**0.40**	**4.43**	**0.20**	**0.25**
Emergent Insects							
ELA-03	5.14	13.36	0.28	0.45	30.82	7.53	0.01
EMA-02	11.35	11.66	5.00	0.67	102	7.36	0.58
EUA-02	4.42	2.00	5.00	0.29	18.37	1.60	2.00
ERA-01	9.22	3.09	0.08	0.28	24.82	1.74	0.31
Average	7.53	7.52	2.59	0.42	43.89	4.56	0.73
Ratio of Means BAF	**0.16**	**0.57**	**0.44**	**0.05**	**0.16**	**0.88**	**0.07**
Benthic Invertebrates							
ELA-03	37.34	3.23	5.00	3.61	709	1.77	2.22
EMA-03	37.33	3.87	4.27	5.00	1620	2.27	2.47
EUA-02	60.00	3.33	4.44	6.00	3589	2.78	2.56
ERA-01	29.34	1.56	2.40	1.56	1090	1.26	1.68
Average	41.00	3.00	4.03	4.04	1751.9	2.02	2.23
Ratio of Means BAF	**0.86**	**0.23**	**0.69**	**0.44**	**6.48**	**0.39**	**0.22**
Crayfish							
ELA-01	107	2.00	5.00	0.94	402	0.02	2.00
EUA-02	162	2.00	5.00	1.80	584	0.02	2.00
EUA-03	199	1.39	5.00	3.28	1026	0.16	1.39
Average	156	1.80	5.00	2.01	671	0.06	1.80
Ratio of Means BAF	**3.26**	**0.14**	**na**	**0.22**	**2.48**	**na**	**0.17**
Mollusks							
ELA-03	33.54	13.66	3.60	3.73	169	4.35	1.49
EMA-03	27.06	9.65	3.88	4.47	172	2.12	1.88
EUA-01	34.78	9.44	3.48	3.60	237	1.74	1.86
ERA-03	42.11	6.18	5.92	1.71	511	4.08	5.53
Average	34.37	9.73	4.22	3.38	272	3.07	2.69
Ratio of Means BAF	**0.72**	**0.73**	**0.72**	**0.37**	**1.01**	**0.59**	**0.26**
Frog							
ELA-03	9.91	2.00	5.00	0.77	40.54	0.02	2.00
ERA-01	8.78	1.45	0.38	0.27	36.26	0.02	0.57
Average	9.34	1.73	2.69	0.52	38.40	0.02	1.29
Ratio of Means BAF	**0.20**	**0.13**	**0.46**	**0.06**	**0.14**	**na**	**0.13**
Snake							
EUA-01	43.70	7.14	1.55	2.65	592	3.28	1.01
EUA-01a	43.98	18.06	1.44	4.12	150	8.80	1.62
Average	43.84	12.60	1.49	3.38	371	6.04	1.31
Ratio of Means BAF	**0.92**	**0.95**	**0.26**	**0.37**	**1.37**	**1.16**	**0.13**

General Note:
Red text indicates value is shown at half the reporting limit.

Acronyms and Abbreviations:
BAF = bioaccumulation factor
mg/kg = milligrams per kilogram
OU = Operable Unit
PCB = polychlorinated biphenyl

Table 4-1
Summary of Sediment to Aquatic Biota Bioaccumulation Factors

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Sediment to Aquatic Plants	Sediment to Emergent Insects	Sediment to Benthic Invertebrates*	Sediment to Crayfish	Sediment to Mollusks	Sediment to Frogs	Sediment to Snakes
tPCB*	0.42	3.80	0.92	0.75	6.50	3.40	26.91
Barium	1.59	0.16	0.86	3.26	0.72	0.20	0.92
Chromium	0.20	0.57	0.23	0.14	0.73	0.13	0.95
Cobalt	0.66	0.44	0.69	*0.72*	0.72	0.46	0.26
Lead	0.40	0.05	0.44	0.22	0.37	0.06	0.37
Manganese	4.43	0.16	6.48	2.48	1.01	0.14	1.37
Mercury	0.11	0.25	0.39	0.27	0.47	0.75	1.11
Nickel	0.20	0.88	0.39	*0.59*	0.59	*1.16*	1.16
Vanadium	0.25	0.07	0.22	0.17	0.26	0.13	0.13

General Notes:
* PCB uptake also evaluated based on the regression equation from the laboratory data analysis (see Appendix A)
Equation based on log normalized sediment dry and tissue dry weight (log (tissue concentration dw) = 0.6272*(log sediment PCBdw)+1.0224
BAFs calculated as dry weight tissue over dry weight sediment.
Values shown in italics could not be computed because all tissue samples were non detected. For crayfish, mollusk value used as surrogate. For frogs, snake value used as a surrogate.

Acronyms and Abbreviations:
BAF = bioaccumulation factor
OU = Operable Unit
tPCB = total polychlorinated biphenyl

Table 4-2
Avian Receptor Exposure Parameters

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Parameter	Aquatic Herbivore		Aerial-Feeding Insectivore		Aquatic Invertivore		Aquatic Omnivore	
	Mallard		Tree Swallow		Spotted Sandpiper		Pied-Billed Grebe	
	Data	Source	Data	Source	Data	Source	Data	Source
Composition of Diet (%)								
Sediment	6%	Beyer et al. (1994) and Connor (1993), average of values	0%	Assumed to be negligible based on feeding strategy	18%	Beyer et al. (1994), average of four sandpiper values	6%	Mallard value assumed as a surrogate
Aquatic Plants	80%	Herbivorous diet was chosen in order to evaluate mallard as an herbivorous receptor. Diet is based on professional judgment, supported by Dillon 1959 (in USEPA 1993) of a plant-based mallard diet in coastal Louisiana.	0%	--	0%	Diet adapted from Oring et al. (1997) using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.	10%	Diet adapted from Wetmore 1924 (in Muller and Storer 1999), using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.
Emergent Insects	0%		100%	Robertson et al. (1992)	50%		5%	
Benthic Invertebrates	10%		0%	--	50%		53%	
Crayfish	0%		0%	--	0%		20%	
Mollusk	10%		0%	--	0%		2%	
Amphibians	0%		0%	--	0%		10%	
Body Weight (kg)	1.2	Average of non-breeding, adult birds (Drilling et al. 2002)	0.021	Robertson et al. (1992)	0.043	USEPA (1993), average of reported values	0.42	Average of both sexes (Muller and Storer 1999)
Food Ingestion Rate (kg/kg bw/d) (dw)	0.087	Average from Chukwudebe et al., 1998. Converted to dw using assumed % moisture in feed of 12%	0.24	Nagy (2001), allometric equation for insectivores	0.18	Nagy (2001), allometric equation for insectivores	0.071	Nagy (2001), allometric equation for omnivores

Acronyms and Abbreviations:
-- = not applicable
dw = dry weight
kg = kilogram
kg/kg bw/d = kg/kg body weight per day
OU = Operable Unit
PCB = polychlorinated biphenyl
USEPA = U.S. Environmental Protection Agency

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Table 4-3
Mammalian Receptor Exposure Parameters

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Parameter	Herbivore		Mammalian Aerial-Feeding Insectivore		Mammalian Omnivore	
	Muskrat		Little Brown Bat		Raccoon	
	Data	Source	Data	Source	Data	Source
Composition of Diet (%)						
Sediment	9%	Beyer et al. (1994), muskrat used as surrogate	0%	Assumed to be negligible for aerial-feeding insectivores	9%	Beyer et al. (1994)
Aquatic Plants	90%	Diet adapted from USEPA 1993, using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2. Primarily herbivorous, but in river and stream habitat diet includes mollusks (Neves and Odom 1989).	0%	--	44%	Diet adapted from USEPA 1993, using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.
Emergent Insects	0%		100%	Belwood and Fenton (1976), as cited in Sample and Suter (1994)	0%	
Benthic Invertebrates	5%		0%	--	13%	
Crayfish	0%		0%	--	15%	
Mollusk	5%		0%	--	13%	
Frogs	0%		0%	--	10%	
Snakes	0%		0%		5%	
Body Weight (kg)	1.1	Average of values given in Reid (2006)	0.01	Nagy (2001), allometric equation for little brown bat	5.6	USEPA (1993), average of adult and juvenile means values
Food Ingestion Rate (kg/kg bw/d) (dw)	0.07	Nagy (2001), allometric equation for Rodentia	0.18	Nagy (2001), allometric equation for little brown bat	0.03	Nagy (2001), allometric equation for Omnivores

Acronyms and Abbreviations:
-- = not applicable
dw = dry weight
kg = kilogram
kg/kg bw/d = kg/kg body weight per day
OU = Operable Unit
PCB = polychlorinated biphenyl
USEPA = U.S. Environmental Protection Agency

References:

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Table 5-1

Summary of Sediment Benchmarks and PCB Site-Specific Toxicity Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston AL

COPC	Low Threshold[1] mg/kg dw	High Threshold[1] mg/kg dw
tPCBs[2]	1.4	4.4
tPCBs	0.06	0.676
Barium	NV	NV
Chromium (III)	43	111
Cobalt	50	NV
Lead	36	128
Manganese	NV	NV
Mercury (total)	0.18	1.1
Nickel	23	49
Vanadium	NV	NV

Footnotes:

[1] Benchmarks are Threshold Effect Concentrations and Probable Effects Concentrations taken from MacDonald et al. (2000) unless otherwise noted.

[2] PCB values are EC0 and EC20 values for most sensitive species and endpoint from site-specific toxicity testing.
See Appendix B for details on development.

Acronyms and Abbreviations:

COPC = constituent of potential concern
mg/kg dw = milligrams per kilogram dry weight
NV = no threshold value available
OU = operable unit
PCB = polychlorinated biphenyl

Reference:

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39:20-31.

Table 5-2
Summary of Avian and Mammalian Toxicity Reference Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

COPC	Wildlife Toxicity Reference Values (mg/kg bw/d)					
	Birds			Mammals		
	NOAEL TRV	LOAEL TRV	Reference	NOAEL TRV	LOAEL TRV	Reference
tPCB (mid-range sensitivity)	0.47	1.4	Koval et al 1987; NOAEL extrapolated	0.23	0.68	McCoy et al. 1995
tPCB (high sensitivity)	0.043	0.13	Lillie et al. 1974; NOAEL extrapolated	NA	NA	NA
Barium	21	42	Sample et al. 1996[1]	52	121	USEPA 2005a
Chromium	2.7	2.8	USEPA 2008	2.4	2.8	USEPA 2008
Cobalt	7.6	7.8	USEPA 2005b	7.3	10	USEPA 2005b
Lead	1.6	3.3	USEPA 2005c	4.7	8.9	USEPA 2005c
Manganese	179	348	USEPA 2007a	52	65	USEPA 2007a
Mercury	0.023	0.068	Spalding et al. 2000; NOAEL extrapolated	0.075	0.15	Dansereau et al. 1999
Nickel	6.7	8.2	USEPA 2007b	1.7	3.4	USEPA 2007b
Vanadium	0.34	0.70	USEPA 2005d	4.2	8.3	USEPA 2005d

Footnotes:
[1] See Appendix C for details on development of specific TRVs.

Acronyms and Abbreviations:
COPC = contaminant of potential concern
LOAEL = lowest observed adverse effect level
mg/kg bw/d = milligrams per kilogram of body weight per day
NA = not applicable
NOAEL = no observed adverse effect level
OU = Operable Unit
tPCB = total polychlorinated biphenyl
TRV = toxicity reference value

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Table 6-1
Avian Site-Specific Risk-Based Concentration Calculations

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

		Percent Diet (%)							Bioaccumulation Factors (dw tissue/dw sediment)						Body Weight (kg)	Normalized Ingestion Rate (kg dw/kg bw/d)	TRV (mg/kg d)		SSRBC (mg/kg sediment)	
Aquatic Receptors	Constituent	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Amphibians	Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Amphibians	BW	IR	NOAEL TRV	LOAEL TRV	NOAEL SSRBC	LOAEL SSRBC
Mallard	tPCB (mid-range sensitivity)	80%	0%	10%	0%	10%	0%	6%	0.42	3.80	0.92	0.75	6.50	3.40	1.17	0.09	0.47	1.4	5	14
	tPCB (high sensitivity)	80%	0%	10%	0%	10%	0%	6%	0.42	3.80	0.92	0.75	6.50	3.40	1.17	0.09	0.043	0.13	0.4	1.3
	Barium	80%	0%	10%	0%	10%	0%	6%	1.59	0.16	0.86	3.26	0.72	0.20	1.17	0.09	21	42	160	322
	Chromium	80%	0%	10%	0%	10%	0%	6%	0.20	0.57	0.23	0.14	0.73	0.13	1.17	0.09	2.7	2.8	97	102
	Cobalt	80%	0%	10%	0%	10%	0%	6%	0.66	0.44	0.69	0.72	0.72	0.46	1.17	0.09	7.6	7.8	120	123
	Lead	80%	0%	10%	0%	10%	0%	6%	0.40	0.05	0.44	0.22	0.37	0.06	1.17	0.09	1.6	3.3	41	82
	Manganese	80%	0%	10%	0%	10%	0%	6%	4.43	0.16	6.48	2.48	1.01	0.14	1.17	0.09	179	348	473	919
	Mercury	80%	0%	10%	0%	10%	0%	6%	0.11	0.25	0.39	0.27	0.47	0.75	1.17	0.09	0.023	0.068	1	3.3
	Nickel	80%	0%	10%	0%	10%	0%	6%	0.20	0.88	0.39	0.59	0.59	1.16	1.17	0.09	6.7	8.2	243	295
	Vanadium	80%	0%	10%	0%	10%	0%	6%	0.25	0.07	0.22	0.17	0.26	0.13	1.17	0.09	0.34	0.70	13	26
Tree Swallow	tPCB (mid-range sensitivity)	0%	100%	0%	0%	0%	0%	0%	0.42	3.80	0.92	0.75	6.50	3.40	0.02	0.24	0.47	1.4	0.51	1.5
	tPCB (high sensitivity)	0%	100%	0%	0%	0%	0%	0%	0.42	3.80	0.92	0.75	6.50	3.40	0.02	0.24	0.043	0.13	0.048	0.14
	Barium	0%	100%	0%	0%	0%	0%	0%	1.59	0.16	0.86	3.26	0.72	0.20	0.02	0.24	21	42	542	1086
	Chromium	0%	100%	0%	0%	0%	0%	0%	0.20	0.57	0.23	0.14	0.73	0.13	0.02	0.24	2.7	2.8	19	20
	Cobalt	0%	100%	0%	0%	0%	0%	0%	0.66	0.44	0.69	0.72	0.72	0.46	0.02	0.24	7.6	7.8	72	74
	Lead	0%	100%	0%	0%	0%	0%	0%	0.40	0.05	0.44	0.22	0.37	0.06	0.02	0.24	1.63	3.3	136	272
	Manganese	0%	100%	0%	0%	0%	0%	0%	4.43	0.16	6.48	2.48	1.01	0.14	0.02	0.24	179	348	4661	9063
	Mercury	0%	100%	0%	0%	0%	0%	0%	0.11	0.25	0.39	0.27	0.47	0.75	0.02	0.24	0.023	0.068	0.4	1
	Nickel	0%	100%	0%	0%	0%	0%	0%	0.20	0.88	0.39	0.59	0.59	1.16	0.02	0.24	6.7	8.2	32	39
	Vanadium	0%	100%	0%	0%	0%	0%	0%	0.25	0.07	0.22	0.17	0.26	0.13	0.02	0.24	0.34	0.70	20	42

Table 6-1
Avian Site-Specific Risk-Based Concentration Calculations

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

		Percent Diet (%)							Bioaccumulation Factors (dw tissue/dw sediment)						Body Weight (kg)	Normalized Ingestion Rate (kg dw/kg bw/d)	TRV (mg/kg d)		SSRBC (mg/kg sediment)	
Aquatic Receptors	Constituent	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Amphibians	Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Amphibians	BW	IR	NOAEL TRV	LOAEL TRV	NOAEL SSRBC	LOAEL SSRBC
Spotted Sandpiper	tPCB (mid-range sensitivity)	0%	50%	50%	0%	0%	0%	18%	0.42	3.80	0.92	0.75	6.50	3.40	0.04	0.18	0.47	1.4	1.0	3.1
	tPCB (high sensitivity)	0%	50%	50%	0%	0%	0%	18%	0.42	3.80	0.92	0.75	6.50	3.40	0.04	0.18	0.043	0.13	0.1	0.3
	Barium	0%	50%	50%	0%	0%	0%	18%	1.59	0.16	0.86	3.26	0.72	0.20	0.04	0.18	21	42	169	340
	Chromium	0%	50%	50%	0%	0%	0%	18%	0.20	0.57	0.23	0.14	0.73	0.13	0.04	0.18	2.7	2.8	26	27
	Cobalt	0%	50%	50%	0%	0%	0%	18%	0.66	0.44	0.69	0.72	0.72	0.46	0.04	0.18	7.6	7.8	57	59
	Lead	0%	50%	50%	0%	0%	0%	18%	0.40	0.05	0.44	0.22	0.37	0.06	0.04	0.18	1.63	3.3	22	43
	Manganese	0%	50%	50%	0%	0%	0%	18%	4.43	0.16	6.48	2.48	1.01	0.14	0.04	0.18	179	348	287	559
	Mercury	0%	50%	50%	0%	0%	0%	18%	0.11	0.25	0.39	0.27	0.47	0.75	0.04	0.18	0.023	0.068	0.3	0.8
	Nickel	0%	50%	50%	0%	0%	0%	18%	0.20	0.88	0.39	0.59	0.59	1.16	0.04	0.18	6.7	8.2	46	56
	Vanadium	0%	50%	50%	0%	0%	0%	18%	0.25	0.07	0.22	0.17	0.26	0.13	0.04	0.18	0.34	0.70	6	12
Pied-Billed Grebe	tPCB (mid-range sensitivity)	10%	5%	53%	20%	2%	10%	6%	0.42	3.80	0.92	0.75	6.50	3.40	0.42	0.07	0.47	1.4	5	14
	tPCB (high sensitivity)	10%	5%	53%	20%	2%	10%	6%	0.42	3.80	0.92	0.75	6.50	3.40	0.42	0.07	0.043	0.13	0.4	1
	Barium	10%	5%	53%	20%	2%	10%	6%	1.59	0.16	0.86	3.26	0.72	0.20	0.42	0.07	21	42	214	429
	Chromium	10%	5%	53%	20%	2%	10%	6%	0.20	0.57	0.23	0.14	0.73	0.13	0.42	0.07	2.7	2.8	131	138
	Cobalt	10%	5%	53%	20%	2%	10%	6%	0.66	0.44	0.69	0.72	0.72	0.46	0.42	0.07	7.6	7.8	149	153
	Lead	10%	5%	53%	20%	2%	10%	6%	0.40	0.05	0.44	0.22	0.37	0.06	0.42	0.07	1.63	3.3	58	117
	Manganese	10%	5%	53%	20%	2%	10%	6%	4.43	0.16	6.48	2.48	1.01	0.14	0.42	0.07	179	348	563	1095
	Mercury	10%	5%	53%	20%	2%	10%	6%	0.11	0.25	0.39	0.27	0.47	0.75	0.42	0.07	0.023	0.068	0.7	2
	Nickel	10%	5%	53%	20%	2%	10%	6%	0.20	0.88	0.39	0.59	0.59	1.16	0.42	0.07	6.7	8.2	164	199
	Vanadium	10%	5%	53%	20%	2%	10%	6%	0.25	0.07	0.22	0.17	0.26	0.13	0.42	0.07	0.34	0.70	19	38

Acronyms and Abbreviations:

ADD_{pot} = potential average daily dose
BW = body weight
dw = dry weight
IR = ingestion rate
kg = kilogram
kg dw/kg bw/d = kilogram dry weight per kilogram body weight per day
LOAEL = lowest observed adverse effect level
mg/kg = milligram per kilogram
mg/kg d = milligram per kilogram per day
NOAEL = no observed adverse effect level
OU = Operable Unit
SSRBC = site-specific risk-based concentration
tPCB = total polychlorinated biphenyl
TRV = toxicity reference value

Table 6-2
Mammalian Site-Specific Risk-Based Concentration Calculations

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

		Percent Diet (%)								Bioaccumulation Factors (dw tissue/dw sediment)							Body Weight (kg)	Normalized Ingestion Rate (kg dw/kg bw/d)	TRV (mg/kg d)		SSRBC (mg/kg sediment)	
Aquatic Receptors	Constituent	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frogs	Snakes	Sediment	Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frogs	Snakes	BW	IR	NOAEL TRV	LOAEL TRV	NOAEL SSRBC	LOAEL SSRBC
Muskrat	tPCB	90%	0%	5%	0%	5%	0%	0%	9%	0.42	3.80	0.92	0.75	6.50	3.40	26.91	1.10	0.07	0.23	0.68	4	12
	Barium	90%	0%	5%	0%	5%	0%	0%	9%	1.59	0.16	0.86	3.26	0.72	0.20	0.92	1.10	0.07	52	121	474	1106
	Chromium	90%	0%	5%	0%	5%	0%	0%	9%	0.20	0.57	0.23	0.14	0.73	0.13	0.95	1.10	0.07	2.4	2.8	109	128
	Cobalt	90%	0%	5%	0%	5%	0%	0%	9%	0.66	0.44	0.69	0.72	0.72	0.46	0.26	1.10	0.07	7.3	10	142	193
	Lead	90%	0%	5%	0%	5%	0%	0%	9%	0.40	0.05	0.44	0.22	0.37	0.06	0.37	1.10	0.07	4.7	8.9	140	265
	Manganese	90%	0%	5%	0%	5%	0%	0%	9%	4.43	0.16	6.48	2.48	1.01	0.14	1.37	1.10	0.07	52	65	169	214
	Mercury	90%	0%	5%	0%	5%	0%	0%	9%	0.11	0.25	0.39	0.27	0.47	0.75	1.11	1.10	0.07	0.075	0.15	5	9
	Nickel	90%	0%	5%	0%	5%	0%	0%	9%	0.20	0.88	0.39	0.59	0.59	1.16	1.16	1.10	0.07	1.7	3.4	77	154
	Vanadium	90%	0%	5%	0%	5%	0%	0%	9%	0.25	0.07	0.22	0.17	0.26	0.13	0.13	1.10	0.07	4.2	8.3	178	355
Little Brown Bat	tPCB	0%	100%	0%	0%	0%	0%	0%	0%	0.42	3.80	0.92	0.75	6.50	3.40	26.91	0.01	0.18	0.23	0.68	0	1
	Barium	0%	100%	0%	0%	0%	0%	0%	0%	1.59	0.16	0.86	3.26	0.72	0.20	0.92	0.01	0.18	52	121	1819	4249
	Chromium	0%	100%	0%	0%	0%	0%	0%	0%	0.20	0.57	0.23	0.14	0.73	0.13	0.95	0.01	0.18	2.4	2.8	24	28
	Cobalt	0%	100%	0%	0%	0%	0%	0%	0%	0.66	0.44	0.69	0.72	0.72	0.46	0.26	0.01	0.18	7.3	10	94	128
	Lead	0%	100%	0%	0%	0%	0%	0%	0%	0.40	0.05	0.44	0.22	0.37	0.06	0.37	0.01	0.18	4.7	8.9	528	1000
	Manganese	0%	100%	0%	0%	0%	0%	0%	0%	4.43	0.16	6.48	2.48	1.01	0.14	1.37	0.01	0.18	52	65	1808	2282
	Mercury	0%	100%	0%	0%	0%	0%	0%	0%	0.11	0.25	0.39	0.27	0.47	0.75	1.11	0.01	0.18	0.075	0.15	2	3
	Nickel	0%	100%	0%	0%	0%	0%	0%	0%	0.20	0.88	0.39	0.59	0.59	1.16	1.16	0.01	0.18	1.7	3.4	11	22
	Vanadium	0%	100%	0%	0%	0%	0%	0%	0%	0.25	0.07	0.22	0.17	0.26	0.13	0.13	0.01	0.18	4.2	8.3	334	667
Raccoon	tPCB	44%	0%	13%	15%	13%	10%	5%	9%	0.42	3.80	0.92	0.75	6.50	3.40	26.91	5.60	0.03	0.23	0.68	3	8
	Barium	44%	0%	13%	15%	13%	10%	5%	9%	1.59	0.16	0.86	3.26	0.72	0.20	0.92	5.60	0.03	52	121	1235	2884
	Chromium	44%	0%	13%	15%	13%	10%	5%	9%	0.20	0.57	0.23	0.14	0.73	0.13	0.95	5.60	0.03	2.4	2.8	229	269
	Cobalt	44%	0%	13%	15%	13%	10%	5%	9%	0.66	0.44	0.69	0.72	0.72	0.46	0.26	5.60	0.03	7.3	10	370	504
	Lead	44%	0%	13%	15%	13%	10%	5%	9%	0.40	0.05	0.44	0.22	0.37	0.06	0.37	5.60	0.03	4.7	8.9	403	763
	Manganese	44%	0%	13%	15%	13%	10%	5%	9%	4.43	0.16	6.48	2.48	1.01	0.14	1.37	5.60	0.03	52	65	549	693
	Mercury	44%	0%	13%	15%	13%	10%	5%	9%	0.11	0.25	0.39	0.27	0.47	0.75	1.11	5.60	0.03	0.075	0.15	7	13
	Nickel	44%	0%	13%	15%	13%	10%	5%	9%	0.20	0.88	0.39	0.59	0.59	1.16	1.16	5.60	0.03	1.70	3.4	110	220
	Vanadium	44%	0%	13%	15%	13%	10%	5%	9%	0.25	0.07	0.22	0.17	0.26	0.13	0.13	5.60	0.03	4.2	8.3	495	988

Acronyms and Abbreviations:

ADD_{pot} = potential average daily dose
BW = body weight
dw = dry weight
IR = ingestion rate
kg = kilogram
kg dw/kg bw/d = kilogram dry weight per kilogram body weight per day
LOAEL = lowest observed adverse effect level
mg/kg = milligram per kilogram
mg/kg d = milligram per kilogram per day
NOAEL = no observed adverse effect level
OU = Operable Unit
SSRBC = site-specific risk-based concentration
tPCB = total polychlorinated biphenyl
TRV = toxicity reference value

Table 6-3
Summary of Benthic Invertebrate Benchmarks/Toxicity Values and Avian and Mammalian Site-Specific Risk-Based Concentrations[1]

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Low Benchmarks/ Toxicity Values[2]	NOAEL Site-Specific Risk-Based Concentrations						
	Benthic Invertebrates	Mallard	Tree Swallow	Spotted Sandpiper	Pied-Billed Grebe	Muskrat	Little Brown Bat	Raccoon
tPCB (mid-range sensitivity)	1	5	1	1	5	4	0.3	3
tPCB (high sensitivity)	nc	0.4	0.05	0.1	0.4	na	na	na
Barium	nc	160	542	169	214	474	1819	1235
Chromium	43	97	19	26	131	109	24	229
Cobalt	50	120	72	57	149	142	94	370
Lead	36	41	136	22	58	140	528	403
Manganese	nc	473	4661	287	563	169	1808	549
Mercury	0.2	1	0.3	0.3	0.7	5	2	7
Nickel	23	243	32	46	164	77	11	110
Vanadium	nc	13	20	5.9	19	178	334	495
	High Benchmarks/ Toxicity Values[2]	LOAEL Site-Specific Risk-Based Concentrations						
tPCB (mid-range sensitivity)	4	14	2	3	14	12	1	8
tPCB (high sensitivity)	nc	1	0.1	0.3	1	na	na	na
Barium	nc	322	1086	340	429	1106	4249	2884
Chromium	111	102	20	27	138	128	28	269
Cobalt	nc	123	74	59	153	193	128	504
Lead	128	82	272	43	117	265	1000	763
Manganese	nc	919	9063	559	1095	214	2282	693
Mercury	1	3	1	0.8	2	9	3	13
Nickel	49	295	39	56	199	154	22	220
Vanadium	nc	26	42	12	38	355	667	988

Footnotes:

[1]All Values are mg/kg sediment

[2]Benthic Invertebrate values for tPCBs represent EC0 and EC20 values for most sensitive species and endpoint from site-specific toxicity testing

Acronyms and Abbreviations:

LOAEL = lowest observed adverse effect level
mg/kg = milligram per kilogram
na = not applicable
nc = no criteria available
NOAEL = no observed adverse effect level
OU = Operable Unit
tPCB = total polychlorinated biphenyl

Table 6-4
Summary of Benchmark/Toxicity Value and SSRBC Exceedances

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Low Benchmark/ Toxicity Value Comparisions	NOAEL SSRBC Comparisons (percent of samples exceeding SSRBC)						
	Benthic Invertebrate	Mallard	Tree Swallow	Spotted Sandpiper	Pied-Billed Grebe	Muskrat	Little Brown Bat	Raccoon
tPCB (mid-range sensitivity)	74%	44%	100%	88%	44%	49%	100%	58%
tPCB (high sensitivity)	na	100%	100%	100%	100%	na	na	na
Barium	nc	33%	8%	33%	17%	8%	0%	0%
Chromium	58%	33%	100%	100%	33%	33%	100%	17%
Cobalt	8%	0%	8%	8%	0%	0%	0%	0%
Lead	67%	67%	8%	92%	42%	8%	0%	8%
Manganese	nc	92%	0%	100%	83%	100%	33%	83%
Mercury	67%	8%	25%	42%	17%	0%	8%	0%
Nickel	33%	0%	25%	25%	0%	17%	100%	0%
Vanadium	nc	83%	50%	92%	67%	0%	0%	0%
	High Benchmark/ Toxicity Value Comparisions	LOAEL SSRBC Comparisons (percent of samples exceeding SSRBC)						
tPCB (mid-range sensitivity)	47%	19%	72%	58%	19%	23%	88%	35%
tPCB (high sensitivity)	na	79%	100%	100%	79%	na	na	na
Barium	nc	8%	0%	8%	8%	0%	0%	0%
Chromium	33%	33%	100%	100%	33%	33%	100%	17%
Cobalt	nc	0%	8%	8%	0%	0%	0%	0%
Lead	8%	17%	8%	67%	17%	8%	0%	0%
Manganese	nc	50%	0%	83%	50%	100%	17%	75%
Mercury	8%	0%	8%	17%	0%	0%	0%	0%
Nickel	25%	0%	25%	17%	0%	0%	42%	0%
Vanadium	nc	25%	25%	83%	25%	0%	0%	0%

Acronyms and Abbreviations:
LOAEL = lowest observed adverse effect level
na = not applicable
nc = no criteria available
NOAEL = no observed adverse effect level
OU = Operable Unit
SSRBC = Site-specific risk-based concentration
tPCB = total polychlorinated biphenyl

95% upper confidence limit (UCL) concentration exceeds SSRBC

Table 6-5
Summary of Avian and Mammalian Site-Specific Risk-Based Concentrations and Percent Sample Exceedances
Laboratory Bioaccumulation Scenario

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Mallard	Spotted Sandpiper	Pied-Billed Grebe	Muskrat	Raccoon
NOAEL Site-Specific Risk-Based Concentrations (mg/kg)					
tPCB (mid-range sensitivity)	2 (67%)	0.2 (100%)	0.5 (100%)	2 (72%)	1 (88%)
tPCB (high sensitivity)	0.2 (100%)	0.02 (100%)	0.05 (100%)	na	na
LOAEL Site-Specific Risk-Based Concentrations (mg/kg)					
tPCB (mid-range sensitivity)	5 (44%)	0.6 (100%)	2 (72%)	5 (44%)	3 (58%)
tPCB (high sensitivity)	0.5 (100%)	0.05 (100%)	0.1 (100%)	na	na

Acronyms and Abbreviations:

LOAEL = lowest observed adverse effect level
mg/kg = milligram per kilogram
na = no criteria available
NOAEL = no observed adverse effect level
OU = Operable Unit
tPCB = total polychlorinated biphenyl

Table 6-6
Mallard and Muskrat Alternative Site-Specific Risk-Based Concentrations
Omnivorous Dietary Composition

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Constituent	Mallard		Muskrat	
	Herbivore	Omnivore	Herbivore	Omnivore
NOAEL Site-Specific Risk-Based Concentrations (mg/kg)				
tPCB (mid-range sensitivity)	5	3	4	2
tPCB (high sensitivity)	0.4	0.2	na	na
Barium	160	182	474	515
Chromium	97	64	109	88
Cobalt	120	127	142	140
Lead	41	56	140	141
Manganese	473	922	169	192
Mercury	1	0.8	5	3.8
Nickel	243	130	77	65
Vanadium	13	16	178	177
LOAEL Site-Specific Risk-Based Concentrations (mg/kg)				
tPCB (mid-range sensitivity)	14	8	12	6
tPCB (high sensitivity)	1	0.7	na	na
Barium	322	366	1106	1204
Chromium	102	67	128	103
Cobalt	123	131	193	191
Lead	82	112	265	267
Manganese	919	1792	214	242
Mercury	3	2.4	9	8
Nickel	295	158	154	131
Vanadium	26	32	355	354

Acronyms and Abbreviations:

LOAEL = lowest observed adverse effect level
mg/kg = milligram per kilogram
na = no criteria available
NOAEL = no observed adverse effect level
OU = Operable Unit
tPCB = total polychlorinated biphenyl

ARCADIS

Figures

CITY: SYR DIV/GROUP: 40 DB: KES EAL KES LD: PIC: PM: TM: TR:
Anniston (B0010291.2010.00005)
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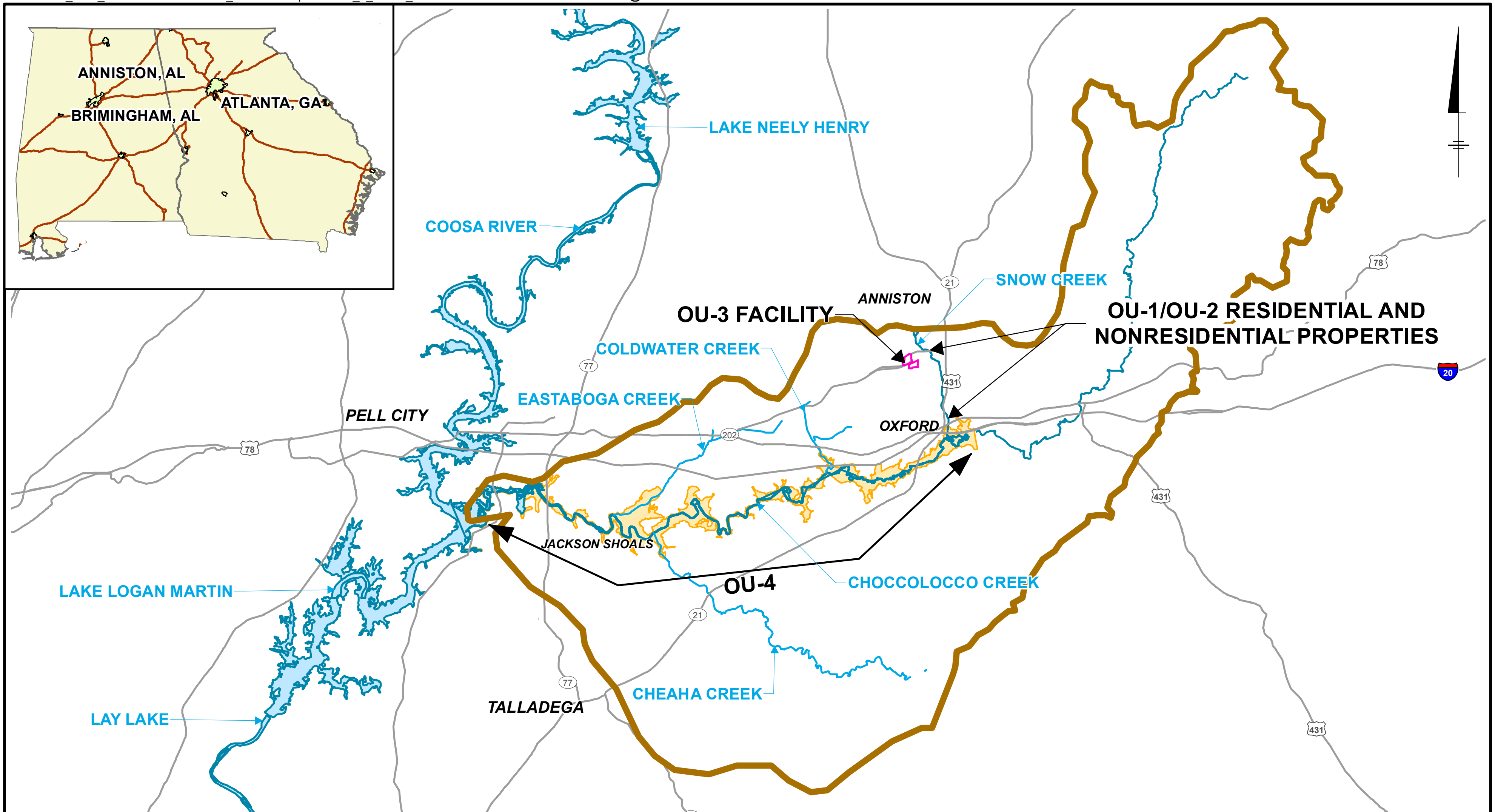

LEGEND:

APPROXIMATE CHOCCOLOCCO CREEK WATERSHED BOUNDARY AS DELINEATED IN BASINS 2.0

100-YEAR FLOODPLAIN

0 6 12 Miles

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

ANNISTON PCB SITE OPERABLE UNITS

Solutia

FIGURE
1-1

CITY: SYR DIV/GROUP: 40 DB: KES EAL KES LD: PIC: PM: TM: TR:
Anniston (B0010291.2010.00005)
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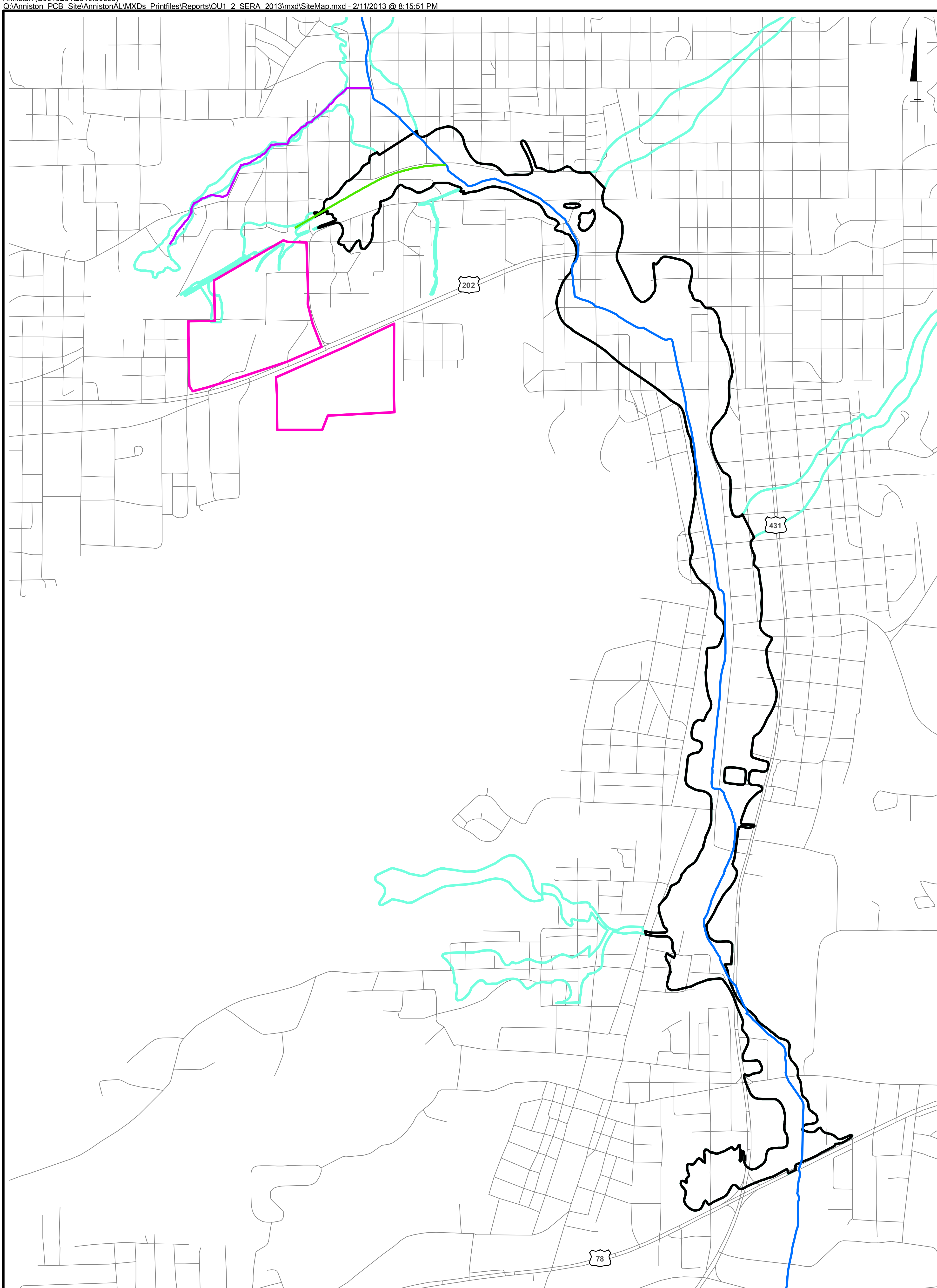

LEGEND:

- SNOW CREEK
- 11th STREET DITCH
- WEST 9th STREET DITCH
- OU-1/OU-2
- OU-3
- 100-YR FLOODPLAIN AND DRAINAGE AREAS

0 1,600 3,200 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

SITE MAP FOR THE OU-1/OU-2 PORTION OF SNOW CREEK

Solutia

FIGURE
1-2

City: SYR Div/Group: SWG Created By: Last Saved By: kives
Anniston (B0010291.2010.00005)
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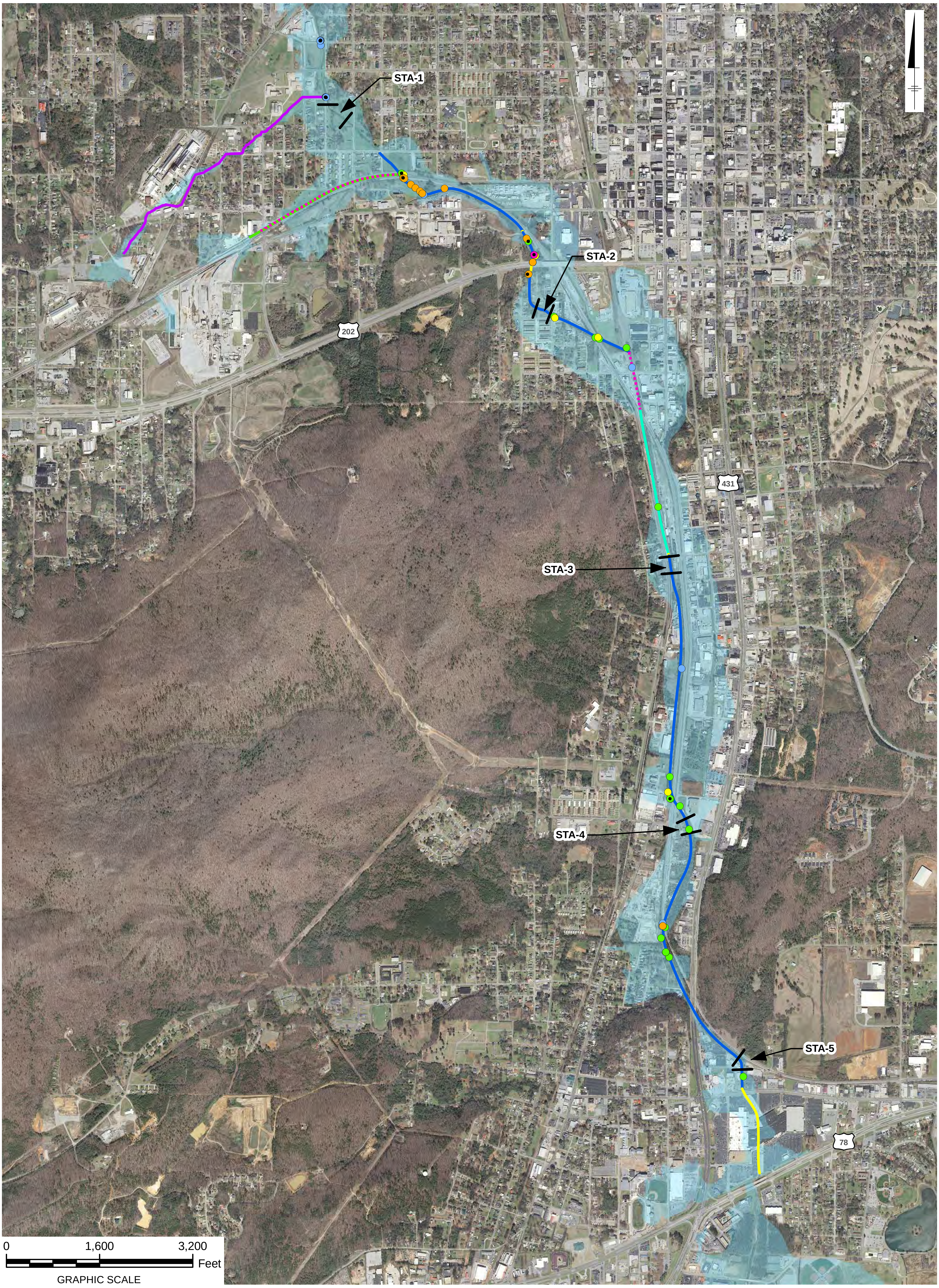


0 1,600 3,200
Feet
GRAPHIC SCALE

LEGEND:

- • SEDIMENT SAMPLE ANALYZED FOR METALS

SEDIMENT SAMPLE LOCATION
MAX PCB RESULT (mg/kg)

- < 1.0
- 1.0 - 5.0
- 5.0 - 10
- 10 - 50
- > 50

- SNOW CREEK BIOLOGICAL SURVEY STATION BOUNDARY
- APPROXIMATE EXTENT OF CONCRETE LINED CHANNEL
- CULVERT
- NATURAL
- NATURAL BOTTOM EAST WALL CONCRETE
- 11th STREET DITCH
- WEST 9th STREET DITCH
- OU-1/OU-2 100-YR FLOODPLAIN

STA-5 BIOLOGICAL SAMPLING STATION LOCATIONS

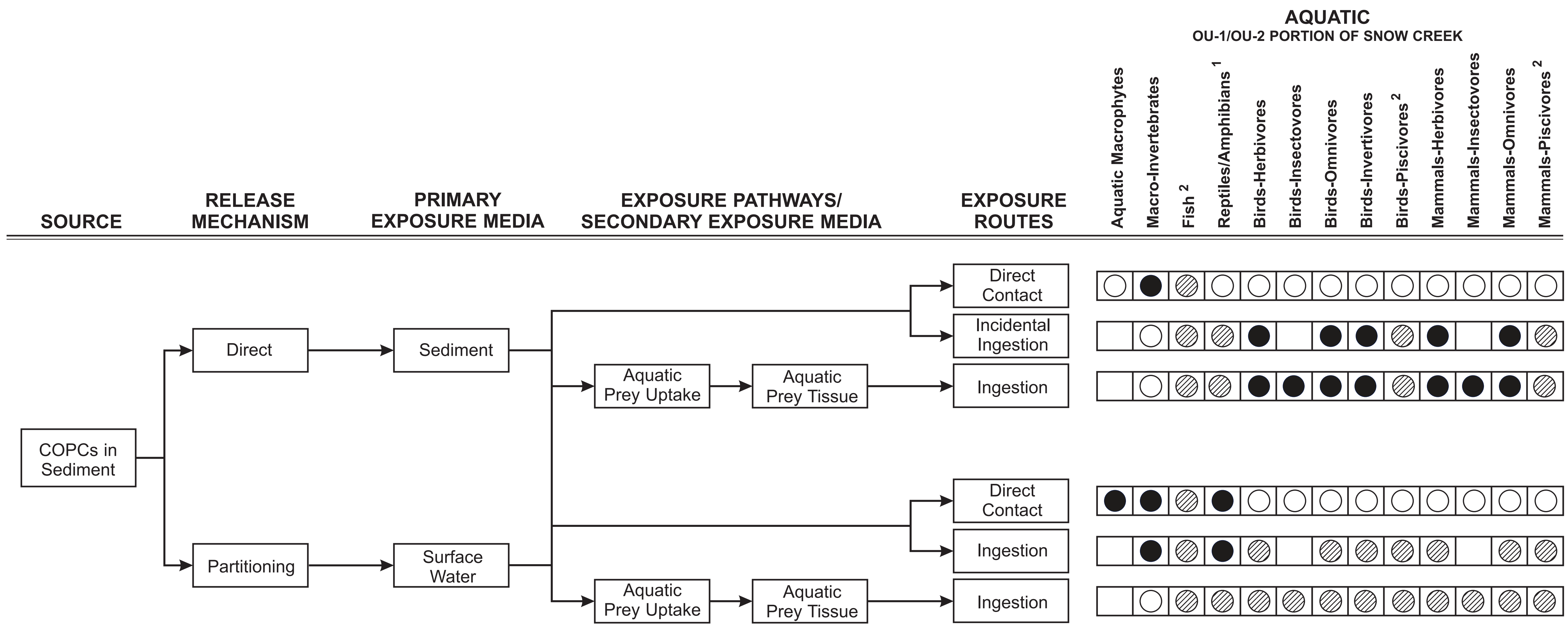
ANNISTON PCB SITE
ANNISTON, AL

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

BIOLOGICAL SURVEY SITE LOCATIONS AND PCB SAMPLE LOCATIONS FOR OU-1/OU-2 SEDIMENT

Solutia

FIGURE
2-1



● = High potential for complete exposure pathway. Primary Pathway quantitatively evaluated.

◌ = Exposure pathway considered *de minimus*. Not quantitatively evaluated.

▨ = Secondary pathway complete but expected to be minimal relative to the identified Primary complete pathways. Not quantitatively evaluated.

☐ = Incomplete exposure pathway.

1 = Pathway may be complete but insufficient toxicity data available. Not quantitatively evaluated.

2 = Pathway considered secondary because minimal fish community present.

ANNISTON PCB SITE
ANNISTON, ALABAMA

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR THE OU-1/OU-2 PORTION OF SNOW CREEK

AQUATIC CONCEPTUAL SITE MODEL

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FIGURE **2-2**

12/04/2013 SYRACUSE, NY-ENV/CAD-DHOWES
B0010294/2012/00005/CDR/10291G02.CDR

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Anniston (B0010291.2010.00005)
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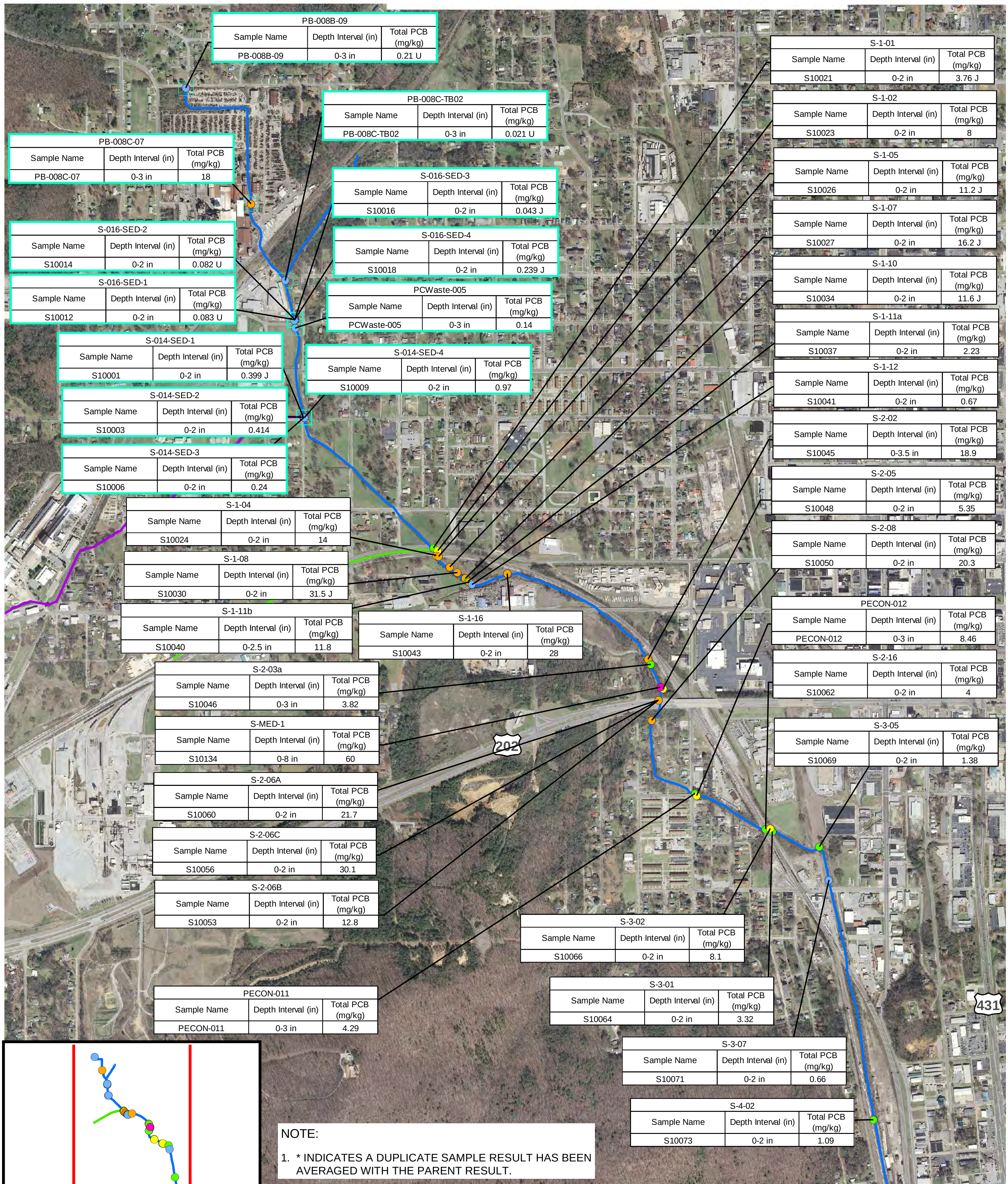
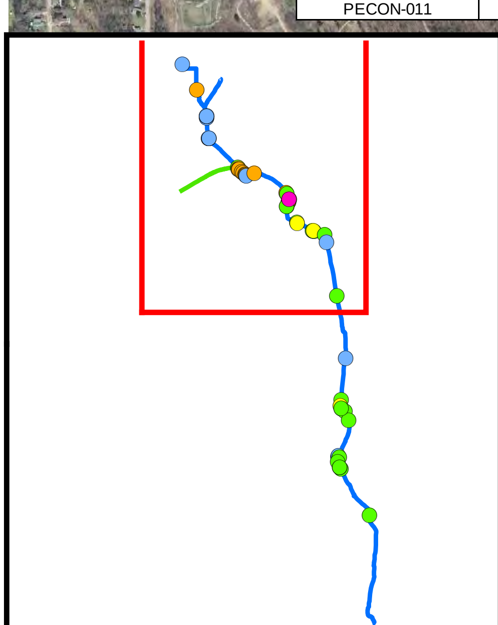




NOTE:

1. * INDICATES A DUPLICATE SAMPLE RESULT HAS BEEN AVERAGED WITH THE PARENT RESULT.

LEGEND:

SEDIMENT SAMPLE LOCATION
MAX PCB RESULT (mg/kg)
- < 1.0
- 1.0 - 5.0
- 5.0 - 10
- 10 - 50
- > 50

- UPSTREAM SEDIMENT SAMPLE LOCATION
- SNOW CREEK
- 11th STREET DITCH
- WEST 9th STREET DITCH

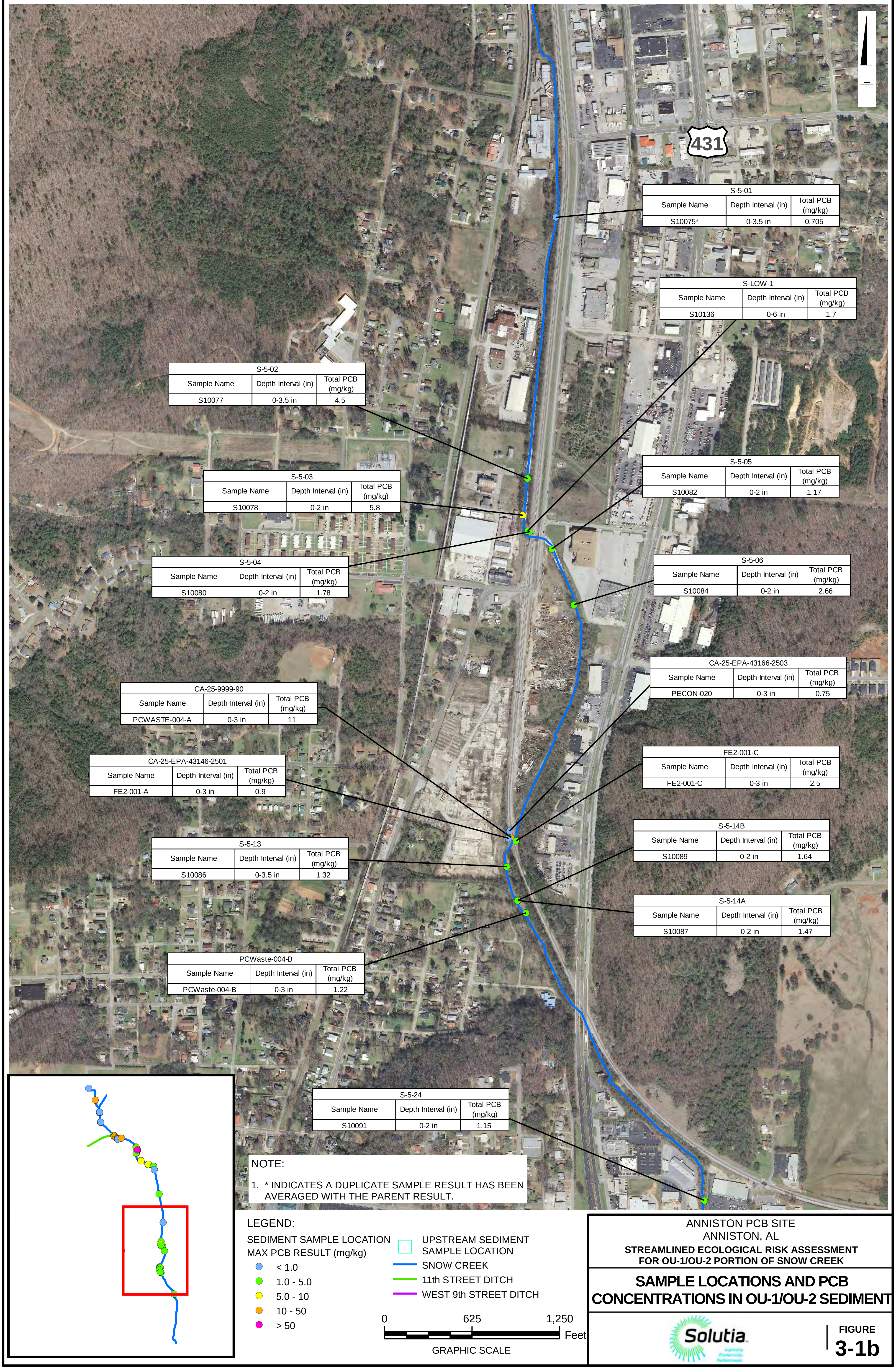
0 1,000 2,000 Feet
GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, AL
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

SAMPLE LOCATIONS AND PCB CONCENTRATIONS IN OU-1/OU-2 SEDIMENT

Solutia

FIGURE
3-1a



NOTE:

1. * INDICATES A DUPLICATE SAMPLE RESULT HAS BEEN AVERAGED WITH THE PARENT RESULT.

LEGEND:

SEDIMENT SAMPLE LOCATION
MAX PCB RESULT (mg/kg)
- < 1.0
- 1.0 - 5.0
- 5.0 - 10
- 10 - 50
- > 50

UPSTREAM SEDIMENT SAMPLE LOCATION
SNOW CREEK
11th STREET DITCH
WEST 9th STREET DITCH

0 625 1,250 Feet
GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, AL

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

SAMPLE LOCATIONS AND PCB CONCENTRATIONS IN OU-1/OU-2 SEDIMENT

Solutia

FIGURE
3-1b

City: SYR Div/Group: SWG Created By: Last Saved By: kives
Anniston (B0010291.2010.00005)
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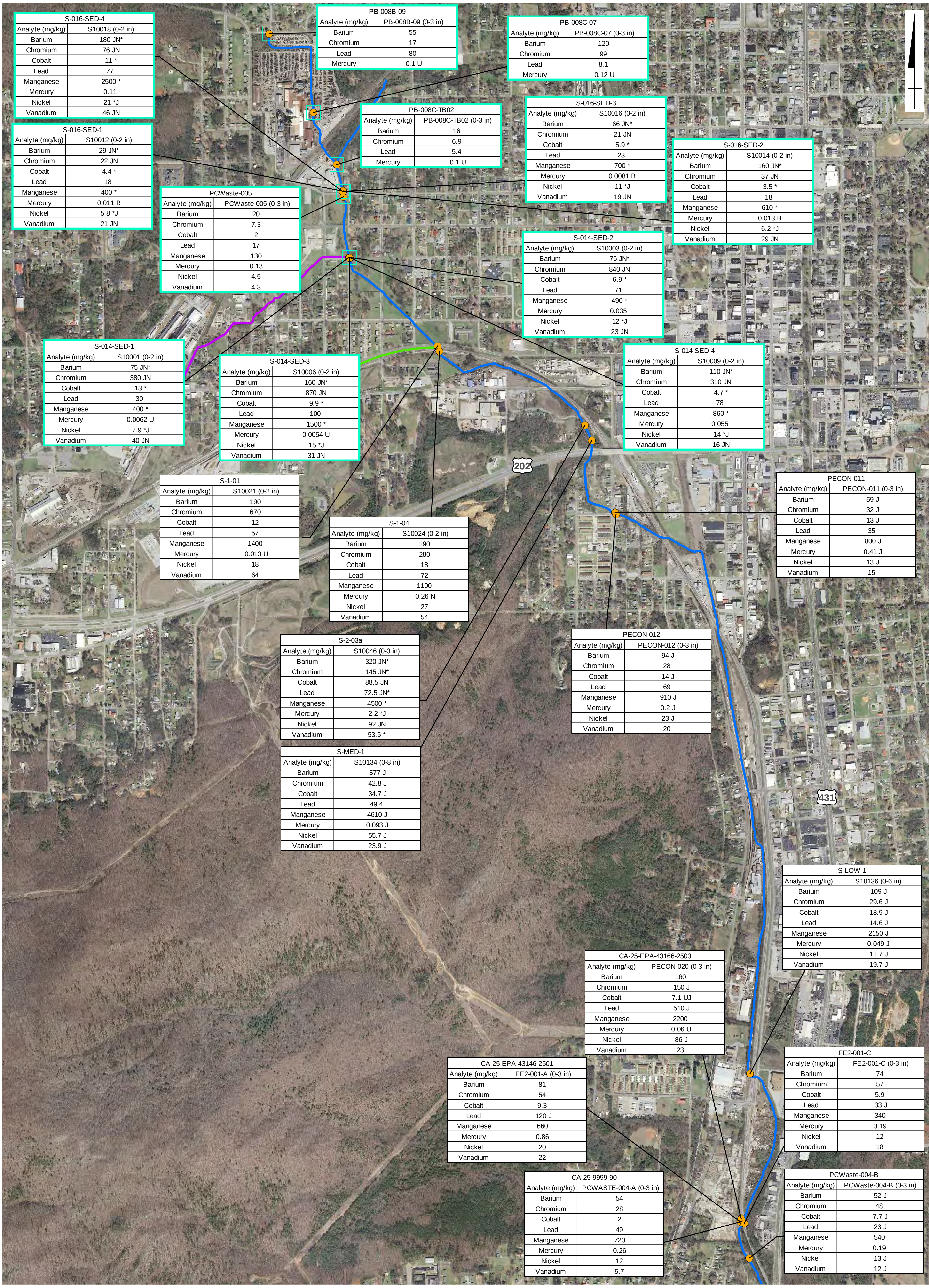


S-016-SED-4	
Analyte (mg/kg)	S10018 (0-2 in)
Barium	180 JN*
Chromium	76 JN
Cobalt	11 *
Lead	77
Manganese	2500 *
Mercury	0.11
Nickel	21 *J
Vanadium	46 JN

PB-008B-09	
Analyte (mg/kg)	PB-008B-09 (0-3 in)
Barium	55
Chromium	17
Lead	80
Mercury	0.1 U

PB-008C-07	
Analyte (mg/kg)	PB-008C-07 (0-3 in)
Barium	120
Chromium	99
Lead	8.1
Mercury	0.12 U

S-016-SED-1	
Analyte (mg/kg)	S10012 (0-2 in)
Barium	29 JN*
Chromium	22 JN
Cobalt	4.4 *
Lead	18
Manganese	400 *
Mercury	0.011 B
Nickel	5.8 *J
Vanadium	21 JN

PB-008C-TB02	
Analyte (mg/kg)	PB-008C-TB02 (0-3 in)
Barium	16
Chromium	6.9
Lead	5.4
Mercury	0.1 U

S-016-SED-3	
Analyte (mg/kg)	S10016 (0-2 in)
Barium	66 JN*
Chromium	21 JN
Cobalt	5.9 *
Lead	23
Manganese	700 *
Mercury	0.0081 B
Nickel	11 *J
Vanadium	19 JN

S-016-SED-2	
Analyte (mg/kg)	S10014 (0-2 in)
Barium	160 JN*
Chromium	37 JN
Cobalt	3.5 *
Lead	18
Manganese	610 *
Mercury	0.013 B
Nickel	6.2 *J
Vanadium	29 JN

PCWaste-005	
Analyte (mg/kg)	PCWaste-005 (0-3 in)
Barium	20
Chromium	7.3
Cobalt	2
Lead	17
Manganese	130
Mercury	0.13
Nickel	4.5
Vanadium	4.3

S-014-SED-2	
Analyte (mg/kg)	S10003 (0-2 in)
Barium	76 JN*
Chromium	840 JN
Cobalt	6.9 *
Lead	71
Manganese	490 *
Mercury	0.035
Nickel	12 *J
Vanadium	23 JN

S-014-SED-1	
Analyte (mg/kg)	S10001 (0-2 in)
Barium	75 JN*
Chromium	380 JN
Cobalt	13 *
Lead	30
Manganese	400 *
Mercury	0.0062 U
Nickel	7.9 *J
Vanadium	40 JN

S-014-SED-3	
Analyte (mg/kg)	S10006 (0-2 in)
Barium	160 JN*
Chromium	870 JN
Cobalt	9.9 *
Lead	100
Manganese	1500 *
Mercury	0.0054 U
Nickel	15 *J
Vanadium	31 JN

S-014-SED-4	
Analyte (mg/kg)	S10009 (0-2 in)
Barium	110 JN*
Chromium	310 JN
Cobalt	4.7 *
Lead	78
Manganese	860 *
Mercury	0.055
Nickel	14 *J
Vanadium	16 JN

PECON-011	
Analyte (mg/kg)	PECON-011 (0-3 in)
Barium	59 J
Chromium	32 J
Cobalt	13 J
Lead	35
Manganese	800 J
Mercury	0.41 J
Nickel	13 J
Vanadium	15

S-1-01	
Analyte (mg/kg)	S10021 (0-2 in)
Barium	190
Chromium	670
Cobalt	12
Lead	57
Manganese	1400
Mercury	0.013 U
Nickel	18
Vanadium	64

S-1-04	
Analyte (mg/kg)	S10024 (0-2 in)
Barium	190
Chromium	280
Cobalt	18
Lead	72
Manganese	1100
Mercury	0.26 N
Nickel	27
Vanadium	54

PECON-012	
Analyte (mg/kg)	PECON-012 (0-3 in)
Barium	94 J
Chromium	28
Cobalt	14 J
Lead	69
Manganese	910 J
Mercury	0.2 J
Nickel	23 J
Vanadium	20

S-2-03a	
Analyte (mg/kg)	S10046 (0-3 in)
Barium	320 JN*
Chromium	145 JN*
Cobalt	88.5 JN
Lead	72.5 JN*
Manganese	4500 *
Mercury	2.2 *J
Nickel	92 JN
Vanadium	53.5 *

S-MED-1	
Analyte (mg/kg)	S10134 (0-8 in)
Barium	577 J
Chromium	42.8 J
Cobalt	34.7 J
Lead	49.4
Manganese	4610 J
Mercury	0.093 J
Nickel	55.7 J
Vanadium	23.9 J

S-LOW-1	
Analyte (mg/kg)	S10136 (0-6 in)
Barium	109 J
Chromium	29.6 J
Cobalt	18.9 J
Lead	14.6 J
Manganese	2150 J
Mercury	0.049 J
Nickel	11.7 J
Vanadium	19.7 J

CA-25-EPA-43166-2503	
Analyte (mg/kg)	PECON-020 (0-3 in)
Barium	160
Chromium	150 J
Cobalt	7.1 UJ
Lead	510 J
Manganese	2200
Mercury	0.06 U
Nickel	86 J
Vanadium	23

CA-25-EPA-43146-2501	
Analyte (mg/kg)	FE2-001-A (0-3 in)
Barium	81
Chromium	54
Cobalt	9.3
Lead	120 J
Manganese	660
Mercury	0.86
Nickel	20
Vanadium	22

FE2-001-C	
Analyte (mg/kg)	FE2-001-C (0-3 in)
Barium	74
Chromium	57
Cobalt	5.9
Lead	33 J
Manganese	340
Mercury	0.19
Nickel	12
Vanadium	18

CA-25-9999-90	
Analyte (mg/kg)	PCWASTE-004-A (0-3 in)
Barium	54
Chromium	28
Cobalt	2
Lead	49
Manganese	720
Mercury	0.26
Nickel	12
Vanadium	5.7

PCWaste-004-B	
Analyte (mg/kg)	PCWaste-004-B (0-3 in)
Barium	52 J
Chromium	48
Cobalt	7.7 J
Lead	23 J
Manganese	540
Mercury	0.19
Nickel	13 J
Vanadium	12 J

LEGEND:
- SEDIMENT SAMPLE LOCATION
- UPSTREAM SEDIMENT SAMPLE LOCATION
- SNOW CREEK
- 11th STREET DITCH
- WEST 9th STREET DITCH

NOTE:

1. * INDICATES A DUPLICATE SAMPLE RESULT HAS BEEN AVERAGED WITH THE PARENT RESULT.

0 1,350 2,700 Feet

GRAPHIC SCALE

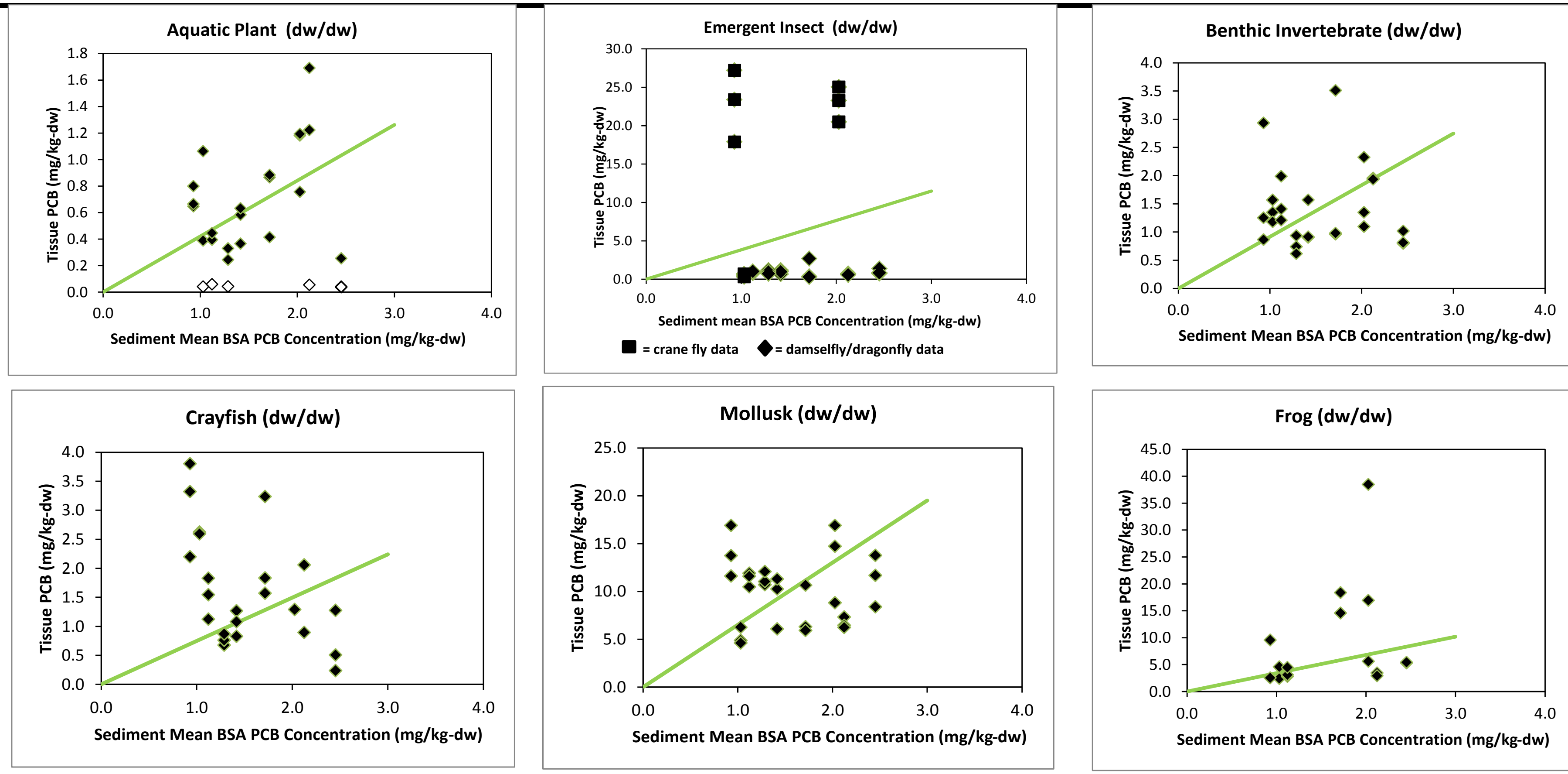
ANNISTON PCB SITE
ANNISTON, AL

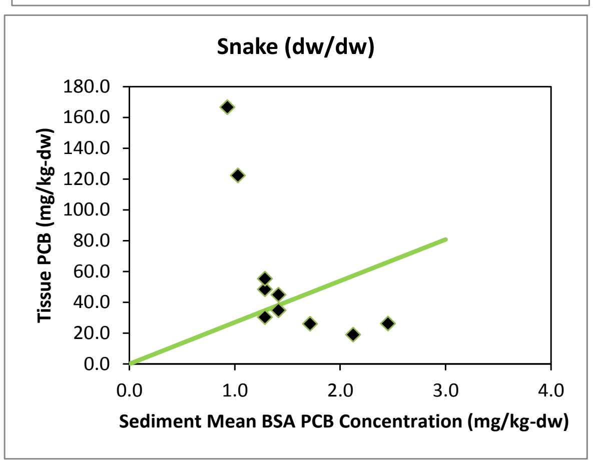
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK

SAMPLE LOCATIONS AND METAL CONCENTRATIONS IN OU-1/OU-2 SEDIMENT

Solutia

FIGURE 3-2





represents the selected median BAF

non-detected tissue concentration (1/2 reporting limit)

detected tissue concentration

ANNISTON PCB SITE

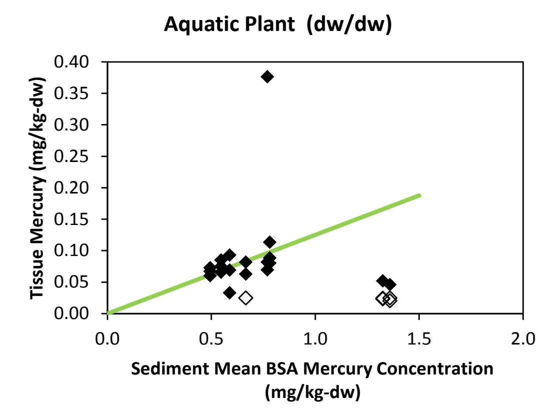
ANNISTON , ALABAMA

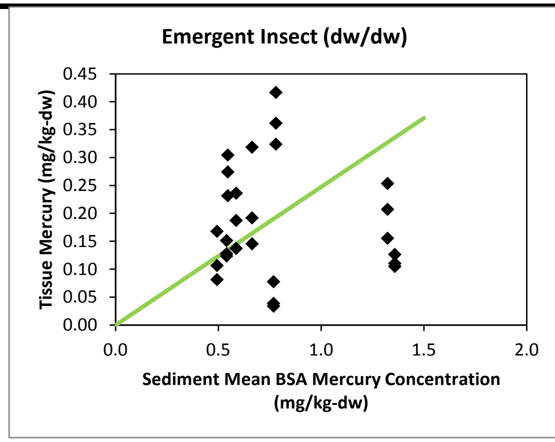
BASELINE ECOLOGICAL RISK ASSESSMENT FOR OU-4 APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

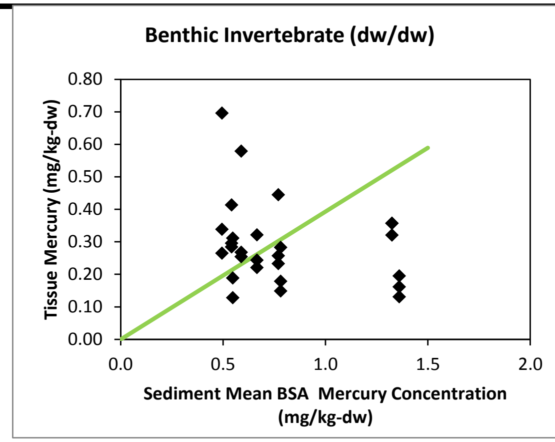
SUMMARY OF OU-4 AQUATIC TISSUE DATA AND SELECTED BIOACCUMULATION FACTORS FOR PCBs

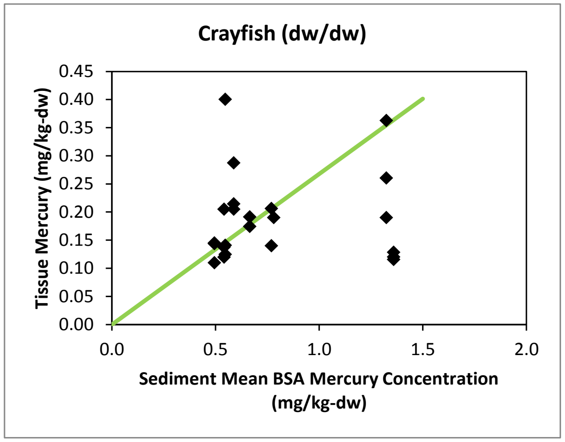
Solutia

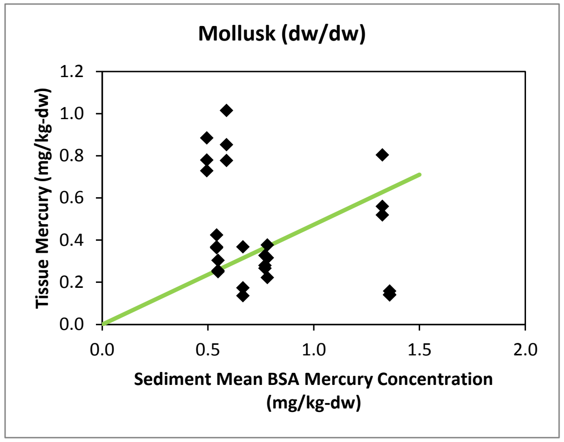
FIGURE 4-1

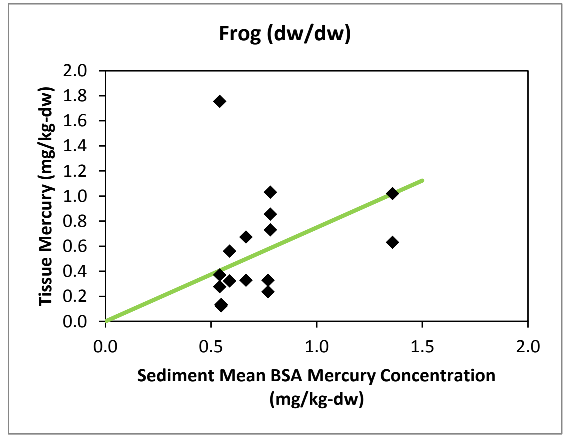


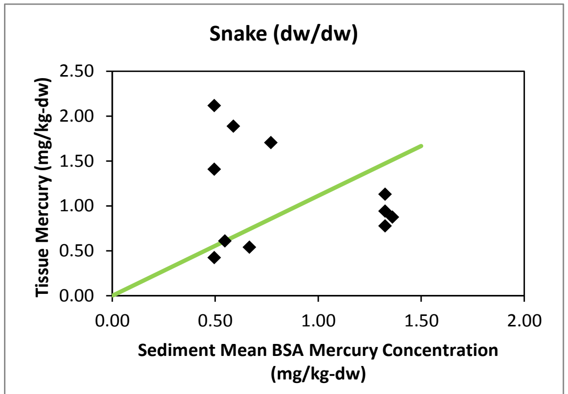












represents the selected median BAF

non-detected tissue concentration (1/2 reporting limit)

detected tissue concentration

ANNISTON PCB SITE

ANNISTON , ALABAMA

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

SUMMARY OF OU-4 TISSUE DATA AND SELECTED BIOACCUMULATION FACTORS FOR MERCURY

Solutia

FIGURE 4-2

Appendix A

Bioaccumulation Factor Development

Imagine the result

Pharmacia LLC and Solutia Inc.

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek

Appendix A: Bioaccumulation Factor Development

Anniston PCB Site, Anniston, Alabama

December 2013 Revision 2

Tables

Figures

Attachment

Acronyms and Abbreviations

ANOVA	analysis of variance
ARCADIS	ARCADIS U.S., Inc.
BAF	bioaccumulation factor
BSA	biological sampling area
BSAF	biota sediment accumulation factor
COPC	constituent of potential concern
dw	dry weight
EDR	ecologically distinct reach
FSP	Field Sampling Plan
mg/kg	milligrams per kilogram
ND	non-detect
OC	organic carbon
OU	Operable Unit
p	probability of Type 1 error
PCB	polychlorinated biphenyl
r^2	coefficient of determination
SERA	Streamlined Ecological Risk Assessment
ww	wet weight

1. Introduction

The Operable Unit (OU)-1/OU-2 Streamlined Ecological Risk Assessment (SERA) was conducted to evaluate the aquatic exposure pathways for ecological receptors and potential risks associated with identified constituents of potential concern (COPCs) (polychlorinated biphenyls [PCBs], barium, chromium, cobalt, lead, manganese, mercury, nickel and vanadium) within the OU-1/OU-2 portion of Snow Creek. Dietary exposure to a range of feeding guilds of birds and mammals was evaluated based on exposure from sediment and contaminated prey tissues. To evaluate the dietary exposure pathways to aquatic-feeding receptors, COPC concentrations in tissues of the prey for the identified receptors were modeled. The prey items for the representative receptors selected for evaluation in the OU-1/OU-2 SERA were aquatic plants, benthic invertebrates, emergent insects, crayfish, mollusks, frogs, and snakes. Table A-1 summarizes the aquatic receptors that are evaluated in the SERA and the assumed dietary components of each receptor's diet.

Table A-1 OU-1/OU-2 Aquatic Receptors and Dietary Components

Receptor	Aquatic Plants	Emergent and Flying Insects	Benthic Invertebrates	Crayfish	Mollusk	Frog	Snake
Mallard	X		X		X		
Tree Swallow		X					
Spotted Sandpiper		X	X				
Pied-Billed Grebe	X	X	X	X	X	X	
Common Muskrat	X		X		X		
Little Brown Bat		X					
Raccoon	X		X	X	X	X	X

Biotic tissue data and sediment data were collected from nine biological sampling areas (BSAs) and three reference areas as a part of the Phase II field sampling in 2009. These data were collected primarily to support the evaluation of potential risk to the identified ecological receptors from dietary exposure in OU-4. Details of the approach for this sampling are provided in the OU-4 Phase II Field Sampling Plan (FSP) (ARCADIS U.S., Inc. [ARCADIS] 2009). The data collected and used herein are described in Section 2.1 below and in Section 3.2 of the SERA, to which this document is an appendix.

The bioaccumulation model represents the relationship between the abiotic media (in this case, creek sediment) and the measured prey tissue concentration. When available data are sufficient, a regression analysis to predict tissue concentrations as a function of the abiotic media concentration is preferred. The regression takes the form (e.g., for a linear model):

tissue concentration (y) = slope (m) of the line x
exposed sediment concentration (x) + the y intercept (b)

If sufficient data are not available or if regression analyses do not result in a predictive relationship between abiotic media and tissue (i.e., not statistically significant or low coefficient of determination [r^2] values), prey tissue concentrations can be estimated using bioaccumulation factors (BAFs) that relate concentrations in abiotic media to tissue concentrations through a simple ratio. As a convention herein, ratios based on wet weight (ww) or dry weight (dw) tissue and abiotic media concentrations are referred to as BAFs. Ratios based on lipid normalized tissue and organic carbon normalized sediment are referred to as biota sediment accumulation factors (BSAFs).

As an example, a BAF can be calculated as follows:

Equation 1: $C_{insect} = BAF_{insect} \times PCB_{sediment}$

When BAFs are used, the predictability of the selected BAF is acknowledged to be uncertain due to the lack of relationship between the sediment and tissue data in the regression analysis. The approach for development of BAFs or regressions for PCBs and mercury was different than the approach used to develop BAFs for the remaining metals, due to differences in the available data for each. The following sections describe the data and analyses used to estimate bioaccumulation for each prey tissue type and COPC.

2. PCB and Mercury BAF Development

For the SERA, conditions influencing bioaccumulation of PCBs and mercury in prey tissues in the OU-1/OU-2 portion of Snow Creek were assumed to be similar to those already assessed in OU-4. There is some uncertainty associated with this assumption because the creek and adjacent floodplain within the OU-1/OU-2 portion of Snow Creek are in a more developed/industrialized area than OU-4. Thus, prey species that are present as well as the make up of the sediments may differ. While these differences do introduce some uncertainty, these data likely introduce less uncertainty than non-site-specific values in the peer reviewed literature and are thus preferred for the SERA. BAFs developed for PCBs and mercury in OU-4 are, therefore, considered reasonably representative of OU-1/OU-2. The following sections detail the data used and the approach for development of PCB and mercury BAFs in OU-4.

2.1 Data Use

Three ecologically distinct reaches (EDRs), upper, middle, and lower, were identified within OU-4 based on habitat surveys conducted in Phase I Ecological Survey (ARCADIS BBL 2007). Three aquatic BSAs were identified within each of the three EDRs for a total of nine aquatic BSAs within OU-4. Samples were also collected from three aquatic reference locations. Six discrete sediment samples were collected from each BSA and reference location. Four field duplicates were collected, one in each EDR and one in the reference location. Field duplicates were averaged for the purposes of this analysis. In addition to the sediment data collected as a part of the biota investigation, 13 historical sediment samples were identified that were collected within or in close proximity to the BSAs. These samples were also included in the sediment datasets for the BSAs. Tables A-2 and A-3 summarize the sediment and biotic tissue for PCBs and mercury, respectively. Figures A-1 through A-9 show the locations of each BSA as well as the locations of the sediment data collected within or in close proximity to each BSA.

In general, individual biotic tissue samples were not precisely co-located with specific sediment samples, rather tissue collected from specified locations within a BSA were composited. Thus, associating a specific tissue sample within a BSA with a specific sediment sample location was not possible. As such, samples were not evaluated on an individual basis. Instead, data from each BSA or reference area were combined to estimate a mean value for each sub-area. These mean values were used to develop bioaccumulation models. To calculate the means for each BSA, all available sediment and tissue data were initially included. When none of the samples collected within a BSA had a detected PCB or mercury concentration (all were non-detect [ND]), that BSA was not used in calculating BAFs; however when at least one sample contained a detected concentration, one-half the reporting limit was used for ND values in conjunction with the detected concentration to calculate a mean value. This approach is expected to adequately account for and represent the spatial variability of measured concentrations within a BSA. PCBs were not detected in sediment at any of the three reference locations. Mercury was detected in a small number of reference area sediments. However, a statistical comparison of means was conducted comparing site and reference location sediment. The dataset did not meet the normality assumptions needed to conduct an analysis of variance (ANOVA) test; therefore, the non-parameter Kruskal-Wallis test was used for the comparison of means. Using the Kruskal-Wallis test, it was determined that site sediment is statistically different from reference locations and, therefore, these data are considered to represent two populations. As such, only the site data were included in the BAF analysis for PCBs and mercury. The calculated BSA means for PCBs and mercury for sediment and tissue are shown in Tables A-4 through A-19.

In addition to the field collected benthic invertebrate data, a laboratory bioaccumulation test was conducted using *lumbriculus verigatus* and site sediments containing a range of PCB concentrations. The specific methods and results for the laboratory bioaccumulation study are provided in the final report from the laboratory (Ingersoll et al, in review). Laboratory sediments were analyzed as both homologs and Aroclors. Tissue was measured as homologs and is provided as wet weight. The laboratory bioaccumulation data for homologs and Aroclors are summarized in Tables A-10 and A-11, respectively. Additional detail regarding data for each prey-tissue type is described in Section 2.2.

2.2 BAF Development Methods

As described above, a regression analysis to predict tissue concentrations as a function of the abiotic media concentration is preferred. Because the tissues and sediments were not specifically co-located (beyond being collected within the area of the BSA), regression analyses were conducted for each tissue type using mean tissue concentrations and mean sediment concentrations for each BSA as described in Section 2.1. Initially, regression analyses based on dry weight sediment and tissue[1] were conducted for PCBs and mercury, as well as organic carbon[2] (dw) sediment and lipid normalized (ww) tissue for PCBs. Fit was tested on a linear and lognormal basis. The results of these analyses are shown in Tables A-4 through A-19 and Figures A-10 through A-25. As these regression analyses did not result in a predictive relationship between sediment and biotic tissue (i.e., coefficient of determination r^2 values < 0.3), further analysis was conducted to evaluate possible correlations based on a range of variations in sediment and tissue estimates. Additional sediment variations include fines normalized dry weight sediment. In general, sediment PCBs were measured as Aroclors. In a subset of samples in six of the nine BSAs, PCBs were measured as homologs. These data were also considered in the correlation analysis. Tissue data were additionally evaluated on a wet weight basis. Percent fines for sediment as well as percent solids for tissue used to calculate these values are provided in Table A-20. Tables A-21 through A-24 summarize the coefficients of determination (r^2) for each sediment and tissue variation for PCBs and mercury on a numeric and log basis (including the dry weight and lipid and organic carbon (OC) normal [PCB only] analyses shown in Figures A-10 through A-25). For those pairings with an r^2 value greater than 0.3, the data were plotted (Figures A-26 through A-29). When the correlation was positive (i.e., tissue concentrations rose as sediment concentrations rose), a statistical evaluation was conducted to determine if the relationship was statistically significant with 90 percent confidence (i.e., p value < 0.1). The statistical output is included in Attachment A. The following sections describe the results of these analyses for each tissue type.

---

[1] Tissue concentrations were reported from the laboratory as wet weight and converted to dry weight using measured percent solids in each sample. If the percent solids was not available for a specific sample, an arithmetic mean of the percent solids in that tissue type was used for the calculation.

[2] When TOC was ND, these samples were excluded from the mean calculations because of uncertainty with estimating TOC based on one-half the reporting limit.

2.2.1 Aquatic Plants

Aquatic plants consisted primarily of the stems and leaves of alligator weed (*Alternanthera philoxeroides*). Three composite samples were collected from BSAs. The arithmetic mean of composites within each BSA was taken and associated with the arithmetic mean of the sediment concentrations for that BSA for the analysis.

The regression analyses for PCBs and mercury did not result in a predictive relationship between sediment and aquatic plant tissue on a dry weight or on an OC and lipid normalized (PCB only) basis (Figures A-10 and A-11). Similarly, the additional correlation analysis (Tables A-21 through A-24) did not indicate a predictive relationship between sediment on a percent fines normalized basis or plant tissue on a wet weight basis. Because a predictive relationship was not identified, it was necessary to calculate BAFs. The medians of the BSA-specific dw/dw BAFs of 0.42 milligrams per kilogram (mg/kg) for PCBs and 0.11 mg/kg for mercury were selected for use in estimating tissue concentrations in aquatic plants (Tables A-4 and A-5, respectively).

2.2.2 Emergent Insects

Emergent insects that were collected consisted primarily of crane flies (Tipulidae), damselflies (Odonata), and dragonflies (Odonata). Three composite samples were collected from each of the nine BSAs for a total of 27 samples from OU-4. Nine of the 27 composite samples contained crane flies as well as other species. Six of the composites, all of which were taken within EUA 02 and EUA 03, contained crane flies only and these samples had PCB concentrations that were substantially higher (5.8 to 7.8 mg/kg dw) than concentrations in the mixed samples, which ranged from 0.1 mg/kg dw to 0.8 mg/kg dw. Because the samples that contained mixtures of species, which included crane flies, did not contain higher PCB concentrations than samples containing only dragon or damsel flies, there appears to be substantial uncertainty associated with the exposure of crane flies. This uncertainty is discussed in Section 6.3.2 of the OU-1/OU-2 SERA. Because the crane fly only PCB data appear to be a separate population from the mixed species data, the approach for calculating emergent insect BAFs will be modified from the approach used for other tissue types as described below.

As was done for the other tissue types, the arithmetic mean of composites within each BSA was taken and associated with the arithmetic mean of the sediment sample concentrations for that BSA for the analysis for a total of nine discrete tissue and sediment concentration estimates. For PCBs, the regression analyses were conducted for mixed species samples only as the sample size for crane fly only samples (n=2) was too small to conduct a regression. The regression analyses for mixed species PCBs and all samples for mercury did not result in a predictive relationship between sediment and emergent insect tissue on a dry weight or on an OC and lipid normalized (PCB only) basis (Figures A-12 and A-13, respectively). Similarly, the additional correlation analysis (Tables A-21 through A-24) did not indicate a predictive relationship between sediment on a percent fines normalized basis or emergent insect tissue on a wet weight basis. Based on this analysis and the lack of a predictive relationship between sediment and tissue, it was necessary to calculate BAFs. Because of the different populations of data for PCBs, a median BAF is not recommended. Alternatively, a mean BAF for mixed samples was calculated separately from the mean BAF for crane flies only. The “mixed diet” BAF was calculated as a weighted average with 22 percent (i.e., the percent of samples collected that were comprised of only crane flies) of the BAF being represented by crane flies only and the remaining 78 percent represented by mixed species. This is considered a conservative proportion based on the survey data collected in 2006 and 2007 and reported in the Operable Unit 4 Ecological Survey Report (ARCADIS BBL 2007). These survey results showed that of the 60 survey sample locations crane flies were found in only four locations (7%) compared to odonates, which were found in 30 locations (50%). The resulting weighted mean BAF is 3.8 and is shown relative to the tissue data on Figure A-30. The selected BAF for mercury is the median value of the BSAs.

2.2.3 Benthic Invertebrates

Benthic invertebrate samples that were collected from each of the nine BSAs consisted of Odonata larvae. Three composite benthic invertebrate samples were collected in each of the nine BSAs. The arithmetic mean of the three composites within each BSA was taken and associated with the arithmetic mean of the sediment sample concentrations for that BSA.

The regression analyses for PCBs and mercury did not result in a predictive relationship between sediment and benthic invertebrate tissue on a dry weight or on an OC and lipid normalized (PCB only) basis (Figures A-14 and A-15, respectively). The additional correlation analysis indicated a correlation between PCBs in sediment normalized to percent fines and benthic invertebrate tissue on a wet weight basis (Tables A-21 and A-22). The correlation to wet weight tissue was statistically significant (p=0.03). None of the other tissue types being consumed by receptors showed a positive correlation with fines normalized PCB concentrations in sediment. In addition, percent fines in sediment did not correlate well with PCB concentrations in sediment (Figure A-30). Thus, it was not possible to estimate a concentration for any other tissue type based on fines normalized sediment. Because no other element of any receptor diet is based on percent fines and because the risk calculations in the SERA require a fixed assumption about the percent of fines in sediment, it was not feasible to incorporate this fines normalized relationship into the overall dose estimation in the SERA. An evaluation of this uncertainty is provided in Section 6.3.2 of the SERA.

The additional correlation analysis for mercury resulted in an r^2 value greater than 0.3 for fines normalized, but the correlation in this case was negative (Figures A-28 and A-29). Based on these analyses, medians of the BSA-specific dw/dw BAFs of 0.92 mg/kg for PCBs and 0.39 mg/kg for mercury were selected for use in estimating tissue concentrations in benthic invertebrates (Tables A-8 and A-9, respectively).

For the laboratory benthic invertebrate data, regression analyses demonstrated statistically significant predictive relationships between sediment PCB concentrations and *lumbriculus variegatus* tissue concentrations. Regressions are shown in Figures A-16 and A-17. The statistical evaluation of these regression analyses is provided in Attachment A. Both the regression equation from the laboratory study and field-based BAF are used to estimate benthic invertebrate tissue concentrations for the OU-1-OU-2 SERA dose calculations. Because sediment Aroclor vs. tissue homolog for both ww and lipid normalized worm tissue basis had good fit, the regression equation that best fit the field data was used, which was log tissue homolog ww versus log PCB Aroclor dw with an r^2 value of 0.89.

2.2.4 Crayfish

Crayfish were collected from all nine BSAs. One to three composite samples were collected opportunistically in either emergent vegetation, run, or riffle habitats in each BSA. The arithmetic mean of the composites within each BSA was taken and associated with the arithmetic mean of the sediment sample concentrations for that BSA.

The regression analyses resulted in a predictive relationship between sediment and crayfish tissue for PCBs on a dry weight basis. However, as shown on Figure A-18, this correlation was negative. The OC and lipid normalized regressions for PCBs were not predictive, nor were the mercury regressions on a dry weight basis (Figures A-18 and A-19, respectively). The additional correlation analysis for PCBs resulted in r^2 values greater than 0.3 for two combinations (Tables A-21 and A-22), but the correlations were negative (Figures A-26 and A-27). For mercury, no predictive relationships were observed in the additional correlation analyses (Tables A-23 and A-24). Because a significant positive relationship was not identified, it was necessary to calculate BAFs. The medians of the BSA-specific dw/dw BAFs of 0.75 mg/kg for PCBs and 0.27 mg/kg for mercury were selected for use in estimating crayfish tissue concentrations (Tables A-12 and A-13, respectively).

2.2.5 Mollusks

Mollusks were collected from all nine BSAs. Efforts were made to collect mollusks in either emergent vegetation, run, or riffle habitats in each BSA. The arithmetic mean of the composites within each BSA was taken and associated with the arithmetic mean of the sediment sample concentrations for that BSA.

The regression analyses did not result in a predictive relationship between sediment and mollusk tissue for PCBs or mercury on a dry weight or on an OC and lipid normalized (PCB only) basis (Figure A-20 and A-21, respectively). Similarly, the additional correlation analysis for PCBs (Tables A-21 and A-22) did not indicate a predictive relationship between sediment on a percent fines normalized basis or tissue on a wet weight basis. The additional correlation analysis for mercury resulted in r^2 values greater than 0.3 for fines normalized sediment and wet weight tissue (Tables A-23 and A-24), but the correlations were negative

(Figures A-28 and A-29). Because a significant positive relationship was not identified, it was necessary to calculate BAFs. The medians of the BSA-specific dw/dw BAFs of 6.5 mg/kg for PCBs and 0.47 mg/kg for mercury were selected for use in estimating mollusk tissue concentrations (Tables A-14 and A-15, respectively).

2.2.6 Snakes and Frogs

Snakes and frogs were collected in all nine BSAs. Efforts were made to collect tissues in each BSA. However, samples were not found in all areas. Tables A-2 and A-3 summarize the data available by BSA for snakes and frogs. Species of frogs collected include southern leopard frogs (*Thobates sphenocephalus*), bullfrogs (*Rana catesbeiana*), bronze or green frogs (*Rana clamitans*), and northern cricket frogs (*Acris crepitans*). Snake species collected include midland water snake (*Nerodia sipedon*), queen snake (*Regina septemvittata*), cottonmouth (*Agkistrodon piscivorus*), and yellow-bellied water snake (*Nerodia erythrogaster*). Because concentrations in frogs and snakes appear to be dissimilar, with snakes typically having higher body burdens than frogs, uptake was evaluated separately for frogs and snakes. The arithmetic mean of the frog or snake tissue samples within each BSA was taken and associated with the arithmetic mean of the sediment sample concentrations for that BSA.

The regression analyses did not result in a predictive relationship between sediment and frog tissue for PCBs or mercury on a dry weight or on an OC and lipid normalized (PCB only) basis (Figures A-22 and A-23, respectively), with the exception of the log PCB OC and lipid normalized regression. The statistical evaluation of this regression analysis is provided in Attachment A and showed that the correlation was not statistically significant. Similarly, the additional correlation analysis for PCBs (Tables A-21 and A-22) did not indicate a predictive relationship between sediment on a percent fines normalized basis or tissue on a wet weight basis. The additional correlation analysis for mercury resulted in r^2 values greater than 0.3 for fines normalized sediment and dry weight and wet weight tissue (Tables A-23 and A-24) and these results were statistically significant (Figures A-28 and A-29). The statistical evaluation of these regression analyses is provided in Attachment A. However, as discussed above for benthic invertebrates and PCBs, none of the other tissue types being consumed by receptors showed a positive correlation with fines normalized mercury concentrations in sediment. In addition, percent fines in sediment did not correlate well with mercury concentrations in sediment (Figure A-30). Thus, it was not possible to estimate a concentration for any other tissue type based on fines normalized sediment. Because no other element of any receptor diet is based on percent fines and because the risk calculations in the SERA require a fixed assumption about the percent of fines in sediment, it was not feasible to incorporate this fines normalized relationship into the overall dose estimation in the SERA.

Based on the results discussed above, the medians of the BSA-specific dw/dw BAFs of 3.4 mg/kg for PCBs and 0.75 mg/kg for mercury were selected for use in estimating frog tissue concentrations (Tables A-16 and A-17, respectively).

For snakes, the regression analyses resulted in a predictive relationship between sediment and snake tissue for PCBs based on seven different sediment and tissue combinations (Tables A-21 and A-22) including on a dry weight basis (Figure A-24). However, the correlations were negative (Figure A-26 and A-27). For mercury (Figures A-28 and 29), no predictive relationship was identified. Because a significant positive relationship was not identified, it was necessary to calculate BAFs. The medians of the BSA-specific dw/dw BAFs of 26.91 mg/kg for PCBs and 1.11 mg/kg for mercury were selected for use in estimating snake tissue concentrations (Tables A-18 and A-19).

3. BAF Development for Remaining COPCs

This section describes the data and method for developing BAFs for barium, chromium, cobalt, lead, manganese, nickel, and vanadium for use in the SERA.

Metal COPCs were measured in sediment and tissue in approximately 10 percent of samples collected for PCB and mercury analysis, as described in Section 3.2 of the SERA. As there were too few samples to develop a regression model, it was necessary to estimate a BAF ratio for these metals.

The data were insufficient to test site data compared to the reference data to determine if these datasets represent different populations. Moreover, because the site-relatedness of the metal COPCs is not clear, it is more likely that site and reference data could be a part of one data population. As such, reference data were included in the BAF development for these metals. Table A-25 summarizes the metals data that were available and included in the BAF development. There were too few samples to develop a regression model or to develop a median of BSA averages, as was done for PCBs and mercury. Thus, BAFs for these seven metal COPCs were calculated using a ratio of mean tissue concentrations to mean sediment concentrations using the data from all BSAs and reference areas as shown in Equation 2. .

Equation 2: BAF = $X_{dwTissue}/X_{dw}s_{ediment}$, (where X is the arithmetic mean)

This ratio of means was chosen as the most appropriate dw/dw BAF for the tissue and sediment data available for the OU-1/OU-2 portion of Snow Creek. A summary of non-mercury metal data and BAF calculations can be found in Table A-25.

4. Summary

As described above, when sufficient data were available, data were evaluated to determine if predictive relationships between sediment and tissue could be identified. Data were compiled by BSAs and initially evaluated on a dry weight basis for PCBs and mercury and lipid/organic carbon normalized basis for PCBs. Additional correlation analyses were conducted using fines normalized sediment as well as wet weight tissue. For the tissues evaluated herein, a predictive relationship was generally not found. Thus, the median

BAF based on dry weight sediment and tissue was selected as the best method for estimating a tissue concentration for the foodweb in the SERA. Table A-26 summarizes the BAFs selected for the OU-1/OU-2 SERA.

5. References

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Ingersoll, CG, J.A. Steevens, DD MacDonald, WG Brumbaugh, MR Coady, J D Farrar, GR Lotufo, NE Kemble, JL Kunz, JK Stanley, JA Sinclair. In review. Evaluation of Toxicity to the Amphipod, Hyalella azteca, and to the Midge, *Chironomus dilutus*, and Bioaccumulation by the Oligochaete, *Lumbriculus variegatus*, with Exposure to PCB-contaminated Sediments from Anniston Alabama.

Tables

Table A-2
Sediment and Aquatic Biota Tissue PCB Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	PCB Results (mg/kg dry weight)[1]; TOC (mg/kg); Lipids (%)															
			Sediment	Sediment TOC	Aquatic Plants	Aquatic Plant Lipids	Emergent Insects	Emergent Insects Lipids	Benthic Invertebrates	Benthic Invertebrates Lipids	Crayfish	Crayfish Lipids	Mollusks	Mollusks Lipids	Frog	Frog Lipids	Snake	Snake Lipids
Lower	ELA-01	ELA-01-55	0.53	3855	0.63	0.50	0.67	2.6	1.6	0.80	1.3	0.60	10	0.50	na	na	45	1.7
		ELA-01-56	0.26	3020	0.37	0.70	0.96	2.7	0.90	0.90	0.83	0.50	11	0.50	na	na	35	2.2
		ELA-01-57	2.0	10600	0.58	0.40	1.2	3.2	0.91	1.0	1.1	0.20	6.1	0.60	na	na	35	4.4
		ELA-01-58	2.7	16200														
		ELA-01-59	0.82	10100														
		ELA-01-60	2.4	22200														
		HHFL-04	1.3	3640														
	ELA-02	ELA-02-61	3.9	24800	0.25	0.90	0.74	4.2	0.80	0.90	0.24	0.20	12	0.40	5.4	1.0	26	1.3
		ELA-02-62	2.4	23300	0.036	0.40	0.83	3.0	0.81	0.90	0.51	0.30	8.4	0.50	5.3	1.3	na	na
		ELA-02-63	3.0	2350	0.042	0.80	1.4	3.0	1.0	0.80	1.3	0.40	14	0.60	na	na	na	na
		ELA-02-64	3.2	660														
		ELA-02-65	1.2	13100														
		ELA-02-66	1.1	4000														
	ELA-03	ELA-03-67	4.2	14300	0.33	0.70	0.71	2.9	0.74	0.80	0.68	0.60	11	0.60	na	na	30	2.5
		ELA-03-68	0.98	3110	0.24	0.70	0.95	1.9	0.94	0.70	0.76	0.60	11	0.60	na	na	48	4.9
		ELA-03-69	2.0	9750	0.042	0.70	1.2	2.9	0.61	0.90	0.87	0.50	12	0.60	na	na	55	2.2
		ELA-03-70	0.04	2090														
		ELA-03-71	0.10	620														
		ELA-03-72	0.4	1850														
Middle	EMA-01	EMA-01-01	1.2	10000	0.041	1.1	0.31	3.1	1.6	1.7	2.6	0.80	4.9	0.60	2.4	0.70	122	1.3
		EMA-01-02	0.70	2270	1.1	0.50	0.55	3.7	1.3	2.1	2.6	0.90	4.6	0.80	4.6	3.2	na	na
		EMA-01-03	1.14	1800	0.39	1.0	0.69	3.9	1.2	1.3	na	na	6.3	0.80	na	na	na	na
		EMA-01-04	0.36	3940														
		EMA-01-05	1.3	11400														
		EMA-01-06	2.3	13400														
		HHFL-05	0.2	2300														
	EMA-02	EMA-02-07	2.4	20100	1.7	0.50	0.68	3.6	2.0	1.9	2.1	0.80	7.3	0.50	3.4	0.70	19	2.0
		EMA-02-08	1.3	3740	1.2	0.40	0.73	3.3	1.9	1.0	na	na	6.4	0.70	2.9	0.70	na	na
		EMA-02-09	5.2	12200	0.054	0.80	0.58	4.0	1.9	1.0	0.89	0.50	6.2	0.70	na	na	na	na
		EMA-02-10	2.3	19300														
		EMA-02-11	2.0	13000														
		EMA-02-12	3.6	23500														
		C-064-SED-1	0.1	250														
		C-065-SED-3	0.2	250														
	EMA-03	EMA-03-31	0.23	3460	0.059	0.50	0.81	4.1	1.4	1.1	1.8	1.1	12	0.90	4.5	2.6	na	na
		EMA-03-32	0.021	30300	0.44	0.60	0.80	4.4	2.0	1.2	1.5	0.80	10	0.60	3.1	3.1	na	na
		EMA-03-33	0.38	7050	0.39	0.50	1.0	4.6	1.2	1.1	1.1	0.70	12	1.1	2.8	0.90	na	na
		EMA-03-34	0.69	4920														
		EMA-03-35	3.9	37300														
		EMA-03-36	1.5	31300														

Table A-2
Sediment and Aquatic Biota Tissue PCB Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	PCB Results (mg/kg dry weight)[1]; TOC (mg/kg); Lipids (%)															
			Sediment	Sediment TOC	Aquatic Plants	Aquatic Plant Lipids	Emergent Insects	Emergent Insects Lipids	Benthic Invertebrates	Benthic Invertebrates Lipids	Crayfish	Crayfish Lipids	Mollusks	Mollusks Lipids	Frog	Frog Lipids	Snake	Snake Lipids
Upper	EUA-01	EUA-01-19	1.1	4010	0.87	0.40	2.7	3.1	3.5	1.2	1.8	0.60	11	0.70	15	1.3	26	6.7
		EUA-01-20	3.1	4880	0.41	0.60	0.36	2.8	0.96	1.3	3.2	1.1	6.3	0.80	18	1.7	na	na
		EUA-01-21	0.81	3790	0.88	0.60	0.31	3.1	0.98	1.0	1.6	0.90	5.9	0.70	na	na	na	na
		EUA-01-22	2.0	3050														
		EUA-01-23	0.35	4370														
		EUA-01-24	2.8	6360														
		C-001-SED-4	1.9	250														
	EUA-02	EUA-02-43	1.9	5855	0.65	0.80	27	1.9	0.86	0.80	3.8	0.90	14	0.90	9.5	1.0	167	0.60
		EUA-02-44	0.40	2140	0.67	0.90	23	1.8	2.9	0.70	3.3	1.4	17	1.1	2.5	2.2	na	na
		EUA-02-45	1.5	2700	0.80	1.2	18	2.0	1.3	0.60	2.2	0.60	12	0.80	na	na	na	na
		EUA-02-46	0.26	7600														
		EUA-02-47	1.6	14000														
		EUA-02-48	0.87	5380														
		C-005-SED-1	0.23	250														
		C-008-SED-2	0.34	15000														
		C-008-SED-4	0.50	250														
		C-009-SED-1	2.13	250														
		C-010-SED-4	0.42	250														
	EUA-03	EUA-03-25	1.2	6950	0.76	0.60	25	2.6	1.1	0.90	1.3	0.50	17	0.90	17	1.0	na	na
		EUA-03-26	1.5	4560	1.2	0.60	23	2.2	2.3	1.6	na	na	15	0.60	38	0.80	na	na
		EUA-03-27	0.28	10700	1.2	0.60	20	2.4	1.3	1.4	na	na	8.8	0.70	5.6	0.90	na	na
		EUA-03-28	0.36	4160														
		EUA-03-29	2.4	4790														
		EUA-03-30	0.42	630														
		C-017-SED-2	8.90	23000														
		C-021-SED-4	1.22	13000														
Reference	ERA-01	ERA-01-49	0.021	2450	0.042	0.90	0.16	3.0	0.15	0.80	na	na	0.28	0.80	na	na	1.3	2.0
		ERA-01-50	0.027	16200	0.040	1.0	0.16	2.8	0.12	0.80	na	na	0.27	0.80	na	na	1.2	1.8
		ERA-01-51	0.019	575	0.040	0.90	0.18	2.4	0.14	0.60	na	na	0.11	1.1	na	na	0.21	1.3
		ERA-01-52	0.020	610														
		ERA-01-53	0.024	2360														
		ERA-01-54	0.037	26000														
		ECO-REF-01	0.029	4310														
	ERA-02	ERA-02-13	0.017	7340	5.1	0.30	0.089	2.5	0.069	0.90	0.064	1.2	0.14	0.60	0.063	0.60	0.074	2.6
		ERA-02-14	0.036	26700	0.037	0.70	0.09	2.1	0.13	1.2	0.051	1.1	0.15	0.50	0.14	2.1	na	na
		ERA-02-15	0.040	36200	0.051	0.40	0.07	2.3	0.15	0.70	0.063	1.0	0.11	0.40	na	na	na	na
		ERA-02-16	0.024	6830														
		ERA-02-17	0.021	3580														
		ERA-02-18	0.022	5180														
		ECO-REF-02	0.029	3430														
	ERA-03	ERA-03-37	0.055	128000	0.042	0.70	0.24	3.0	0.16	0.60	na	na	0.15	0.70	0.06	0.80	0.028	4.2
		ERA-03-38	0.030	34600	0.039	0.70	0.17	3.1	0.18	0.50	na	na	0.14	0.80	na	na	4.5	8.5
		ERA-03-39	0.036	26500	0.039	0.70	0.16	3.4	0.17	0.60	na	na	0.13	0.90	na	na	na	na
		ERA-03-40	0.020	2480														
		ERA-03-41	0.021	5320														
		ERA-03-42	0.047	48300														
		ECO-REF-03	0.025	1560														

General Note:
Red text indicates value is shown at half the reporting limit
Total PCB calculated as non-detect = 0 if one or more Aroclor or homolog detected; if all are non-detect then one-half the highest reporting limit for individual Aroclor or homolog shown in red.
Footnote:
[1] Sediment, crayfish tissue, and mollusk tissue concentrations were measured as Aroclors while all other tissue concentrations were measured as homologs

Acronyms and Abbreviations:
BSA = biological sampling area
EDR = ecologically distinct reach
mg/kg = milligrams per kilogram
na = no sample aquired in specified area
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-3
Sediment and Aquatic Biota Tissue Mercury Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Mercury Results (mg/kg dry weight); TOC (mg/kg); lipid (%)															
			Sediment	Sediment TOC	Aquatic Plants	Aquatic Plants Lipids	Emergent Insects	Emergent Insects Lipids	Benthic Invertebrates	Benthic Invertebrates Lipids	Crayfish	Crayfish Lipids	Mollusks	Mollusks Lipids	Frog	Frog Lipids	Snake	Snake Lipids
Lower	ELA-01	ELA-01-55	0.35	2250	0.023	0.50	0.16	2.6	0.36	0.80	0.36	0.60	0.56	0.50	na	na	0.78	1.7
		ELA-01-56	0.19	3020	0.052	0.70	0.21	2.7	0.36	0.90	0.26	0.50	0.80	0.50	na	na	1.1	2.2
		ELA-01-57	0.62	10600	0.024	0.40	0.25	3.2	0.32	1.0	0.19	0.20	0.52	0.60	na	na	0.94	4.4
		ELA-01-58	0.69	16200														
		ELA-01-59	6.3	10100														
		ELA-01-60	0.58	22200														
		HHFL-04	0.38	3640														
	ELA-02	ELA-02-61	0.91	24800	0.092	0.90	0.14	4.2	0.27	0.90	0.29	0.20	0.78	0.40	0.56	1.0	1.9	1.3
		ELA-02-62	0.75	23300	0.069	0.40	0.19	3.0	0.58	0.90	0.20	0.30	0.85	0.50	0.32	1.3	na	na
		ELA-02-63	0.49	2350	0.033	0.80	0.24	3.0	0.25	0.80	0.21	0.40	1.0	0.60	na	na	na	na
		ELA-02-64	0.27	660														
		ELA-02-65	0.52	13100														
		ELA-02-66	0.59	4000														
	ELA-03	ELA-03-67	1.6	14300	0.073	0.70	0.08	2.9	0.26	0.80	0.11	0.60	0.73	0.60	na	na	2.1	2.5
		ELA-03-68	0.37	3110	0.067	0.70	0.11	1.9	0.70	0.70	0.14	0.60	0.88	0.60	na	na	1.4	4.9
		ELA-03-69	0.43	9750	0.060	0.70	0.17	2.9	0.34	0.90	0.14	0.50	0.78	0.60	na	na	0.42	2.2
		ELA-03-70	0.16	2090														
		ELA-03-71	0.22	620														
		ELA-03-72	0.19	1850														
Middle	EMA-01	EMA-01-01	0.43	10000	0.063	1.1	0.15	3.1	0.22	1.7	0.19	0.80	0.17	0.60	0.67	0.70	0.54	1.3
		EMA-01-02	0.61	2270	0.024	0.50	0.19	3.7	0.24	2.1	0.17	0.90	0.37	0.80	0.33	3.2	na	na
		EMA-01-03	0.73	2345	0.081	1.0	0.32	3.9	0.32	1.3	na	na	0.14	0.80	na	na	na	na
		EMA-01-04	0.74	3940														
		EMA-01-05	0.50	11400														
		EMA-01-06	0.91	13400														
		HHFL-05	0.74	2300														
	EMA-02	EMA-02-07	0.65	20100	0.069	0.50	0.077	3.6	0.44	1.9	0.21	0.80	0.27	0.50	0.33	0.70	1.7	2.0
		EMA-02-08	0.84	3740	0.081	0.40	0.034	3.3	0.26	1.0	na	na	0.28	0.70	0.24	0.70	na	na
		EMA-02-09	1.1	12200	0.38	0.80	0.038	4.0	0.23	1.0	0.14	0.50	0.33	0.70	na	na	na	na
		EMA-02-10	0.69	19300														
		EMA-02-11	0.47	13000														
		EMA-02-12	0.87	23500														
	EMA-03	EMA-03-31	0.30	3460	0.024	0.50	0.15	4.1	0.30	1.1	0.12	1.1	0.42	0.90	0.28	2.6	na	na
		EMA-03-32	0.43	30300	0.023	0.60	0.13	4.4	0.41	1.2	0.14	0.80	0.37	0.60	0.37	3.1	na	na
		EMA-03-33	0.45	7050	0.025	0.50	0.12	4.6	0.28	1.1	0.20	0.70	0.36	1.1	1.8	0.90	na	na
		EMA-03-34	0.51	4920														
		EMA-03-35	0.81	37300														
		EMA-03-36	0.75	31300														

Table A-3
Sediment and Aquatic Biota Tissue Mercury Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Mercury Results (mg/kg dry weight); TOC (mg/kg); lipid (%)															
			Sediment	Sediment TOC	Aquatic Plants	Aquatic Plants Lipids	Emergent Insects	Emergent Insects Lipids	Benthic Invertebrates	Benthic Invertebrates Lipids	Crayfish	Crayfish Lipids	Mollusks	Mollusks Lipids	Frog	Frog Lipids	Snake	Snake Lipids
Upper	EUA-01	EUA-01-19	2.6	4010	0.024	0.40	0.13	3.1	0.13	1.2	0.12	0.60	0.14	0.70	0.63	1.3	0.88	6.7
		EUA-01-20	0.83	4880	0.020	0.60	0.10	2.8	0.19	1.3	0.13	1.1	0.14	0.80	1.0	1.7	na	na
		EUA-01-21	2.90	3790	0.046	0.60	0.11	3.1	0.16	1.0	0.12	0.90	0.16	0.70	na	na	na	na
		EUA-01-22	0.30	3050														
		EUA-01-23	0.78	4370														
		EUA-01-24	0.75	6360														
	EUA-02	EUA-02-43	0.47	5855	0.075	0.80	0.27	1.9	0.13	0.80	0.40	0.90	0.26	0.90	0.12	1.0	0.61	0.60
		EUA-02-44	0.039	2140	0.085	0.90	0.23	1.8	0.31	0.70	0.12	1.4	0.30	1.1	0.13	2.2	na	na
		EUA-02-45	0.32	2700	0.065	1.2	0.30	2.0	0.19	0.60	0.14	0.60	0.25	0.80	na	na	na	na
		EUA-02-46	0.054	7600														
		EUA-02-47	1.0	14000														
		C-005-SED-2	0.65	250														
		EUA-02-48	1.3	5380														
	EUA-03	EUA-03-25	1.3	6950	0.088	0.60	0.42	2.6	0.18	0.90	0.19	0.50	0.32	0.90	0.73	1.0	na	na
		EUA-03-26	0.91	4560	0.080	0.60	0.36	2.2	0.28	1.6	na	na	0.38	0.60	1.0	0.80	na	na
		EUA-03-27	0.27	10700	0.11	0.60	0.32	2.4	0.15	1.4	na	na	0.22	0.70	0.86	0.90	na	na
		EUA-03-28	0.35	4160														
		EUA-03-29	0.86	4790														
		EUA-03-30	1.0	630														
Reference	ERA-01	ERA-01-49	0.007	2450	0.064	0.90	0.066	3.0	0.091	0.80	na	na	0.23	0.80	na	na	1.0	2.0
		ERA-01-50	0.024	16200	0.017	1.0	0.047	2.8	0.072	0.80	na	na	0.20	0.80	na	na	0.52	1.8
		ERA-01-51	0.007	575	0.046	0.90	0.035	2.4	0.090	0.60	na	na	0.24	1.1	na	na	0.41	1.3
		ERA-01-52	0.008	610														
		ERA-01-53	0.008	2360														
		ERA-01-54	0.014	26000														
		ECO-REF-01	0.01	4310														
	ERA-02	ERA-02-13	0.006	7340	0.019	0.30	0.068	2.5	0.10	0.90	0.06	1.2	0.70	0.60	0.11	0.60	0.50	2.6
		ERA-02-14	0.013	26700	0.035	0.70	0.041	2.1	0.16	1.2	0.10	1.1	0.57	0.50	0.11	2.1	na	na
		ERA-02-15	0.034	36200	0.021	0.40	0.048	2.3	0.20	0.70	0.09	1.0	0.68	0.40	na	na	na	na
		ERA-02-16	0.008	6830														
		ERA-02-17	0.008	3580														
		ERA-02-18	0.008	5180														
		ECO-REF-02	0.022	3430														
	ERA-03	ERA-03-37	0.11	128000	0.018	0.70	0.17	3.0	0.075	0.60	na	na	0.29	0.70	0.11	0.80	0.32	4.2
		ERA-03-38	0.032	34600	0.016	0.70	0.17	3.1	0.064	0.50	na	na	0.20	0.80	na	na	0.57	8.5
		ERA-03-39	0.041	26500	0.017	0.70	0.25	3.4	0.070	0.60	na	na	0.17	0.90	na	na	na	na
		ERA-03-40	0.007	2480														
		ERA-03-41	0.007	5320														
		ERA-03-42	0.041	48300														
		ECO-REF-03	0.016	1560														

General Note:
Red text indicates value is shown at half the reporting limit

Acronyms and Abbreviations:
BSA = biological sampling area
EDR = ecologically distinct reach
mg/kg = milligrams per kilogram
na = no sample aquired in specified area
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-4
PCB - Aquatic Plant Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA Location ID	Sediment		Tissue		BAF	BSAF
	mg PCB/kg sediment dw	mg PCB/kg toc dw	mg PCB/kg tissue-dw	mg PCB/kg lipid ww	dw sed/dw tissue	toc dw/lipid ww
ELA-01	1.42	168.18	0.53	17.33	0.37	0.10
ELA-02	2.45	379.43	0.11	3.41	0.05	0.01
ELA-03	1.29	206.52	0.21	5.88	0.16	0.03
EMA-01	1.03	221.93	0.50	13.39	0.48	0.06
EMA-02	2.12	218.80	0.99	28.30	0.47	0.13
EMA-03	1.12	69.21	0.30	8.11	0.27	0.12
EUA-01	1.72	380.99	0.72	22.92	0.42	0.06
EUA-02	0.93	265.58	0.70	17.13	0.76	0.06
EUA-03	2.03	225.60	1.04	32.78	0.52	0.15
BSA Average	1.57	237.36	0.57	16.58	0.36	0.07
BSA Median					0.42	0.06

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-5
Mercury - Aquatic Plant Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

	Sediment	Tissue	BAF
BSA Location ID	mg Hg/kg sediment dw	mg Hg/kg tissue-dw	dw sed/dw tissue
ELA-01	1.33	0.033	0.02
ELA-02	0.59	0.065	0.11
ELA-03	0.50	0.066	0.13
EMA-01	0.67	0.056	0.08
EMA-02	0.77	0.18	0.23
EUA-01	1.36	0.030	0.022
EUA-02	0.55	0.075	0.14
EUA-03	0.78	0.094	0.12
BSA Average	0.82	0.074	0.09
BSA Median			0.11

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-6
PCB - Emergent Insect Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sample ID	Sediment		Tissue		BAF	BSAF
		mg PCB/kg sediment dw	mg PCB/kg toc dw	mg PCB/kg tissue-dw	mg PCB/kg lipid ww	dw sed/dw tissue	toc dw/lipid ww
ELA-01	C85020	1.42	168.18	1.17	10.81	0.83	0.06
	C85015	1.42	168.18	0.67	7.81	0.47	0.05
	C85016	1.42	168.18	0.96	11.22	0.68	0.07
ELA-02	C85001	2.45	379.43	0.74	6.57	0.30	0.02
	C85023	2.45	379.43	1.38	14.23	0.56	0.04
	C85017	2.45	379.43	0.83	9.50	0.34	0.03
ELA-03	C85027	1.29	206.52	1.19	11.97	0.92	0.06
	C85019	1.29	206.52	0.95	9.42	0.74	0.05
	C85018	1.29	206.52	0.71	6.93	0.55	0.03
EMA-01	C85024	1.03	221.93	0.31	3.10	0.30	0.01
	C85026	1.03	221.93	0.69	5.56	0.67	0.03
	C85025	1.03	221.93	0.55	4.97	0.53	0.02
EMA-02	C85011	2.12	218.80	0.68	5.64	0.32	0.03
	C85012	2.12	218.80	0.73	7.21	0.34	0.03
	C85013	2.12	218.80	0.58	5.68	0.27	0.03
EMA-03	C85002	1.12	69.21	0.81	6.24	0.72	0.09
	C85003	1.12	69.21	0.80	6.27	0.71	0.09
	C85004	1.12	69.21	1.01	7.85	0.90	0.11
EUA-01	C85021	1.72	380.99	0.36	3.86	0.21	0.01
	C85022	1.72	380.99	0.31	3.13	0.18	0.01
	C85014	1.72	380.99	2.68	26.68	1.56	0.07
BSA Average (ELA-01 thru EUA-01)[1]		1.59	235.01	0.86	8.32	0.54	0.04
EUA-02	C85005	0.93	266	27	387	29	1.46
	C85006	0.93	266	23	382	25	1.44
	C85007	0.93	266	18	288	19	1.08
EUA-03	C85008	2.03	226	25	300	12	1.33
	C85009	2.03	226	23	351	11	1.56
	C85010	2.03	226	20	264	10	1.17
BSA Average (EUA-02 and EUA-03)[1]		1.48	245.59	22.89	328.76	15.48	1.34
BSA Weighted Average[2]						3.8	

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

[1] The data consisted of two populations, mixed emergent insect species and cranefly only, so data for samples with cranefly only (EUA-02 and EUA-03) were separated out. The BAF for each population was calculated as a ratio of the mean tissue (dw) to the mean sediment (dw).

[2] Based on the two populations, a "mixed diet" BAF was calculated as a weighted average with 22% of the BAF represented by cranefly only data and the remaining 78% represented by mixed species data.

Table A-7
Mercury - Emergent Insect Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment mg Hg/kg sediment dw	Tissue mg Hg/kg tissue-dw	BAF dw sed/dw tissue
ELA-01	1.33	0.21	0.15
ELA-02	0.59	0.19	0.32
ELA-03	0.50	0.12	0.24
EMA-01	0.67	0.22	0.33
EMA-02	0.77	0.05	0.06
EMA-03	0.54	0.13	0.25
EUA-01	1.36	0.11	0.08
EUA-02	0.55	0.27	0.49
EUA-03	0.78	0.37	0.47
BSA Average	0.79	0.18	0.24
BSA Median			0.25

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-8

PCB - Benthic Invertebrate Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek

Appendix A – Bioaccumulation Factor Development

Anniston PCB Site, Anniston, Alabama

	Sediment		Tissue		BAF	BSAF
BSA	mg PCB/kg sediment dw	mg PCB/kg toc dw	mg PCB/kg tissue-dw	mg PCB/kg lipid ww	dw sed/dw tissue	toc dw/lipid ww
ELA-01	1.42	168.18	1.13	20.19	0.80	0.12
ELA-02	2.45	379.43	0.87	18.61	0.36	0.05
ELA-03	1.29	206.52	0.76	16.59	0.59	0.08
EMA-01	1.03	221.93	1.36	17.74	1.32	0.08
EMA-02	2.12	218.80	1.95	31.85	0.92	0.15
EMA-03	1.12	69.21	1.54	22.97	1.37	0.33
EUA-01	1.72	380.99	1.82	28.81	1.06	0.08
EUA-02	0.93	265.58	1.68	33.78	1.81	0.13
EUA-03	2.03	225.60	1.59	24.45	0.78	0.11
BSA Average	1.57	237.36	1.41	23.89	0.90	0.10
BSA Median					0.92	0.11

Notes:

BSA = biological sampling area

dw = dry weight

toc = total organic carbon

BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)

BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)

ww = wet weight

kg = kilogram(s)

mg = milligram(s)

OU = Operable Unit

PCB = polychlorinated biphenyl

Table A-9
Mercury - Benthic Invertebrate Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment mg Hg/kg sediment dw	Tissue mg Hg/kg tissue-dw	BAF dw sed/dw tissue
ELA-01	1.33	0.34	0.26
ELA-02	0.59	0.37	0.62
ELA-03	0.50	0.43	0.88
EMA-01	0.67	0.26	0.39
EMA-02	0.77	0.31	0.40
EMA-03	0.54	0.33	0.61
EUA-01	1.36	0.16	0.12
EUA-02	0.55	0.21	0.38
EUA-03	0.78	0.20	0.26
BSA Average	0.79	0.29	0.37
BSA Median			0.39

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-10
PCB - *Lumbriculous* Tissue Uptake Summary
(sediment and tissue measured as homolog groups)

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

	Sediment		Tissue		BAF	BSAF
Sample Name	mg Homolog PCB/kg sediment dw	mg Homolog PCB/kg TOC dw	mg Homolog PCB/kg tissue ww	mg Homolog PCB/kg lipid tissue ww	dw sediment/w w tissue	toc dw/lipid ww
1	68.0	3617	106	6190	1.6	1.7
2	120	3922	60.0	3681	0.5	0.94
11	170	4521	137	10748	0.8	2.4
13	31.0	2818	47.2	3152	1.5	1.1
14	68.0	3560	118	8129	1.7	2.3
16	0.0912	34	1.92	128	21	3.7
20	8.80	793	23.4	1399	2.7	1.8
23	15.0	721	21.3	1214	1.4	1.7
24	0.310	140.9	8.01	607	26	4.3
25	60.0	2317	101	3500	1.7	1.5
27	14.0	915	65.9	3615	4.7	4.0
28	0.410	74	2.3	178	5.6	2.4
Average	46.3	1953	57.8	3545	1.2	1.8
Median					1.7	1.8

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-11
***PCB - Lumbriculous* Tissue Uptake Summary**
(sediment measures as Aroclors and tissue as homolog groups)

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

Sample Name	Sediment		Tissue		BAF	BSAF
	mg Aroclor PCB/kg sediment dw	mg Aroclor PCB/kg TOC dw	mg Homolog PCB/kg tissue ww	mg Homolog PCB/kg lipid tissue ww	dw sediment/ww tissue	toc dw/lipid ww
1	27.0	1436	106	6190	3.9	4.3
2	37.1	1212	60.0	3681	1.6	3.0
11	71.0	1888	137	10748	1.9	5.7
13	14.1	1282	47.2	3152	3.4	2.5
14	28.3	1482	118	8129	4.2	5.5
16	0.0480	18.1	1.92	128	40	7.1
20	3.08	277	23.4	1399	7.6	5.0
23	4.90	236	21.3	1214	4.4	5.2
24	0.270	123	8.01	607	30	4.9
25	26.3	1015	101	3500	3.9	3.4
27	7.23	473	65.9	3615	9.1	7.6
28	0.535	97.0	2.28	178	4.3	1.8
Average	18.3	795	57.8	3545	3.2	4.5
Median					4.2	4.9

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-12
PCB - Crayfish Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment		Tissue		BAF	BSAF
	mg PCB/kg sediment dw	mg PCB/kg toc dw	mg PCB/kg tissue-dw	mg PCB/kg lipid ww	dw sed/dw tissue	toc dw/lipid ww
ELA-01	1.42	168.18	1.06	85.88	0.75	0.51
ELA-02	2.45	379.43	0.67	54.75	0.27	0.14
ELA-03	1.29	206.52	0.77	40.78	0.60	0.20
EMA-01	1.03	221.93	2.61	82.64	2.53	0.37
EMA-02	2.12	218.80	1.48	53.03	0.69	0.24
EMA-03	1.12	69.21	1.50	63.51	1.34	0.92
EUA-01	1.72	380.99	2.21	66.06	1.29	0.17
EUA-02	0.93	265.58	3.11	85.76	3.34	0.32
EUA-03	2.03	225.60	1.29	70.60	0.64	0.31
BSA Average	1.57	237.36	1.63	67.00	1.04	0.28
BSA Median					0.75	0.31

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-13
Mercury - Crayfish Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment mg Hg/kg sediment dw	Tissue mg Hg/kg tissue-dw	BAF dw sed/dw tissue
ELA-01	1.33	0.27	0.20
ELA-02	0.59	0.24	0.40
ELA-03	0.50	0.13	0.27
EMA-01	0.67	0.18	0.27
EMA-02	0.77	0.17	0.22
EMA-03	0.54	0.15	0.28
EUA-01	1.36	0.12	0.09
EUA-02	0.55	0.22	0.40
EUA-03	0.78	0.19	0.24
BSA Average	0.79	0.19	0.24
BSA Median			0.27

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-14
PCB - Mollusk Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

	Sediment		Tissue		BAF	BSAF
BSA	**mg PCB/kg sediment dw**	**mg PCB/kg toc dw**	**mg PCB/kg tissue-dw**	**mg PCB/kg lipid ww**	**dw sed/dw tissue**	**toc dw/lipid ww**
ELA-01	1.42	168.18	9.21	105.40	6.50	0.63
ELA-02	2.45	379.43	11.27	178.04	4.59	0.47
ELA-03	1.29	206.52	11.26	142.78	8.75	0.69
EMA-01	1.03	221.93	5.24	66.14	5.09	0.30
EMA-02	2.12	218.80	6.66	91.91	3.13	0.42
EMA-03	1.12	69.21	11.30	123.72	10.07	1.79
EUA-01	1.72	380.99	7.61	85.21	4.44	0.22
EUA-02	0.93	265.58	14.07	126.47	15.13	0.48
EUA-03	2.03	225.60	13.46	163.94	6.64	0.73
BSA Average	1.57	237.36	10.01	120.40	6.39	0.51
BSA Median					6.50	0.48

Notes:
BSA = biological sampling area
dw = dry weight
toc = total organic carbon
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-15
Mercury - Mollusk Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment mg Hg/kg sediment dw	Tissue mg Hg/kg tissue-dw	BAF dw sed/dw tissue
ELA-01	1.33	0.63	0.47
ELA-02	0.59	0.88	1.50
ELA-03	0.50	0.80	1.61
EMA-01	0.67	0.23	0.34
EMA-02	0.77	0.29	0.38
EMA-03	0.54	0.38	0.71
EUA-01	1.36	0.15	0.11
EUA-02	0.55	0.27	0.49
EUA-03	0.78	0.30	0.39
BSA Average	0.79	0.44	0.56
BSA Median			0.47

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-16

PCB - Frog Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek

Appendix A – Bioaccumulation Factor Development

Anniston PCB Site, Anniston, Alabama

	Sediment		Tissue		BAF	BSAF
BSA	**mg PCB/kg sediment dw**	**mg PCB/kg toc dw**	**mg PCB/kg tissue-dw**	**mg PCB/kg lipid ww**	**dw sed/dw tissue**	**toc dw/lipid ww**
ELA-02	2.45	379.43	5.36	102.23	2.18	0.27
EMA-01	1.03	221.93	3.50	59.18	3.40	0.27
EMA-02	2.12	218.80	3.18	88.07	1.50	0.40
EMA-03	1.12	69.21	3.46	41.66	3.08	0.60
EUA-01	1.72	380.99	16.48	250.23	9.61	0.66
EUA-02	0.93	265.58	6.04	106.39	6.49	0.40
EUA-03	2.03	225.60	20.33	489.06	10.03	2.17
BSA Average	1.63	251.65	8.33	162.40	5.12	0.65
BSA Median					3.40	0.40

Notes:

BSA = biological sampling area

dw = dry weight

toc = total organic carbon

BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)

BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)

ww = wet weight

kg = kilogram(s)

mg = milligram(s)

OU = Operable Unit

PCB = polychlorinated biphenyl

Table A-17
Mercury - Frog Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

BSA	Sediment mg Hg/kg sediment dw	Tissue mg Hg/kg tissue-dw	BAF dw sed/dw tissue
ELA-02	0.59	0.44	0.75
EMA-01	0.67	0.50	0.75
EMA-02	0.77	0.28	0.37
EMA-03	0.54	0.80	1.48
EUA-01	1.36	0.82	0.61
EUA-02	0.55	0.13	0.23
EUA-03	0.78	0.87	1.12
BSA Average	0.75	0.55	0.73
BSA Median			0.75

Notes:
BSA = biological sampling area
dw = dry weight
BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)
BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic
ww = wet weight
kg = kilogram(s)
mg = milligram(s)
OU = Operable Unit

Table A-18

PCB - Snake Tissue Uptake Summary

Streamlined Ecological Risk Assessment for OU-1/OU-2 Portion of Snow Creek

Appendix A – Bioaccumulation Factor Development

Anniston PCB Site, Anniston, Alabama

	Sediment		Tissue		BAF	BSAF
BSA	mg PCB/kg sediment dw	mg PCB/kg toc dw	mg PCB/kg tissue-dw	mg PCB/kg lipid ww	dw sed/dw tissue	toc dw/lipid ww
ELA-01	1.42	168.18	38.09	406.19	26.91	2.42
ELA-02	2.45	379.43	26.08	531.54	10.63	1.40
ELA-03	1.29	206.52	44.59	397.29	34.65	1.92
EMA-01	1.03	221.93	122.30	2438.46	118.65	10.99
EMA-02	2.12	218.80	18.94	250.00	8.91	1.14
EUA-01	1.72	380.99	25.89	114.78	15.10	0.30
EUA-02	0.93	265.58	166.52	6383.33	179.11	24.04
BSA Average	1.57	263.06	63.20	1503.08	40.38	5.71
BSA Median					26.91	1.92

Notes:

BSA = biological sampling area

dw = dry weight

toc = total organic carbon

BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)

BSAF = biota/sediment accumulation factor (ww lipid normalized tissue vs dw organic carbon normalized sediment)

ww = wet weight

kg = kilogram(s)

mg = milligram(s)

OU = Operable Unit

PCB = polychlorinated biphenyl

Table A-19

Mercury - Snake Tissue Uptake Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A – Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

	Sediment	Tissue	BAF
BSA	**mg Hg/kg sediment dw**	**mg Hg/kg tissue-dw**	**dw sed/dw tissue**
ELA-01	1.33	0.95	0.72
ELA-02	0.59	1.89	3.21
ELA-03	0.50	1.32	2.66
EMA-01	0.67	0.54	0.81
EMA-02	0.77	1.70	2.21
EUA-01	1.36	0.88	0.64
EUA-02	0.55	0.61	1.11
BSA Average	0.82	1.13	1.37
BSA Median			1.11

Notes:

BSA = biological sampling area

dw = dry weight

BAF = bioaccumulation factor (dry weight tissue vs dry weight sediment)

carbon normalized sediment)

ww = wet weight

kg = kilogram(s)

mg = milligram(s)

OU = Operable Unit

Table A-20
Sediment and Aquatic Biota Tissue Percent Solids Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Sediment	Sediment TOC	Percent Fines	% Solids Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Lower	ELA-01	ELA-01-55	0.35	2250	51	15.6	30.3	14.3	27.6	5.9	na	23.2
		ELA-01-56	0.19	3020	14	18.0	31.4	15.7	27.7	5.1	na	25.7
		ELA-01-57	0.62	10600	48	15.7	29.6	18.4	28.5	7.9	na	25.5
		ELA-01-58	0.69	16200	56							
		ELA-01-59	6.3	10100	53							
		ELA-01-60	0.58	22200	71							
		HHFL-04	0.38	3640	21							
	ELA-02	ELA-02-61	0.91	24800	40	24.9	37.2	17.2	27.2	8.2	23.2	26.5
		ELA-02-62	0.75	23300	48	23.3	34.2	19.0	27.9	8.1	19.3	na
		ELA-02-63	0.49	2350	41	20.3	30.9	18.5	24.3	6.9	na	na
		ELA-02-64	0.27	660	25							
		ELA-02-65	0.52	13100	27							
		ELA-02-66	0.59	4000	70							
	ELA-03	ELA-03-67	1.6	14300	52	19.3	28.3	17.0	29.3	8.2	na	22.2
		ELA-03-68	0.37	3110	95	21.0	18.8	15.8	27.9	6.9	na	27.7
		ELA-03-69	0.43	9750	76	20.1	29.2	18.9	31.1	7.7	na	25.9
		ELA-03-70	0.16	2090	11							
		ELA-03-71	0.22	620	14							
		ELA-03-72	0.19	1850	73							
Middle	EMA-01	EMA-01-01	0.43	10000	36	20.8	31.0	23.6	26.7	9.8	23.8	25.9
		EMA-01-02	0.61	2270	17	14.5	33.4	22.2	27.0	8.7	25.1	na
		EMA-01-03	0.73	2345	18	22.1	31.4	19.0	na	8.8	na	na
		EMA-01-04	0.74	3940	38							
		EMA-01-05	0.50	11400	46							
		EMA-01-06	0.91	13400	71							
		HHFL-05	0.74	2300	19							
	EMA-02	EMA-02-07	0.65	20100	33	12.6	29.7	22.5	23.8	7.9	18.9	26.4
		EMA-02-08	0.84	3740	18	13.5	32.6	17.1	na	8.2	20.0	na
		EMA-02-09	1.1	12200	22	15.7	39.0	20.2	25.1	9.5	na	na
		EMA-02-10	0.69	19300	49							
		EMA-02-11	0.47	13000	55							
		EMA-02-12	0.87	23500	39							
	EMA-03	EMA-03-31	0.30	3460	16	14.5	31.8	19.3	36.1	8.5	24.6	na
		EMA-03-32	0.43	30300	12	15.2	34.5	15.0	34.3	8.7	24.1	na
		EMA-03-33	0.45	7050	29	14.4	35.7	17.6	40.1	10.2	18.8	na
		EMA-03-34	0.51	4920	27							
		EMA-03-35	0.81	37300	21							
		EMA-03-36	0.75	31300	22							
Upper	EUA-01	EUA-01-19	2.6	4010	16	14.9	30.9	18.4	24.3	7.8	23.8	29.7
		EUA-01-20	0.83	4880	20	17.9	29.6	19.5	25.8	8.6	21.6	na
		EUA-01-21	2.90	3790	7	16.4	31.8	18.6	27.6	8.2	na	na
		EUA-01-22	0.30	3050	51							
		EUA-01-23	0.78	4370	10							
		EUA-01-24	0.75	6360	62							
	EUA-02	EUA-02-43	0.47	5855	86	24.1	27.0	24.2	25.0	8.2	19.6	23.0
		EUA-02-44	0.039	2140	33	22.4	29.4	9.0	29.8	8.2	22.4	na
		EUA-02-45	0.32	2700	73	23.0	32.2	18.0	22.1	8.8	na	na
		EUA-02-46	0.054	7600	69							
		EUA-02-47	1.0	14000	68							
		EUA-02-48	1.3	5380	24							
	EUA-03	EUA-03-25	1.3	6950	14	19.3	31.2	19.6	27.4	8.2	24.7	na
		EUA-03-26	0.91	4560	18	18.8	33.2	18.4	na	8.2	19.4	na
		EUA-03-27	0.27	10700	10	18.6	30.9	23.6	na	10.8	18.7	na
		EUA-03-28	0.35	4160	9							
		EUA-03-29	0.86	4790	46							
		EUA-03-30	1.0	630	15							

Table A-20

Sediment and Aquatic Biota Tissue Percent Solids Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek

Appendix A - Bioaccumulation Factor Development

Anniston PCB Site, Anniston, Alabama

EDR	BSA	Sediment Location	Sediment	Sediment TOC	Percent Fines	% Solids						
						Aquatic Plants	Emergent Insects	Benthic Invertebrates	Crayfish	Mollusks	Frog	Snake
Reference	ERA-01	ERA-01-49	0.007	2450	13	20.2	32.0	17.5	na	10.4	na	26.2
		ERA-01-50	0.024	16200	73	21.2	31.8	22.2	na	10.4	na	25.2
		ERA-01-51	0.007	575	28	21.4	28.2	16.7	na	8.8	na	23.4
		ERA-01-52	0.008	610	34							
		ERA-01-53	0.008	2360	29							
		ERA-01-54	0.014	26000	64							
	ERA-02	ERA-02-13	0.006	7340	7	20.1	28.0	19.5	24.3	7.3	19.7	23.9
		ERA-02-14	0.013	26700	38	23.2	26.6	21.4	29.4	6.5	17.6	na
		ERA-02-15	0.034	36200	15	16.8	33.2	17.2	24.5	9.0	na	na
		ERA-02-16	0.008	6830	55							
		ERA-02-17	0.008	3580	16							
		ERA-02-18	0.008	5180	30							
	ERA-03	ERA-03-37	0.11	128000	7	20.2	27.2	15.9	na	6.5	21.1	30.6
		ERA-03-38	0.032	34600	30	21.9	30.0	15.7	na	7.4	na	29.6
		ERA-03-39	0.041	26500	10	21.8	30.6	15.7	na	7.6	na	na
		ERA-03-40	0.007	2480	9							
		ERA-03-41	0.007	5320	6							
		ERA-03-42	0.041	48300	35							

General Note:

Red text indicates value is shown at half the reporting limit

Acronyms and Abbreviations:

BSA = biological sampling area
EDR = ecologically distinct reach
mg/kg = milligrams per kilogram
na = no sample aquired in specified area
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-21

Correlation Analysis of PCBs in Sediment and Biotic Tissues - r^2 Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek

Anniston PCB Site, Anniston, Alabama

Tissue Type	Measure	Sediment Measurement			
		Aroclor - DW	Homolog - DW	Aroclor TOC Normal - DW	Aroclor Fines Normal - DW
Aquatic Plants	DW	0.03	0.23	0.00	0.20
	WW	0.00	0.02	0.01	0.03
	Lipid Normal - WW	0.07	0.27	0.00	0.23
Emergent Insects	DW	0.01	0.06	0.00	0.04
	WW	0.00	0.06	0.00	0.03
	Lipid Normal - WW	0.02	0.06	0.00	0.06
Benthic Invertebrates	DW	0.00	0.24	0.00	0.33 (0.11)
	WW	0.03	0.25	0.00	0.50 (0.03)
	Lipid Normal - WW	0.00	0.24	0.03	0.18
Crayfish	DW	*0.33*	0.24	0.01	0.02
	WW	*0.47*	0.28	0.00	0.04
	Lipid Normal - WW	0.21	*0.57*	0.01	0.18
Mollusks	DW	0.00	0.01	0.00	0.11
	WW	0.00	0.01	0.01	0.03
	Lipid Normal - WW	0.19	0.00	0.02	0.01
Frogs	DW	0.09	0.02	0.11	0.05
	WW	0.08	0.03	0.12	0.06
	Lipid Normal - WW	0.14	0.00	0.05	0.04
Snakes	DW	*0.61*	*0.40*	0.04	*0.39*
	WW	*0.62*	*0.45*	0.03	*0.38*
	Lipid Normal - WW	*0.40*	0.21	0.00	0.26

DW = dry weight WW = wet weight TOC - total organic carbon

Red values indicate that regression showed a negative correlation (See Figure A-26)

r^2 = the coefficient of determination

Highlighted cells indicate an r^2 value $\geq$ 0.3 and a p value < 0.1

(p values in parenthesis) - p value of 0.1 indicates statistical significance at a probability of 90%

p values calculated only for positive correlations with r^2 > 0.3

Table A-22
Correlation Analysis of log PCBs in Sediment and Biotic Tissues - r^2 Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Tissue Type	Measure	Sediment Measurement			
		Aroclor - DW	Homolog - DW	Aroclor TOC Normal - DW	Aroclor Fines Normal - DW
Aquatic Plants	DW	0.00	0.01	0.00	0.04
	WW	0.01	0.00	0.03	0.01
	Lipid Normal - WW	0.00	0.03	0.00	0.06
Emergent Insects	DW	0.01	0.00	0.03	0.04
	WW	0.00	0.00	0.02	0.03
	Lipid Normal - WW	0.01	0.00	0.03	0.05
Benthic Invertebrates	DW	0.00	0.10	0.01	0.20
	WW	0.01	0.04	0.00	0.37 (0.08)
	Lipid Normal - WW	0.00	0.32 (0.24)	0.01	0.12
Crayfish	DW	*0.38*	0.20	0.00	0.01
	WW	*0.46*	0.19	0.03	0.02
	Lipid Normal - WW	0.17	*0.61*	0.00	0.12
Mollusks	DW	0.00	0.08	0.01	0.06
	WW	0.00	0.05	0.03	0.01
	Lipid Normal - WW	0.13	0.15	0.00	0.00
Frogs	DW	0.14	0.00	0.19	0.04
	WW	0.08	0.01	0.17	0.03
	Lipid Normal - WW	0.24	0.03	0.31 (0.19)	0.08
Snakes	DW	*0.84*	*0.58*	0.04	*0.60*
	WW	*0.84*	*0.62*	0.03	*0.55*
	Lipid Normal - WW	*0.53*	*0.37*	0.02	*0.47*

DW = dry weight WW = wet weight TOC - total organic carbon

Red values indicate that regression showed a negative correlation (See Figure A-27)

r^2 = the coefficient of determination

Highlighted cells indicate an r^2 value $\geq$ 0.3 and a p value < 0.1

(p values in parenthesis) - p value of 0.1 indicates statistical significance at a probability of 90%

p values calculated only for positive correlations with r^2 > 0.3

Table A-23

Correlation Analysis of Mercury in Sediment and Biotic Tissues - r^2 Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Tissue Type	Measure	Sediment Measurement	
		Hg - DW	Hg Fines Normal - DW
Aquatic Plants	DW	0.16	0.09
	WW	0.17	0.13
Emergent Insects	DW	0.01	0.01
	WW	0.01	0.01
Benthic Invertebrates	DW	0.14	*0.43*
	WW	0.16	*0.37*
Crayfish	DW	0.01	0.22
	WW	0.00	0.27
Mollusks	DW	0.06	0.27
	WW	0.17	*0.31*
Frogs	DW	0.21	0.35 (0.16)
	WW	0.26	0.40 (0.12)
Snakes	DW	0.05	0.05
	WW	0.02	0.01

Notes:

DW = dry weight WW = wet weight

Red values indicate that regression showed a negative correlation (See Figure A-28)

r^2 = the coefficient of determination

(p values in parenthesis) - p value of 0.1 indicates 90% probability that the slope of the regression is significantly different from zero

p values calculated only for positive correlations with $r^2 > 0.3$

Table A-24
Correlation Analysis of log Mercury in Sediment and Biotic Tissues - r^2 Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Anniston PCB Site, Anniston, Alabama

Tissue Type	Measure	Sediment Measurement	
		Hg - DW	Hg Fines Normal - DW
Aquatic Plants	DW	0.23	0.19
	WW	0.14	0.17
Emergent Insects	DW	0.00	0.00
	WW	0.00	0.00
Benthic Invertebrates	DW	0.14	*0.50*
	WW	0.14	*0.31*
Crayfish	DW	0.00	0.17
	WW	0.01	0.20
Mollusks	DW	0.13	*0.45*
	WW	0.25	*0.51*
Frogs	DW	0.28	0.46 (0.09)
	WW	0.20	0.46 (0.10)
Snakes	DW	0.01	0.02
	WW	0.00	0.00

Notes:
DW = dry weight WW = wet weight
Red values indicate that regression showed a negative correlation (See Figure A-29)
r^2 = the coefficient of determination
Highlighted cells indicate an r^2 value $\geq$ 0.3 and a p value < 0.1
(p values in parenthesis) - p value of 0.1 indicates 90% probability that the slope of the regression is significantly different from zero
p values calculated only for positive correlations with r^2 > 0.3

Table A-25
Sediment and Aquatic Biota Tissue for Metals Data and BAF Calculation Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Evaluation Technical Memorandum
Anniston PCB Site, Anniston, Alabama

Sample ID	Measured Concentrations (mg/kg) (dw)						
	Barium	Chromium	Cobalt	Lead	Manganese	Nickel	Vanadium
Sediment							
ELA-01	18.95	8.15	2.45	7.05	146	2.30	5.05
ELA-02	26.90	8.50	3.40	8.40	110	3.20	5.30
EMA-01	33.00	7.60	3.50	8.00	271	3.80	5.00
EMA-03	33.90	7.60	2.30	4.30	171	2.40	3.40
EUA-02	82.90	16.90	7.00	13.90	397	4.40	17.20
EUA-03	35.10	18.10	4.10	10.40	354	5.00	7.40
ERA-01	90.90	8.30	8.50	12.60	245	6.20	11.00
ERA-03	84.70	30.90	14.90	12.60	537	11.90	34.30
HHFL-04	14.30	13.60	3.90	9.20	86	3.40	7.60
HHFL-05	24.10	6.30	2.55	5.95	217	2.25	3.15
C-005-SED-2	47.50	20.80	10.50	10.20	519	9.20	9.40
ECO-REF-01	42.80	4.50	3.90	6.20	45	3.70	6.30
ECO-REF-02	110.00	8.20	8.10	11.60	442	6.40	11.40
ECO-REF-03	24.80	26.60	6.70	8.00	248	8.40	17.30
Average	47.85	13.29	5.84	9.17	271	5.18	10.27
Aquatic Plants							
ELA-01	66	1.15	2.87	1.78	1274	0.64	1.15
EMA-03	50	3.1	34.72	3.96	861	0.97	1.94
EUA-02	70	FALSE	20.75	7.05	1012	0.18	1.49
ERA-03	118	4.6	5.02	1.92	1648	2.4	6.85
Average	76	2.9	15.8	3.7	1199	1.1	2.9
Ratio of Means BAF	**1.6**	**0.22**	**2.71**	**0.40**	**4.43**	**0.20**	**0.28**
Emergent Insects							
ELA-03	5.1	13	0.28	0.45	31	7.5	0.3425
EMA-02	11	12	15.3	0.67	102	7.4	0.58
EUA-02	4.4	6.8	17.0	0.29	18	1.6	6.8
ERA-01	9.2	3.1	0.082	0.28	25	1.7	0.31
Average	7.5	8.7	8.2	0.42	44	4.6	2.01
Ratio of Means BAF	**0.16**	**0.66**	**1.40**	**0.05**	**0.16**	**0.9**	**0.196**
Benthic Invertebrates							
ELA-03	37	3.2	31.6	3.6	709	1.8	2.2
EMA-03	37	3.9	4.3	5.0	1620	2.3	2.5
EUA-02	60	3.3	4.4	6.0	3589	2.8	2.6
ERA-01	29	1.6	2.4	1.6	1090	1.3	1.7
Average	41	3.0	10.7	4.0	1752	2.0	2.2
Ratio of Means BAF	**0.86**	**0.23**	**1.83**	**0.44**	**6.5**	**0.39**	**0.22**

Table A-25
Sediment and Aquatic Biota Tissue for Metals Data and BAF Calculation Summary

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Evaluation Technical Memorandum
Anniston PCB Site, Anniston, Alabama

Sample ID	Measured Concentrations (mg/kg) (dw)						
	Barium	Chromium	Cobalt	Lead	Manganese	Nickel	Vanadium
Crayfish							
ELA-01	107	7.2	18.1	0.94	402	0.054	7.2
EUA-02	162	8.0	20.0	1.8	584	0.072	8.0
EUA-03	199	1.4	18.2	3.3	1026	0.58	1.4
Average	156	5.5	18.8	2.0	671	0.237	5.5
Ratio of Means BAF	**3.3**	**0.42**	**na**	**0.22**	**2.5**	**na**	**0.54**
Mollusks							
ELA-03	34	14	3.6	3.7	169	4.3	1.5
EMA-03	27	9.6	3.9	4.5	172	2.1	1.9
EUA-01	35	9.4	3.5	3.6	237	1.7	1.9
ERA-03	42	6.2	5.9	1.7	511	4.1	5.5
Average	34	9.7	4.2	3.4	272	3.1	2.7
Ratio of Means BAF	**0.72**	**0.73**	**0.72**	**0.37**	**1.0**	**0.59**	**0.26**
Frog							
ELA-03	9.91	9.01	22.52	0.77	40.54	0.090	9.01
ERA-01	8.78	1.45	0.38	0.27	36.26	0.076	0.57
Average	9.34	5.23	11.45	0.52	38.40	0.083	4.79
Ratio of Means BAF	**0.20**	**0.39**	**1.96**	**0.06**	**0.14**	**na**	**0.47**
Snake							
EUA-01	44	7.1	1.6	2.6	592	3.3	1.0
EUA-01a	44	18	1.4	4.1	150	8.8	1.6
Average	44	12.6	1.5	3.4	371	6.0	1.3
Ratio of Means BAF	**0.92**	**0.95**	**0.26**	**0.37**	**1.37**	**1.16**	**0.13**

Notes:
Red text indicates value is shown at half the reporting limit

Acronyms and Abbreviations:
BAF = bioaccumulation factor
mg/kg = milligram/kilogram
OU = Operable Unit
PCB = polychlorinated biphenyl

Table A-26
Summary of OU-1/OU-2 Bioaccumulation Factors

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix A - Bioaccumulation Factor Development
Anniston PCB Site, Anniston, Alabama

Constituent	Sediment to Aquatic Plants	Sediment to Emergent Insects	Sediment to Benthic Invertebrates*	Sediment to Crayfish	Sediment to Mollusks	Sediment to Frog	Sediment to Snake
tPCB	0.42	3.8	0.92	0.75	6.50	3.40	26.91
Barium	1.59	0.16	0.86	3.26	0.72	0.20	0.92
Chromium	0.22	0.66	0.23	0.42	0.73	0.39	0.95
Cobalt	2.71	1.40	1.83	*0.72*	0.72	1.96	0.26
Lead	0.40	0.05	0.44	0.22	0.37	0.06	0.37
Manganese	4.43	0.16	6.48	2.48	1.01	0.14	1.37
Mercury	0.11	0.25	0.39	0.27	0.47	0.75	1.11
Nickel	0.20	0.88	0.39	*0.59*	0.59	*1.16*	1.16
Vanadium	0.28	0.20	0.22	0.54	0.26	0.47	0.13

General Notes:

* PCB uptake also evaluated based on the regression equation from the laboratory data analysis (see Appendix A)

Equation based on log normalized sediment dry and tissue dry weight (log (tissue concentration dw) = 0.6272*(log sediment PCBdw)+1.0224

BAFs calculated as dry weight tissue to dry weight sediment.

Values shown in italics could not be computed because all the tissue samples were non detected. For crayfish, mollusk value used as a surrogate. For frogs, snake value used as a surrogate

Acronyms and Abbreviations:

BAF = bioaccumulation factor

OU = Operable Unit

PCB = polychlorinated biphenyl

tPCB = total polychlorinated biphenyl

ARCADIS

Figures

LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10

APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

100-YR FLOODPLAIN

CREEK

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

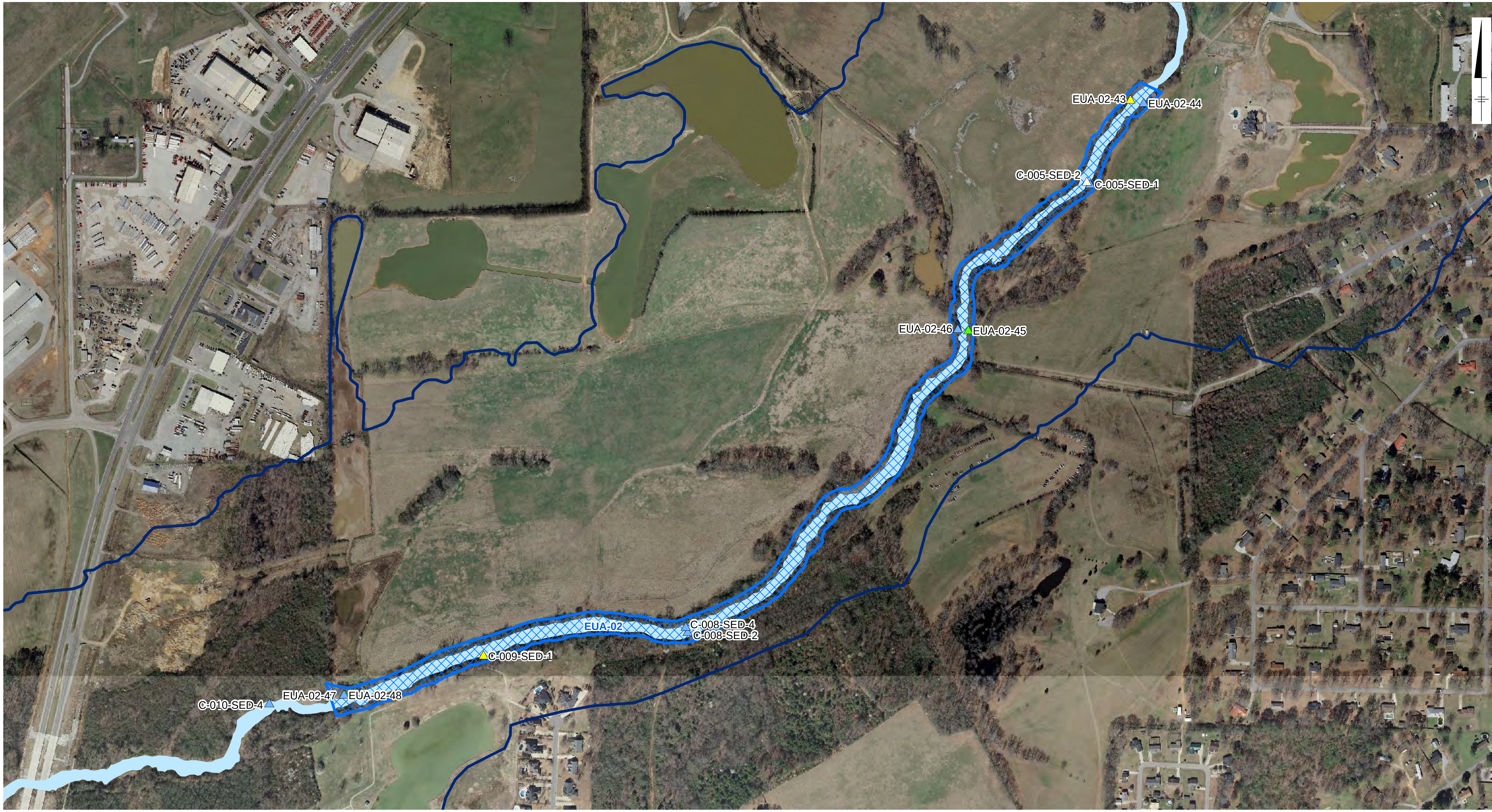
GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
UPPER EDR: EUA-01

FIGURE
A-1

CITY: ROCH DIV/GROUP: 40 DB: LD: EAL PIC: AF PM: TM: MS TR:
Anniston
Q:\Anniston_PCB_Site\AnnistonAL\MXDs_Printfiles\Reports\OU1_2_SERA_2013\mxd\EcoFigs1.mxd - 2/11/2013 @ 7:13:30 PM



LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION
PCB RESULT IN DEPTHS 0 - 6 IN

- △ NO PCB RESULT
- ▲ < 1.0
- ▲ 1.0 - 2.0
- ▲ 2.0 - 5.0
- ▲ 5.0 - 10
- ▲ > 10

- APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING
- 100-YR FLOODPLAIN
- CREEK

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
UPPER EDR: EUA-02

Solutia

FIGURE
A-2

City: ROCH Div/Group: 40 Created By: EAL Last Saved By: kives
Anniston
Q:\Anniston_PCB_Site\AnnistonAL\MXDs_Printfiles\Reports\OU1_2_SERA_2013\mxd\EcoFigs2.mxd 4/2/2013 12:05:31 PM

LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- ▲ < 1.0
- ▲ 1.0 - 2.0
- ▲ 2.0 - 5.0
- ▲ 5.0 - 10
- ▲ > 10
- APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING
- 100-YR FLOODPLAIN
- CREEK

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
UPPER EDR: EUA-03

Solutia

FIGURE
A-3

LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10

APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

100-YR FLOODPLAIN

CREEK

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
MIDDLE EDR: EMA-01, EMA-02, EMA-03

Solutia

FIGURE
A-4

CITY: ROCH DIV/GROUP: 40 DB: LD: EAL PIC: AF PM: TM: MS TR:
Anniston
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LEGEND:
OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION
PCB RESULT IN DEPTHS 0 - 6 IN
- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10

APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING
100-YR FLOODPLAIN
CREEK

NOTE:
1. BSA = BIOLOGICAL SAMPLING AREA
EDR = ECOLOGICALLY DISTINCT DISTRICT
OU = OPERABLE UNIT

0 500 1,000 Feet
GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
LOWER EDR: ELA-01

Solutia

FIGURE
A-5

CITY: ROCH DIV/GROUP: 40 DB: LD: EAL PIC: AF PM: TM: MS TR:
Anniston
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LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10

APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

100-YR FLOODPLAIN

CREEK

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

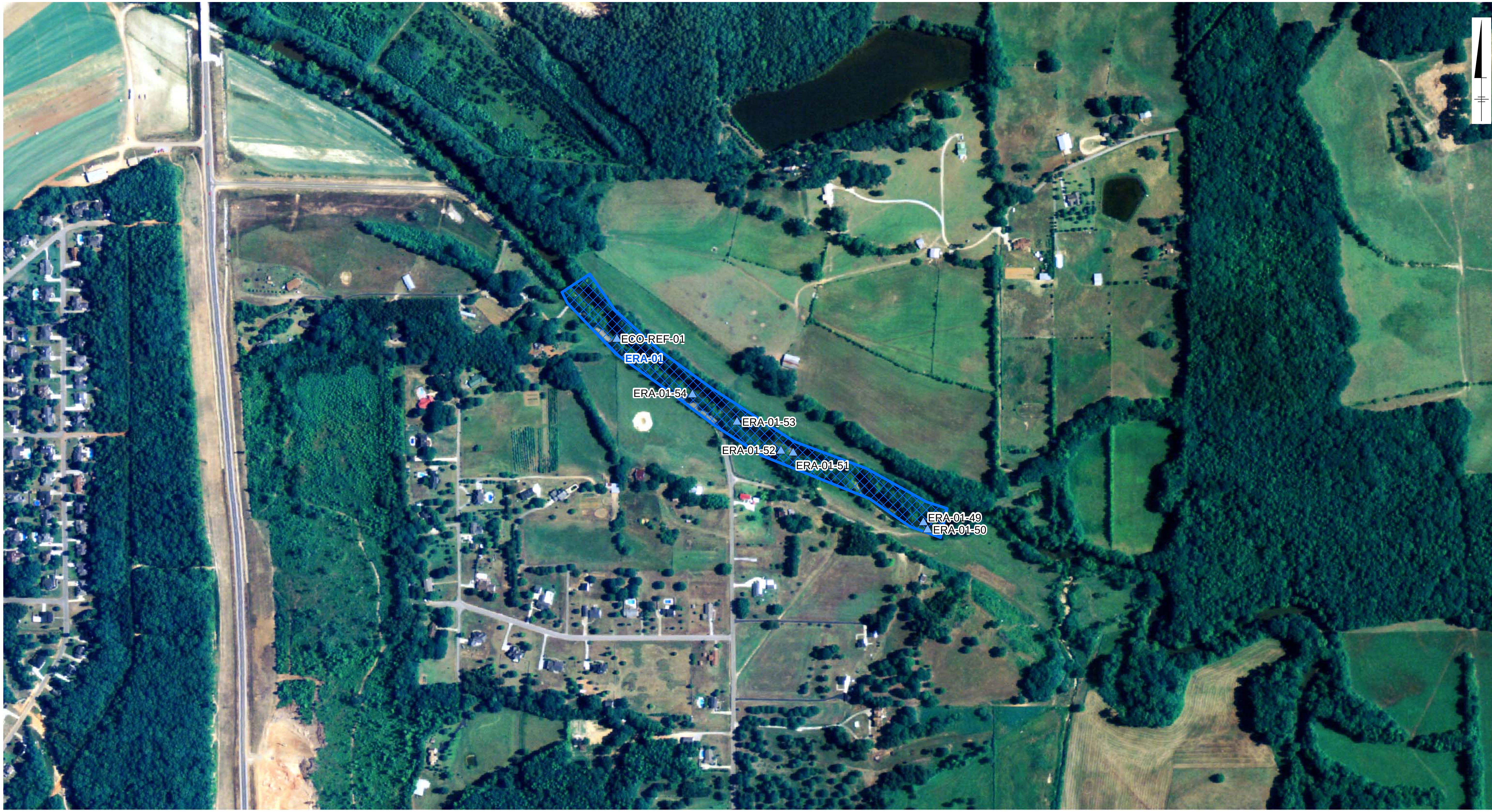
GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
LOWER EDR: ELA-02, ELA-03

FIGURE
A-6

CITY: ROCH DIV/GROUP: 40 DB: LD: EAL PIC: AF PM: TM: MS TR:
Anniston
Q:\Anniston PCB Site\AnnistonAL\MXDs Printfiles\Reports\OU1 2 SERA 2013\mxd\EcoFigs6.mxd - 2/11/2013 @ 7:18:08 PM



LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10
- APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
REFERENCE AREA 1: ERA-01

Solutia

FIGURE
A-7

City: SYR Div/Group: SWG Created By: K.Ives Last Saved By: kives
Anniston
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LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION
PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10

APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
REFERENCE AREA 2: ERA-02

Solutia

FIGURE
A-8

City: SYR Div/Group: SWG Created By: K.Ives Last Saved By: kives
Anniston
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LEGEND:

OU-4 PHASE II ECOLOGICAL SEDIMENT SAMPLE LOCATION

PCB RESULT IN DEPTHS 0 - 6 IN

- < 1.0
- 1.0 - 2.0
- 2.0 - 5.0
- 5.0 - 10
- > 10
- APPROXIMATE AREA OF AQUATIC BSA - OU-4 PHASE II ECOLOGICAL SAMPLING

NOTE:

1. BSA = BIOLOGICAL SAMPLING AREA
   EDR = ECOLOGICALLY DISTINCT DISTRICT
   OU = OPERABLE UNIT

0 500 1,000 Feet

GRAPHIC SCALE

ANNISTON PCB SITE
ANNISTON, ALABAMA
STREAMLINED ECOLOGICAL RISK ASSESSMENT
FOR OU-1/OU-2 PORTION OF SNOW CREEK
APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

BIOLOGICAL SAMPLE AREA
REFERENCE AREA 3: ERA-03

Solutia

FIGURE **A-9**

City: SYR Div/Group: SWG Created By: K.Ives Last Saved By: kives
Anniston
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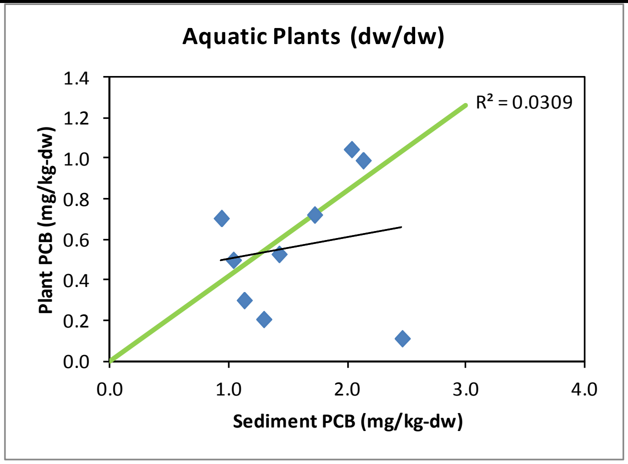
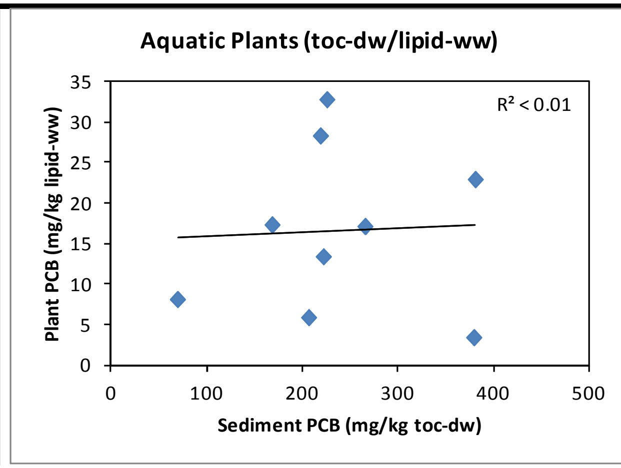
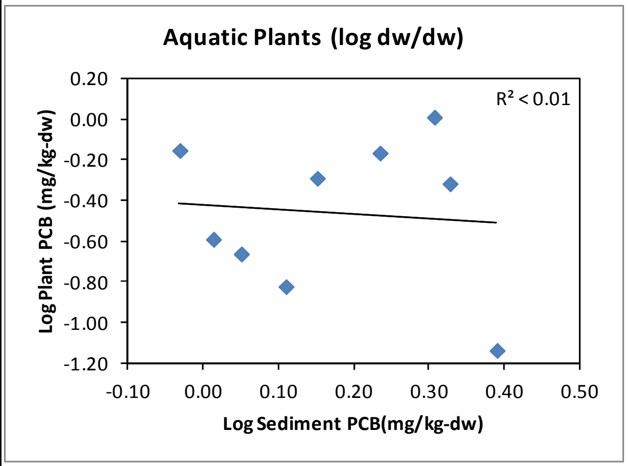
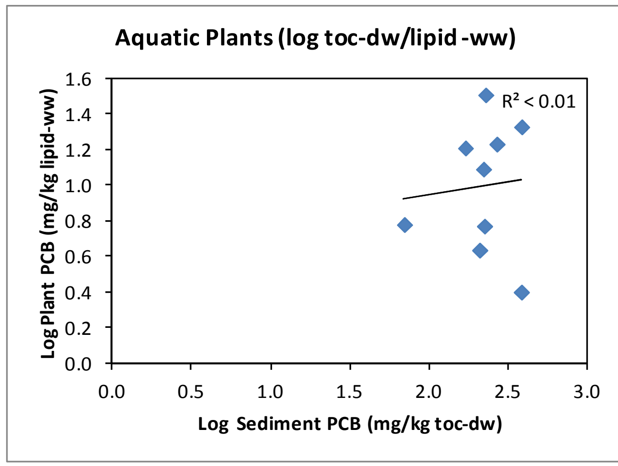








represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

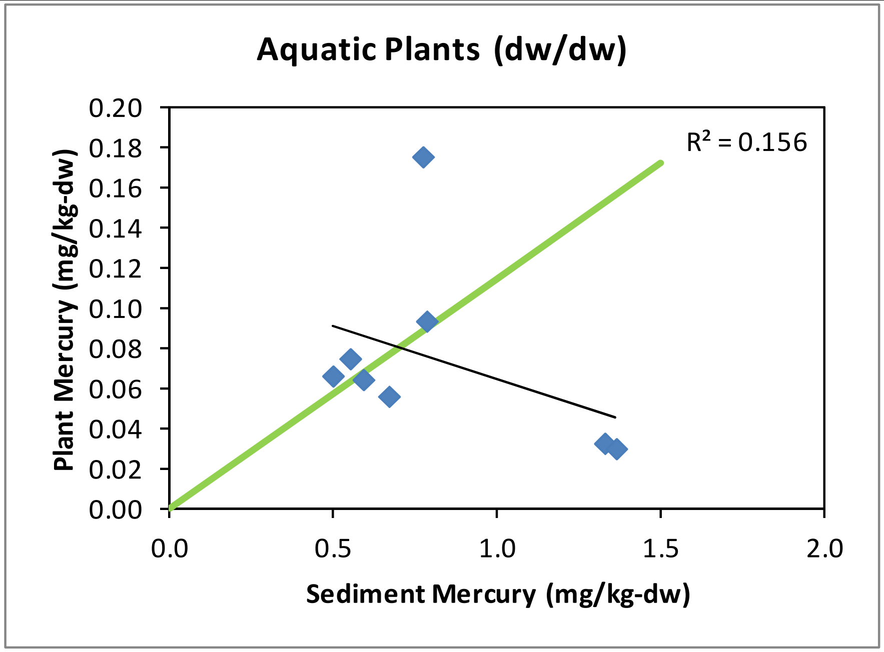
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

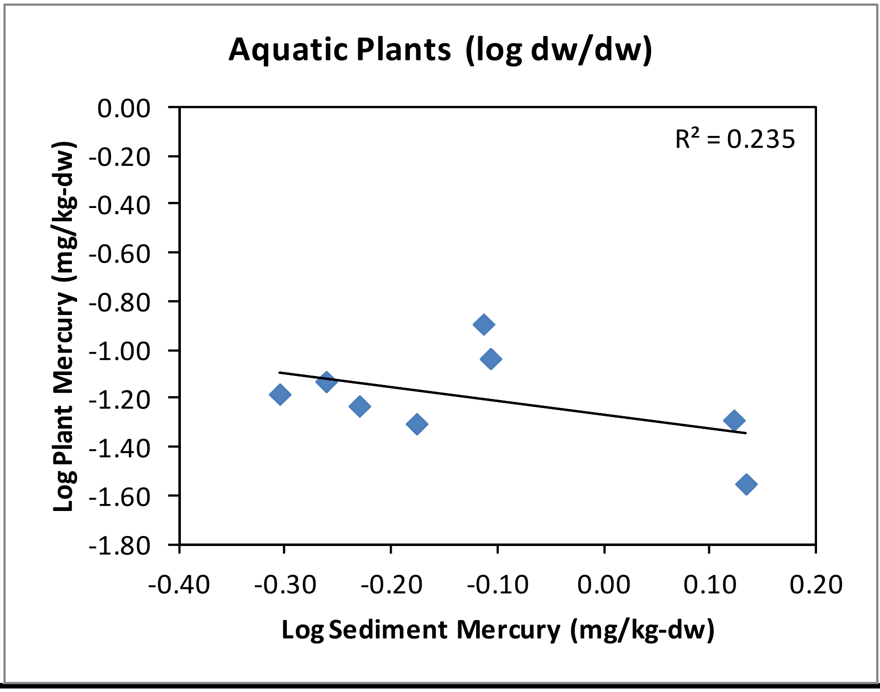
PCB - AQUATIC PLANT - REGRESSION ANALYSIS

Solutia

FIGURE

A-10





represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

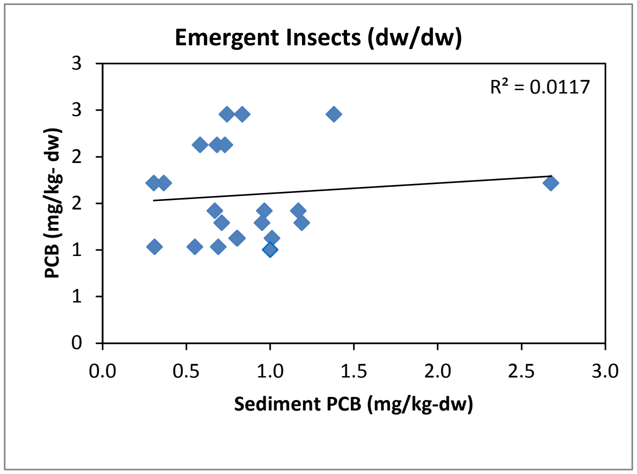
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

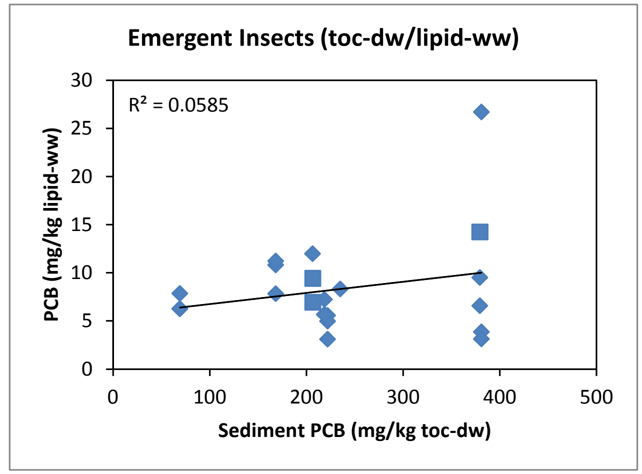
MERCURY - AQUATIC PLANT - REGRESSION ANALYSIS

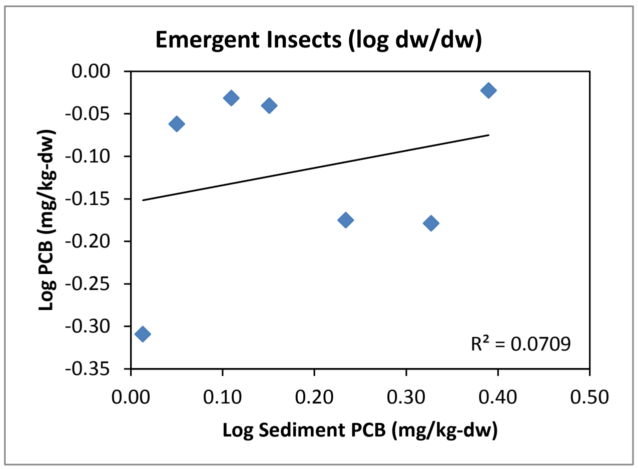
Solutia

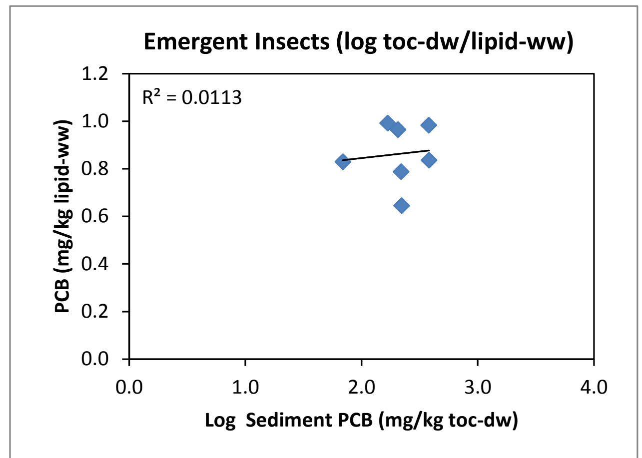
FIGURE

A-11









* Data for emergent insects was divided into two populations (crane fly only and mixed species), therefore regressions represent the mixed species population of emergent insects.

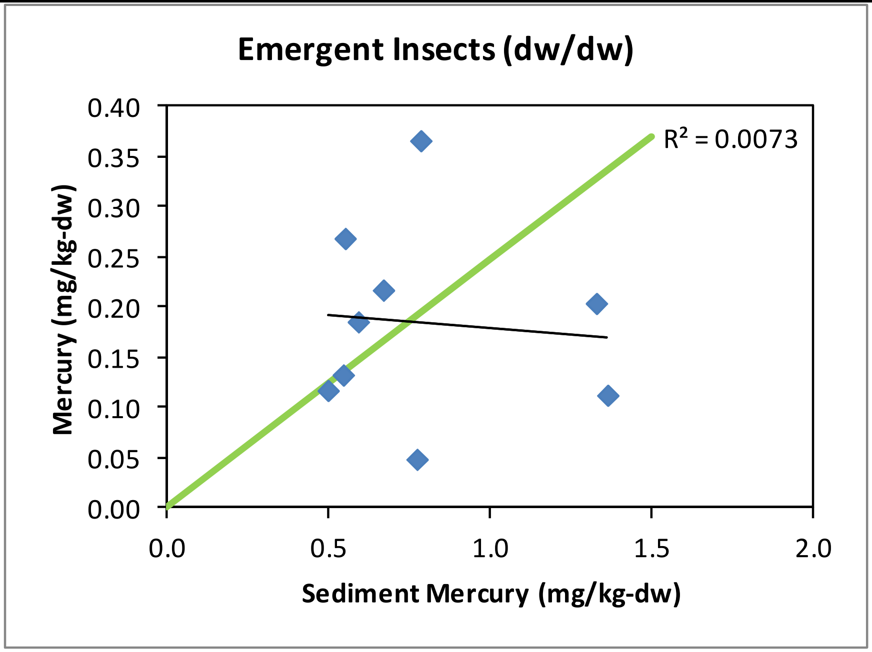
ANNISTON PCB SITE
ANNISTON , ALABAMA

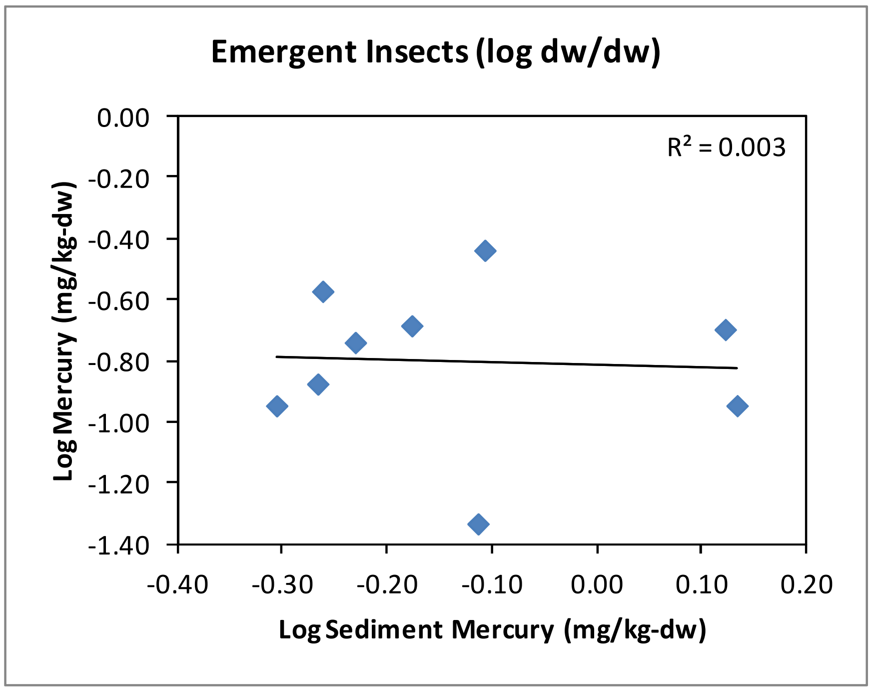
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

PCB - EMERGENT INSECT* - REGRESSION ANALYSIS

Solutia

FIGURE
A-12





represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

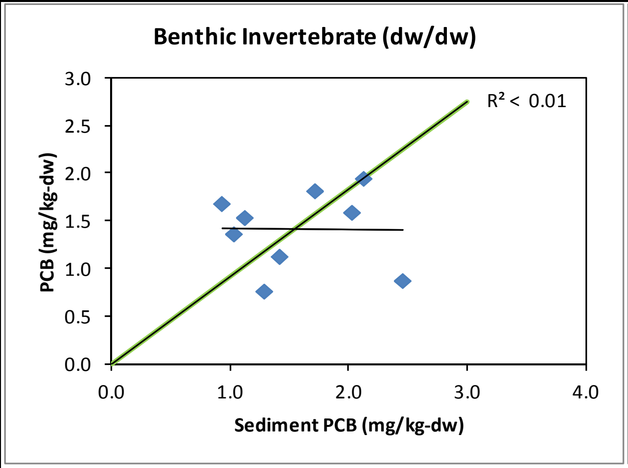
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

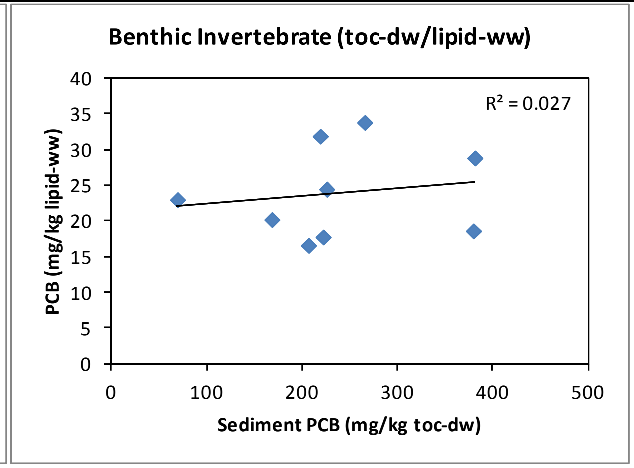
MERCURY - EMERGENT INSECT - REGRESSION ANALYSIS

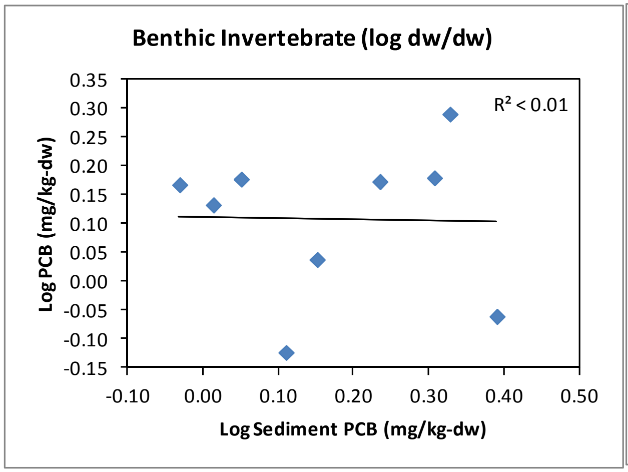
Solutia

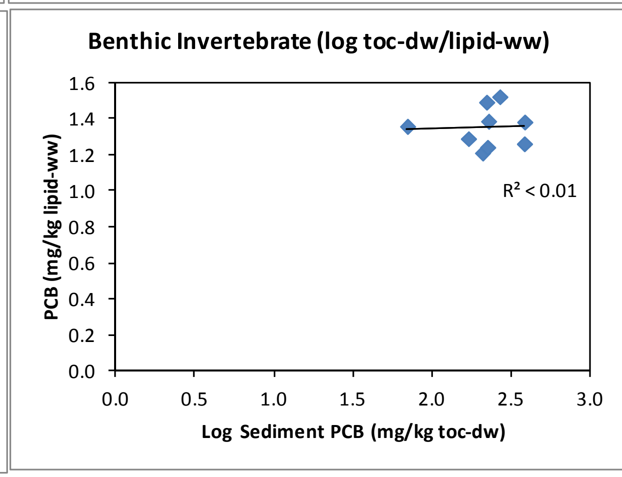
FIGURE

A-13









represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

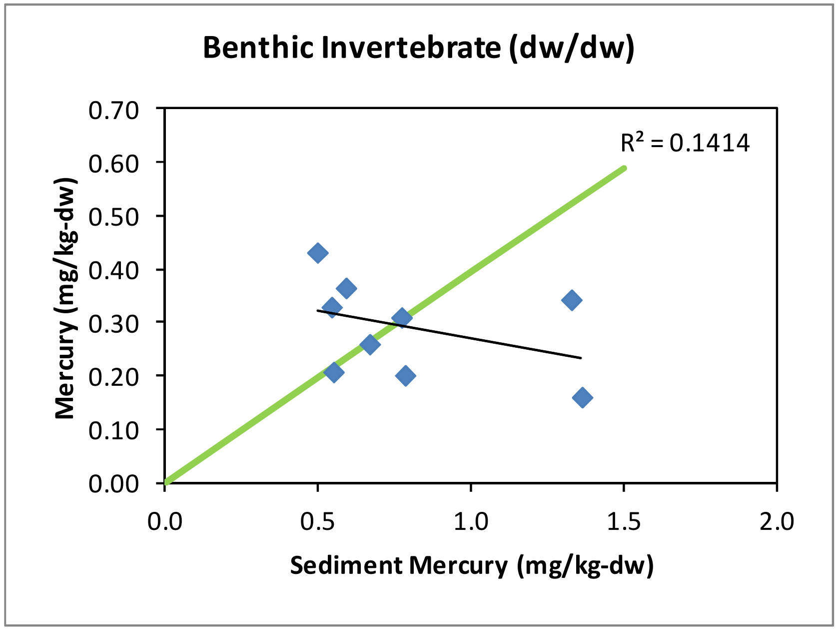
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

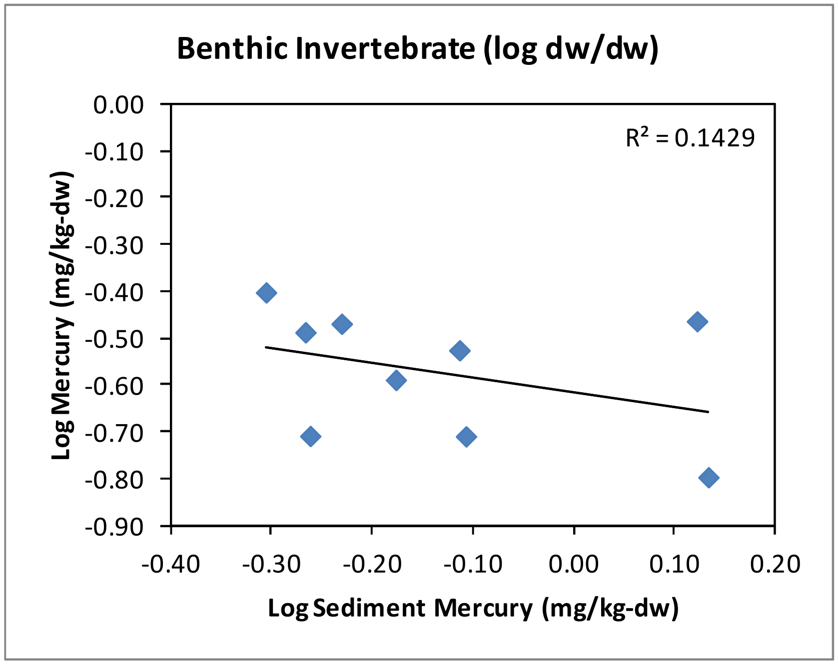
PCB - BENTHIC INVERTEBRATE - REGRESSION ANALYSIS

Solutia

FIGURE

A-14





represents the selected median BAF

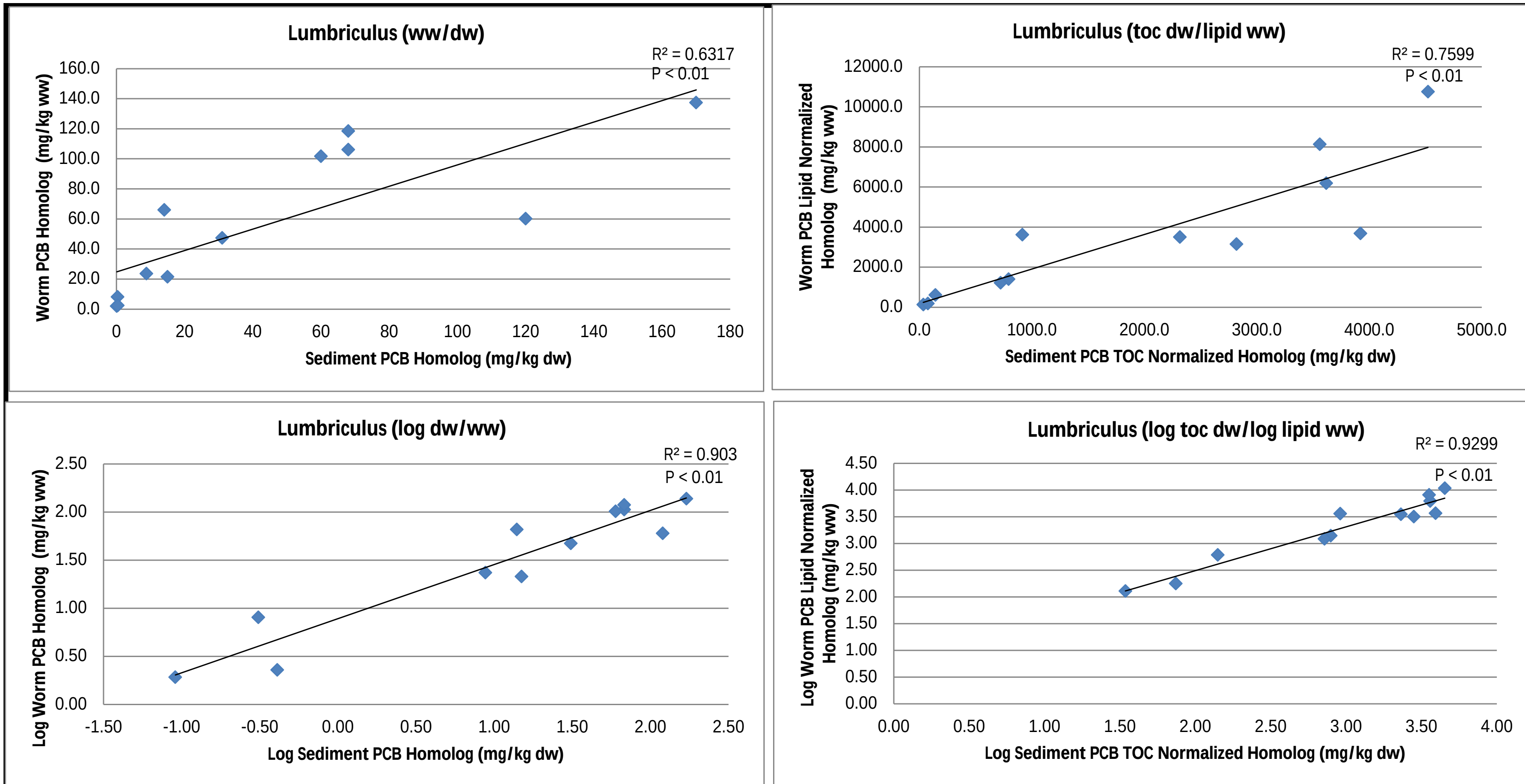
ANNISTON PCB SITE
ANNISTON , ALABAMA

STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

MERCURY - BENTHIC INVERTEBRATE - REGRESSION ANALYSIS

Solutia

FIGURE
A-15



ANNISTON PCB SITE

ANNISTON , ALABAMA

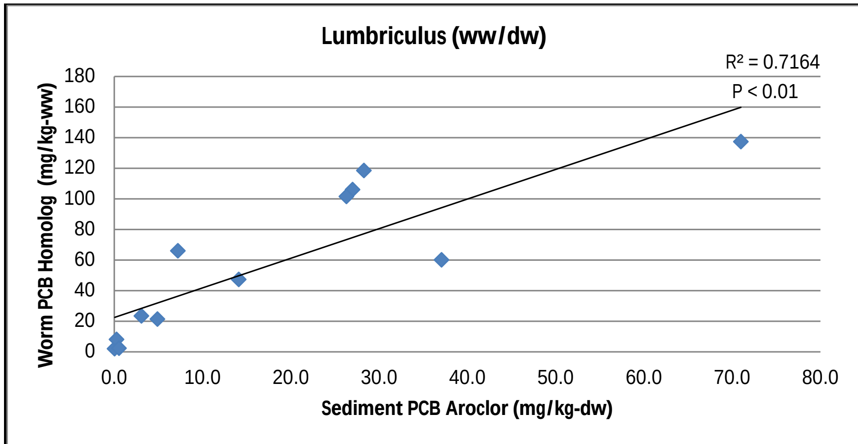
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

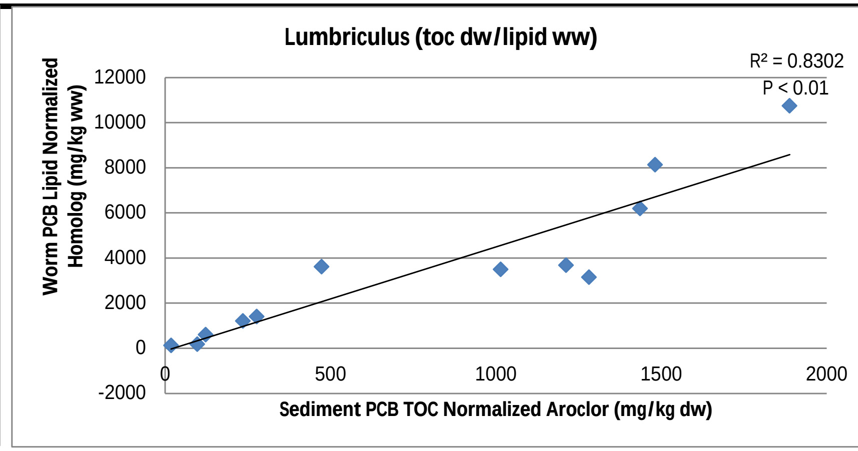
PCB – REGRESSION ANALYSIS OF LABORATORY BIOACCUMULATION DATA (SEDIMENT AND TISSUE MEASURED AS HOMOLOGUES)

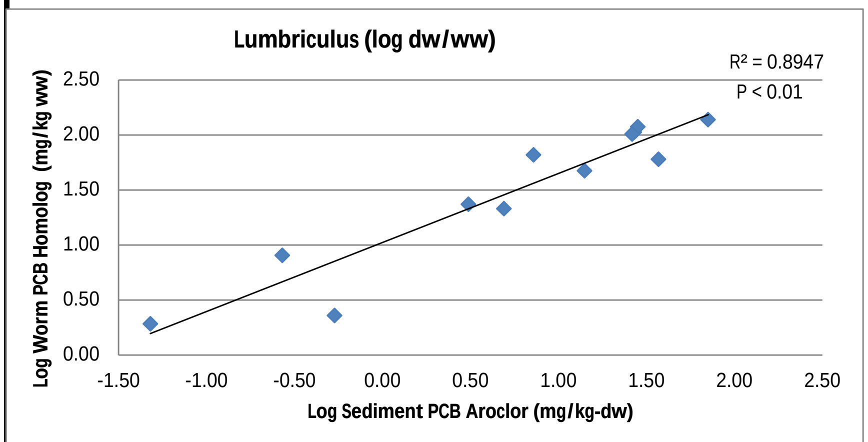
Solutia

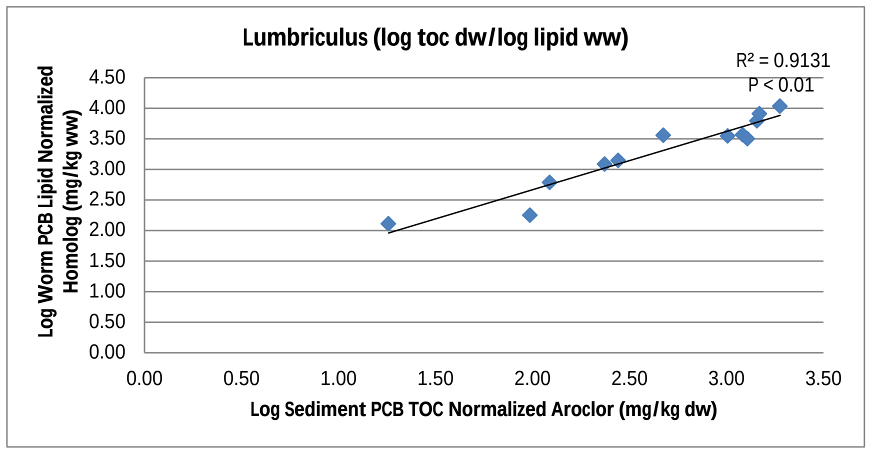
FIGURE

A-16









ANNISTON PCB SITE

ANNISTON , ALABAMA

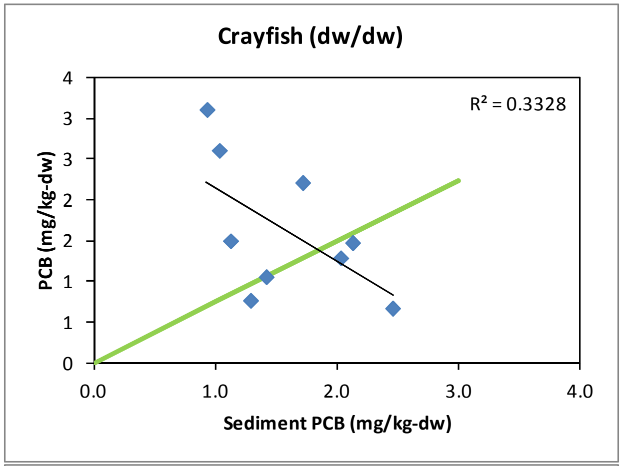
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

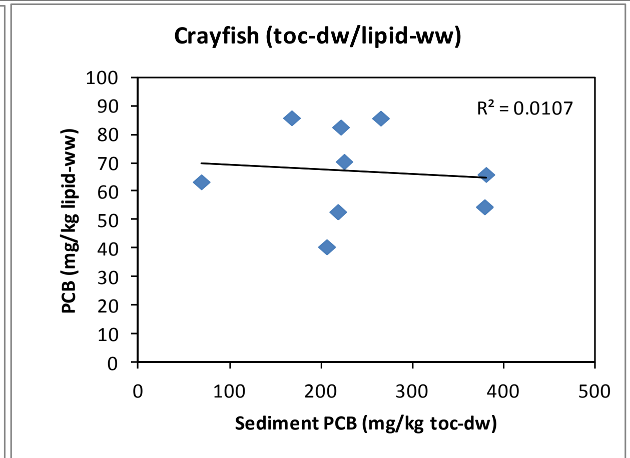
PCB – REGRESSION ANALYSIS OF LABORATORY BIOACCUMULATION DATA (SEDIMENT MEASURED AS AROCLORS AND TISSUE AS HOMOLOGUES)

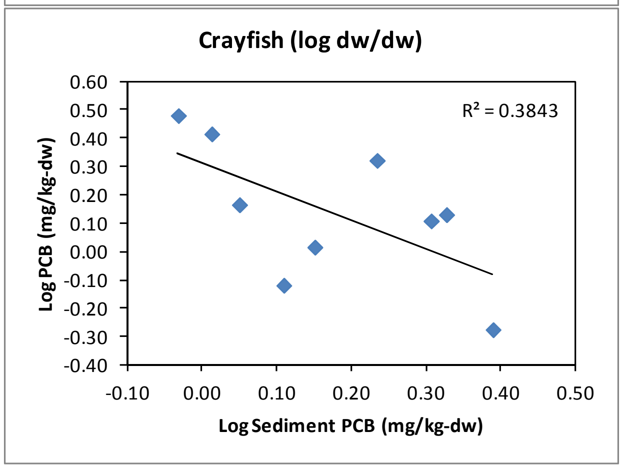
Solutia

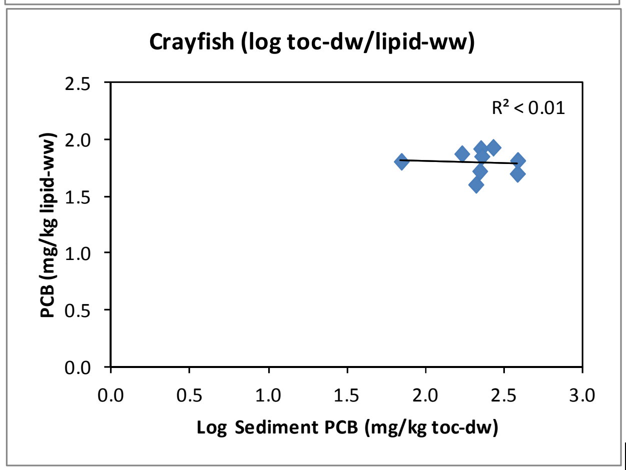
FIGURE

A-17









represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

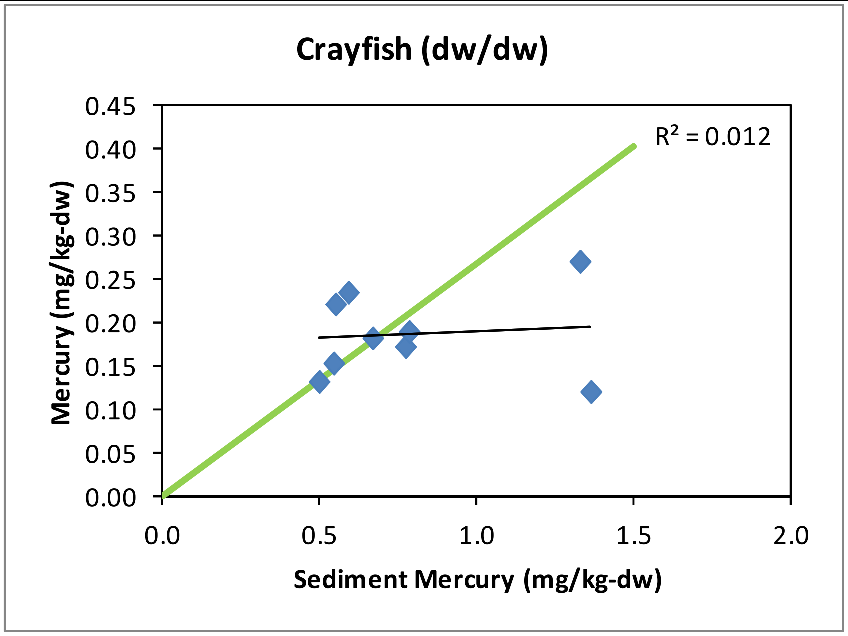
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

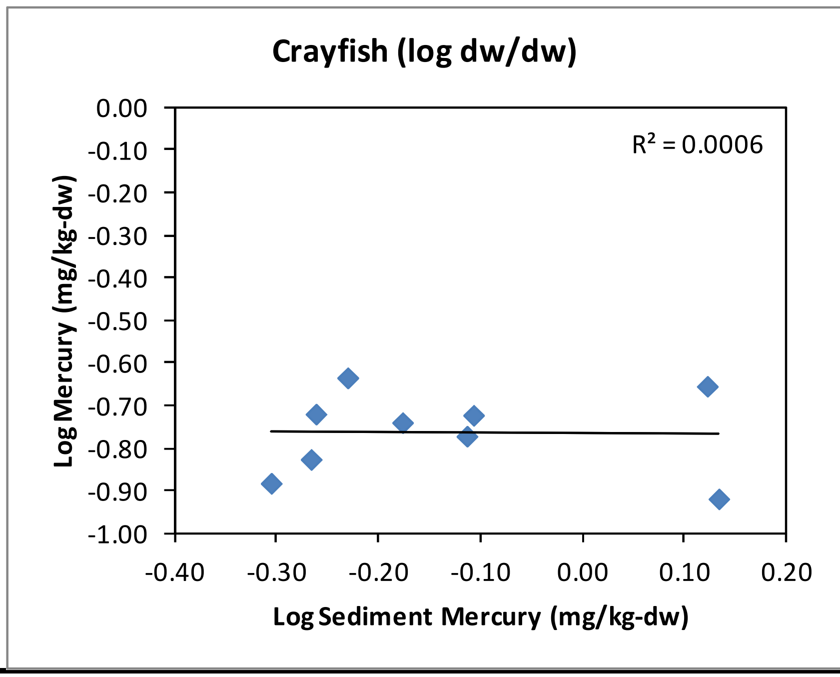
PCB - CRAYFISH - REGRESSION ANALYSIS

Solutia

FIGURE

A-18





represents the selected median BAF

ANNISTON PCB SITE

ANNISTON , ALABAMA

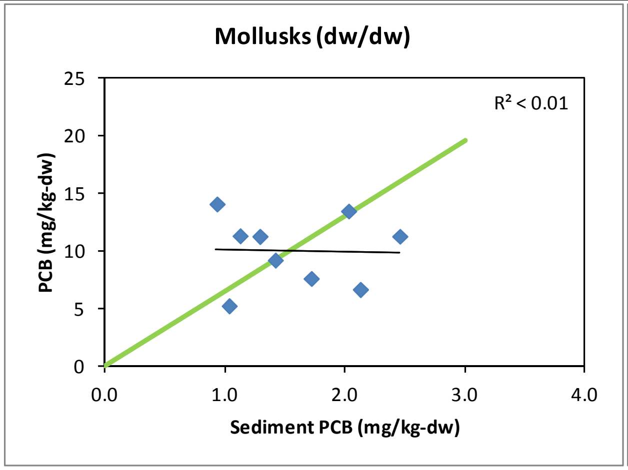
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

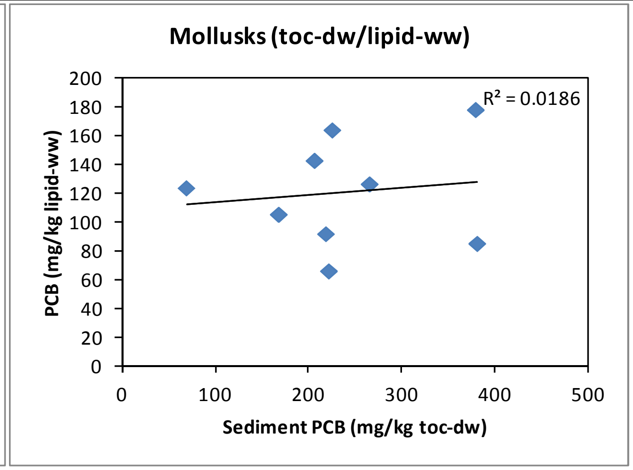
MERCURY - CRAYFISH - REGRESSION ANALYSIS

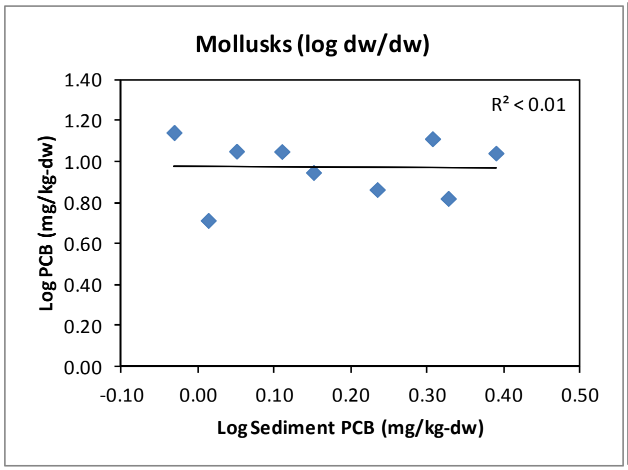
Solutia

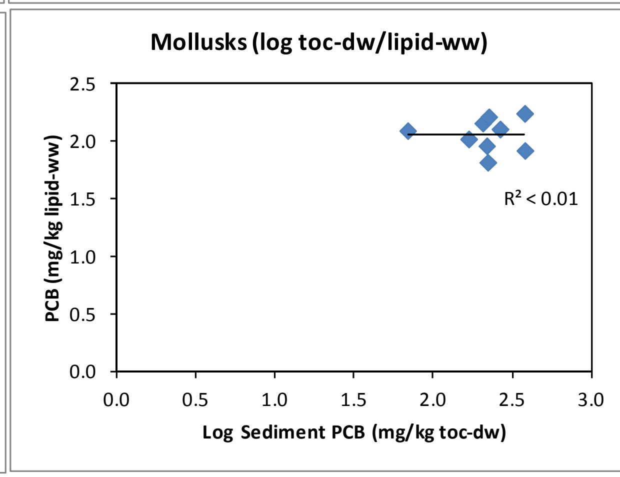
FIGURE

A-19









represents the selected median BAF

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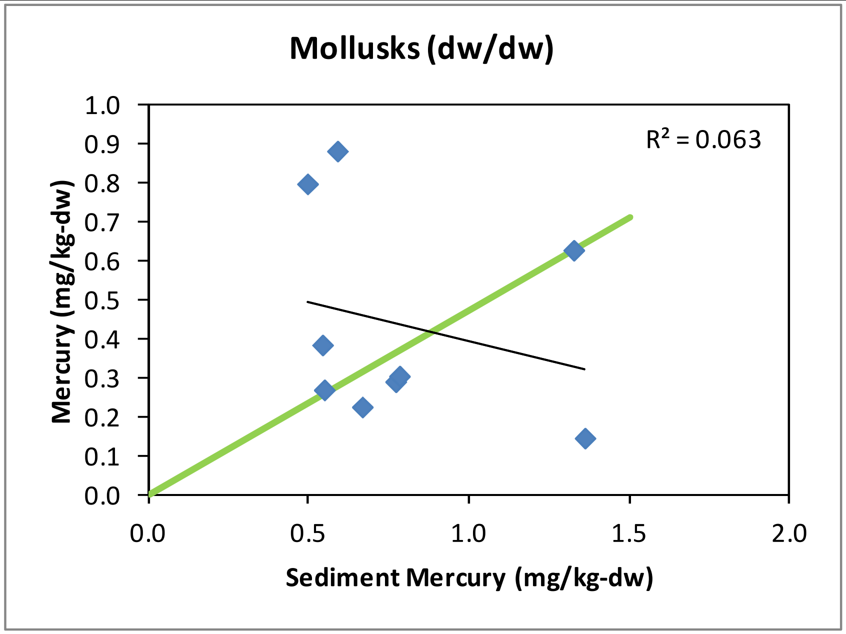
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

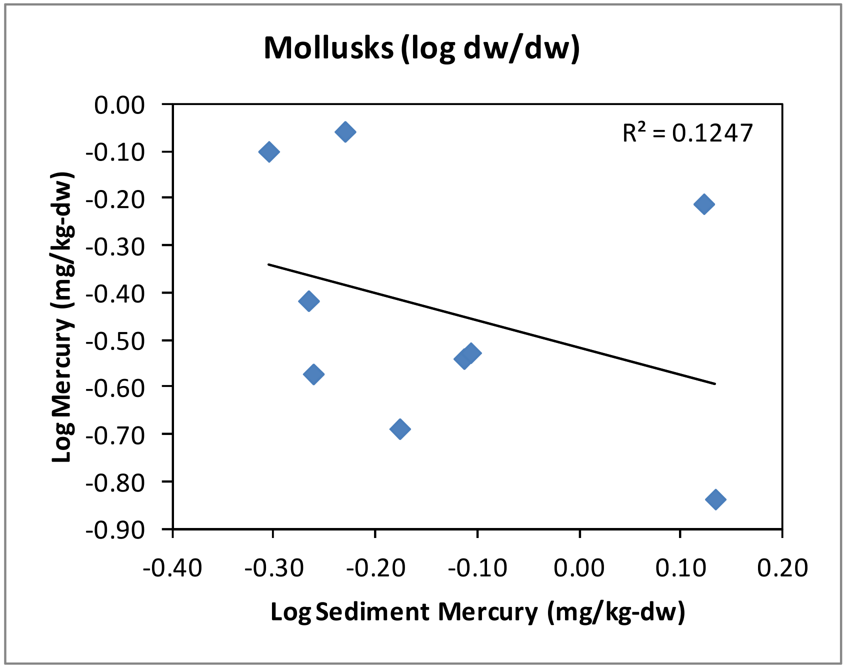
PCB - MOLLUSK - REGRESSION ANALYSIS

Solutia

FIGURE

A-20





represents the selected median BAF

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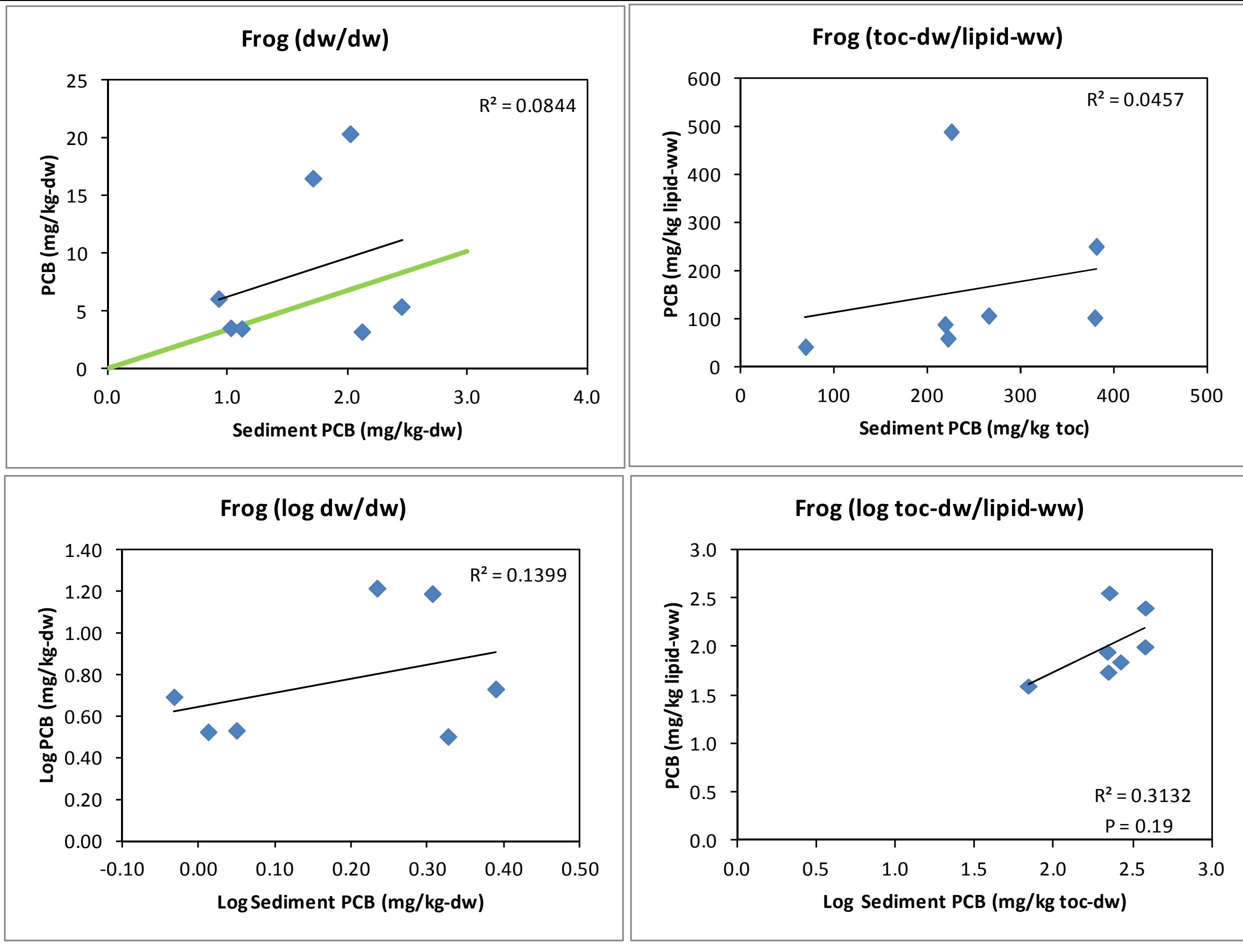
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

MERCURY - MOLLUSK - REGRESSION ANALYSIS

Solutia

FIGURE
A-21



represents the selected median BAF

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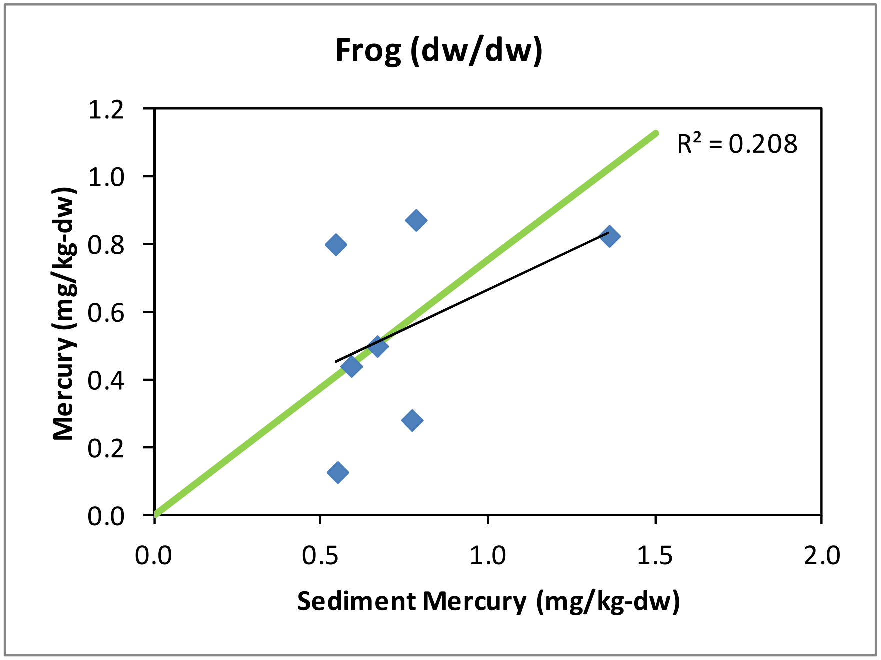
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

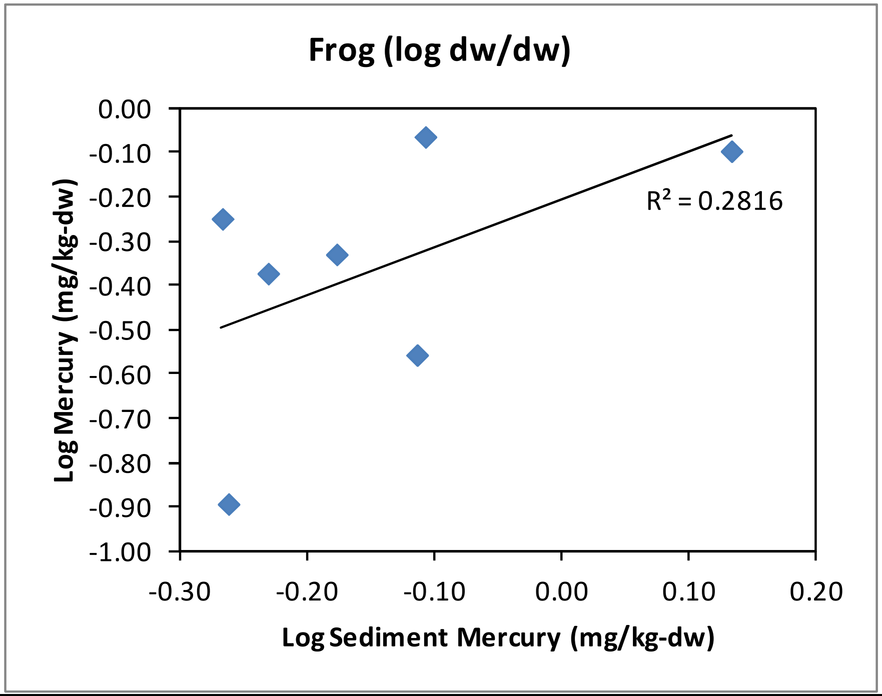
PCB - FROG - REGRESSION ANALYSIS

Solutia

FIGURE

A-22





represents the selected median BAF

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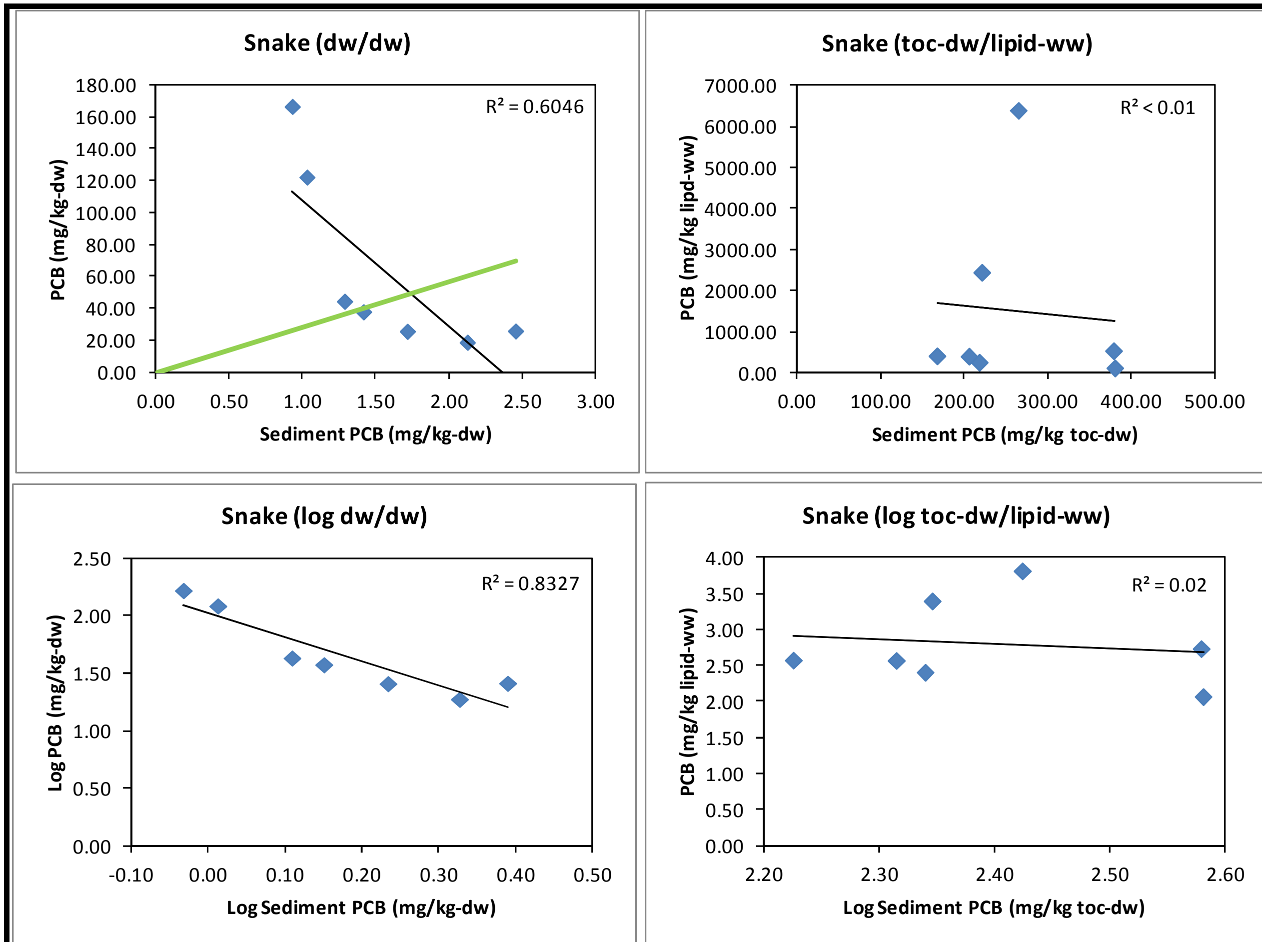
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

MERCURY - FROG - REGRESSION ANALYSIS

Solutia

FIGURE

A-23



represents the selected median BAF

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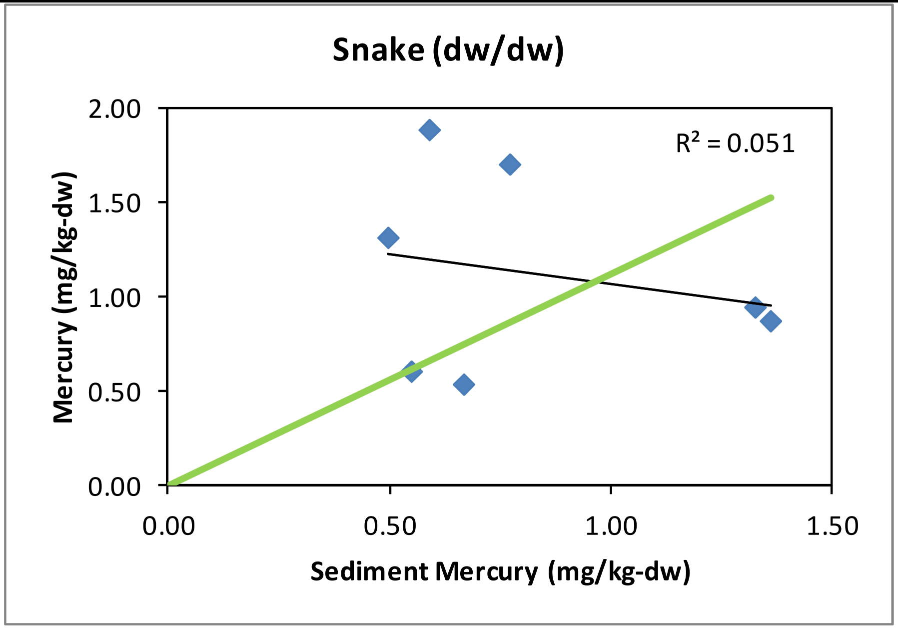
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

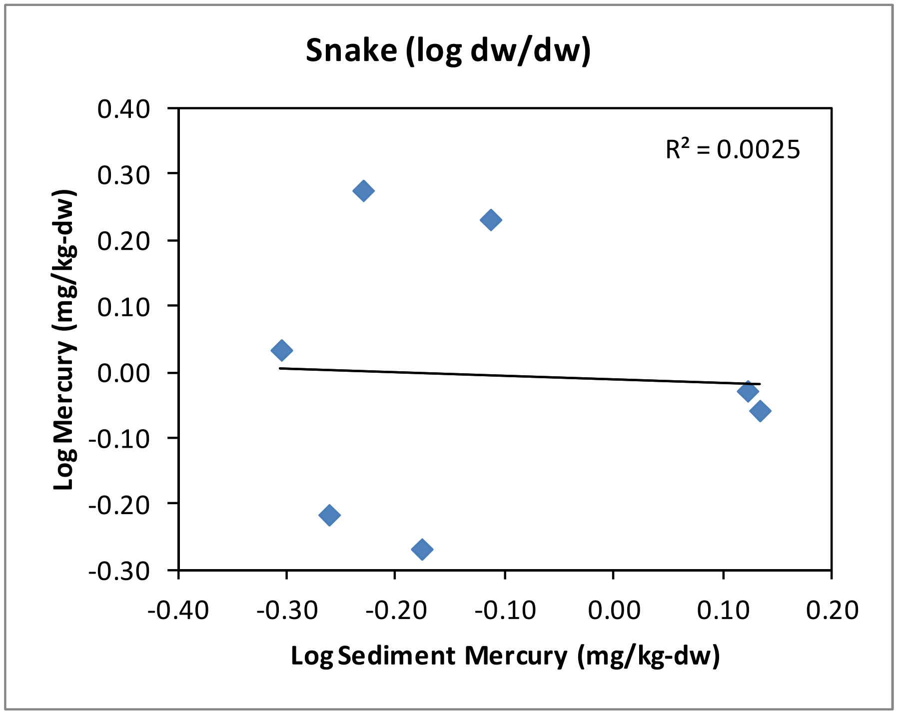
PCB - SNAKE - REGRESSION ANALYSIS

Solutia

FIGURE

A-24





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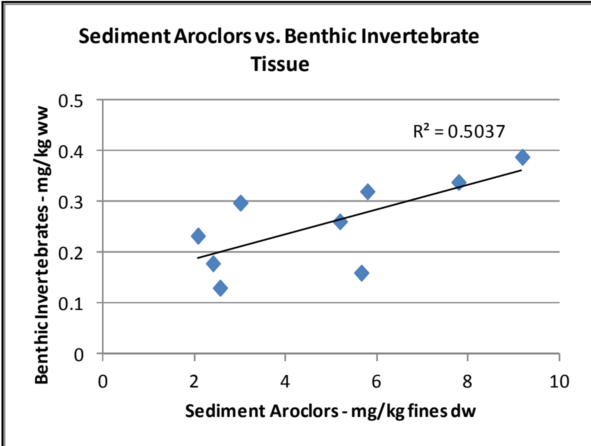
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

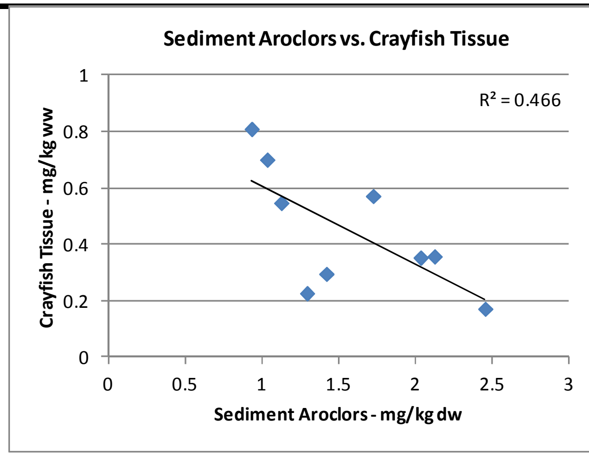
MERCURY - SNAKE - REGRESSION ANALYSIS

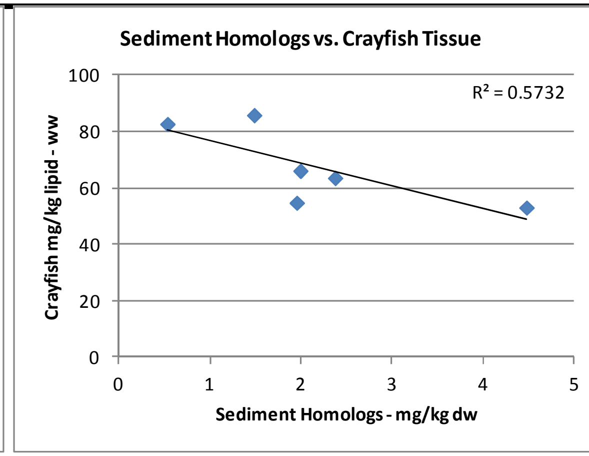
Solutia

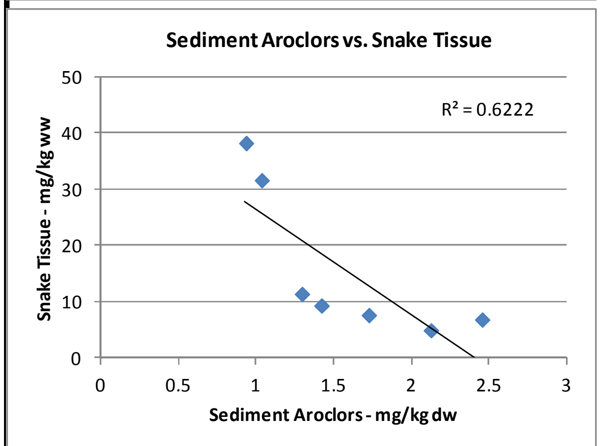
FIGURE

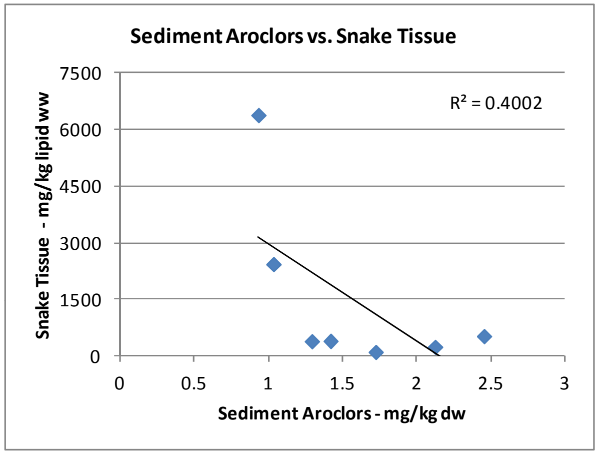
A-25

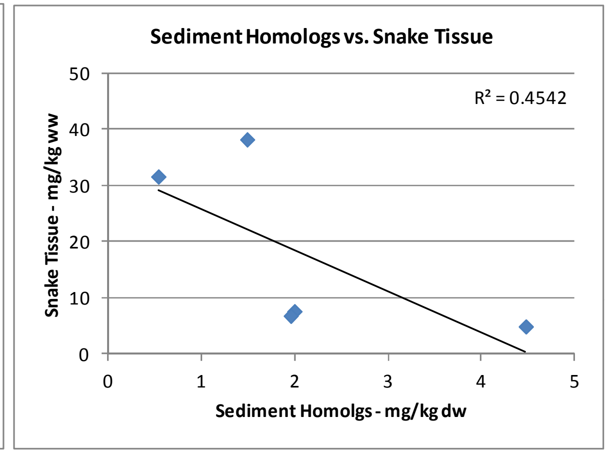


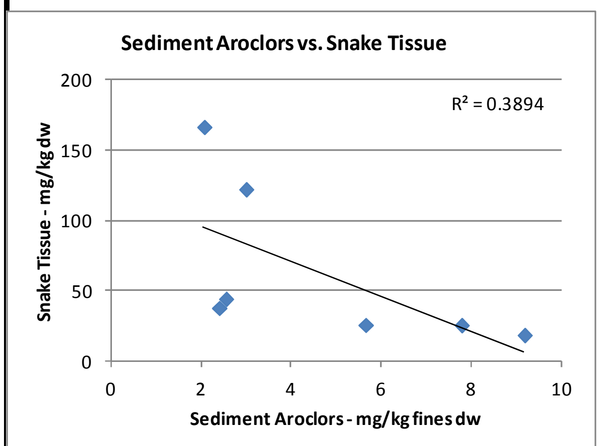












ww - wet weight
dw - dry wieight
PCB - polychlorinated biphenyl
mg/kg - milograms per kilogram
*When both wet ww and dw tissue correlations had r2 values > 0.3, only the higher correlation plotted.

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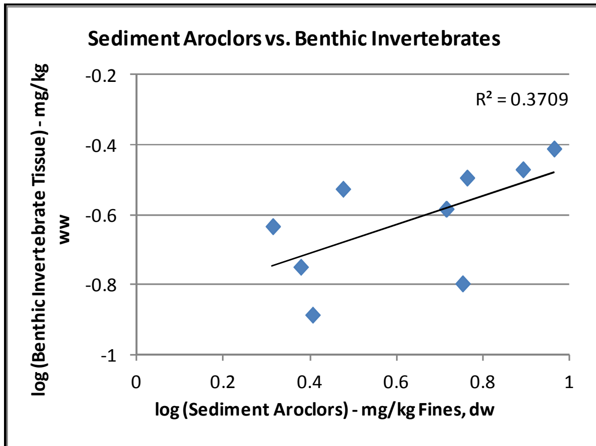
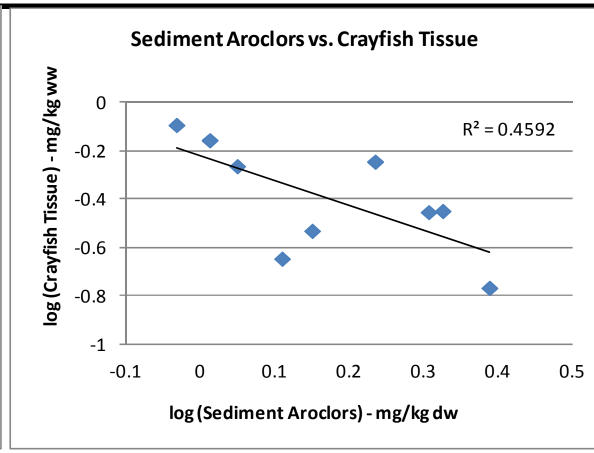
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

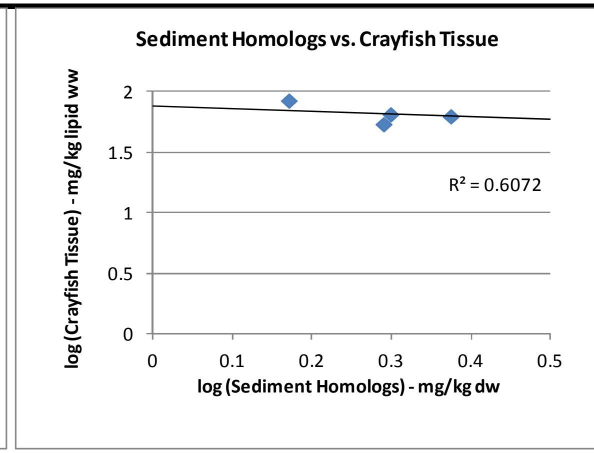
REGRESSION PLOTS OF SEDIMENT PCB AND TISSUE PCB CORRELATIONS WITH R2 VALUES >0.3*

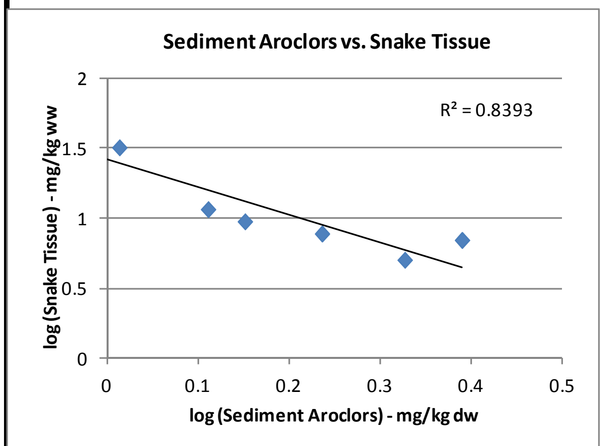
FIGURE

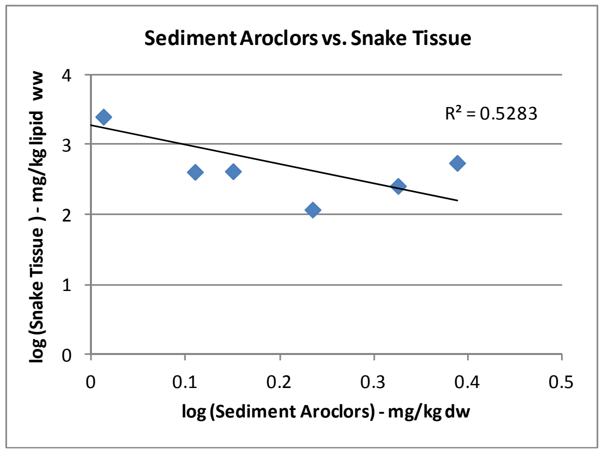
A-26

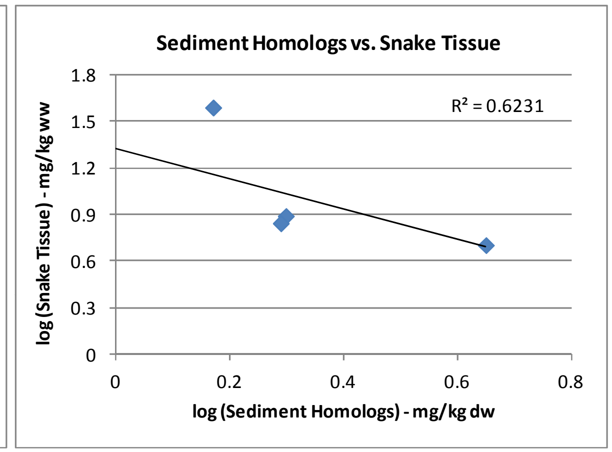


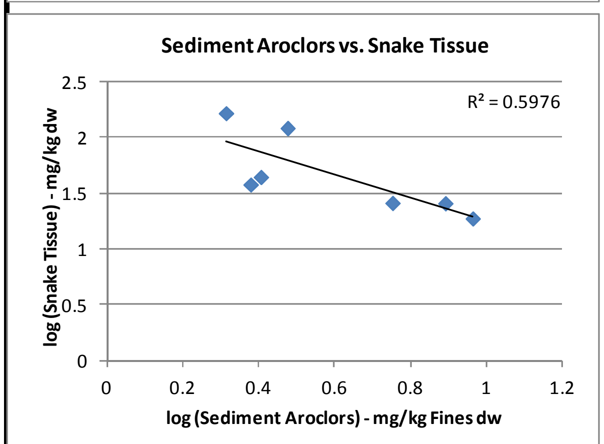












ww - wet weight
dw - dry wieight
PCB - polychlorinated biphenyl
mg/kg - milograms per kilogram
*When both wet ww and dw tissue correlations had r2 values > 0.3, only the higher correlation plotted.

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STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

REGRESSION PLOTS OF LOG SEDIMENT PCB AND TISSUE PCB CORRELATIONS WITH R2 VALUES > 0.3*

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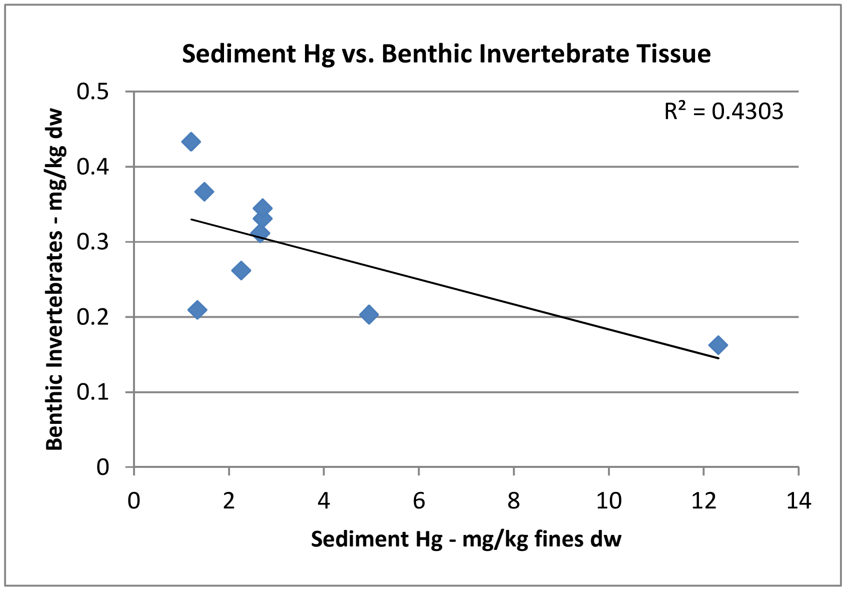
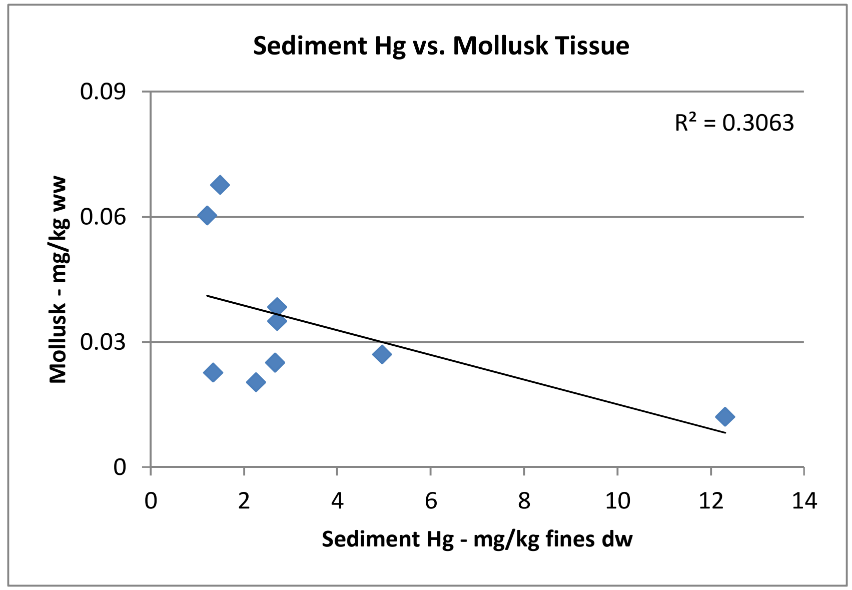
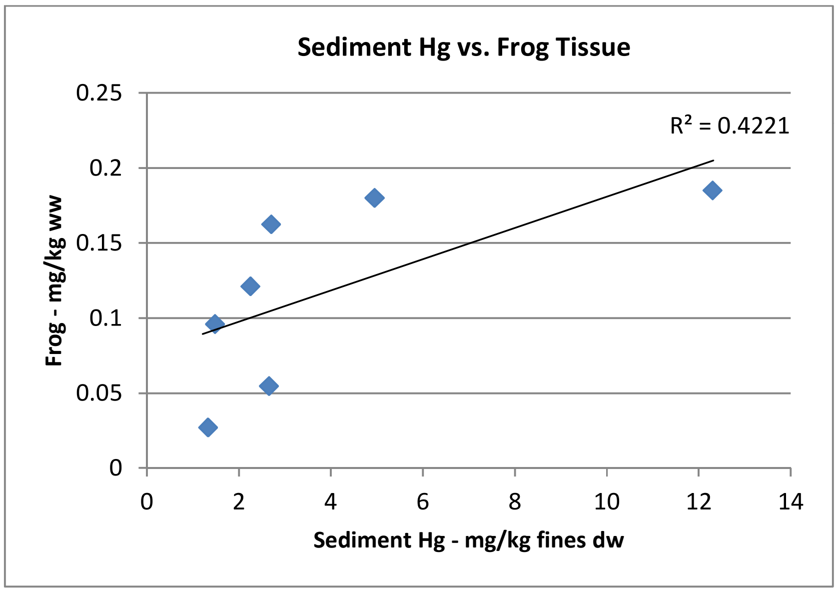
FIGURE

A-27

5/31/2013
G:\AProjects\Anniston 2013\OU-1 OU-2 SERA\Appendix A\Figure A-28.xlsxA-28







ww - wet weight
dw - dry wieight
Hg - mercury
mg/kg - milograms per kilogram
*When both wet ww and dw tissue correlations had r2 values > 0.3, only the higher correlation plotted.

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STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

REGRESSION PLOTS OF SEDIMENT MERCURY AND TISSUE MERCURY CORRELATIONS WITH R2 VALUES > 0.3*

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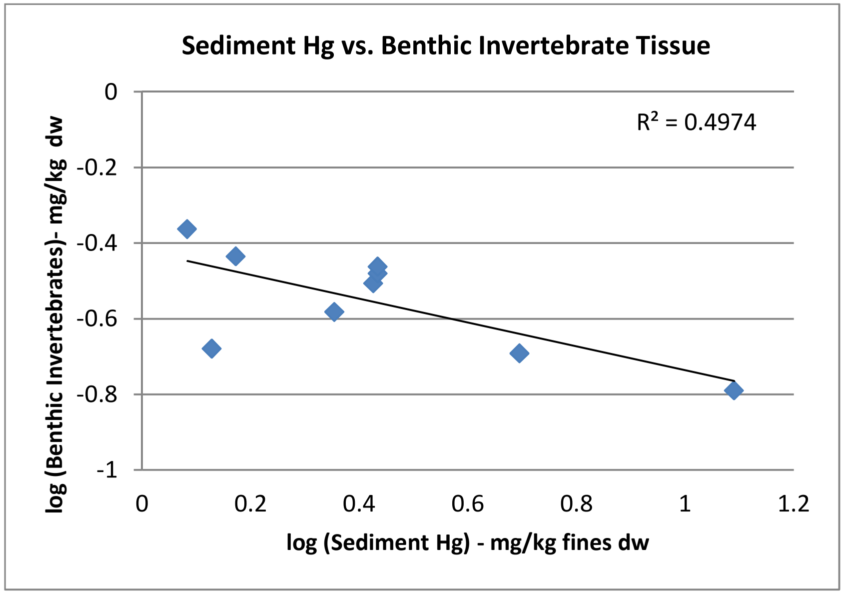
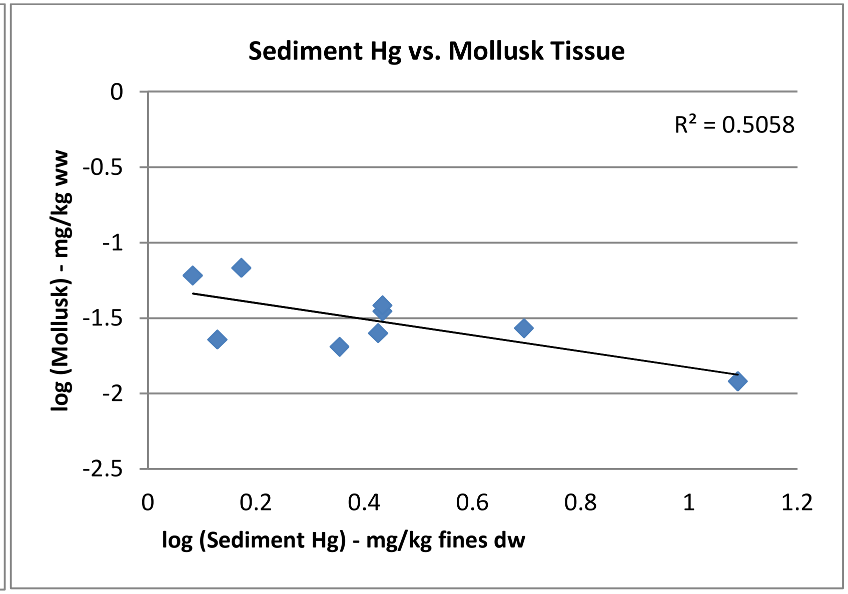
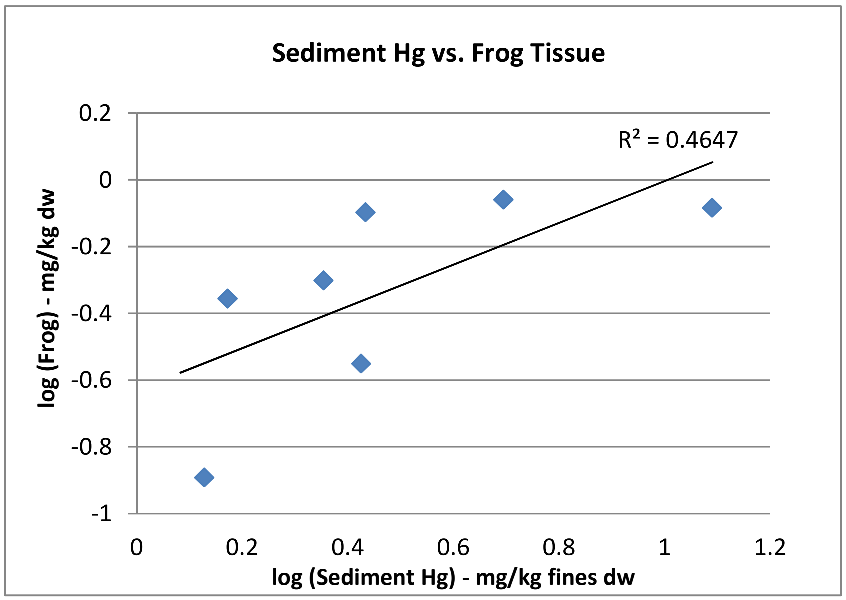
FIGURE
A-28







ww - wet weight
dw - dry wieight
Hg - mercury
mg/kg - milograms per kilogram
*When both ww and dw correlations had $r^2 > 0.3$, the higher correlation was plotted

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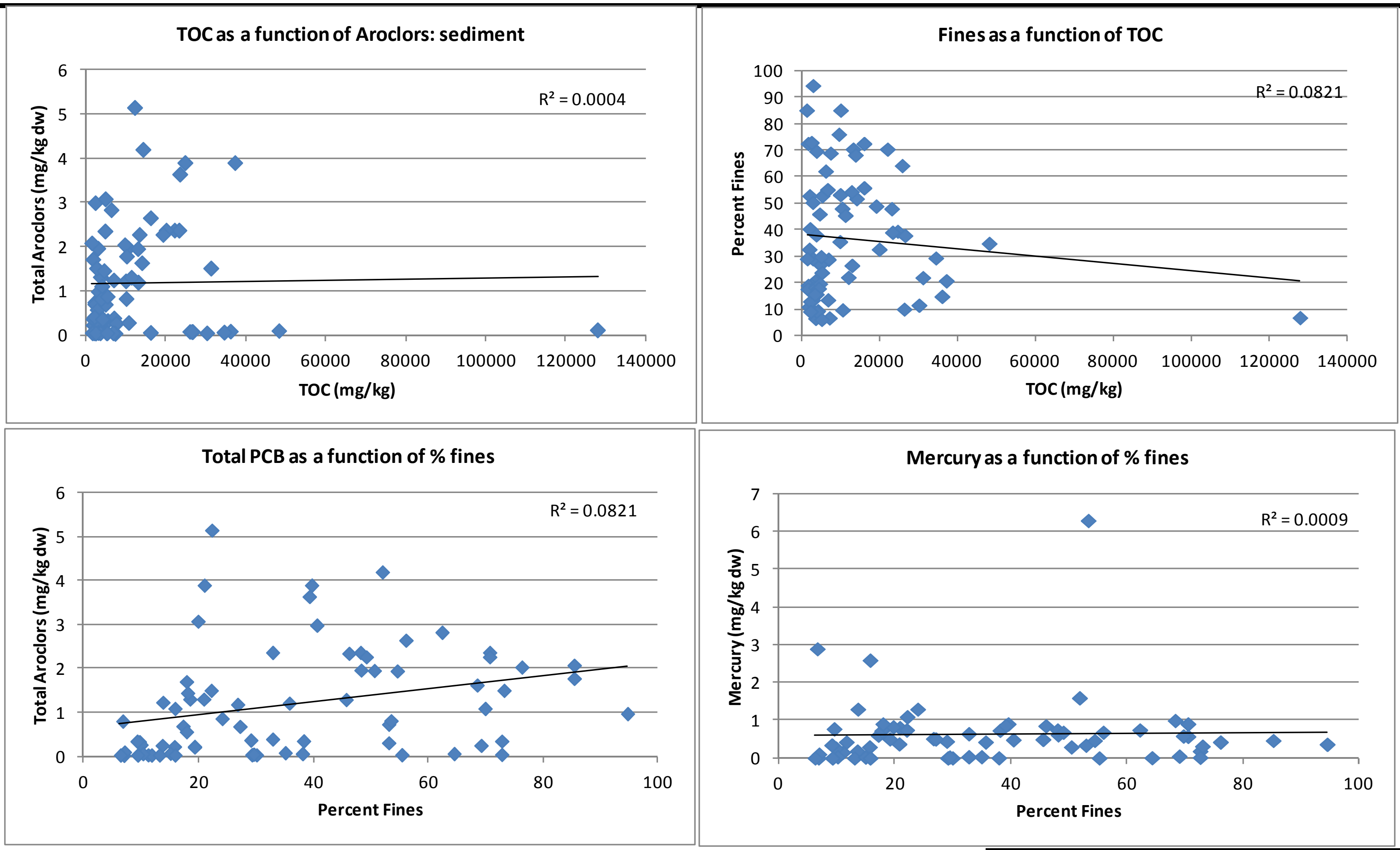
STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

REGRESSION PLOTS OF LOG SEDIMENT MERCURY AND TISSUE MERCURY CORRELATIONS WITH R2 VALUES > 0.3*

Solutia

FIGURE
A-29



ww - wet weight
dw - dry wieight
Hg - mercury
mg/kg - milograms per kilogram

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STREAMLINED ECOLOGICAL RISK ASSESSMENT FOR OU-1/OU-2 PORTION OF SNOW CREEK APPENDIX A – BIOACCUMULATION FACTOR DEVELOPMENT

REGRESSION ANALYSIS OF PCB AND MERCURY CONCENTRATIONS AND PERCENT FINES; TOTAL ORGANIC CARBON AND PERCENT FINES

Solutia

FIGURE

A-30

ARCADIS

Attachment A

Statistical Evaluation of Regression Analyses

Attachment A

Regression Statistics

Table 1a: PCB – Lumbriculus and Sediment Homolog Regression Statistical Summary Output (dw/dw basis)

Table 1b: PCB – Lumbriculus and Sediment Homolog Regression Statistical Summary Output (lipid/toc basis)

Table 1c: PCB – Lumbriculus and Sediment Aroclor and Homolog Regression Statistical Summary Output (dw/dw)

Table 1d: PCB – Lumbriculus and Sediment Aroclor and Homolog Regression Statistical Summary Output (lipid/toc)

Table 2a: PCB – Frog and Sediment Regression Statistical Summary Output (log lipid/toc basis)

Table 3a. PCB - Benthic Invertebrates vs. Aroclor in Sediment Normalized by Fines (dw/dw basis)

Table 3b. PCB - Benthic Invertebrates vs. Aroclor in Sediment Normalized by Fines (ww/dw basis)

Table 3c. PCB - Log Benthic Invertebrates vs. Log Aroclor in Sediment Normalized by Fines (ww/dw basis)

Table 3d. PCB - Log Benthic Invertebrates Normalized by Lipids vs. Log Sediment Homologs (ww/dw basis)

Table 4a. Mercury - Frog vs. Sediment Normalized by Fines (dw/dw basis)

Table 4b. Mercury - Frog vs. Sediment Normalized by Fines (ww/dw basis)

Table 4c. Mercury - Log Frog vs. Log Sediment Normalized by Fines (dw/dw basis)

Table 4d. Mercury - Log frog vs. Log Sediment Normalized by Fines (ww/dw basis)

Table 1a - *Lumbriculous* and Sediment Homolog Regression Statistical Summary Output
Evaluation based on Laboratory Replicate Mean PCB Concentrations
(Sediment and tissue measured as homolog groups)
Dry weight/Dry weight basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.794764916
R Square	0.631651272
Adjusted R Square	0.594816399
Standard Error	30.7026748
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	16164.81078	16164.811	17.14819	0.002008512
Residual	10	9426.542399	942.65424		
Total	11	25591.35318			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	24.80278975	11.91380351	2.0818532	0.063998	-1.742818619	51.3484
X Variable 1	0.712048935	0.17194943	4.1410369	0.002009	0.32892173	1.095176

Log dry weight/log dry weight basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.950288913
R Square	0.903049018
Adjusted R Square	0.893353919
Standard Error	0.212480294
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.205294625	4.2052946	93.14491	2.19882E-06
Residual	10	0.451478754	0.0451479		
Total	11	4.656773379			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.890654383	0.086542243	10.291557	1.22E-06	0.697826251	1.083483
X Variable 1	0.562271653	0.058259484	9.6511609	2.2E-06	0.432461433	0.692082

Table 1b - *Lumbriculous* and Sediment Homolog Regression Statistical Summary Output
Evaluation based on Laboratory Replicate Mean PCB Concentrations
(Sediment and tissue measured as homolog groups)
Lipid normal/organic carbon normalized basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.871697698
R Square	0.759856877
Adjusted R Square	0.735842565
Standard Error	1710.031769
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	92527324.1	92527324	31.64183	0.000219897
Residual	10	29242086.52	2924208.7		
Total	11	121769410.6			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	178.6530326	775.7564163	0.2302953	0.822505	-1549.839971	1907.146
X Variable 1	1.723789259	0.30644557	5.6251074	0.00022	1.040985981	2.406593

Log lipid normal/log organic carbon normal basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.96513248
R Square	0.931480703
Adjusted R Square	0.924628773
Standard Error	0.17050155
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.952006303	3.9520063	135.9443	3.8278E-07
Residual	10	0.290707787	0.0290708		
Total	11	4.24271409			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.85010336	0.213497115	3.9818026	0.002593	0.374402146	1.325805
X Variable 1	0.819949012	0.070324453	11.659515	3.83E-07	0.663256366	0.976642

Table 1c - *Lumbriculous* and Sediment Aroclor and Homolog Regression Statistical Summary Output (dw/dw)
Evaluation based on Laboratory Replicate Mean PCB Concentrations
(Sediment measured as Aroclors and tissue measured as homolog groups)
Dry weight/Dry weight basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.846420972
R Square	0.716428462
Adjusted R Square	0.688071308
Standard Error	26.93878132
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	18334.37379	18334.37	25.26447	0.00051687
Residual	10	7256.979392	725.6979		
Total	11	25591.35318			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	22.31447156	10.49933043	2.125323	0.059488	-1.0794944	45.70843752
X Variable 1	1.935215026	0.385011881	5.026377	0.000517	1.0773551	2.793074953

Log dry weight/log dry weight basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.94589203
R Square	0.894711732
Adjusted R Square	0.884182905
Standard Error	0.221428003
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.166469775	4.16647	84.97734	3.3341E-06
Residual	10	0.490303603	0.04903		
Total	11	4.656773379			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.022412578	0.08092262	12.63445	1.8E-07	0.84210575	1.202719411
X Variable 1	0.627238831	0.068042672	9.218316	3.33E-06	0.47563031	0.778847351

Table 1d - *Lumbriculous* and Sediment Arochlor and Homolog Regression Statistical Summary Output (lipid/toc)
Evaluation based on Laboratory Replicate Mean PCB Concentrations

(Sediment measured as Aroclors and tissue measured as homolog groups)
Lipid normal/organic carbon normalized basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.911147767
R Square	0.830190253
Adjusted R Square	0.813209278
Standard Error	1437.971933
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	101091777.8	1.01E+08	48.88943	3.7512E-05
Residual	10	20677632.79	2067763		
Total	11	121769410.6			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-116.399667	668.2071766	-0.1742	0.865187	-1605.25803	1372.458698
X Variable 1	4.605939298	0.658734944	6.992098	3.75E-05	3.13818638	6.073692214

Log lipid normal/log organic carbon normal basis
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.955554558
R Square	0.913084513
Adjusted R Square	0.904392965
Standard Error	0.192030612
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.87395653	3.873957	105.0543	1.2675E-06
Residual	10	0.36875756	0.036876		
Total	11	4.24271409			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.757905058	0.251503858	3.013493	0.01304	0.19751954	1.318290574
X Variable 1	0.9540822	0.093084825	10.2496	1.27E-06	0.74667629	1.161488115

Table 2a. PCB - Frog and Sediment Regression Statistical Summary Output (lipid/toc basis)
Log lipid normal/log ocrganic carbon normal basis

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.559635818
R Square	0.313192249
Adjusted R Square	0.175830699
Standard Error	0.316117144
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.22784627	0.227846	2.280058	0.191432191
Residual	5	0.499650245	0.09993		
Total	6	0.727496515			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.166365658	1.22591293	0.135708	0.897347	-2.984943852	3.317675167	-2.984943852	3.317675167
X Variable 1	0.783289794	0.518739784	1.509986	0.191432	-0.550173272	2.116752861	-0.550173272	2.116752861

Table 3a. PCB - Benthic Invertebrates (dw) vs. Aroclor in Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.573585379
R Square	0.329000187
Adjusted R Square	0.23314307
Standard Error	0.361152091
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.447663877	0.4477	3.4322	0.106357685
Residual	7	0.913015828	0.1304		
Total	8	1.360679705			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.965886481	0.268841524	3.5928	0.0088	0.330177293	1.601595668	0.330177293	1.601595668
X Variable 1	0.09248369	0.049920538	1.8526	0.1064	-0.025559625	0.210527004	-0.025559625	0.210527004

Table 3b. PCB - Benthic Invertebrates (ww) vs. Aroclor in Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.713048528
R Square	0.508438203
Adjusted R Square	0.438215089
Standard Error	0.065923378
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.031465671	0.0315	7.2403	0.031050417
Residual	7	0.030421242	0.0043		
Total	8	0.061886914			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.138117758	0.049073346	2.8145	0.026	0.022077734	0.254157781	0.022077734	0.254157781
X Variable 1	0.024519275	0.009112312	2.6908	0.0311	0.002972081	0.046066469	0.002972081	0.046066469

Table 3c. PCB - Log Benthic Invertebrates [ww] vs. Log Aroclor in Sediment Normalized by Fines

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.608978558
R Square	0.370854884
Adjusted R Square	0.28097701
Standard Error	0.137624052
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.078151963	0.07815	4.126208917	0.081754928
Residual	7	0.132582658	0.01894		
Total	8	0.210734621			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.876499793	0.13581242	-6.4538	0.000349027	-1.197645135	-0.55535445	-1.197645135	-0.55535445
X Variable 1	0.413727786	0.203675637	2.03131	0.081754928	-0.067888564	0.895344136	-0.067888564	0.895344136

Table 3d. PCB - Log Benthic Invertebrates Normalized by Lipids [ww] vs. Log Sediment Homologs

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.567211986
R Square	0.321729437
Adjusted R Square	0.152161796
Standard Error	0.110367385
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.023111564	0.02311	1.897351616	0.240426417
Residual	4	0.048723839	0.01218		
Total	5	0.071835402			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.338994519	0.060801649	22.0223	2.51623E-05	1.170182078	1.507806961	1.170182078	1.507806961
X Variable 1	0.223563289	0.162303012	1.37744	0.240426417	-0.227062114	0.674188691	-0.227062114	0.674188691

Table 4a. Mercury - Frog [dw] vs. Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.593770041
R Square	0.352562862
Adjusted R Square	0.223075434
Standard Error	0.255963223
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.178387369	0.1784	2.7228	0.159839688
Residual	5	0.327585859	0.0655		
Total	6	0.505973228			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.373656863	0.143929261	2.5961	0.0485	0.003674919	0.743638808	0.003674919	0.743638808
X Variable 1	0.044833227	0.027170368	1.6501	0.1598	-0.025010428	0.114676882	-0.025010428	0.114676882

Table 4b. Mercury - Frog [ww] vs. Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.636095773
R Square	0.404617832
Adjusted R Square	0.285541399
Standard Error	0.052452113
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.00934857	0.0093	3.398	0.124608408
Residual	5	0.013756121	0.0028		
Total	6	0.02310469			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.07772225	0.029494057	2.6352	0.0462	0.001905363	0.153539137	0.001905363	0.153539137
X Variable 1	0.010263383	0.005567766	1.8434	0.1246	-0.004049014	0.02457578	-0.004049014	0.02457578

Table 4c. Mercury - Log Frog [dw] vs. Log Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.679908902
R Square	0.462276115
Adjusted R Square	0.354731338
Standard Error	0.244109484
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.256142378	0.25614	4.29845	0.092852674
Residual	5	0.297947201	0.05959		
Total	6	0.55408958			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.634142476	0.171548825	-3.69657	0.01405	-1.075122769	-0.19316218	-1.0751228	-0.193162183
X Variable 1	0.637858195	0.307657902	2.07327	0.09285	-0.153001619	1.42871801	-0.1530016	1.42871801

Table 4d. Mercury - Log Frog [ww] vs. Log Sediment Normalized by Fines
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.67515444
R Square	0.45583352
Adjusted R Square	0.34700022
Standard Error	0.25138417
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.26467951	0.2647	4.1884	0.096064015
Residual	5	0.315970001	0.0632		
Total	6	0.580649511			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.309706	0.176661135	-7.4137	0.0007	-1.763827883	-0.8555841	-1.763828	-0.85558407
X Variable 1	0.64840086	0.316826387	2.0465	0.0961	-0.166027295	1.462829	-0.166027	1.462829015

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Appendix B

Analysis of OU-4 Sediment Toxicity Test Results and Development of Site-Specific Risk-Based Concentrations for PCBs in Sediment

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Appendix B: Analysis of OU-4 Sediment Toxicity Test Results and Development of Site-Specific Risk-Based Concentrations for PCBs in Sediment

Anniston PCB Site, Anniston, Alabama

December 2013 Revision 2

Tables

Figures

Acronyms and Abbreviations

°C	degrees Celsius
COPC	constituent of potential concern
d	day
dw	dry weight
kg	kilogram(s)
OC	organic carbon
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon

PCB	polychlorinated biphenyl
PEC	probable effect concentration
TOC	total organic carbon
tPCB	total polychlorinated biphenyl
$tPCB_A$	total polychlorinated biphenyl Aroclor
$tPCB_H$	total polychlorinated biphenyl homolog
USACE-ERDC	U.S. Army Corps of Engineers' Engineer Research and Development Center
USEPA	U.S. Environmental Protection Agency
USGS-CERC	U.S. Geologic Survey's Columbia Environmental Research Center

1. Introduction

As part of a baseline ecological risk assessment to be prepared for Operable Unit 4 (OU-4) of the Anniston Polychlorinated Biphenyl (PCB) Site, sediment toxicity tests were conducted to provide information about the site-specific effects of PCBs in OU-4 sediments to benthic macroinvertebrates. This appendix reports the results of those tests, which are used to develop Site-Specific Risk-Based Concentrations for PCBs that are protective of the benthic invertebrate community that may be present in OU-1/OU-2 sediments.

2. Methods

2.1 Overview

The objective of this study was to develop concentration-response relationships for prediction of chronic toxicity to benthic invertebrates in OU-4 sediments that might be caused by PCBs and other constituents of potential concern (COPCs). Therefore, candidate sediments were selected to span a wide range of combinations of total PCB (tPCB) and organic carbon (OC) concentrations, instead of randomly sampling the OU-4 sediments. The six targeted bins of OC-normalized PCB concentrations (expressed as milligrams of tPCB per kilogram OC [mg tPCB/kg OC]) were: <100; 100 to 500; 501 to 1,000; 1,001 to 5,000; 5,001 to 10,000; and >10,000. In an attempt to test multiple sediments within each concentration bin, a total of 32 sediments were collected from: (1) various depths at six OU-4 locations (26 sediments), and (2) a reference location (six sediment samples; on Choccolocco Creek approximately 3 kilometers upstream of the site). The higher tPCB-concentration samples were collected from a backwater area near the confluence of Snow and Choccolocco Creeks that had stable sediments and is the only place in OU-4 that contains such high concentrations. Because the reference sediments were collected well upstream of the confluence with Snow Creek, they do not reflect the background signal of urban runoff and, therefore, from a site perspective, do not constitute true reference samples.

Specific details of the analyses and methods employed during the testing program and the sediment toxicity and laboratory bioaccumulation testing data are presented in draft form in Ingersoll et al (in review). The sediments were chemically characterized, and chronic toxicity tests were conducted with two benthic macroinvertebrates (*Chironomus dilutus* [a freshwater midge] and *Hyalella azteca* [a freshwater amphipod]) exposed to the sediments. A variety of survival, growth, and reproduction endpoints were monitored in the toxicity tests (Table B-1); and sigmoid concentration-response relationships between the endpoints and tPCB concentration in the sediment were fit to the data. Additionally, concentrations of non-PCB COPCs in the sediments were compared to screening-level concentrations to determine if additional variables should be added as predictors in the concentration-response relationships. Reference envelopes were calculated for each toxicity endpoint; and the sediment PCB concentrations associated with 10, 20, and 50 percent impairment beyond the lower limit of each reference envelope were calculated and compared to published "consensus-based" sediment quality guidelines.

2.2 Sediment Collection and Processing

All sediment samples were collected between August 18 and 23, 2010. At each sampling location, a Lexan® tube was hand-pushed into the sediment to the desired depth. Cores that did not remain intact were discarded, and the sediment depth was re-sampled. For each depth increment at each sample-collection location, a minimum of 16 liters of sediment was collected and composited in high-density polyethylene buckets. The composited samples were stored at 4 degrees Celsius (°C) until, within 24 hours of sampling, they were sieved through a 2-millimeter stainless-steel or brass sieve. The sediment that passed through the sieve ranged from 64 to 99 percent by weight of the total sediment sieved and was typically >75 percent by weight.

Sieved samples were then shipped under refrigeration to the U.S. Geological Survey's Columbia Environmental Research Center (USGS-CERC) in Columbia, Missouri, where they were stored at 4 °C in the dark. The sediments were homogenized and subsampled for initial analyses of PCB Aroclor and total organic carbon (TOC) concentrations, and preliminary 10-day (d) lethality tests were conducted with *H. azteca* at USGS-CERC. Results of the Aroclor and TOC analyses and the lethality tests were used to select sediment samples for subsequent rounds of chronic toxicity tests.

2.3 Toxicity Tests

Because of the large number of sediments to be tested, the chronic toxicity tests were conducted in three separate batches during two different rounds of testing in two different labs (at the USGS-CERC, and at the U.S. Army Corps of Engineers' Engineer Research and Development Center [USACE-ERDC] in Vicksburg, Mississippi). Sediments to be tested at USACE-ERDC were transported there under refrigeration from USGS-CERC and were then stored at 4 °C in the dark.

The definitive chronic toxicity tests were conducted in two cycles (1a and 1b), which were started during the week of November 1, 2010, for Cycle 1a and during the week of January 17, 2011, for Cycle 1b. One control, one reference, and 10 site sediments (containing intermediate to high concentrations of tPCBs) were tested in Cycle 1a. In Cycle 1b, one control, the remaining five reference, and 10 additional site sediments (mostly containing low to intermediate concentrations of tPCBs) were tested. Because one sediment (#20) was tested in both Cycle 1a and Cycle 1b, 26 different sediment samples (20 site sediment samples and six reference sediment samples) were tested. The USGS-CERC laboratory conducted most of the *C. dilutus* toxicity tests, whereas the USACE-ERDC laboratory conducted most of the *H. azteca* toxicity tests. However, in Cycle 1a, the two labs conducted additional tests with *H. azteca* (at USGS-CERC) and *C. dilutus* (at USACE-ERDC) exposed to one control and five site sediment samples to allow inter-laboratory comparisons of toxicity results. At the end of Cycle 1b, USGS-CERC also conducted side-by-side sets of 20-d *C. dilutus* toxicity tests for one control and five site sediment samples that were started with 7-d-old larvae or <24-hour-old larvae, to compare relative sensitivity of the two life stages.

Seven days before the start of a test, each sediment sample to be tested was removed from cold storage, re-homogenized, and placed into the exposure chambers along with overlying water. The exposure chambers were then kept at 23 °C for 7 days without renewal of the overlying water, to allow the sediment-water system to equilibrate before organisms were placed in the chambers at the start of the test. All tests were conducted in basic accordance with ASTM International (2012) and U.S. Environmental Protection Agency (USEPA 2000) guidance. However, except in the life-stage-sensitivity tests conducted at the end of Cycle 1b, all *C. dilutus* tests were started with 7-d-old larvae instead of <24-hour-old larvae (the age specified in ASTM International 2012) to increase the probability of meeting control-survival acceptability and, thus, have acceptable test results. Twelve survival, growth, and reproduction endpoints were measured in the *C. dilutus* tests; and 11 survival, growth, and reproduction endpoints were measured in the *H. azteca* tests (Table B-1). Although six additional *H. azteca* endpoints were reported by the laboratories, those endpoints are not included in this analysis because they were: (1) 35-d survival and reproduction endpoints that did not provide additional discrimination beyond that provided by the 28-d and 42-d survival and reproduction endpoints, or (2) 28-d and 42-d dry weight (dw) per individual and biomass per replicate endpoints that were calculated from measured lengths of *H. azteca* (using generic length-weight regressions) and, thus, are not considered as reliable as the same endpoints based on dw measured during the toxicity tests (i.e., the 28-d and 42-d dw per individual and biomass per replicate endpoints listed in Table B-1). The test durations were 42 d for *H. azteca* and up to 54 d for *C. dilutus*.

2.4 Chemical Analyses

Sub-samples of the sediments collected for toxicity testing were analyzed for six grain-size categories, moisture content, loss on ignition, concentrations of OC, 23 major and trace elements (including the 16 metals and metalloids on the USEPA Target Analyte List), acid volatile sulfide, five simultaneously extracted metals, nine PCB Aroclors, 13 PCB congeners, 10 PCB homolog groups, one biphenyl, 46 parent and alkylated polycyclic aromatic hydrocarbons (PAHs), 21 organochlorine pesticides, and 17 polychlorinated dibenzo-*p*-dioxins and furans congeners. Additionally, during the toxicity tests, porewaters (collected by centrifugation or by peepers placed approximately 1 centimeter into the sediment in the exposure chambers) were analyzed for pH; conductivity; alkalinity; hardness; and concentrations of ammonia, hydrogen sulfide, dissolved organic carbon, four inorganic anions, and 61 major and trace elements.

2.5 Data Analyses

Because the definitive chronic toxicity tests for each species were conducted in three separate batches (at different times and/or in different labs) and the control responses sometimes differed considerably among those batches (Table B-2), the response measured for each endpoint for each species was normalized to the average response measured for that endpoint in the control sediment tested concurrently with that batch of sediments. Therefore, the response for each endpoint in each sediment sample was expressed as a percentage of the control response; and thus, control-normalized responses greater than 100 percent sometimes occurred in reference and/or site sediments.

After control normalization, each endpoint response was regressed against dry-weight-normalized tPCB Aroclor ($tPCB_A$) concentration and separately against OC-normalized $tPCB_A$ concentration to develop two concentration-response relationships for each endpoint. The dry-weight-normalized and OC-normalized $tPCB_A$ concentrations were chosen as the predictors for the concentration-response relationships because sediments at the OU-4 site previously had been characterized in terms of their $tPCB_A$ concentrations instead of their tPCB homolog ($tPCB_H$) concentrations; thus, necessitating development of toxicity-predictor equations based on $tPCB_A$ concentrations for use in remediation decisions. The concentration-response curves were calculated using nonlinear regression in SPSS 8.0.0 for Windows® (SPSS, Inc., Chicago, IL), by fitting the data to the following sigmoid logistic equation:

Equation 1:

$$R = \frac{R_{\max}}{1 + \left(\dfrac{tPCB_A}{EC50}\right)^{slope}}$$

Where:

R	=	response value (percent of control),
R_{max}	=	regression-fitted maximum response (percent of control),
$tPCB_A$	=	total PCB Aroclor concentration (mg/kg dry sediment or mg/kg OC),
EC50	=	50 percent effect concentration of $tPCB_A$ (mg/kg dry sediment or mg/kg OC), and
slope	=	slope of the logistic regression of R vs. $tPCB_A$ concentration.

A reference envelope was calculated for each endpoint, using the control-normalized responses of the six reference sites; and the "bottom" of that response envelope was defined as the lowest control-normalized response percentage observed in the six reference sediment samples (except for time to emergence of *C. dilutus*, for which the highest control-normalized response percentage [i.e., the most delayed emergence from the pupal cocoon] represented the most adverse effect). That bottom-of-the-envelope response was defined as R0* (i.e., a reference-sediment-adjusted zero response). Then, R10*, R20*, and R50* (i.e., the reference-adjusted 10, 20, and 50 percent response percentages) were calculated by multiplying R0* by 0.9, 0.8, and 0.5, respectively. For example, if the lowest control-normalized survival among the six reference sediments was 80 percent, R0*, R10*, R20*, and R50* would be 80, 72, 64, and 40 percent, respectively.

The regression-predicted EC0*, EC10*, EC20*, and EC50* values (i.e., the dry-weight-normalized and OC-normalized $tPCB_A$ concentrations associated with the R0*, R10*, R20*, or R50* reference-sediment response percentages) were back-calculated by entering R0*, R10*, R20*, or R50* as R and the regression-specific values of R_{max}, slope, and EC50 into Equation 1, and then solving for $tPCB_A$. The "bottom" of the response envelope was defined as the lowest response percentage instead of as the 5th percentile of the reference-sediment response percentages because only six reference sediments were tested, thus leaving high uncertainty about the true numerical value of the 5th percentile reference response.

3. Results and Discussion

Results of chemical analyses of bulk sediments collected from OU-4 for the sediment-toxicity tests and of porewater and overlying water in the toxicity tests are reported in Ingersoll et al. (In review). Concentrations of metals, PAHs, and organochlorine pesticides were generally lower than "consensus-based" probable effect concentrations (PECs) published by MacDonald et al. (2000b). Therefore, those COPCs are not likely to have contributed significantly (relative to PCBs) to toxicity in OU-4 sediments, leaving PCBs as the likely dominant contaminant. Therefore, the remainder of this discussion about OU-4 sediment toxicity tests focuses only on PCBs.

When regressed across all the OU-4 sediments collected for toxicity testing, the $tPCB_H$ concentration was approximately 2 times the $tPCB_A$ concentration (Figure B-1a). That relationship was evident down to a concentration of approximately 0.6 mg $tPCB_A$/kg dw sediment; however, at concentrations less than 0.6 mg $tPCB_A$/kg dw sediment, the $tPCB_H$:$tPCB_A$ ratio was approximately 1:1 (Figure B-1b).

The same laboratory-control sediment was used in all three batches of toxicity tests; however, responses of the test organisms to the laboratory-control sediment varied considerably for some toxicity-endpoint responses (Table B-2). The variation among the three control responses for each endpoint (expressed as 100%•[max{control response} - min{control response}]/[mean{control response}]) ranged from 1.3 percent (42-d survival of *H. azteca*) to 137 percent (42-d young/female for *H. azteca*). In general, survival and hatch-percentage endpoints varied by relatively small percentages (1.3 to 4.4 percent), growth endpoints varied by intermediate percentages (18 to 80 percent), and reproduction endpoints varied by intermediate to large percentages (25 to 137 percent). Given the sometimes large variability in control responses for a toxicity endpoint, large variability can also be expected in responses of organisms exposed to OU-4 sediments. Therefore, to account for uncertainty associated with the sometimes intermediate to high variability in toxicity-test responses, the regression-predicted PCB concentration at the bottom of a reference envelope should not be used as a threshold for remediation decisions. Instead, a percentage response lower than the lowest response observed in control and reference sediments (e.g., 20 percent lower than the bottom of the reference envelope) should be used for defining a PCB concentration threshold for remediation decisions.

As another indication of variability in the sediment-toxicity results, USGS-CERC conducted *C. dilutus* tests with Sediment #20 once in Cycle 1a and once in Cycle 1b (i.e., approximately 2½ months apart). The difference in control-normalized response for each endpoint (expressed as 100%•[absolute value {Cycle 1b response - Cycle 1a response}]/[mean{Cycle 1a and 1b responses}]) ranged from 0.2 percent (13-d biomass/replicate) to 74 percent (number of egg cases). Of the 12 endpoints, six (50 percent) had differences that were less than 20 percent of the mean control-normalized response, and five (42 percent) had differences between 20 and 50 percent of the mean control-normalized response (including a 27 percent difference in percent emergence, which was the most sensitive endpoint for *C. dilutus*). The median difference was 22.4 percent. Those differences between Cycle 1a and Cycle 1b results might have been caused by: (1) different sensitivity of the batches of *C. dilutus* tested approximately 2½ months apart, (2) chemical changes in Sediment #20 during storage between the two cycles of testing, or (3) random variability to be expected in sediment-toxicity tests. Regardless of the cause(s), these results also support not using the lowest response observed in control and reference sediments for defining a PCB concentration threshold for remediation decisions (e.g., instead using 20 percent lower than the bottom of the reference envelope for defining a PCB concentration threshold for remediation decisions).

Toxicity responses were similar when the same sediment was tested by both USGS-CERC and USACE-ERDC (with either *C. dilutus* or *H. azteca*) in the inter-laboratory comparison conducted during Cycle 1a (Ingersoll et al. In review). Therefore, there did not appear to be a substantial between-species-comparison bias caused by conducting most of the *C. dilutus* tests at USGS-CERC and most of the *H. azteca* tests at USACE-ERDC, or by combining results from both testing labs when constructing concentration-response relationships for either species.

In the side-by-side sets of 20-d *C. dilutus* toxicity that were started with 7-d-old larvae or <24-hour-old larvae, survival, weight, and biomass were relatively consistent between the two life stages (Ingersoll et al. In review). Therefore, tests started with 7-d-old larvae (i.e., all the results reported below for *C. dilutus*) did not appear to underestimate the toxicity of OU-4 sediments to *C. dilutus* compared to tests started with <24-hour-old larvae, and that deviation from standard protocol (ASTM International 2012) did not bias interpretations of the toxicity of OU-4 sediments.

A variety of concentration-response relationships were observed among the 23 total toxicity endpoints (Figures B-2 and B-3). Most of the *C. dilutus* and *H. azteca* endpoints had response vs. $tPCB_A$ concentration relationships in which survival, growth, or reproduction in most of the reference and OU-4 sediments was less than in the laboratory control sediment and decreased as $tPCB_A$ concentration increased (e.g., Figure B-2); however, for some endpoints, most of the reference sediments and some of the OU-4 sediments exceeded the control-sediment responses (e.g., Figure B-2). Moreover, responses for some endpoints remained approximately constant as $tPCB_A$ concentration increased (e.g., Figure B-3); and for a few endpoints, the response tended to increase as $tPCB_A$ concentration increased, contrary to traditional expectations (e.g., Figure B-3). Logistic regressions and EC0*, EC10*, EC20*, and EC50* values were only calculated when an endpoint response decreased as $tPCB_A$ concentration increased. Regression coefficients for the concentration-response curves are listed in Table B-3.

For *H. azteca*, the dry-weight-normalized EC0*, EC10*, and EC20* values ranged from 1.38 to 31.0 mg $tPCB_A$/kg dw sediment for EC0* values, from 2.58 to 127 mg $tPCB_A$/kg dw sediment for EC10* values, and from 4.43 to 165 mg $tPCB_A$/kg dw sediment for EC20* values (Table B-1). The corresponding OC-normalized EC0*, EC10*, and EC20* values ranged from 72.8 to 2,380 mg $tPCB_A$/kg OC for EC0* values, from 120 to 5,250 mg $tPCB_A$/kg OC for EC10* values, and from 195 to 7,600 mg $tPCB_A$/kg OC for EC20* values (Table B-1). The most sensitive endpoint in the *H. azteca* tests was 42-d young/female normalized to 42-d survival of the adult females, for which the EC0*, EC10*, and EC20* values were 1.38, 2.58, and 4.43 mg $tPCB_A$/kg dw sediment (72.8, 120, and 195 mg $tPCB_A$/kg OC; Table B-1 and Figure B-3).

For *C. dilutus*, the dry-weight-normalized EC0*, EC10*, and EC20* values ranged from 0.43 to 209 mg $tPCB_A$/kg dw sediment for EC0* values, from 1.19 to 260 mg $tPCB_A$/kg dw sediment for EC10* values, and from 2.54 to 324 mg $tPCB_A$/kg dw sediment for EC20* values (Table B-1). The corresponding OC-normalized EC0*, EC10*, and EC20* values ranged from 58.2 to 8,390 mg $tPCB_A$/kg OC for EC0* values, from 131 to 9,890 for EC10* values, and from 241 to 13,900 mg $tPCB_A$/kg OC for EC20* values (Table B-1). The most sensitive endpoint in the *C. dilutus* tests was adult biomass per replicate chamber, for which the EC0*, EC10*, and EC20* values were 0.43, 1.19, and 2.54 mg $tPCB_A$/kg dw sediment (58.2, 131, and 241 mg $tPCB_A$/kg OC; Table B-1 and Figure B-2). However, that adult-biomass endpoint has high uncertainty associated with it. It was estimated by the testing laboratories by calculating adult emergence × 13-d ash-free dry weight, with an explicit assumption that the ratio of adult ash-free dry weight (not measured during the toxicity tests) to the 13-d ash-free dry weight (which was measured) was constant for all the control, reference, and OU-4 sediments. That assumption cannot be verified, thus leaving that adult-biomass endpoint highly uncertain. Therefore, remediation goals for OU-4 should not be based on estimated adult biomass. The next most-sensitive *C. dilutus* endpoint was emergence percentage, for which the dry-weight-normalized EC0*, EC10*, and EC20* values were 2.04, 6.80, and 14.3 mg $tPCB_A$/kg dw sediment (170, 465, and 873 mg $tPCB_A$/kg OC; Table B-1 and Figure B-2).

The results described above are based on an approach in which all laboratory results were treated independently (i.e., results for same sediments tested at two different labs were treated as independent). To evaluate possible uncertainty associated with this approach, an additional analysis comparing the nonlinear-regression results with and without duplicate sediment results averaged was performed. During Cycle 1a of the Anniston PCB sediment toxicity testing program, both the USGS lab and the USACE lab conducted sediment toxicity tests with *Chironomus dilutus* and *Hyalella azteca* exposed to six duplicated sediments. The most sensitive endpoint among both species was *Hyalella azteca* 42-d young/female (normalized to 42-d survival) (Table B-4). Table B-5 compares results of the nonlinear regressions of that reproduction endpoint vs. PCB concentration, with and without the control-normalized results for those sediments averaged. Only five of the six duplicate sediments were included in the regressions because one of the six repeated sediments was the lab-control sediment, and the lab-control sediments were not included in the nonlinear regressions (because the Anniston sediment responses were normalized to their within-batch control responses). As shown in Table B-6, when the nonlinear-regression results were compared with and without the duplicate sediment results averaged, the results are similar with and without averaging the duplicate sediments. A comparison of which OU-4 sediments selected for the testing program exceeded the reference envelope response for each endpoint for *C. dilutus* and *H. azteca* are provided in Tables B-7 and B-8, respectively.

4. Summary of Findings

Results of the site-specific toxicity testing indicate that toxicity thresholds could range from approximately 1.38 to 165 mg/kg dw depending on the species and endpoint tested and the effect level that is considered most relevant. For the most sensitive endpoint and species (i.e., *H. azteca* 42-d young/female normalized to 42-d survival), the range of results were 1.38 (the EC0*), 2.58 (the EC10*), and 4.43 (the EC20*) mg $tPCB_A$/kg dw of sediment.

5. References

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Tables

Table B-1

Concentrations of total PCB Aroclors ($tPCB_A$) predicted to decrease growth, survival, or reproduction by *Chironomus dilutus* or *Hyalella azteca* exposed to OU-4 sediments from the Anniston PCB Site by 0, 10, 20, and 50% relative to the lowest reference-sediment response.

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Species	Endpoint	Dry-weight-normalized conc. (mg $tPCB_A$/kg dw sed)				OC-normalized conc. (mg $tPCB_A$/kg OC)			
		EC0*[a]	EC10*[a]	EC20*[a]	EC50*[a]	EC0*[a]	EC10*[a]	EC20*[a]	EC50*[a]
C. dilutus	13-d survival	14.2	75.7	123	288	1,000	3,710	5,570	11,500
	13-d ash-free dry weight	6	17.3	32.3	121	322	880	1,610	5,790
	13-d biomass per replicate chamber	9.65	17.7	28	85.7	346	711	1,170	3,670
	Emergence percentage	2.04	6.8	14.3	71.2	170	465	873	3,410
	Emergence time	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	Adult survival time	98	186	323	1,420	4,580	8,320	13,900	55,200
	No. of egg cases	21.1	31.4	45.9	146	1,160	1,660	2,310	6,440
	No. of eggs/egg case	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	Hatch percentage	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	Total young	69.4	89	114	261	3,390	4,150	5,080	9,950
	Young/egg case	209	260	324	685	8,390	9,890	11,700	20,800
	Adult biomass per replicate chamber [c]	0.43	1.19	2.54	16.5	58.2	131	241	1,050
H. azteca	28-d survival	UND[d]	105	152	261	UND[d]	4,636	6,390	10,400
	28-d dry weight	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	28-d biomass per replicate chamber	1.69	25.1	57.7	252	UND[d]	4,880	7,600	11,900
	28-d length	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	42-d survival	31	127	165	262	2,380	5,250	6,690	10,300
	42-d dry weight	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	42-d biomass per replicate chamber	18.2	39.6	67.7	231	1,220	2,520	3,930	10,200
	42-d length	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]	---[b]
	42-d total young	9.18	12.8	17.8	50.1	453	627	866	2,480
	42-d young/female	1.46	3	5.42	25.6	102	181	302	1,270
	42-d young/female (normalized to 42-d survival)	1.38	2.58	4.43	19.8	72.8	120	195	902

[a] EC0*, EC10*, EC20* and EC50* are the regression-predicted PCB_A concentrations that would cause an additional 0%, 10%, 20%, or 50% effect beyond the lowest response measured in the reference sediments (i.e., 1×, 0.9×, 0.8×, and 0.5× the response at the “bottom” of the reference envelope).

[b] Could not be calculated because a decreasing concentration-response relationship did not exist for this endpoint.

[c] Estimated as adult emergence × 13-d ash-free dry weight, assuming adult ash-free dry weight (which was not measured) for each sediment was proportional to the 13-d ash-free dry weight that was measured for the sediment. Therefore, this endpoint has high uncertainty associated with it.

[d] UND: undefined EC0*, because the lowest control-normalized reference-sediment response (88.8%) was greater than the regression-predicted maximum control-normalized

mg tPCBA/kg dw sed: milligrams total polychlorinated biphenyl Aroclor per kilogram dry weight sediment

mg tPCBA/kg OC: milligrams total polychlorinated biphenyl Aroclor per kilogram organic carbon

Table B-2
Variability among toxicity-endpoint responses in the laboratory-control sediments tested in the three batches of OU-4 sediments from the Anniston PCB Site.

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Species	Endpoint	Control response in each sediment-testing batch[a]			Range of control responses (% of mean of controls)
		1	2	3	
C. dilutus	13-d survival (%)	93.8	97.9	95.8	4.4
	13-d ash-free dry weight (mg/individual)	0.93	1.41	0.96	43.6
	13-d biomass per replicate chamber (mg)	10.4	16.5	11	47.5
	Emergence (%)	77.1	74	67.7	12.9
	Emergence time (d)	31.6	27.2	23.9	27.7
	Adult survival time (d)	6.8	4.8	6.1	34.2
	No. of egg cases	4.1	3	4.4	35.9
	No. of eggs/egg case	850	1,100	1,030	25.2
	Hatch (%)	90.9	93.6	89.6	4.4
	Total young	3,080	2,950	4,090	33.6
	Young/egg case	770	1,040	930	29.8
	Adult biomass per replicate chamber (mg)[c]	8.1	12.2	7.5	51
H. azteca	28-d survival (%)	97.5	99.2	96.7	2.6
	28-d dw (mg/individual)	0.23	0.36	0.24	45.9
	28-d biomass per replicate chamber (mg)	2.21	3.44	2.33	46
	28-d length (mm)	4.06	4.7	3.77	22.1
	42-d survival (%)	92.5	93.8	93.8	1.3
	42-d dw (mg/individual)	0.42	0.63	0.28	79.5
	42-d biomass per replicate chamber (mg)	3.83	5.97	2.62	80.8
	42-d length (mm)	4.52	5.21	4.35	18.2
	42-d total young	19.8	36.4	10.5	116.5
	42-d young/female	4.2	9.1	2.1	137.2
	42-d young/female (normalized to 42-d survival)	3.8	8.1	1.9	135.2

[a] For *C. dilutus* , Batch 1, 2, and 3 tests were conducted at USGS-CERC, USACE-ERDC, and USGS-CERC, respectively; for *H. azteca* , Batch 1, 2, and 3 tests were conducted at USACE-ERDC, USGS-CERC, and USACE-ERDC, respectively.

[b] Equals 100%·[max(control response) - min(control response)]/mean(control response).

[c] Estimated as adult emergence × 13-d ash-free dry weight, assuming adult ash-free dry weight (which was not measured) for each sediment was proportional to the 13-d ash-free dry weight that was measured for the sediment. Therefore, this endpoint has high uncertainty associated with it.

Table B-3

Regression coefficients for the concentration-response curves in Figures B-2 and B-3. The logistic equation to which the toxicity data were fit is: R = Rmax/[1 + (tPCBA/EC50)slope], where R = response value (% of control), Rmax = regression-fitted maximum response (% of control), tPCBA = total PCB Aroclor concentration (mg/kg dry sediment or mg/kg OC), EC50 = regression-fitted 50% effect concentration of tPCBA (mg/kg dry sediment or mg/kg OC), and slope = slope of the logistic regression of R vs. tPCBA concentration.

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Species	Endpoint	Regressions using dw-normalized concentration (mg tPCBA/kg dw sediment)				Regressions using OC-normalized concentration (mg tPCBA/kg OC)			
		R_{max}	Slope	EC50	EC0* [a]	R_{max}	Slope	EC50	EC0* [a]
C. dilutus	13-d survival	98.63	1.598	285	14.2	98.85	1.8746	11,360	1,000
	13-d ash-free dry weight	111.6	0.9218	104.28	6	111.98	0.9426	4,984	322
	13-d biomass per replicate chamber	111.74	0.9578	63.76	9.65	113.26	0.9896	2,957	346
	Emergence percentage	96.64	0.7435	57.91	2.04	96.89	0.8714	2,845	170
	Emergence time	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	Adult survival time	82.59	0.6472	723.86	98	82.73	0.693	29,278	4,580
	No. of egg cases	77.54	0.7141	54.81	21.1	78.53	0.7968	2,620	1,160
	No. of eggs/egg case	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	Hatch percentage	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	Total young	76.3	0.874	84.15	69.4	76	1.0773	3,992	3,390
	Young/egg case	99.77	0.9168	201.31	209	99.24	1.203	8,218	8,390
	Adult biomass per replicate chamber [c]	121.3	0.5693	9.92	0.43	120.12	0.7349	721	58.2
H. azteca	28-d survival	85.93	2.7541	267.39	UND [d]	86.48	3.0335	10,566	UND [d]
	28-d dw	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	28-d biomass per replicate chamber	87.46	0.9186	246.96	1.69	80.23	3.7766	12,374	UND [d]
	28-d length	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	42-d survival	84.14	3.0052	261.5	31	84.87	3.1362	10,247	2,380
	42-d dw	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	42-d biomass per replicate chamber	92.02	0.9233	183.8	18.2	89.03	1.2498	9,051	1,220
	42-d length	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]	--- [b]
	42-d total young	105.06	0.7511	16.83	9.18	112.71	0.7078	676	453
	42-d young/female	136.99	0.6403	14.04	1.46	147.74	0.6373	573	102
	42-d young/female (normalized to 42-d survival)	129.99	0.6256	9.27	1.38	161.93	0.5089	183	72.8

[a] EC0* is the regression-predicted PCB_A concentration at the lowest response measured in the reference sediments (i.e., the "bottom" of the reference envelope) for that endpoint.

[b] Could not be calculated because a decreasing concentration-response relationship did not exist for this endpoint.

[c] Estimated as adult emergence × 13-d ash-free dry weight, assuming adult ash-free dry weight (which was not measured) for each sediment was proportional to the 13-d ash-free dry weight that was measured for the sediment. Therefore, this endpoint has high uncertainty associated with it.

[d] UND: undefined EC0*, because the lowest control-normalized reference-sediment response (88.8%) was greater than the regression-predicted maximum control-normalized response (85.9%).

mg tPCBA/kg dw sed: milligrams total polychlorinated biphenyl Aroclor per kilogram dry weight sediment
mg tPCBA/kg OC: milligrams total polychlorinated biphenyl Aroclor per kilogram organic carbon

Table B-4
Independent and averaged *Hyalella azteca* 42-d young/female (normalized to 42-d survival), for the six sediments that were tested in both the USGS and the USACE labs during Cycle 1a.

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Sediment I.D.	PCB Aroclors (mg/kg dw)	OC-normalized PCB Aroclors (mg/kg OC)	Reproduction (% of control)		
			USGS	USACE	Average
6	59.9	4,504	8.2	5.9	7.1
11	85.5	3,393	19.8	37.1	28.5
19	437	16,873	0	0	0
25	26.3	1,015	53.4	54.4	53.9
30	204	8,870	17.1	16.4	16.7
33	0.06	5	100	100	100

mg/kg dw: milligrams per kilogram dry weight
mg/kg OC: milligrams per kilogram organic carbon
PCB: polychlorinated biphenyls
USACE: United States Army Corps of Engineers
USGS: United States Geological Survey

Table B-5
Nonlinear regression fits for Hyalella azteca 42-d young/female (normalized to 42-d survival) fitted to all USGS and USACE sediment data from Cycles 1a and 1b, with and without the results for the duplicate sediments averaged. Regression equation was: Response = Maxresponse/(1+[PCB/EC50)^slope], where Response is the within-batch control-normalized percent reproduction.

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PCB Concentration	Parameter	Without averaging	With averaging	Units
PCB Aroclors	Maxresp	130	131.8	%
	Slope	0.6257	0.5817	---
	EC50	9.265	8.794	mg/kg dw
OC-normalized PCB Aroclors	Maxresp	161.9	189.7	%
	Slope	0.5089	0.4168	---
	EC50	183.4	78	mg/kg OC

mg/kg dw: milligrams per kilogram dry weight
mg/kg OC: milligrams per kilogram organic carbon
PCB: polychlorinated biphenyls

Table B-6

Inhibition concentrations (relative to the bottom of the reference envelope) in Anniston PCB sediment toxicity tests, for Hyalella azteca 42-d young/female (normalized to 42-d survival) with and without the results for the duplicate sediments averaged.

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PCB Concentration	Parameter	Without averaging	With averaging	Units
PCB Aroclors	EC0*	1.38	1.26	mg/kg dw
	EC10*	2.58	2.4	mg/kg dw
	EC20*	4.43	4.23	mg/kg dw
	EC50*	19.8	20.7	mg/kg dw
OC-normalized PCB Aroclors	EC0*	72.8	61.2	mg/kg OC
	EC10*	120	101	mg/kg OC
	EC20*	195	169	mg/kg OC
	EC50*	902	928	mg/kg OC

mg/kg dw: milligrams per kilogram dry weight
mg/kg OC: milligrams per kilogram organic carbon
PCB: polychlorinated biphenyls

Table B-7

Results of toxicity tests with *Chironomus dilutus* exposed to OU-4 sediments from the Anniston PCB Site, Anniston, Alabama. Responses in OU-4 sediments are expressed as a percentage of the lowest response recorded among the six reference sediments (i.e., bottom-of-reference-envelope response), after all OU-4 and reference sediments had first been normalized to the control response within the batch in which they were tested.

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				Transformed results (% of bottom-of-reference-envelope response) sorted by PCB-Aroclor concentration										
Location	Sediment ID	PCB-A (mg/kg)	PCB-A/OC (mg/kg)	13-d Survival (%)	13-d Total ash-free biomass (mg)	13-d Ind. ash-free dry wt (mg)	Emergence (%)	Median emergence time (days)[a]	Median adult survival time (days)	# Egg cases	# Eggs/ egg case	Hatch (%)	Total # young	# Young/ egg case
TX10	16	0.05	18.1	93.3	98.9	106.9	96.6	106.1	147.2	138.7	138.4	148.8	195.7	211.5
TX20	28	0.22	30.6	106.7	138.1	128.3	103.4	99.4	124.1	110.9	159.7	124.7	158.0	242.7
TX20	24	0.27	122.7	103.7	116.7	111.5	105.2	105.6	101.8	94.3	145.1	144.5	133.9	215.2
TX40	15	0.60	40.8	97.8	80.6	82.5	74.1	109.8	151.1	133.1	123.5	146.9	176.1	213.8
TX60	20	2.42	350.2	104.4	90.7	86.4	103.4	103.5	119.3	166.4	122.7	141.8	204.7	210.6
TX60	20[c]	3.08	277.5	93.1	90.9	97.0	78.8	75.8	84.3	76.5	146.7	146.9	126.4	224.2
TX30	23	4.90	235.6	102.2	102.2	99.3	100.0	105.0	151.1	144.2	135.4	139.0	198.7	222.5
TX40	27	7.28	667.9	100.0	71.8	71.5	70.7	104.6	149.5	122.0	126.5	142.8	156.6	211.7
TX60	13	12.40	837.8	95.6	100.0	104.3	86.2	104.0	135.2	133.1	130.8	148.8	187.3	199.7
TX30	25	26.30	1015.4	106.8	82.8	77.1	57.5	73.5	61.4	47.1	161.0	145.7	79.0	174.0
TX30	25[b]	26.30	1015.4	97.9	49.1	50.1	104.2	80.8	150.2	137.5	163.3	140.3	242.9	268.1
TX40	1	27.00	1436.2	106.8	68.9	64.2	72.7	82.3	97.1	100.0	121.0	140.4	129.1	154.7
TX40	14	28.30	1481.7	68.9	98.4	147.7	72.4	100.8	127.2	133.1	134.3	145.0	190.2	200.0
TX-30	2	37.10	1212.4	95.6	84.1	87.3	39.7	110.4	80.0	33.3	124.9	110.8	36.4	87.1
TX40	17	37.80	3500.0	73.3	98.0	136.1	79.3	118.7	116.1	88.7	120.0	138.2	103.6	171.7
TX60	6	59.90	4503.8	109.0	38.6	35.1	9.1	93.5	57.1	5.9	138.0	0.0	0.0	0.0
TX60	6[b]	59.90	4503.8	84.8	25.9	31.7	28.4	85.9	129.9	32.4	151.0	139.2	48.2	92.5
TX30	7	65.40	1639.1	100.0	60.8	59.9	46.9	79.3	89.5	70.6	147.4	135.8	110.1	149.2
TX50	11	85.50	3392.9	102.2	80.4	78.1	92.4	81.4	85.7	111.8	134.0	135.3	145.5	191.1
TX50	11[b]	85.50	3392.9	97.9	56.2	56.4	94.7	76.3	142.1	145.6	114.8	137.6	167.8	185.7

Table B-7

Results of toxicity tests with *Chironomus dilutus* exposed to OU-4 sediments from the Anniston PCB Site, Anniston, Alabama. Responses in OU-4 sediments are expressed as a percentage of the lowest response recorded among the six reference sediments (i.e., bottom-of-reference-envelope response), after all OU-4 and reference sediments had first been normalized to the control response within the batch in which they were tested.

				Transformed results (% of bottom-of-reference-envelope response) sorted by PCB-Aroclor concentration										
Location	Sediment ID	PCB-A (mg/kg)	PCB-A/OC (mg/kg)	13-d Survival (%)	13-d Total ash-free biomass (mg)	13-d Ind. ash-free dry wt (mg)	Emergence (%)	Median emergence time (days)[a]	Median adult survival time (days)	# Egg cases	# Eggs/ egg case	Hatch (%)	Total # young	# Young/ egg case
TX50	30	204.00	8869.6	77.2	30.0	39.1	48.5	73.9	95.7	88.2	183.3	136.6	163.0	262.2
TX50	30[b]	204.00	8869.6	21.7	4.9	21.5	6.3	91.8	135.3	16.2	62.5	140.2	10.7	12.8
TX50	8	320.00	11594.2	61.3	22.2	35.8	33.3	90.0	77.1	52.9	174.0	136.8	88.3	248.3
TX50	19	437.00	16872.6	61.3	16.8	27.1	4.5	88.1	68.6	0.0	NA	NA	0.0	0.0
TX30	18	476.00	18030.3	22.7	4.2	20.6	4.5	83.0	51.4	0.0	NA	NA	0.0	0.0
TX30	18[b]	476.00	18030.3	10.9	2.4	22.5	0.0	NA	NA	0.0	NA	NA	0.0	0.0

(blue)	100% and higher of response (≥EC0*)
(light blue)	90-99% of response (<EC0* - EC10*)
(green)	80-89% of response (<EC10* - EC20*)
(light green)	70-79% of response (<EC20* - EC30*)
(yellow)	60-69% of response (<EC30* - EC40*)
(light yellow)	50-59% of response (<EC40* - EC50*)
(orange)	<50% response (below EC50*)

Notes:

NA = not applicable; endpoint could not be calculated because of no survival or reproduction.

[a] Effect becomes more adverse as emergence time increases beyond the reference envelope. These values were compared to the maximum of the reference envelope responses, to calculate percentage of emergence time beyond the maximum reference response. Therefore, cooler colors are the lower values for this endpoint.

[b] Split sample tested by Army Corps of Engineers (ACOE) and U.S. Geological Survey (USGS).

[c] Sediment tested twice by U.S. Geological Survey (USGS).

Table B-8
Results of toxicity tests with *Hyalella azteca* exposed to OU-4 sediments from the Anniston PCB Site, Anniston, Alabama. Responses in OU-4 sediments are expressed as a percentage of the lowest response recorded among the six reference sediments (i.e., bottom-of-reference-envelope response), after all OU-4 and reference sediments had first been normalized to the control response within the batch in which they were tested.

				Transformed results (% of bottom-of-reference-envelope response) sorted by PCB-Aroclor concentration										
Location	Sed ID	PCB-A (mg/kg)	PCB-A/OC (mg/kg)	28-d Survival (%)	28-d Meas-ured total biomass (mg)	28-d Meas-ured ind. dry wt (mg)	28-d Length (mm)	42-d Survival (%)	42-d Meas-ured total biomass (mg)	42-d Meas-ured ind. dry wt (mg)	42-d Length (mm)	Total # Young	42-d Repro-duction (young/ female)	42-d Repro-duction (young/ female; 42-d normal.)[b]
TX10	16	0.05	18.1	98.1	69.9	83.3	96.6	93.7	80.8	113.3	98.9	27.8	18.2	18.3
TX20	28	0.22	30.6	106.8	81.2	94.7	112.6	106.3	125.7	144.9	106.4	220.4	153.1	154.4
TX20	24	0.27	122.7	100.0	96.2	126.7	108.9	109.5	113.5	125.9	100.7	140.7	105.3	107.4
TX40	15	0.60	40.8	95.1	109.3	117.5	106.4	92.1	113.7	161.8	105.8	148.1	113.5	88.8
TX60	20	3.08	277.5	93.4	91.9	114.3	108.0	107.8	98.5	111.2	102.9	104.4	56.1	65.5
TX30	23	4.90	235.6	104.9	81.8	81.1	101.2	95.2	100.4	129.7	101.4	114.8	78.5	70.2
TX40	27	7.28	667.9	97.1	92.5	100.3	105.3	95.2	128.8	161.4	101.0	137.0	102.6	103.2
TX60	13	12.40	837.8	90.3	67.2	92.4	108.4	92.1	84.6	111.8	96.8	24.1	20.2	18.5
TX30	25	26.30	1015.4	104.9	91.0	92.4	99.5	106.2	108.4	127.6	105.3	64.0	53.1	53.6
TX30	25[a]	26.30	1015.4	111.7	101.4	102.8	99.8	127.0	85.6	82.3	94.9	114.4	44.0	54.6
TX40	1	27.00	1436.2	102.0	84.3	103.3	102.3	115.8	84.5	88.8	105.4	96.5	48.3	53.2
TX40	14	28.30	1481.7	95.1	64.7	92.4	102.6	100.0	107.0	131.2	98.7	72.2	78.5	78.9
TX-30	2	37.10	1212.4	38.8	43.3	196.3	114.0	34.9	57.7	221.3	117.9	29.6	67.0	27.7
TX40	17	37.80	3500.0	102.9	107.7	128.5	111.4	101.6	108.8	129.8	104.9	88.9	78.4	77.1
TX60	6	59.90	4503.8	66.4	89.7	151.9	110.7	70.8	81.0	149.5	119.5	13.8	12.9	8.3
TX60	6[a]	59.90	4503.8	75.7	82.3	109.4	98.9	76.2	55.5	87.6	98.3	9.1	7.1	5.9
TX30	7	65.40	1639.1	74.1	64.6	89.1	94.6	77.2	57.4	90.5	108.2	56.1	43.6	33.3
TX50	11	85.50	3392.9	100.1	86.5	103.5	104.1	109.4	104.3	118.1	103.8	45.3	23.1	19.9
TX50	11[a]	85.50	3392.9	104.1	97.8	96.7	99.9	109.5	90.2	100.2	100.9	74.8	33.7	37.3
TX50	30	204.00	8869.6	42.4	58.4	152.4	115.9	45.0	84.6	313.1	114.4	22.6	42.3	17.1

Table B-8
Results of toxicity tests with *Hyalella azteca* exposed to OU-4 sediments from the Anniston PCB Site, Anniston, Alabama. Responses in OU-4 sediments are expressed as a percentage of the lowest response recorded among the six reference sediments (i.e., bottom-of-reference-envelope response), after all OU-4 and reference sediments had first been normalized to the control response within the batch in which they were tested.

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix B Analysis of OU 4 Sediment Toxicity Test Results and Development of Site-Specific Risk-Based Concentrations for PCBs in Sediment
Anniston PCB Site, Anniston, Alabama

				Transformed results (% of bottom-of-reference-envelope response) sorted by PCB-Aroclor concentration										
Location	Sed ID	PCB-A (mg/kg)	PCB-A/OC (mg/kg)	28-d Survival (%)	28-d Meas-ured total biomass (mg)	28-d Meas-ured ind. dry wt (mg)	28-d Length (mm)	42-d Survival (%)	42-d Meas-ured total biomass (mg)	42-d Meas-ured ind. dry wt (mg)	42-d Length (mm)	Total # Young	42-d Repro-duction (young/female)	42-d Repro-duction (young/female; 42-d normal.)[b]
TX50	30[a]	204.00	8869.6	90.9	87.5	93.9	98.9	87.3	72.7	102.5	100.3	27.8	19.4	16.5
TX50	8	320.00	11594.2	51.0	51.6	109.8	105.6	53.1	53.0	134.5	117.5	2.0	1.4	1.2
TX50	19	437.00	16872.6	5.8	4.9	190.2	NA	8.0	11.1	166.1	109.1	0.0	0.0	0.0
TX50	19[a]	437.00	16872.6	22.7	36.8	113.5	97.2	12.7	11.8	122.2	110.5	0.0	0.0	0.0
TX30	18	476.00	18030.3	6.7	19.9	365.1	NA	6.4	20.9	393.7	141.4	0.0	0.0	0.0

- 100% and higher of response (≥EC0*)
- 90-99% of response (<EC0* - EC10*)
- 80-89% of response (<EC10* - EC20*)
- 70-79% of response (<EC20* - EC30*)
- 60-69% of response (<EC30* - EC40*)
- 50-59% of response (<EC40* - EC50*)
- <50% response (below EC50*)

Notes:

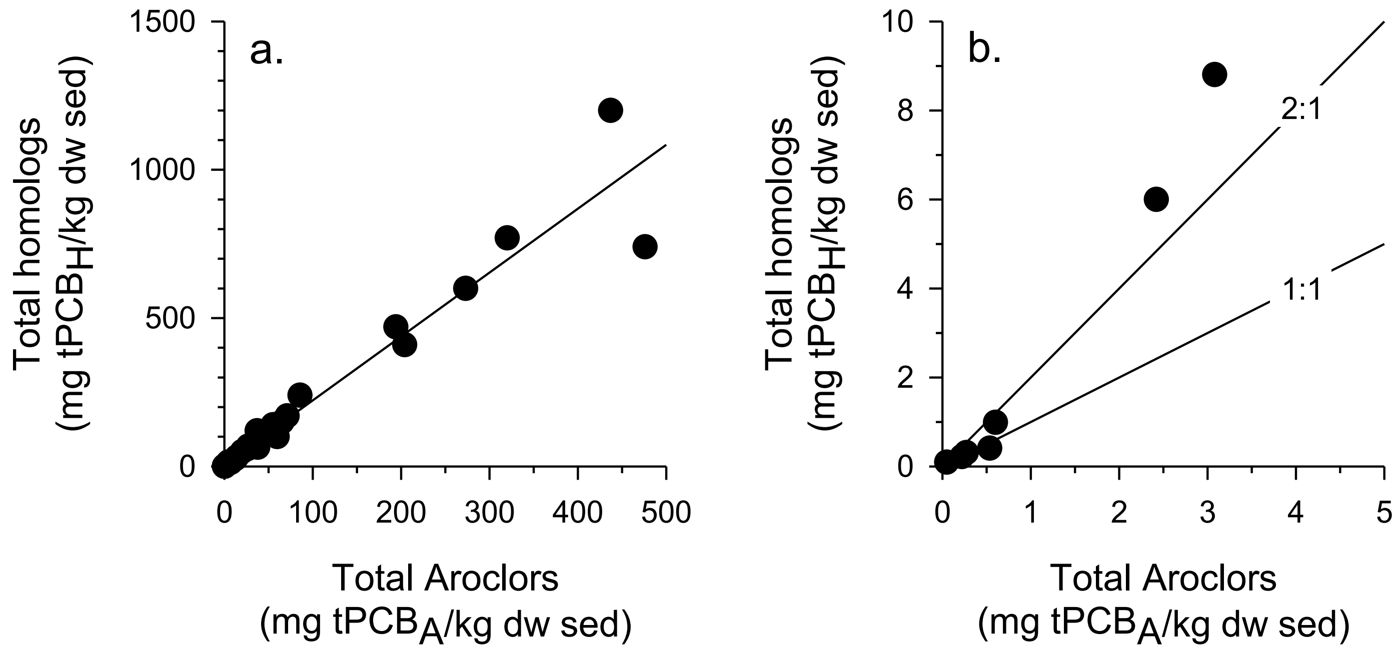
NA = not applicable; endpoint could not be calculated because of no survival or reproduction.

[a] Split sample tested by Army Corps of Engineers (ACOE) and U.S. Geological Survey (USGS).

[b] 42-day reproduction (young/female) normalized to survival of adult females.

ARCADIS

Figures



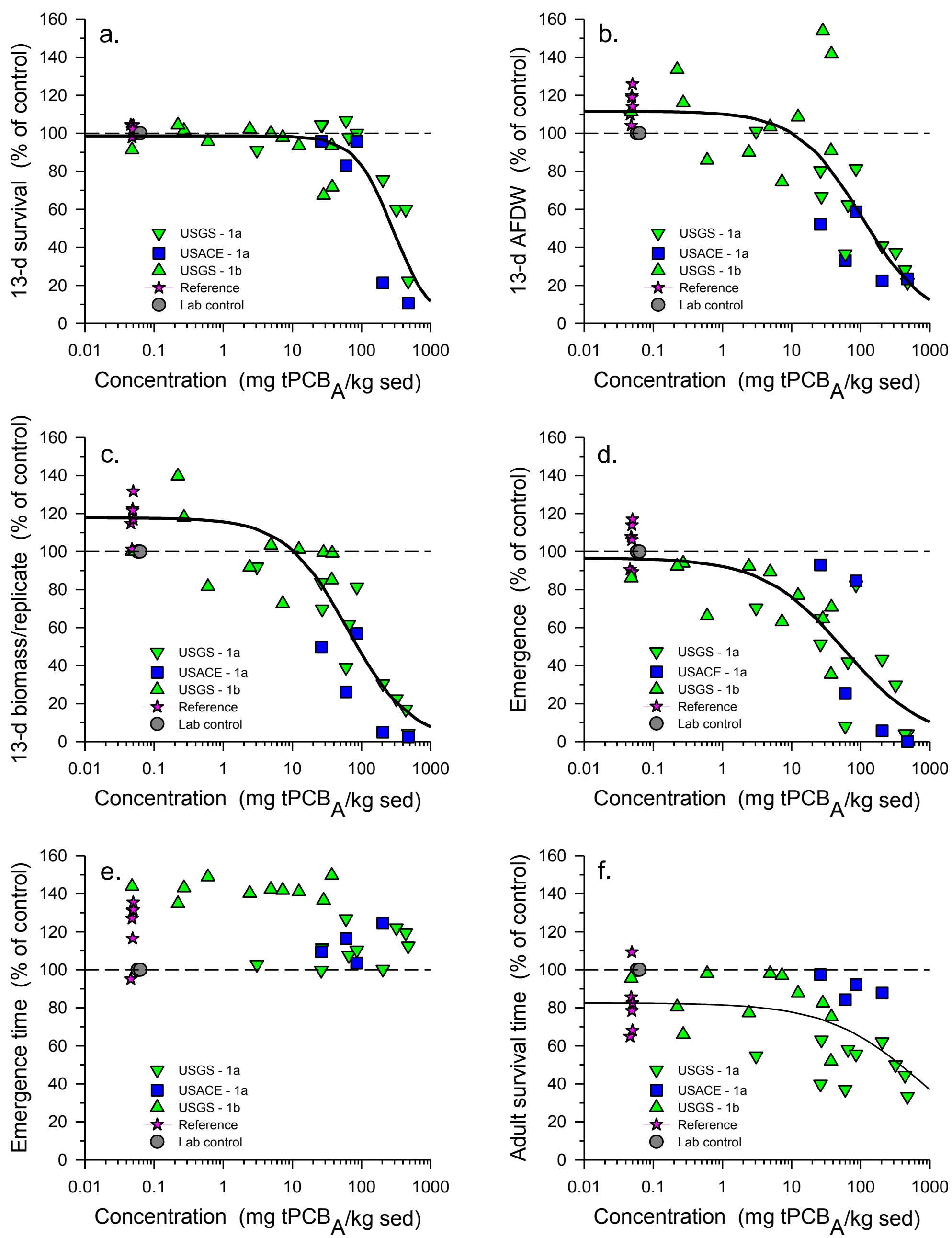
ANNISTON PCB SITE

ANNISTON , ALABAMA

Relationship between total PCB homolog (tPCBH) and total PCB Aroclor (tPCBA) concentrations in OU-4 sediments collected for toxicity testing. (a) All the sediments; the least-squares regression fit (the diagonal line) is tPCBH = 2.154×tPCBA + 7.363. (b) Only the 7 sediments having <4 mg tPCBA/kg dw sediment; the diagonal lines show homolog:Aroclor ratios of 2:1 and 1:1 for illustrative purposes.

Solutia

FIGURE
B-1



ANNISTON PCB SITE

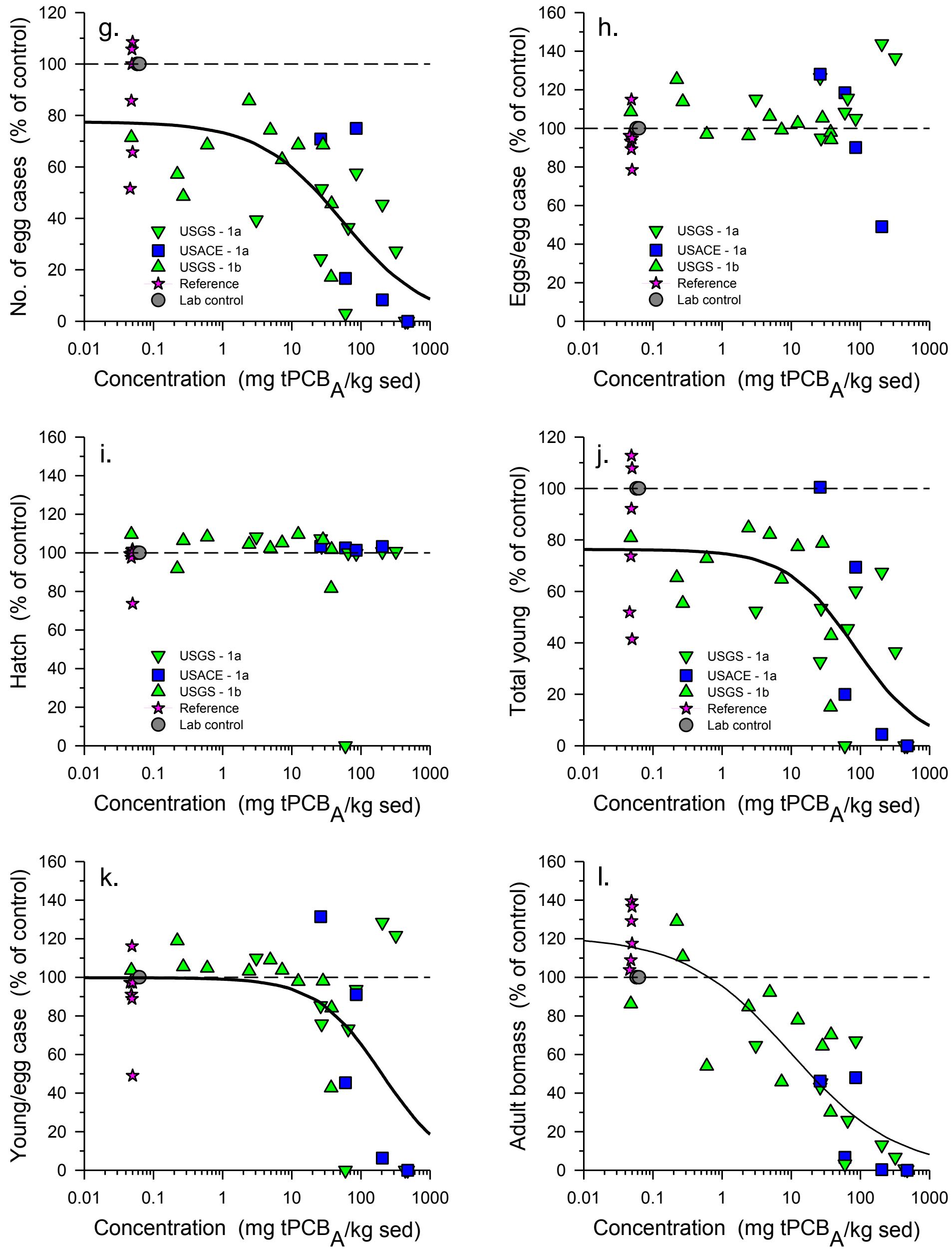
ANNISTON , ALABAMA

Response vs. dry weight-normalized tPCBA concentration relationships in the Chironomus dilutus toxicity tests conducted with OU-4 sediments from the Anniston PCB Site. Curves are logistic regressions; where no curve is shown, the response variable did not decrease as tPCBA concentration decreased. AFDW = ash-free dry weight; USACE = U.S. Army Corps of Engineers; USGS = U.S. Geological Survey.

Solutia

FIGURE

B-2



ANNISTON PCB SITE

ANNISTON , ALABAMA

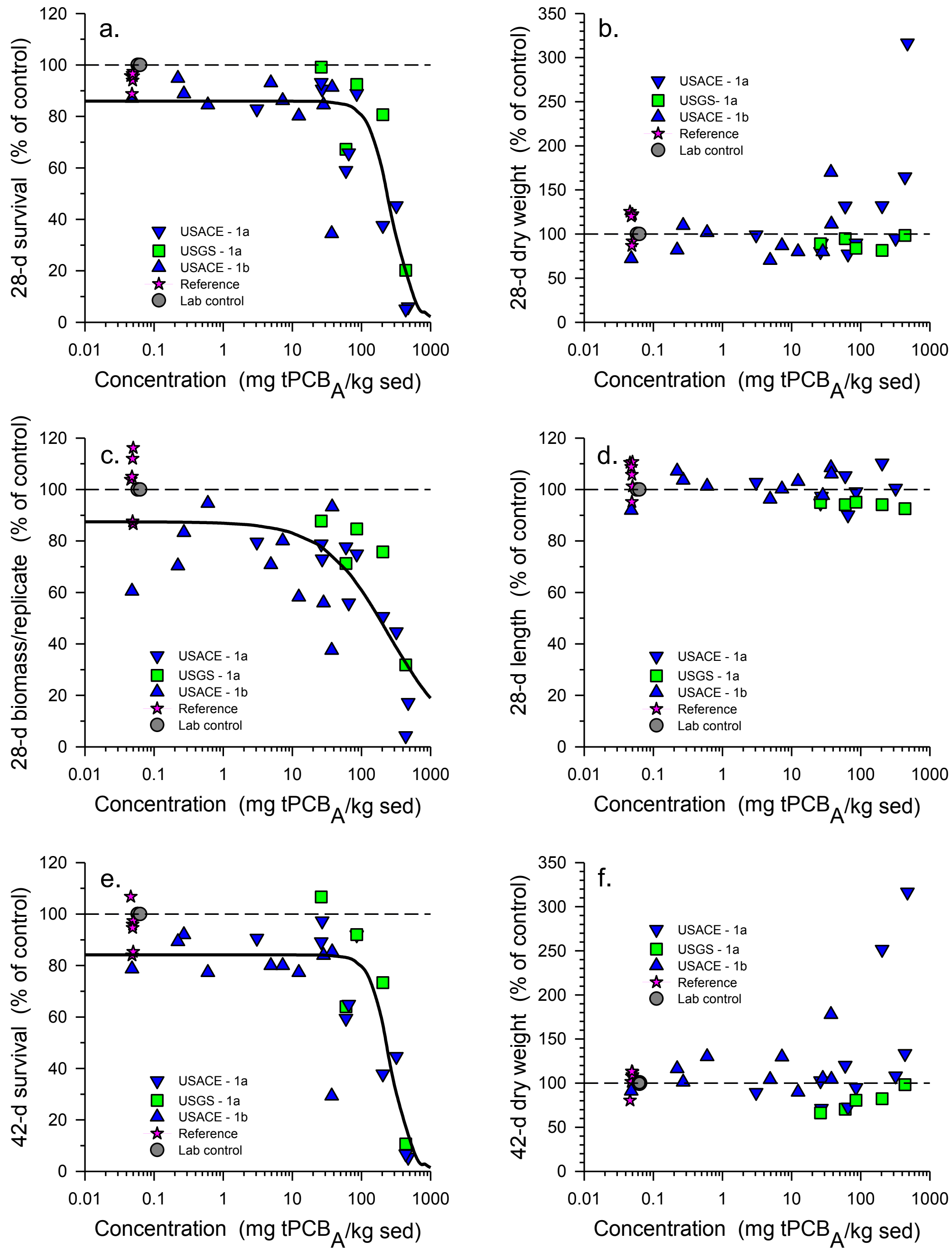
Response vs. dry weight-normalized tPCBA concentration relationships in the Chironomus dilutus toxicity tests conducted with OU-4 sediments from the Anniston PCB Site. Curves are logistic regressions; where no curve is shown, the response variable did not decrease as tPCBA concentration decreased. AFDW = ash-free dry weight; USACE = U.S. Army Corps of Engineers; USGS = U.S. Geological Survey.

Solutia

Ingenuity Productivity Performance

FIGURE

B-2



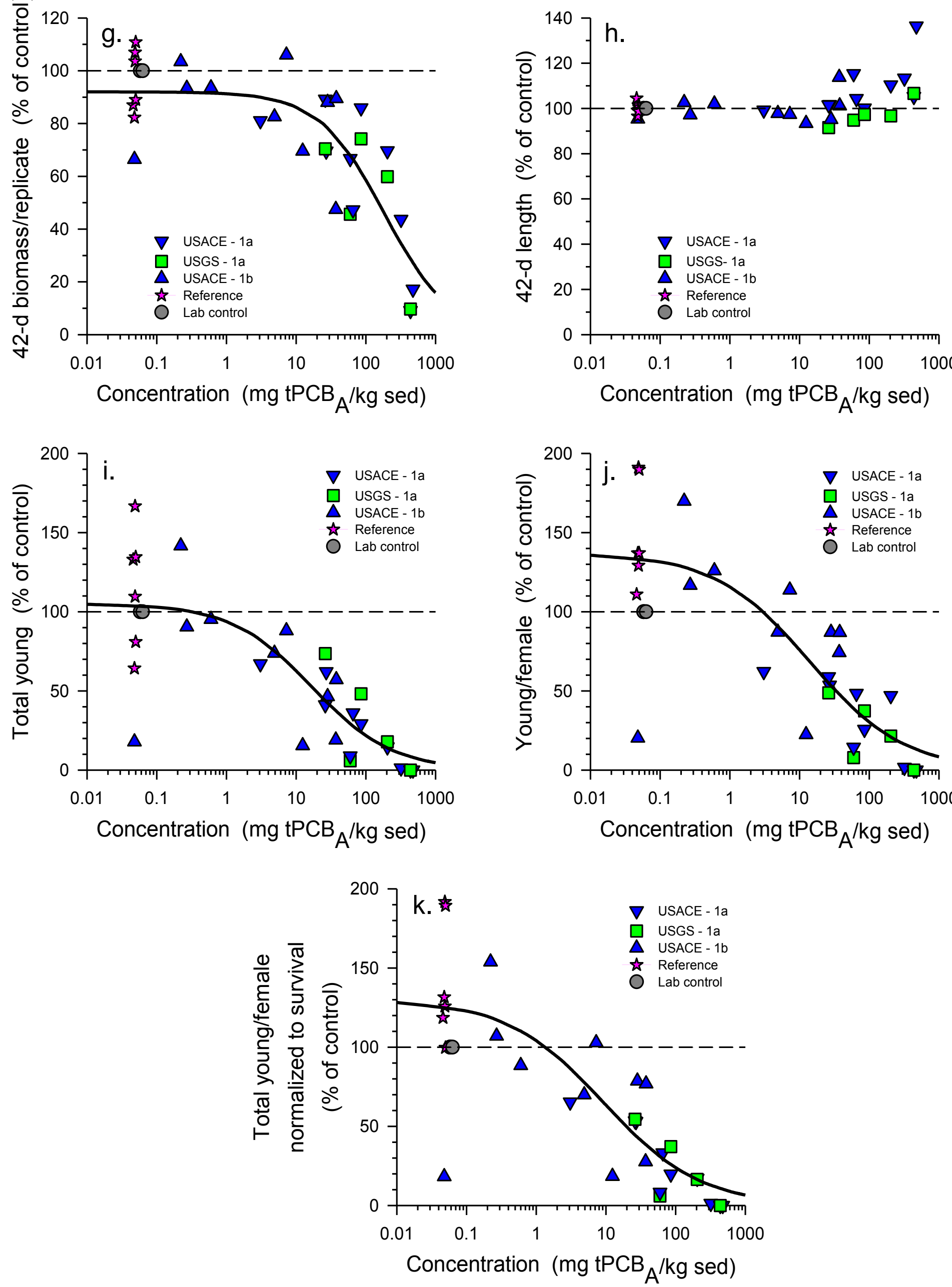
ANNISTON PCB SITE

ANNISTON , ALABAMA

Response vs. dry weight-normalized tPCBA concentration relationships in the Hyalella azteca toxicity tests conducted with OU-4 sediments from the Anniston PCB Site. Curves are logistic regressions; where no curve is shown, the response variable did not decrease as tPCBA concentration decreased. AFDW = ash-free dry weight; USACE = U.S. Army Corps of Engineers; USGS = U.S. Geological Survey.

Solutia

FIGURE
B-3



ANNISTON PCB SITE

ANNISTON , ALABAMA

Response vs. dry weight-normalized tPCBA concentration relationships in the Hyalella azteca toxicity tests conducted with OU-4 sediments from the Anniston PCB Site. Curves are logistic regressions; where no curve is shown, the response variable did not decrease as tPCBA concentration decreased. AFDW = ash-free dry weight; USACE = U.S. Army Corps of Engineers; USGS = U.S. Geological Survey.

Solutia

FIGURE

B-3

Appendix C

Development of Toxicity Reference Values for Birds and Mammals

Imagine the result

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Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek

Appendix C: Development of Toxicity Reference Values for Birds and Mammals

Anniston PCB Site, Anniston, Alabama

December 2013 Revision 2

Tables

Acronyms and Abbreviations

AHR	aryl hydrocarbon receptor
EcoSSL	Ecological Soils Screening Levels
COPC	constituent of potential concern
DLC	dioxin-like compound
kg	kilogram(s)
kg/kg BW-d	kilograms per kilogram of body weight per day
LOAEL	lowest-observed adverse effects level
mg/kg	milligrams per kilogram
mg/kg BW-d	milligrams per kilogram of body weight per day
NOAEL	no-observed adverse effects level
OU	Operable Unit
p	probability of a type 1 error
PCB	polychlorinated biphenyl
SERA	Streamlined Ecological Risk Assessment
TRV	toxicity reference value
USEPA	U.S. Environmental Protection Agency
ww	wet weight

1. Introduction

This document describes the identification of toxicity reference values (TRVs) for birds and mammals that will be used to evaluate potential risk to avian and mammalian receptors being evaluated in the *Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek* (SERA), to which this document is an appendix. The problem formulation identified dietary exposure as the most likely and significant exposure, thus, this document describes the development of dietary TRVs for the specified constituents of potential concern (COPCs). The COPCs being evaluated in the SERA are: polychlorinated biphenyls (PCBs), barium, chromium, cobalt, lead, manganese, mercury, nickel and vanadium.

Following U.S. Environmental Protection Agency (USEPA) guidance (1997), TRVs were developed based on endpoints that could result in population-level impacts such as survival, reproduction, development, and growth. The dietary dose-based TRV is defined as a daily dose of a chemical expressed in milligrams of chemical per kilogram of body weight per day (mg/kg BW-d). TRVs are generally developed to represent a dose associated with no-observed adverse effects levels (NOAEL or low TRV) or lowest-observed adverse effects levels (LOAEL or high TRV). TRVs were developed herein by considering the toxicity data available in the peer-reviewed literature using the following criteria as a guideline:

1. Close relatedness of the test species to the wildlife receptor of concern
2. Chronic duration of exposure and/or included sensitive life stages to evaluate potential developmental and reproductive effects
3. Measurement of ecologically relevant endpoints
4. Minimal impact of co-contaminants.

For PCBs and mercury, the primary literature was reviewed to develop TRVs. For other metals, dietary TRVs were taken from available sources commonly used in ecological risk assessment. Specifically, for the remaining seven metals, except for the avian TRVs for barium, TRVs were taken from USEPA Ecological Soil Screening Level (USEPA EcoSSL)[1] Guidance (USEPA 2005 and 2007). The avian TRVs for barium were taken from Oak Ridge National Laboratory Toxicological Benchmarks for Wildlife (Sample et al. 1996). The following sections describe the specific details of TRV development.

[1] Only NOAEL values are available in EcoSSL documents. LOAELs were developed from the underlying datasets as described in Section 3.

2. PCB TRVs

The following sections describe the development of dietary TRVs for PCBs. TRVs are summarized in Table C-1.

2.1 Avian Dietary PCB TRVs

For the SERA, avian PCB TRVs were developed based on the available toxicity data for all avian species. Individual avian studies were evaluated to select the most relevant study or studies based on the criteria described in Section 1 (i.e., relatedness of the test species, chronic duration/sensitive life stage of exposure, ecologically relevant endpoints, and minimal co-contaminants).

In considering the relatedness of the laboratory test species to the species of interest at the Operable Unit (OU)-1/OU-2 portion of Snow Creek, the relevance of the domestic chicken (the most common test species in the toxicity dataset) to wild species was considered. While TRVs are most often based on species other than the actual receptor species being evaluated, as detailed in USEPA (2003), the use of laboratory tested species to represent communities relies on the assumption that the tested species are an unbiased sample of the community. USEPA (2003) further explains that although test species are not chosen randomly, there is no reason to expect that the selection is biased because species sensitivities are unknown prior to testing. However, the available avian toxicological data clearly show that the domestic chicken is more sensitive to the effects of PCBs than the other species tested (Tables C-2 and C-3).

Recent research conducted by Dr. Sean Kennedy and others has focused on identifying specific mechanisms behind avian sensitivities to PCBs and other dioxin-like compounds (DLCs) (Karchner et al. 2006; Head and Kennedy 2010; Farmahin et al. 2012). This research has correlated differences in the genetic structure of the aryl hydrocarbon receptor (AHR) in avian species to species-specific sensitivity to DLCs. Specifically, research has demonstrated that there are three primary AHR types that are associated with high (type 1), moderate (type 2), and low sensitivity (type 3) to DLCs. The genetic sequence of the AHR has been identified and classified for more than 85 avian species, with the domestic chicken being identified as Type 1/most sensitive (Farmahin et al. 2012). Other identified species for which PCB toxicity studies are available include: pheasant (type 2), wild turkey (type 2), mallard (type 3), kestrel (type 3), and double-crested cormorant (type 3). These relative sensitivities have been established based on the correlation between the available toxicological data (primarily embryo lethality endpoints) and the genetic sequences (Head et al. 2008; Head and Kennedy 2010).

Based on the large disparity in the PCB datasets for chicken and other avian species and the fact that chickens are not related to nor representative of wild species present in the OU-1/OU-2 portion of Snow Creek, development of a range of TRVs to reflect the sensitivity ranges is provided herein. Two sets of avian

TRVs were developed to represent the high end of the range of sensitivity (based on the chicken dataset) and the mid-range of sensitivity (based on the non-chicken dataset).

Based on the second criteria, studies with a relatively short duration (e.g., less than one month) were only considered if the dose was administered over the course of a sensitive life stage for reproductive effects (i.e., Call and Harrell 1974). Based on these criteria, endpoints such as biomarkers of exposure, pathology (without other supporting endpoints), and behavior were excluded. Lastly, only studies that evaluated PCBs either as Aroclors or total PCBs without other constituents were considered. The toxicity of individual congeners may dramatically over- or underestimate potential toxicity. In most cases, studies using individual congeners were conducted with the most toxic congeners (i.e., PCB 126 and PCB 77) and would overestimate potential toxicity of PCB mixtures. In other words, comparing toxicity based on an individual congener value would be equivalent to assuming that the total concentration of a mixture or mixtures found in the environment are made up of 100% of this congener. Because this is a not supportable assumption, individual congener studies were excluded from consideration. The specific selection of dietary PCB TRVs for high- and mid-range sensitivity species is described below.

Dietary PCB NOAEL- and LOAEL-based TRVs were developed to represent the high end of the range of sensitivity and the mid-range of sensitivity for avian species. The NOAEL is generally selected as the highest NOAEL that is below the lowest LOAEL, and the LOAEL is the lowest relevant effect level observed. For dietary toxicity data, most studies reviewed reported doses as milligrams per kilogram (mg/kg) in diet. Unless specified in the study, it was assumed all dietary doses provided were on a wet weight (ww) basis. To facilitate TRV development, it was necessary to convert these dietary values into body weight normalized daily doses (mg/kg BW-d) using body weight and ingestion rate information for the test species. When this information was not available in the study, the body weight was taken from literature sources, and the ingestion rate was modeled using the allometric equation for all birds from Nagy (2001). Tables C-2 and C-3 summarize the toxicity data considered for chicken and non-chicken species respectively.

2.1.1 High End of Sensitivity Range

Nine studies conducted with domestic chickens were initially considered in the selection of NOAEL and LOAEL TRVs for high sensitivity species. One study, Summer et al. (1996a,b), was excluded from further consideration due to co-contamination in the Great Lakes fish diet fed to the chickens. The literature considered is summarized in Table C-2.

From the remaining eight studies, the LOAEL TRV is based on Lillie et al. (1974) in which a decline in chick growth was observed at 0.13 mg/kg BW-d Aroclor 1254 and 1248. This value is the selected LOAEL and is proposed as the LOAEL TRV for high sensitivity avian species. The chronic NOAEL of 0.043 mg/kg BW-d was estimated by dividing the chronic LOAEL from the Lillie et al. (1974) study by an uncertainty factor of three. A factor of 10 is considered excessive based on the range of the NOAEL data reviewed in which the lowest tested NOAEL was 0.065 mg/kg-BW-d (see Table C-2).

2.1.2 Mid-Range of Sensitivity

For mid-range sensitivity (i.e., non-chicken) species, a comprehensive dataset from the peer-reviewed literature was reviewed and considered to select NOAEL and LOAEL TRVs. A total of 14 studies were compiled for consideration, but a study by Custer et al. (1998) was rejected from further review because it was a field-scale study. From the remaining 13 studies, a total of 25 no-effect and 17 low-effect levels were observed for seven different non-chicken avian species, including Japanese quail, mallard, American kestrel, and screech owl (type 3 species); ring-neck pheasant (type 2 species); mourning dove, ring dove and white starling (unsequenced to date). The complete list of dietary PCB studies compiled for review for non-chicken avian species is shown in Table C-3.

The LOAEL from the Koval et al. (1987) study of 1.4 mg/kg BW-d was selected as the LOAEL TRV for the SERA. In this study, mated mourning dove pairs were isolated for 28 days and fed pellets containing 10 mg/kg Aroclor 1254 or control feed ad libitum. At the end of the treatment period, the dividers were removed and observations on reproductive behaviors were initiated. Mourning doves exposed to PCBs at 10 mg/kg resulted in a lower percentage of treated females that laid eggs and an increased time interval between nest occupation and egg laying. The dietary concentration was converted to a dietary dose of 1.4 mg/kg-BW-d using an ingestion rate of 15 g/day (Taber 1928) and a body weight of 0.108 kg (MacMillen 1962). While the study was not designed to measure this endpoint and no statistical analysis was conducted on this result, this value was selected as the basis for the LOAEL TRV for conservatism. This value is also consistent with an egg shell thinning LOAEL observed by Lowe and Stendell (1991) for American kestrels. While the relevance of shell thinning to reproductive output is uncertain, this selection of this study is also protective of this endpoint. In addition, the selected value is generally consistent with, but slightly lower than, the next lowest LOAEL from Dahlgren et al (1972) of 1.8 for reduced hatching success in a chronic study conducted with ring-necked pheasants.

To derive the NOAEL for mid-range sensitivity species, the chronic LOAEL from the Koval et al. (1987) study was divided by an uncertainty factor of three, resulting in the chronic NOAEL of 0.47 mg/kg BW-d. A factor of 10 is considered excessive based on the range of the NOAEL data reviewed in which the lowest measured NOAEL was 0.41 mg/kg-BW-d (see Table C-2).

2.2 Mammalian Dietary PCB TRVs

Following USEPA guidance (1997), dietary TRVs for mammals were developed based on endpoints that could result in population-level impacts such as survival, reproduction, development, and growth. As with avian species, the available toxicity data indicate that mink are more sensitive to PCBs than other mammalian species. As mink are not identified as a receptor in the SERA, the development of mammalian TRVs focuses on studies conducted with non-mink mammal species as described below.

A total of 11 studies were considered in the development of PCB dietary TRVs for small mammal species (Table C-4). The mouse and rat comprise most of the available species data, with the exception of two studies reporting toxicity results for the ferret and rabbit. A study conducted by McCoy et al. (1995) reported the lowest effect level of the available data and was selected as the basis for the LOAEL TRV. McCoy et al. (1995) was a multigenerational study with mice and a single dietary exposure of 5 mg/kg Aroclor 1254 for 12 months. This dietary concentration was converted to a daily dose of 0.68 mg/kg BW-d by using a mouse food ingestion rate of 0.135 kg/kg BW-d reported by Linzey (1987), which was not reported by McCoy et al. (1995). This dosage elicited significantly fewer offspring born per month and reduced body weights of newborn mice. Only two sets of bounded NOAEL and LOAEL values were available; however, these NOAELs were higher than the TRV selected for the LOAEL. Thus, a NOAEL TRV of 0.23 mg/kg BW-d was derived by applying an extrapolation factor of three. A factor of 10 would have been excessive based on the fact that the other NOAELs available for non-mink small mammals were higher than the TRV selected for the LOAEL.

3. Mercury TRVs

The following sections describe the development and selection of avian and mammalian dietary TRVs for mercury.

3.1 Avian Dietary Mercury TRVs

As a part of the Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife (USEPA 1995), dietary NOAEL and LOAEL TRVs for mercury were selected based on evaluation of the range of underlying studies available in the peer-reviewed literature. As a part of this process and outlined in the criteria document (USEPA 1995), a comprehensive literature search was conducted, and the evaluation focused on studies that included dose-response data. Studies with both methylmercury and inorganic forms of mercury were considered, with birds demonstrating much greater sensitivity to methylmercury than inorganic forms.

Unlike PCBs, chickens do not appear to be more sensitive to mercury than other wild avian species (Heinz et al. 2009). As such, one set of TRVs are developed herein and will be considered applicable to all avian species evaluated for the OU-1/OU-2 portion of Snow Creek. The studies considered in the USEPA (2005) criteria document focus on endpoints that could result in population-level impacts such as survival, reproduction, development, and growth.

Because the TRVs provided in the criteria document (USEPA 1995) are based on a literature search conducted in or prior to 1995, other more recent toxicity studies for mercury in avian species were reviewed. Specifically, three studies were identified that provided dose-response data for dietary mercury. These included Albers et al. (2007), Spalding et al. (2000), and Frederick and Jayasana (2011). Albers et al. (2007) studied the effects of methylmercury on reproduction of American kestrels and determined the dose of 0.08 mg/kg BW-d[2] resulted in a reduced number of fledglings and decreased percent of nestlings fledged. Frederick and Jayasana (2011) found increased homosexual pairing behavior at a dose of 0.1 mg/kg in diet and also a decrease in egg production at 0.05 mg/kg in diet. There were no significant differences in the number fledglings per female across all dose groups, including the high dose of 0.5 mg/kg in diet. Converting the food concentrations to a daily dose, the range of doses was 0.01 to 0.1 mg/kg BW-d[3] for the range of endpoints evaluated in the study. While the ecological relevance of all of the measured endpoints and observed effects to local populations of birds is not clear, the selected LOAEL TRV for mercury is within this range. The selected LOAEL TRV is based on a study conducted by Spalding et al. (2000). The study determined that dietary methylmercury resulted in adverse effects on growth of great egret nestlings at the low dose of 0.068 mg/kg BW-d[4]. The selected LOAEL from the Spalding et al. (2000) study was divided by an uncertainty factor of three, resulting in the chronic NOAEL of 0.023 mg/kg BW-d. A factor of 10 is considered excessive based on the range of the data considered and the selection of a LOAEL TRV that is based on the lowest value in this range.

3.2 Mammalian Dietary Mercury TRVs

As for avian species, the Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife (USEPA 1995) provides the basis for the selection of mammalian dietary TRVs. Values developed for use in the USEPA (1995) criteria document were reviewed along with peer-reviewed studies that have been conducted and published since the development of the criteria document values. Of the studies considered, a study by Dansereau et al. (1999), a two-generation study in which mink were fed a range of doses of total mercury in their contaminated fish-based diet, included the lowest LOAEL. Mortalities occurred in 11 month old G1 and G2 females fed the 1.0 mg/kg mercury diet after 90 days and 330 days of exposure, respectively. No mortality was observed in the 0.5 mg/kg exposure group. Converting this dietary concentration using an ingestion rate of 0.15 kg/day and a body weight of 1 kg (USEPA 1995), the LOAEL

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[2] Dose calculated from the LOAEL of 0.26 mg/kg ww in diet using a food ingestion rate for kestrel from USEPA (1993) of 0.31 kg/kg BW-d.

[3] Dose calculated from the dietary concentrations using a food ingestion rate and body weight for ibises taken from Kushlan (1977a,b).

[4] Dose calculated from the LOAEL of 0.5 mg/kg ww in diet using an estimated food ingestion rate from the low dose group of 17 percent body weight (range in study was 6 to 27 percent).

dose is 0.15 mg/kg BW-d. This study also provided a corresponding NOAEL of 0.075 mg/kg BW-d. These values are selected as the mammalian dietary TRVs for the SERA.

4. Other Metal Dietary TRVs

This section describes the selection and development of dietary TRVs for barium, chromium, cobalt, lead, manganese, nickel, and vanadium. As described in Section 1, the USEPA EcoSSL guidance was the primary source used to obtain TRVs for these metals (with the exception of the barium avian TRVs). Because the USEPA EcoSSL guidance (2005 and 2007) provides only NOAEL-based TRVs, in cases where the EcoSSL was the basis for a TRV, it was necessary to develop a LOAEL from the underlying data. LOAEL-based TRVs were developed as follows:

- When a bounded NOAEL-based TRV was recommended (i.e., the same study included a LOAEL for that endpoint) the LOAEL from that study was selected. For mammals this was the case for lead and nickel; for birds, lead and vanadium.

- When the recommended NOAEL-based TRV was unbounded, the lowest reproduction, growth, and survival LOAEL greater than the NOAEL-based TRV was selected. For mammals, this was the case for vanadium.

- When the recommended NOAEL-based TRV was a geometric mean of the reproduction and growth NOAELs, the lowest reproduction, growth, and survival LOAEL greater than the NOAEL-based TRV was selected. For mammals, this was the case for barium, chromium, cobalt, and manganese; for birds this was the case for chromium, cobalt, manganese, and nickel.

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Tables

Table C-1
Summary of Avian and Mammalian Toxicity Reference Values

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix C - Development of Toxicity Reference Values for Birds and Mammals
Anniston PCB Site, Anniston, Alabama

COPC	Wildlife Toxicity Reference Values (mg/kg BW-d)					
	Birds			Mammals		
	NOAEL TRV	LOAEL TRV	Reference	NOAEL TRV	LOAEL TRV	Reference
tPCB (mid-range sensitivity)	0.47	1.4	Koval et al 1987; NOAEL extrapolated	0.23	0.68	McCoy et al. 1995
tPCB (high sensitivity)	0.043	0.13	Lillie et al. 1974; NOAEL extrapolated	NA	NA	NA
Barium	20.8	41.7	Sample et al. 1996[1]	51.8	121	USEPA 2005a
Chromium	2.66	2.8	USEPA 2008	2.40	2.8	USEPA 2008
Cobalt	7.61	7.8	USEPA 2005b	7.33	10	USEPA 2005b
Lead	1.63	3.26	USEPA 2005c	4.70	8.90	USEPA 2005c
Manganese	179	348	USEPA 2007a	51.5	65	USEPA 2007a
Mercury	0.023	0.068	Spalding et al. 2000; NOAEL extraploated	0.075	0.15	Dansereau et al. 1999
Nickel	6.71	8.2	USEPA 2007b	1.70	3.40	USEPA 2007b
Vanadium	0.34	0.70	USEPA 2005d	4.16	8.31	USEPA 2005d

Footnotes:

[1] See Appendix C for details on development of specific TRVs.

[2] LOAELs selected from USEPA Eco SSL datasets were selected as the lowest LOAEL in the dataset for reproduction, growth or survival that was above the selected NOAEL. Values were used as presented in the Eco SSL dataset. Specific underlying studies were note reviewed.

Acronyms and Abbreviations:

COPC = contaminant of potential concern
LOAEL = lowest observed adverse effect level
mg/kg BW-d = milligrams per kilogram of body weight per day
NA = not applicable
NOAEL = no observed adverse effect level
OU = Operable Unit
tPCB = total polychlorinated biphenyl
TRV = toxicity reference value

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Table C-2
Summary of Chicken PCB Toxicity Data Considered for Toxicity Reference Value Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix C - Development of Toxicity Reference Values for Birds and Mammals
Anniston PCB Site, Anniston, Alabama

		Exposure					Effects					Results	
Study #	Reference	Chemical Form (Aroclor)	Dose	Dose Units [1]	Exposure Duration	Duration Units	Effect Group	Endpoint	Study NOAEL	Study LOAEL	Study Units	NOAEL (mg/kg BW-d)	LOAEL (mg/kg BW-d)
1	Briggs and Harris 1973	1242	20 and 50	mg/kg in food	6	weeks	reproduction	egg hatchability		20	mg/kg in food		1.3
2	Britton and Huston 1973	1242	5, 10, 20, 40, 80	mg/kg in food	12	weeks	reproduction	egg hatchability	5	10	mg/kg in food	0.32	0.65
3	Harris et al. 1976	1232	5, 10, 20	mg/kg in food	8	weeks	reproduction	egg hatchability		10	mg/kg in food		0.65
3	Harris et al. 1976	1242	5, 10, 20	mg/kg in food	8	weeks	reproduction	egg hatchability		10	mg/kg in food		0.65
3	Harris et al. 1976	1248	5, 10, 20	mg/kg in food	8	weeks	reproduction	egg hatchability		10	mg/kg in food		0.65
3	Harris et al. 1976	1254	5, 10, 20	mg/kg in food	8	weeks	reproduction	egg hatchability	5		mg/kg in food	0.32	
3	Harris et al. 1976	1016	5, 10, 20	mg/kg in food	8	weeks	reproduction	egg hatchability	5		mg/kg in food	0.32	
4	Lillie et al. 1974	1242	2 and 20	mg/kg in food	63	days	reproduction	egg hatchability	2	20	mg/kg in food	0.13	1.3
4	Lillie et al. 1974	1248	2 and 20	mg/kg in food	63	days	growth	chick growth		2	mg/kg in food		0.13
4	Lillie et al. 1974	1254	2 and 20	mg/kg in food	63	days	growth	chick growth		2	mg/kg in food		0.13
4	Lillie et al. 1974	1268	2 and 20	mg/kg in food	63	days	reproduction	egg production		20	mg/kg in food		1.3
4	Lillie et al. 1974	1221	2 and 20	mg/kg in food	63	days	growth	chick growth	20		mg/kg in food	1.3	
4	Lillie et al. 1974	1232	2 and 20	mg/kg in food	63	days	growth	chick growth		20	mg/kg in food		1.3
5	Lillie et al. 1975	1232	5, 10 and 20	mg/kg in food	16	weeks	reproduction	egg hatchability	5	10	mg/kg in food	0.32	0.65
5	Lillie et al. 1975	1016	5, 10 and 20	mg/kg in food	16	weeks	growth	chick growth	20		mg/kg in food	1.3	
5	Lillie et al. 1975	1242	5, 10 and 20	mg/kg in food	16	weeks	reproduction	egg hatchability	5	10	mg/kg in food	0.32	0.65
5	Lillie et al. 1975	1248	5, 10 and 20	mg/kg in food	16	weeks	reproduction	egg hatchability	5	10	mg/kg in food	0.32	0.65
5	Lillie et al. 1975	1254	5, 10 and 20	mg/kg in food	16	weeks	growth	chick growth	20		mg/kg in food	1.3	
6	Platanow and Reinhart 1973	1254	5 and 50	mg/kg in food	39	weeks	reproduction	egg production		5	mg/kg in food		0.32
6	Platanow and Reinhart 1973	1254	5 and 50	mg/kg in food	39	weeks	reproduction	egg hatchability		5	mg/kg in food		0.32
7	Scott 1977	1248	0.5, 1, 10 and 20	mg/kg in food	8	weeks	reproduction	egg production		20	mg/kg in food		1.3
7	Scott 1977	1248	0.5, 1, 10 and 20	mg/kg in food	8	weeks	reproduction	egg hatchability	1	10	mg/kg in food	0.065	0.65
8	Tumasonis et al. 1973	1254	50	mg/L in water	20	weeks	reproduction	egg hatchability		50	mg/L in water		3.2

General Notes:
Life stage for all test organisms is mature.
Dose conversion: Body weight for all test organisms was 1.95 kg, ingestion rates were 0.126 kg/day and 0.06 kg/kg BW-d.

Footnotes:
[1] When wet or dry weight was not specified in study, diet doses were assumed to be wet weight.

Acronyms and Abbreviations:
kg = kilogram(s)
kg/kg BW-d = kilograms per kilogram body weight per day
LOAEL = lowest-observed adverse effects level
mg/kg = milligrams per kilogram
mg/kg BW-d = milligrams per kilogram of body weight per day
mg/L = milligrams per liter
NOAEL = no-observed adverse effects level
OU = Operable Unit
PCB = polychlorinated biphenyl

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Table C-3
Summary of Non-Chicken Avian Dietary PCB Toxicity Data Considered for Toxicity Reference Value Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix C - Development of Toxicity Reference Values for Birds and Mammals
Anniston PCB Site, Anniston, Alabama

		Exposure											Effects					Dose Conversion			Results	
Study #	Reference	Chemical Form (Aroclor)	Test Organism	Dose	Dose Units [1]	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Life Stage	Sex	Effect Group	Endpoint	Study NOAEL	Study LOAEL	Study Units	Body Weight (kg)	Ingestion Rate (kg/day)	Ingestion Rate (kg/kg/day)	NOAEL (mg/kg BW-d)	LOAEL (mg/kg BW-d)
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	morphology	egg shell thickness		150	mg/kg diet	1.12	0.26	0.23		35
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	morphology	gross abnormalities	150		mg/kg diet	1.12	0.26	0.23	35	
14	Lowe and Stendell 1991	1248	American kestrel	3	mg/kg diet	FD	6	months	NA	NA	MA	B	morphology	egg shell thickness		3	mg/kg diet	0.12	0.054	0.47		1.4
15	McLane and Hughes 1980	1248	screech owl	3	mg/kg diet	FD	8	weeks	NA	NA	MA	B	morphology	egg shell thickness	3		mg/kg diet	0.18	0.025	0.14	0.41	
17	Risebrough and Anderson 1975	1254	mallard	40	mg/kg dw diet	FD	4	months	1	year	MA	B	morphology	egg shell thickness	40		mg/kg dw diet	1.0	0.18	0.18	7.4	
19	Scott et al. 1975	1248	Japanese quail	20	mg/kg diet	FD	10	weeks	NA	NA	MA	F	morphology	egg breaking strength	20		mg/kg diet	0.15	0.065	0.43	8.7	
11	Dahlgren et al. 1972	1254	ring-necked pheasant	12.5 and 50	mg/week	GV	16	weeks	1	year	MA	F	growth	chick growth	50		mg/week	1.0	NA	NA	7.1	
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	growth	adult female body weight		150	mg/kg diet	1.12	0.26	0.23		35
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	growth	duckling growth	150		mg/kg diet	1.12	0.26	0.23	35	
14	Lowe and Stendell 1991	1248	American kestrel	3	mg/kg diet	FD	6	months	NA	NA	MA	B	growth	egg weight	3		mg/kg diet	0.12	0.054	0.47	1.4	
19	Scott et al. 1975	1248	Japanese quail	20	mg/kg diet	FD	10	weeks	NA	NA	MA	F	growth	egg weight	20		mg/kg diet	0.15	0.065	0.43	8.7	
20	Dieter 1975	1254	wild starlings	1,5,25,100	mg/kg diet	FD	49	days	NA	NA	NA	NA	Mortality	mortality	5	25	mg/kg diet	0.085	0.044	0.52	2.6	13
9	Call and Harrell 1974	1242	Japanese quail	312.5/ 5000	mg/kg diet	FD	21	days	7	week	JV	F	reproduction	egg production		313	mg/kg diet	0.15	0.065	0.43		136
9	Call and Harrell 1974	1254	Japanese quail	78.1 / 1250	mg/kg diet	FD	21	days	7	week	JV	F	reproduction	egg production		78	mg/kg diet	0.15	0.065	0.43		34
9	Call and Harrell 1974	1260	Japanese quail	62.5 / 1000	mg/kg diet	FD	21	days	7	week	JV	F	reproduction	egg production		63	mg/kg diet	0.15	0.065	0.43		27
10	Custer and Heinz 1980	1254	mallard	25	mg/kg diet	FD	1+	month	9	month	MA	B	reproduction	reproductive success	25		mg/kg diet	1	0.10	0.10	2.5	
10	Custer and Heinz 1980	1254	mallard	25	mg/kg diet	FD	1+	month	9	month	MA	B	reproduction	hatchling success	25		mg/kg diet	1	0.10	0.10	2.5	
11	Dahlgren et al. 1972	1254	ring-necked pheasant	12.5 and 50	mg/week	GV	16	weeks	1	year	MA	F	reproduction	egg production	12.5	50	mg/week	1	NA	NA	1.8	7.1
11	Dahlgren et al. 1972	1254	ring-necked pheasant	12.5 and 50	mg/week	GV	16	weeks	1	year	MA	F	reproduction	egg fertility	50		mg/week	1	NA	NA	7.1	
11	Dahlgren et al. 1972	1254	ring-necked pheasant	12.5 and 50	mg/week	GV	16	weeks	1	year	MA	F	reproduction	chick survival	12.5	50	mg/week	1	NA	NA	1.8	7.1
11	Dahlgren et al. 1972	1254	ring-necked pheasant	12.5 and 50	mg/week	GV	16	weeks	1	year	MA	F	reproduction	egg hatchability		12.5	mg/week	1	NA	NA		1.8
12	Fernie et al. 2001	1248/1254/1260	American kestrel	7	mg/kg BW-d	FD	100	days	NA	NA	MA	B	reproduction	egg production		7	mg/kg BW-d					7.0
12	Fernie et al. 2001	1248/1254/1260	American kestrel	7	mg/kg BW-d	FD	100	days	NA	NA	MA	B	reproduction	number of fledglings		7	mg/kg BW-d					7.0
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	reproduction	egg fertility	150		mg/kg diet	1.12	0.26	0.23	35	
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	reproduction	embryo mortality	150		mg/kg diet	1.12	0.26	0.23	35	
13	Haseltine and Prouty 1980	1242	mallard	150	mg/kg diet	FD	12	weeks	NA	NA	MA	B	reproduction	duckling survival	150		mg/kg diet	1.12	0.26	0.23	35	
14	Lowe and Stendell 1991	1248	American kestrel	3	mg/kg diet	FD	6	months	NA	NA	MA	B	reproduction	egg production	3		mg/kg diet	0.12	0.054	0.47	1.4	
15	McLane and Hughes 1980	1248	screech owl	3	mg/kg ww diet	FD	8	weeks	NA	NA	MA	B	reproduction	egg production	3		mg/kg ww diet	0.18	0.025	0.14	0.41	
15	McLane and Hughes 1980	1248	screech owl	3	mg/kg ww diet	FD	8	weeks	NA	NA	MA	B	reproduction	eggs hatched	3		mg/kg ww diet	0.18	0.025	0.14	0.41	
15	McLane and Hughes 1980	1248	screech owl	3	mg/kg ww diet	FD	8	weeks	NA	NA	MA	B	reproduction	young fledged	3		mg/kg ww diet	0.18	0.025	0.14	0.41	
16	Peakall and Peakall 1973	1254	ring dove	10	mg/kg ww diet	FD	270	days	NA	NA	MA	B	reproduction	Egg production	10		mg/kg ww diet	0.15	0.065	0.43	4.3	
16	Peakall and Peakall 1973	1254	ring dove	10	mg/kg ww diet	FD	270	days	NA	NA	MA	B	reproduction	eggs hatched		10	mg/kg ww diet	0.15	0.065	0.43		4.3
16	Peakall and Peakall 1973	1254	ring dove	10	mg/kg ww diet	FD	270	days	NA	NA	MA	B	reproduction	young fledged		10	mg/kg ww diet	0.15	0.065	0.43		4.3
17	Peakall et al. 1972	1254	ring dove	10	mg/kg diet	FD	270	days	NA	NA	MA	B	reproduction	egg production		10	mg/kg diet	0.15	0.065	0.43		4.3
17	Peakall et al. 1972	1254	ring dove	10	mg/kg diet	FD	270	days	NA	NA	MA	B	reproduction	eggs hatched		10	mg/kg diet	0.15	0.065	0.43		4.3
17	Peakall et al. 1972	1254	ring dove	10	mg/kg diet	FD	270	days	NA	NA	MA	B	reproduction	young fledged		10	mg/kg diet	0.15	0.065	0.43		4.3
18	Risebrough and Anderson 1975	1254	mallard	40	mg/kg dw diet	FD	4	months	1	year	MA	B	reproduction	egg production	40		mg/kg dw diet	1.0	0.18	0.18	7.4	
19	Scott et al. 1975	1248	Japanese quail	20	mg/kg diet	FD	10	weeks	NA	NA	MA	F	reproduction	egg production	20		mg/kg diet	0.15	0.065	0.43	8.7	
19	Scott et al. 1975	1248	Japanese quail	20	mg/kg diet	FD	10	weeks	NA	NA	MA	F	reproduction	hatchability	20		mg/kg diet	0.15	0.065	0.43	8.7	
21	Koval et al. 1987	1254	mourning dove	10	mg/kg diet	FD	28	days	NA	NA	MA	B	reproduction	egg production		10	mg/kg diet	0.108	0.015	0.14		1.4

Footnotes:
[1] When wet or dry weight was not specified in study, diet doses were assumed to be wet weight.

Acronyms and Abbreviations:
B = both sexes
F = females
FD = in food
GV = oral gavage
JV = juvenile
kg = kilogram(s)
kg/d = kilograms per day
kg/kg/day = kilograms per kilogram per day
LOAEL = lowest-observed adverse effects level
MA = mature
mg/kg = milligrams per kilogram
mg/kg BW-d= milligrams per kilogram of body weight per day
dw = dry weight
ww = wet weight
mg = milligrams
NA = not available
NOAEL = no-observed adverse effects level
OU = Operable Unit
PCB = polychlorinated biphenyl

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Table C-4
Summary of Non-Mink Dietary PCB Toxicity Data Considered for Toxicity Reference Value Development

Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek
Appendix C - Development of Toxicity Reference Values for Birds and Mammals
Anniston PCB Site, Anniston, Alabama

	Exposure							Effects					Dose Conversion			Results	
Reference	Chemical Form (Aroclor)	Test Organism	Dose	Dose Units	Route of Exposure	Exposure Duration	Duration Units	Effect Group	Endpoint	Study NOAEL	Study LOAEL	Study Units	Body Weight (kg)	Ingestion Rate (kg/day)	Ingestion Rate (kg/kg/day)	NOAEL (mg/kg BW-d)	LOAEL (mg/kg BW-d)
Baker et al. 1977	1254	mouse	6.4	mg/kg BW	W	9	weeks	growth	body weight	6.4	NA	mg/kg BW	NR	NR	0.135	6.4	NA
Baker et al. 1977	1254	mouse	6.4	mg/kg BW	W	9	weeks	biochemistry	Cyp 450 and Aniline hydroxylase	NA	6.4	mg/kg BW	NR	NR	0.135	NA	6.4
Bleavins et al. 1980	1242	ferret	5,10,20,40	mg/kg diet	D	247	days	reproduction	reproductive failure	NA	20	mg/kg food	0.009	NR	0.13	NA	2.6
Bruckner et al. 1973	1242	rat	100	mg/kg BW	D-O	1	day	growth	decreased body weight	NA	100	mg/kg BW	NR	NR	NR	NA	100
Bruckner et al. 1973	1242	rat	100	mg/kg BW	D-O	1	day	biochemistry	increased liver microsomal and P450 enzymes	NA	100	mg/kg BW	NR	NR	NR	NA	100
Linder et al. 1974	1254	rat	1,5,20,100	mg/kg diet	D	274	days	reproduction	fewer pups per litter	NA	1.5	mg/kg BW-d	0.5	NR	NR	NA	1.5
Linzey 1987	1254	mouse	10	mg/kg diet	D	16	weeks	mortality	survival to weaning; fewer pups per litter; body weight	NA	10	mg/kg diet	NR	NR	0.142	NA	1.4
McCoy et al. 1995	1254	mouse	5	mg/kg diet	D	12	months	reproduction	reduced number weaned per month	NA	5	mg/kg diet	NR	NR	0.135	NA	0.68
McCoy et al. 1995	1254	mouse	5	mg/kg diet	D	12	months	growth	reduced birth and weaning weight	NA	5	mg/kg diet	NR	NR	0.135	NA	0.675
Merson and Kirkpatrick 1976	1254	mouse	200	mg/kg diet	D	60	days	reproduction	reduced number of litters	NA	200	mg/kg diet	NR	NR	0.135	NA	27
Neskovic et al. 1984	1242	rat	NR	NR	O-G	30	days	growth	NR	NA	75	mg/kg BW-d	NR	NR	NR	75	NA
Neskovic et al. 1984	1242	rat	NR	NR	O-G	30	days	biochemistry	SGOT and SGPT changes	NA	75	mg/kg BW-d	NR	NR	NR	NA	75
Spencer 1982	1254	rat	0,25,20,100,200,300,600,900	mg/kg diet	D	9	days	reproduction	reduced fetal survival rate per litter	200	300	mg/kg diet	0.25	0.0177/0.158	0.0708/0.0632	14	19
Spencer 1982	1254	rat	0,25,20,100,200,300,600,900	mg/kg diet	D	9	days	growth	decreased body weight	50	100	mg/kg diet	0.25	0.018/0.0193	0.072/0.0772	3.6	7.7
Villeneuve et al. 1971	1254	rabbit	0,1,10	mg/kg BW-d	D-O	28	days	reproduction	progeny counts/number	NA	NA	NR	2.5-3	NR	NR	10	13
Villeneuve et al. 1971	1254	rat	0,6.25,12.5,25,50,100	mg/kg BW-d	D-O	9	days	reproduction	progeny counts/number	NA	100	mg/kg BW-d	0.175-0.200	NR	NR	100	NA
Villeneuve et al. 1971	1254	rat	0,6.25,12.5,25,50,100	mg/kg BW-d	D-O	9	days	growth	body weight	NA	100	mg/kg BW-d	0.175-0.200	NR	NR	NA	100

Acronyms and Abbreviations:

D = diet
D-O = dose oral
W = daily via water
kg = kilogram(s)
kg/day = kilograms per day
kg/kg/day = kilograms per kilogram per day
LOAEL = lowest-observed adverse effect level
mg/kg BW = milligrams per kilogram of body weight
mg/kg BW-d = milligrams per kilogram of body weight per day
NA = not applicable
NOAEL = no-observed adverse effects level
NR = not reported
O-G = oral gavage
OU = Operable Unit
PCB = polychlorinated biphenyl
SGOT = Serum glutamic oxaloacetic transaminase
SGPT = serum glutamic pyruvic transaminase

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Appendix D

Site-Specific Risk-Based Concentrations for Dioxin Toxic Equivalents (TEQs) in Sediment, and Screening Assessment for the OU-1/OU-2 Portion of Snow Creek

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Appendix D

Site-Specific Risk-Based Concentrations for Dioxin Toxic Equivalents (TEQs) in Sediment, and Screening Assessment for the OU-1/OU-2 Portion of Snow Creek

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Appendix D

Site-Specific Risk-Based Concentrations for Dioxin Toxic Equivalents (TEQs) in Sediment, and Screening Assessment for the OU-1/OU-2 Portion of Snow Creek

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Appendix D

Site-Specific Risk-Based Concentrations for Dioxin Toxic Equivalents (TEQs) in Sediment, and Screening Assessment for the OU-1/OU-2 Portion of Snow Creek

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December 2013

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Acronyms and Abbreviations

AHR	aryl hydrocarbon receptor
BAF	bioaccumulation factors
COPC	chemical of potential concern
DLC	dioxin-like compound
DL-PCBs	dioxin-like PCBs
HHRA	human health risk assessment
LOAEL	lowest-observed-adverse-effect level
ND	non-detect
NOAEL	no-observed-adverse-effect level
OU	operable unit
PCB	polychlorinated biphenyl
PCDDs	polychlorinated dibenzodioxins
PCDFs	polychlorinated dibenzofurans
PeCDF	2,3,4,7,8-pentachlorodibenzofuran
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
RL	reporting limit
SERA	streamlined ecological risk assessment
SLERA	screening-level ecological risk assessment
SSRBC	site-specific risk based concentration
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TEF	Toxic Equivalency Factor
TEQ	toxic equivalent
TRV	toxicity reference value
USEPA	U.S. Environmental Protection Agency

1 Introduction

In 2005, Solutia Inc. (Solutia), and Pharmacia LLC completed the *Screening Level Ecological Risk Assessment for Operable Units 1, 2, and 3* (OU-1/OU-2 and OU-3 SLERA; BBL 2005) at the Anniston Polychlorinated Biphenyl (PCB) Site (the Site). The SLERA determined that terrestrial exposure pathways for ecological receptors throughout OU-1/OU-2 were truncated and incomplete. Habitat throughout "was severely disturbed and dominated by mowed and maintained lands with low-habitat quality plant cover, impervious surfaces, and transportation infrastructure." Development pressure continues to be strong in OU-1/OU-2, and over time, the remaining terrestrial habitat fragments will likely be subject to increasing disturbance as more urban infrastructure is constructed. The United States Environmental Protection Agency (USEPA) approved the OU-1/OU-2 and OU-3 SLERA, with the exception of the aquatic portions of Snow Creek located within the bounds of OU-1/OU-2. The USEPA approved the SLERA for the terrestrial portion of OU-1/OU-2, based on the finding that the terrestrial habitat could not support a thriving ecological community. The approval also recognized that no additional assessment of ecological risk in the terrestrial portion of OU-1/OU-2 was required.

The aquatic habitat in the OU-1/OU-2 portion of Snow Creek between the confluence with the 11th Street Ditch and Highway 78 is disturbed and generally consists of low-quality ecological habitat. However, this portion of the Creek likely supports some ecological receptors, and complete exposure pathways exist for sediment. Therefore, the USEPA required additional investigation of the potential effects of Site-related constituents on wildlife that may frequent the Snow Creek aquatic ecosystem. For this assessment, the USEPA requested consideration of risk associated with several constituents in addition to PCBs. These other constituents include barium, chromium, cobalt, lead, manganese, mercury, nickel, and vanadium. In addition, risk from exposure to polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD or dioxin) toxic equivalents (TEQs), was to be assessed. These constituents are evaluated in the *Streamlined Ecological Risk Assessment for the OU-1/OU-2 Portion of Snow Creek* (SERA; ARCADIS 2013). This development of Site-specific risk-based concentrations (SSRBCs) for dioxin and dioxin like compounds and TEQ screening assessment for Snow Creek sediment is being conducted as part of the SERA, and is provided as an appendix to the SERA report.

Although this memorandum and the approach to addressing TEQ in the SERA is responsive to the USEPA's request to evaluate these constituents, there are no relationships between the presence of PCBs and the presence of PCDDs/PCDFs in OU-1/OU-2 sediment. The *Remedial Investigation Report* for OU-1/OU-2 (OU-1/OU-2 RI; ENVIRON 2013) evaluates chemicals of potential concern (COPCs) and reaches the conclusion that the distributions of PCBs and PCDDs/PCDFs in OU-1/OU-2 are different. Soil and sediment samples with elevated PCDD/PCDF concentrations are not collocated with the higher-PCB concentration samples. If the source of the PCDDs/PCDFs in OU-1/OU-2 was contamination from PCB mixtures, one would expect these two classes of compounds to be collocated. Rather, the distribution of PCDDs/PCDFs is more reflective of urban background. A more probable explanation for the presence of PCDDs/PCDFs is general atmospheric dispersion from multiple industrial sources in the region (ENVIRON 2013). However, to meet the request of the USEPA, PCDDs/PCDFs and dioxin-like PCBs (DL-PCBs) are considered in this TEQ screening assessment.

1.1 TEQ Approach

TCDD, PCDDs/PCDFs, and certain DL-PCBs are structurally and toxicologically related halogenated aromatic hydrocarbons that have a common mechanism of action, involving binding of the chemicals to the aryl hydrocarbon receptor (AHR). The USEPA (2008) recommends that the TEQ component mixture method be used to evaluate ecological risks posed by these compounds, using TCDD as the index chemical. Therefore, PCDDs/PCDFs and DL-PCBs are evaluated as TCDD TEQs throughout this assessment. Table D-1 summarizes the sediment data for Snow Creek and provides the avian and mammalian toxic equivalency factors (TEFs) from the USEPA (USEPA 2008) and Van den Berg et al. (2006) that were used in the calculation of TEQs. TEFs are used to equate the potential toxicity of each PCDD/PCDF and DL-PCB congener based on their potency relative to TCDD. The concentration of each congener is multiplied by its TEF, resulting in a TCDD toxic equivalent concentration (i.e., the TEQ). TEQ values for each of the congeners are then summed to derive a total TEQ for each sample.

At the request of the USEPA, DL-PCBs were included in the TEQ assessment, even though there is a substantial amount of uncertainty regarding the use of the TEQ methodology for PCBs; this is particularly true when assessing risks to ecological receptors (Moore et al. 2012). The TEQ approach also places a significant weight on three PCB congeners—PCB-126, PCB-81, and PCB-77—with high avian TEF values (0.1, 0.1, and 0.05, respectively). However, these congeners were not detected in sediment samples collected from OU-1/OU-2, although detection limits were elevated for sample S-MED-1 (Table D-1). While the technical approach used by the USEPA in the human health risk assessment (HHRA; CDM 2010b) assumed these congeners to be absent from sediment at OU-1/OU-2 (CDM 2010a), they are included in this memorandum. In addition, PCBs were detected in sediment samples collected from locations upstream of the Site, indicating an upstream source for these compounds (ENVIRON 2013). While exposure to PCBs is already being assessed as part of the SERA, the USEPA requested that the TEQs for the derivation of the SSRBCs be calculated both with and without the inclusion of PCB congeners. This is addressed in Section 4, the Snow Creek Sediment Risk Screening, and is shown in Table D-1.

1.2 Document Organization

Consistent with the streamlined nature of the SERA, the potential ecological risks posed by PCDDs/PCDFs in Snow Creek sediment are evaluated in this memorandum via a screening assessment that uses a TEQ approach. Using this approach, SSRBCs were derived for TEQs and compared to Site sediment TEQ concentrations to assess risk to ecological receptors, and to provide important information to risk managers regarding the need for further ecological investigation at the Site. This assessment includes:

- Review of the literature to derive appropriate TEQ-based toxicity reference values (TRVs) for representative ecological receptors (i.e., birds and mammals) (Section 2)
- Derivation of SSRBCs for representative receptor species (Section 3)
- Screening of Snow Creek sediment data to assess risk to ecological receptors from exposure to dioxin-like compounds (DLCs) (Section 4)
- An analysis of the uncertainties associated with this procedure (Section 5)
- References cited (Section 6).

2 Derivation of Avian and Mammalian TRVs

Food-web modeling and TRVs from the scientific literature were used to calculate SSRBCs for TEQs that would be protective of ecological receptors potentially exposed to sediment at Snow Creek (refer to Section 3, Calculation of Site-Specific Risk-Based Concentrations). Ecological receptors and exposure parameters (e.g., food ingestion rates, body weights) used in this procedure are summarized in the SERA (ARCADIS 2013) and are reproduced in Tables D-2 and D-3, for birds and mammals, respectively. The same wildlife receptors as those evaluated in the SERA were evaluated in this TEQ screening assessment; these receptors include several trophic levels and multiple species, including benthic organisms, three mammals (muskrat, little brown bat, and the raccoon), and four bird species (mallard, tree swallow, spotted sandpiper, and pied-billed grebe).

2.1 Avian Dietary TRV for Dioxin-Like Compounds

To derive the TRV, the literature was reviewed for studies that investigated the effects of dioxin (as TCDD or on a TEQ basis) on avian species. The most relevant studies are summarized below.

2.1.1 Tittabawassee River Study (Fredricks et al. 2011)

Fredricks et al. (2011) studied tree swallows exposed to TCDD along the Tittabawassee River near Midland, Michigan. They observed that hatching success and overall productivity through fledging stage were not statistically different between TCDD-containing sites and reference areas. These investigators used a ring-necked pheasant intraperitoneal injection study (Nosek et al. 1992) as the basis for the dietary TRV for TCDD in their assessment. The dietary TRVs from the Nosek et al. (1992) study were 140 nanograms of TCDD per kilogram body weight per day (ng/kg bw-d) for the lowest-observed-adverse-effect level (LOAEL), and 14 ng/kg bw-d for the no-observed-adverse-effect level (NOAEL) for the endpoints of fertility and hatching success. The Fredricks et al. (2011) study suggested that these were conservative TRVs, due to the method of exposure and the likely greater sensitivity of pheasants compared to tree swallows.

Fredricks et al. (2011) determined food-web-based TCDD doses (34 to 630 ng/kg bw-d calculated from measured invertebrate residues) and bolus-based dietary doses (24 to 800 ng/kg bw-d). These estimated doses were greater than the NOAEL TRV from the Nosek et al. (1992) study (14 ng/kg bw-d). The maximum dietary TCDD doses (630 ng/kg bw-d from food web, and 800 ng/kg bw-d from bolus) were also greater than the LOAEL TRV (140 ng/kg bw-d). Reference-area dietary exposures were lower than both TRVs. This suggests that 800 ng TCDD/kg bw-d would be an unbounded dietary NOAEL for tree swallow hatching success and productivity at the Tittabawassee River, because, despite exceeding the TRV from the Nosek et al. (1992) study, no adverse effects were observed at these exposures. This also reinforces the notion that the TRV derived from the Nosek et al. (1992) pheasant study is likely overly conservative.

2.1.2 Woonasquatucket River Study (Custer et al. 2005)

In a field study at the Woonasquatucket River, Rhode Island, by Custer et al. (2005), a reduction in tree swallow hatching success was observed at estimated doses ranging from 61 to 190 ng TEQ/kg bw-d (concentrations in diet were 72 to 230 ng TEQ/kg diet, average 136.5 ng TEQ/kg wet weight [ww]). The authors reported that approximately 90% of the TEQ was due to the presence of 2,3,7,8-TCDD. Tree swallows from the Lyman pond at this site, with an average dietary concentration of 119.5 ng TEQ/kg ww, exhibited a reduction in hatching success (70% of eggs hatched), but it was not statistically different from the reference location (77%). Likewise, nestling periods were not statistically different between swallows at Lyman (100%) and the reference location (89%). A concentration of 119.5 ng TEQ/kg ww is the lowest dietary NOAEL observed for tree swallows in this study.

A dose-based TRV was calculated using these data from the Custer et al. (2005) study. Assuming that the moisture content of invertebrate prey is 80%, a dietary concentration of 597 ng TEQ/kg dry weight [dw] was calculated. Using the tree swallow ingestion rate of 0.24 kg food/kg bw-d (refer to Table D-2), a NOAEL-based TRV of 143.4 ng TEQ/kg bw-d was derived.

2.1.3 Avian NOAEL-Based TRV

The literature on the effects of TCDD on birds from field studies is inconsistent; some studies show no effects at relatively high concentrations of TCDD in diet, while others show effects at lower levels of exposure. In the Tittabawassee River study by Fredricks et al. (2011) described above, no adverse effects on tree swallow hatching success or productivity were observed at dietary doses as high as 800 ng TCDD/kg bw-d, whereas the study by Custer et al. (2005) on the Woonasquatucket River showed that adverse effects on hatching success were observed at dietary doses estimated as low as 190 ng TEQ/kg-d (Fredricks et al. 2011).

The study by Custer et al. (2005) was selected as the basis of the NOAEL-based avian TRV (143.4 ng TEQ/kg bw-d), for the following reasons:

- The evaluation looked at sensitive and population-relevant endpoints: hatching success and fledging.
- The study was conducted on tree swallows, the species that was selected for inclusion as a representative receptor in the Snow Creek SERA.
- The authors reported that nearly 97% of the TEQ in tree swallow eggs and nestling carcass samples was from a single congener—2,3,7,8-TCDD. Thus, this study is specific to the single congener used as the standard for the TEQ method (USEPA 2008).
- The data from Fredricks et al. (2011) suggested that the results of the Nosek et al. (1992) study, which was the basis of the TRV in their Tittabawassee River study, were uncertain or overly conservative, at least for the assessment of tree swallows.

- Because the NOAEL derived from the Custer et al. (2005) study (143.4 ng TEQ/kg bw-d) is lower than the NOAEL derived from the results of the study by Fredricks et al. (2011) (800 ng TCDD/kg bw-d), the 143.4-ng TEQ/kg bw-d TRV can be considered adequately protective.

Similar to mammalian species, most, if not all, biochemical and toxic effects of TCDD and other DLCs in birds are thought to be mediated by the AHR. Data show a link between the adverse effects and a mode of action in which binding and activation of the AHR is the critical initiating event (Denison et al. 2011; Okey 2007). Farmahin et al. (2012a) recently reported that the sensitivity of avian species to the toxic effects of DLCs varies up to 1000-fold among species. Further, their research and that conducted by others (e.g., Head et al. 2008; Karchner et al. 2006) suggests that this variability has been associated with inter-species differences in the AHR 1 ligand binding domain (AHR1 LBD) sequence.

Farmahin et al. (2012b) studied the AHR1 LBD sequences of 86 avian species, and differences were identified. The authors classified birds into three major types based on their sensitivity to the toxic and biochemical effects of DLCs: chicken-like or Group 1 (most sensitive), pheasant-like or Group 2 (intermediate sensitivity, 6-fold lower than Group 1), and quail-like or Group 3 (least sensitive, 35-fold less sensitive than Group 1).

Of the four avian species selected for evaluation in the OU-1/OU-2 SERA (mallard, tree swallow, spotted sandpiper, and pied-billed grebe), three were evaluated in the Farmahin et al. (2012b) study—spotted sandpiper, tree swallow, and mallard. The spotted sandpiper and tree swallow were placed in Group 2 (intermediate sensitivity), while the mallard was assigned to Group 3 (least sensitive). Although pied-billed grebe was not a species included in the Farmahin et al. (2012b) study, Hackett et al. (2008) published a phylogenomic analysis of various bird species using multiple genes as markers. In this report, the authors assign flamingo as a close phylogenetic relative of grebes, based on molecular and genetic studies. The flamingo was also not evaluated by Farmahin et al. (2012b), but close relatives of this species were classified as Group 3 (least sensitive). This suggests that the Custer et al. (2005) study provides an appropriately protective TRV for Group 2 species, including the tree swallow and spotted sandpiper, but may overstate risks to Group 3 birds in the assessment—the mallard and possibly the pied-billed grebe.

2.2 Mammalian Dietary TRV for Dioxin-Like Compounds

As with avian species, the literature was reviewed for studies that evaluated the effects of dioxin (on a TCDD or TEQ basis) on mammals for the derivation of the mammalian TRV.

Previous studies of individual PCDD and PCDF congeners or their mixtures have demonstrated that mink are among the more sensitive mammalian species tested, with reported effects on reproduction, development, and morphological lesions of the jaw (Bursian et al. 2006; Heaton et al. 1995; Restum et al. 1998). Studies on the mink jaw lesion suggest that this endpoint is considered the best sentinel for adverse effects in mink populations (Ellick et al. 2013; Zwiernik et al. 2009). However, from a population-impact perspective, adverse effects on reproduction and development are considered the more appropriate assessment endpoints. Mink are typically encountered in riparian ecosystems, and studies with mink are environmentally more relevant than those conducted on laboratory species such as mice or rats (e.g., Murray et al. 1979; DeVito et al. 1997), especially with compounds such as PCDDs/PCDFs, which exhibit a high degree of variability in species sensitivity. While mink are unlikely to be found along Snow Creek due to habitat constraints, this species provides a conservative basis for the less sensitive mammals that are being evaluated at the site: muskrat, little brown bat, and raccoon.

As discussed previously, in choosing the study for development of the TRV, one of the primary criteria is that the animals were not co-exposed to PCBs, particularly PCB-126. A recent high-quality study by Moore et al. (2012) satisfies this principle and was selected as the basis for the mammalian TRV.

Moore et al. (2012) investigated the effect of 3 congeners: TCDD, 2,3,4,7,8-pentachlorodibenzofuran (PeCDF), and 2,3,7,8-tetrachlorodibenzofuran (TCDF) on mink reproductive success and offspring viability and growth. Nine adult female mink were assigned randomly to one of 13 dietary treatments: one control and four doses each of TCDD, PeCDF, and TCDF (2.1–8.4, 4.0–15, and 5.2–25 ng TEQ/kg bw-d, respectively). The mink were exposed from two months prior to breeding through weaning of offspring at six weeks of age. At least nine kits per treatment group were maintained on these diets through 27 weeks of age. No effects on litter size or viability of offspring were observed at any of these treatment levels. In addition, consistent effects on body mass or relative organ masses were not observed in animals at any age. Therefore, this recent study by Moore et al. provides an unbounded NOAEL of 25 ng TEQ/kg bw-d, the highest dose at which no effects were observed.

Similarly, Zwiernik et al. (2009) exposed mink to 2,3,7,8-TCDF in diet up to 240 ng TEQ/kg ww. These authors reported that dietary doses as high as 30 ng TEQ/kg bw-d did not affect reproduction and kit viability, although body masses of offspring through 36 weeks of age were decreased compared with controls at various time points in the experiment.

The study by Moore et al. (2012) was selected as the basis for the derivation of the mammalian TRV (25 ng TEQ/kg bw-d), for the following reasons:

- The study evaluated sensitive and population-relevant endpoints: litter size and viability of offspring.
- Mink are likely more sensitive to the effects of PCDDs/PCDFs than are the representative mammalian receptors identified in the Snow Creek SERA: muskrat, little brown bat, and raccoon. Therefore, the TRV should be adequately protective of these species.
- Mink were exposed only to constituents that are the focus of this assessment: TCDD and PCDDs/PCDFs.
- The NOAEL-based TRV is supported by the results of the study by Zwiernik et al. (2009), in which exposure to doses in diet up to 30 ng TEQ/kg bw-d did not affect mink reproduction and kit viability. The NOAEL from Zwiernik et al. (2009) is also supported by the review by Blankenship et al. (2008), wherein the highest diet-based LOAEL, 242 ng TEQ/kg (ww feed), is similar

to the 240 ng TEQ/kg ww reported by Zwiernik et al. (2009) where the only effects observed were on offspring weight.

3 Calculation of Site-Specific Risk-Based Concentrations

The SSRBCs are sediment TEQ concentrations that are derived to be protective of resident wildlife that might forage at Snow Creek. SSRBCs were derived for each ecological receptor from the TRVs presented in Section 2. The SSRBCs are compared to Site sediment TEQ concentrations in Section 4 to assess risk to resident ecological receptors.

Food-web modeling was used to develop the SSRBCs for each representative receptor. The exposure factors and dietary profiles for the avian and mammalian species used in these calculations are described in detail in Section 4.4 of the SERA, and are provided here in Tables D-2 and D-3, for birds and mammals, respectively. Likewise, bioaccumulation factors (BAFs) are summarized in Section 4.3 and Appendix A of the SERA, and are repeated in Table D-4. Because the environmental transport through the aquatic food web is not as thoroughly studied for DLCs as for PCBs, the BAFs for PCBs used in the SERA were adopted for use in deriving the SSRBCs.

At the request of the USEPA, BAFs for PCBs were developed using two different approaches: 1) use of field data collected in Snow Creek; and 2) use of data collected as part of the sediment toxicity studies conducted for OU-4. While the first approach resulted in a single value for use in the bioaccumulation models, the latter method involved developing a linear regression for accumulation in worms relative to sediment concentrations of Aroclors. However, this approach was not appropriate for the estimation of accumulation of dioxin-like compounds, including PCBs, for several reasons. First, the data set used for the OU-4 laboratory bioaccumulation program did not contain PCDDs or PCDFs, and thus, there was no way of knowing whether the linear relationship derived for "Aroclors" was appropriate for these other compounds. Second, the concentrations of Aroclors in sediment used to derive the regression were significantly higher than the TEQ concentrations measured in Snow Creek sediments. Therefore, the derivation of the TEQ SSRBC relied on the BAF from Snow Creek field data.

The assessment endpoints that are relevant to the development of the SSRBCs for TEQ are similar to those described for PCBs—that is, the survival, growth, and reproduction of resident birds and mammals. Reproduction and development of young are considered the most sensitive endpoints that are relevant to population-level effects; therefore, the TRVs and, subsequently, the SSRBCs were derived from studies that assessed these effects.

Food-web modeling was used to calculate the SSRBCs using a target hazard of 1 and the TRVs derived in Section 2. The formula to calculate the SSRBCs for TEQ in sediment is:

$$\frac{\text{TH x TRV}}{\text{IR x }[(\text{CD}_i\ \text{ x BAF}_i)+(\text{CD}_2\ \text{ x BAF}_2)+\cdots(\text{CD}_i\ \text{ x BAF}_i)]}$$

where:

TH	Target hazard (unitless)
TRV	Toxicity reference value (ng/kg bw-d)
IR	Ingestion rate (kg/kg bw-d)
CD_i	Composition of diet (%)
BAF	Bioaccumulation factor (unitless)

The parameters used in the calculations are provided in Tables D-5 and D-6, for birds and mammals, respectively. The results of the SSRBC calculation for each receptor identified by the USEPA as relevant to OU-1/OU-2 are presented in Table D-7. Because the target hazard equals 1 and NOAEL-based TRVs are used to derive the SSRBCs, these values represent "safe" sediment concentrations to which the receptors could be exposed with no risk of adverse effects.

4 Snow Creek Sediment Risk Screening

The species-specific SSRBCs derived in Section 3 and presented in Table D-7 were used to evaluate the risks to resident wildlife receptors using sediment data from samples collected from Snow Creek. If TEQ concentrations in Snow Creek sediment are less than the SSRBCs, then risk to birds and mammals can be concluded to be negligible from exposure to DLCs in Snow Creek.

Avian and mammalian TEFs from the USEPA (USEPA 2008) and Van den Berg et al. (2006) were used to calculate TEQ concentrations for the Snow Creek sediment data. Data are available for two sediment samples in Snow Creek (Table D-1). These samples were part of a larger 2006 sampling effort conducted to support the OU-1/OU-2 remedial investigation/feasibility study (RI/FS). The sampling locations are described in the *Preliminary Site Characterization Summary Report for OU-1/OU-2* (ARCADIS BBL 2007). Sediment TEQ concentrations were calculated using these data for PCDDs/PCDFs and also for DL-PCB congeners. Total TEQs (PCDD/PCDFs + PCBs) were also calculated for each sample. The resulting sediment TEQ concentrations are reported in Table D-1.

Because several congeners were not detected in the sediment samples, a potential area of uncertainty associated with the TEQ calculation is the manner in which the samples with non-detected (ND) values are handled in developing TEQ concentrations. For example, nine of the fifteen (60%) PCDD/PCDF congeners on the analyte list were not detected in Snow Creek sample S-MED-1, and eight of the twelve individual PCB congeners were not detected in any of the samples. How these ND concentrations are handled can substantially affect the analysis of the data. An appropriate approach to address this issue of ND values for risk assessment purposes is to derive bounding estimates of the TEQ concentration (USEPA 2002). This method involves determining the lower and upper bounds based on the full range of possible values for NDs: 1) assuming that all of the ND concentrations are zero; and 2) assuming that the ND analytes are present at the detection or reporting limit (RL) and, at the recommendation of the USEPA, at 0.5 RL for PCBs. The following is a summary of Snow Creek sediment TEQ concentrations calculated using each of these scenarios and TEFs for mammals and birds (from Table D-1):

Total PCDD/PCDF TEQ, mammalian:

- When ND = 0, range: 1.9–36 ng/kg
- When ND = RL, range: 7.6–70 ng/kg

Total TEQ including PCBs (PCDDs/PCDFs + PCBs), mammalian:

- When ND = 0, range: 5.4–179
- When ND = RL for PCDDs/PCDFs and 0.5 RL for PCBs, range: 286–11,337 ng/kg

Total PCDD/PCDF TEQ, avian:

- When ND = 0, range: 9–94 ng/kg
- When ND = RL, range: 18–244 ng/kg

Total TEQ including PCBs (PCDDs/PCDFs + PCBs), avian:

- When ND = 0, range: 14–337 ng/kg
- When ND = RL for PCDDs/PCDFs and 0.5 RL for PCBs, range: 760.3–30,343 ng/kg

Although only two stations were sampled along the 4 miles of creek, they do provide sufficient information to assess a range of PCBs concentrations and their impact on the calculated TEQ.

- The levels of PCDDs/PCDFs and PCB congeners are generally low, with many—and in some cases, most—of the congeners below the analytical detection limit (ND).
- The maximum TEQ for PCDDs/PCDFs calculated using the mammalian TEFs (70 ng/kg, assuming ND = RL from Table D-1) is greater than the lowest SSRBC for mammals (37 ng/kg derived for the little brown bat, Table D–7), but would represent an HQ of only approximately 2.
- The maximum TEQ for PCDDs/PCDFs calculated using the avian TEFs (244 ng/kg, assuming ND = RL from Table D-1) is higher than the lowest SSRBC for birds (156 ng/kg derived for the tree swallow, Table D-7), but the HQ is still lower than 2.

As discussed previously, a high degree of uncertainty is associated with including the DL-PCB congeners in the TEQ estimate. This uncertainty is driven by including one half of the laboratory reporting limit concentration for these compounds (PCB-126, PCB-81, and PCB-77) when these congeners were not detected in Snow Creek sediment; and the high TEFs for these three specific PCB congeners. The uncertainty is underscored for sample S-MED-1, for which the sample-specific reporting limits are two orders of magnitude greater than the other sample results (Table D-1). Using one half of the sample-specific reporting limit significantly increases the total TEQ values (inclusive of PCDD/PCDF and DL-PCBs) despite the most important congeners (PCB-126, PCB-81, and PCB-177) not being detected by the laboratory. The calculated TEQ values (TEQ for PCDD/PCDF and TEQ for PCDD/PCDF and DL-PCBs) are presented in Table D-1. Including these non-detect values, even at one-half the reporting limit, would artificially inflate the “total TEQ” concentration and would not provide any useful information on the risks to wildlife from exposure to these compounds in Snow Creek Sediments. Therefore, this total TEQ analysis was not included as part of this assessment.

5 Uncertainty Analysis

As with any risk assessment, some degree of uncertainty is inherent in the assumptions and calculations. Several areas of uncertainty described in the SERA (SERA Section 6.3) are relevant to this assessment. Below are several of the more significant areas that contribute to the uncertainty associated with the derivation of the SSRBCs.

1. Relying on highly conservative TRVs for mammalian receptors. The TRV for mammalian species was derived from studies on mink. Mink are acknowledged to be uniquely and highly sensitive to the adverse effects of DLCs. Applying this TRV to all mammalian receptors evaluated in the assessment is very conservative and likely to overstate risk. Recent studies with avian species using advanced technology provide information on the relative sensitivity of various species of birds to the toxic effects of DLCs (refer to Section 2). However, similar studies are not available to assess the relative sensitivity of mammals. Therefore, it is not possible to assess the relative sensitivity of species such as the raccoon or muskrat, and the magnitude of the conservative nature of the mammalian risk-based TEQ concentration cannot be quantified.

2. Assuming that 100% of wildlife diet is made up of prey originating from Snow Creek. As described in detail in the SLERA (BBL 2005), both the aquatic and terrestrial habitat throughout much of Snow Creek is poor. Data provided in the SLERA indicate that the aquatic ecosystem of Snow Creek is unproductive throughout large portions of the creek. Therefore, it is unlikely that Snow Creek is sufficiently productive to support significant populations of birds and mammals. Those individuals that might visit Snow Creek would likely forage in other areas in addition to Snow Creek to support their dietary needs. Assuming that 100% of the receptors' diet originates from Snow Creek is highly conservative and is likely to overstate risk.

3. Assuming that a *population* of a given receptor species can be adversely affected by exposure to DLCs in Snow Creek sediment. As mentioned previously, because of the poor habitat provided by Snow Creek, including the patchy nature of the few areas of reasonably marginal habitat, and also due to the inaccessibility of the creek from development along its floodplain, few if any individuals from these species could be exposed in the manner assumed in this assessment (e.g., 100% of diet obtained from Snow Creek). Therefore, population-level effects are unlikely and risks would be overstated.

4. Using TRVs derived from field studies. Use of a TRV derived from a field study actually reduces the uncertainty associated with extrapolating administered dose (diet) to internal dose. For example, in the case of the avian TRV, if the oral absorption efficiency of DLCs in prey items from the Woonasquatucket River is assumed to be the same as that in prey from Snow

Creek, there would be no uncertainty in the extrapolation of doses. Therefore, there is an advantage to using field-derived TRVs versus those derived from laboratory studies that employ injection or oral gavage as the exposure route. This reduces the uncertainty associated with the derivation of the TRVs and the SSRBCs, and therefore would more accurately reflect actual risks.

5. Including dioxin-like PCB congeners in the calculation of the sediment TEQ concentrations. SSRBCs are exceeded only when the dioxin-like PCBs are included in the calculation of the TEQ. There is a high degree of uncertainty regarding the use of the TEQ method for PCBs, particularly when assessing risks to ecological receptors. The most significant PCB congeners in terms of "dioxin-like potency," and therefore significant contributors to the TEQ, are PCB-126, PCB-81, and PCB-77. These congeners were not detected in sediment at OU-1/OU-2. Furthermore, RLs for PCB congeners in sample S-MED-1 were very high. These factors contribute artificially to a high degree of uncertainty for the TEQs calculated, including the dioxin-like PCBs. For example, when 0 is used as a surrogate for ND congener concentrations, the maximum avian PCB TEQ is 243 ng/kg; using 0.5 RL the maximum avian PCB TEQ is 30,098 ng/kg (Table D-1), or more then 100-times higher. Because the Snow Creek data set for OU-1/OU-2 is limited to two analytical results for these three PCB congeners, we examined the available PCB congener data for sediment from the OU-4 portion of the Site. The OU-4 sediment data set supports the limited presence of these three congeners in the aquatic portions of the Site. There were 27 sediment samples from OU-4 analyzed for these three PCB congeners, and PCB-77 and PCB-81 were not detected in any of these 27 samples. PCB congener PCB-126 was only detected in two of the 27 samples (7.4%), which further supports the general absence of this congener. The OU-4 data set further confirms the limited impact of these PCB congeners, because the average sample-specific reporting limits for these three non-detected congeners is a factor of 10 to 100 lower than the sample-specific reporting limit associated with sample S-MED-1 from the OU-1/OU-2 portion of Snow Creek. For these reasons, exceeding the SSRBCs is not considered to be a significant finding for the OU-1/OU-2 portion of Snow Creek.

   The limited detection of PCB -126 is also supported by the floodplain soil data collected in OU-1/OU-2 and OU-4. PCB-126 was detected in only 12% of the floodplain soil samples (25 of 212) collected from these two OUs and analyzed for this particular congener. The analytical results for PCB-126 in the sediment samples are similar, with this congener being detected only in 15% (5 of 33) of the samples collected from these two OUs. In considering the effect of the other PCB congeners that make up the list of dioxin-like PCB congeners, the potential presence of congeners PCB-77, PCB-81, and PCB-169 is often considered. In addition to PCB-126, these other non-ortho-substituted PCB congeners have the largest effect on the calculated risk levels. The frequency of detection for these three congeners for the OU-1/OU-2 and

OU-4 data set includes PCB-77 at 9%, PCB-81 at 8%, and PCB-169 at 1%. These detection frequency percentages are based on all of the sample results, inclusive of parent and duplicate samples. This approach was necessary, because the PCB congeners were sometimes not detected in both the parent and duplicate samples. The collective frequency of detection for sediment in these two OUs includes PCB-77 at 15%, PCB-81 at 15%, and PCB-169 at 0%. While the frequency of detection of PCB-126 is higher (42%) in the 29 analyses that were conducted for sediments collected for the sediment toxicity and bioaccumulation testing program, these analyses were conducted on samples that are not representative of Site conditions and will not be used for defining the nature and extent of contamination in the yet-to-be-developed OU-4 Preliminary Site Characterization Summary Report and the OU-4 Remedial Investigation Report. These sediment samples were initially sieved in the field, re-handled and re-stored several times at the sediment toxicity testing laboratory over a 9-month period, and the same parent samples were often re-mixed and reanalyzed several times to arrive at the 29 analytical results. It is noteworthy that PCB-126 was detected only when the total PCB concentrations were elevated. Of the 11 of 26 samples in which PCB-126 was detected, nine of the samples had total PCB concentrations greater than 25 mg/kg, and two of samples had total PCB concentrations between 5 and 10 mg/kg. In any of these cases, the total PCB concentration would be the risk driver, and the potential presence of PCB-126 would not be a significant consideration. Concentrations of the other non-ortho-substituted PCB congeners (PCB-77, PCB-81, and PCB-169) were also not detected in any of the sediment samples collected for the sediment toxicity and bioaccumulation testing program.

The limited presence of PCB-126 in the Anniston area is also supported by research published in the mid-1990s (Frame et al. 1996). This research indicates that PCB congener PCB-126 was detected only in measurable concentrations in what is referred to as “late Aroclor 1254.” This particular mixture was manufactured only from 1974 to 1977, and based on the PCB production dates for the Anniston facility, it was not produced in Anniston.

The lines of evidence presented above support PCB-126 not being a significant risk contributor for OU-1/OU-2 and the Site as a whole. This finding is consistent with the human health risk assessments that were prepared for OU-1/OU-2 and OU-4 by the USEPA (CDM, 2010b and JM Waller and Associates, Inc. 2013).

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Appendix D Tables

Table D-1. Snow Creek sediment concentrations and TEQs

PCDDs/PCDFs	Units	TEF Mammalian	TEF Avian	S-LOW-1 S10136 0-6 in	S-MED-1 S10134 0-8 in	Average
2,3,7,8-TCDD	ng/kg	1	1	1.8 U	16 UXA	
1,2,3,7,8-PeCDD	ng/kg	1	1	2.2 U	3 U	
1,2,3,4,6,7,8-HpCDD	ng/kg	0.01	0.001	24	24	
1,2,3,4,7,8-HxCDD	ng/kg	0.1	0.05	1.1 U	2.2 U	
1,2,3,6,7,8-HxCDD	ng/kg	0.1	0.01	1.4	2.4 U	
1,2,3,7,8,9-HxCDD	ng/kg	0.1	0.1	1 U	2.1 U	
Octa CDD	ng/kg	0.0003	0.0001	180	267	
2,3,7,8-TCDF	ng/kg	0.1	1	8.3	130 UXB	
1,2,3,7,8-PeCDF	ng/kg	0.03	0.1	4 U	13	
2,3,4,7,8-PeCDF	ng/kg	0.3	1	4.1 U	82	
1,2,3,4,6,7,8-HpCDF	ng/kg	0.01	0.01	7.4 UXA	55 UXA	
1,2,3,4,7,8,9-HpCDF	ng/kg	0.01	0.01	1.3 UXA	40.6	
1,2,3,4,7,8-HxCDF	ng/kg	0.1	0.1	3.36	73.6	
1,2,3,6,7,8-HxCDF	ng/kg	0.1	0.1	1.62	19.6	
1,2,3,7,8,9-HxCDF	ng/kg	0.1	0.1	1 U	2.7	
2,3,4,6,7,8-HxCDF	ng/kg	0.1	0.1	1.18	10.2	
Octa CDF	ng/kg	0.0003	0.0001	11.2	115	
Total PCDD/PCDF TEQ (ND = 0) Mammalian	ng/kg	-	-	1.9	36	19
Total PCDD/PCDF TEQ (ND = RL) Mammalian	ng/kg	-	-	7.6	70	39
Total PCDD/PCDF TEQ (ND = 0) Avian	ng/kg	-	-	9.0	94	52
Total PCDD/PCDF TEQ (ND = RL) Avian	ng/kg	-	-	18.0	244	131

Table D-1. Cont.

PCB Congeners	Units	TEF Mammalian	TEF Avian	S-LOW-1 S10136 0-6 in	S-MED-1 S10134 0-8 in	Average
BZ#77	mg/Kg	0.0001	0.05	0.0042 U	0.17 U	
BZ#81	mg/Kg	0.0003	0.1	0.0084 UJ	0.34 UJ	
BZ#105	mg/Kg	0.00003	0.0001	0.028	1.7	
BZ#114	mg/Kg	0.00003	0.0001	0.0042 U	0.17 U	
BZ#118	mg/Kg	0.00003	0.00001	0.077	2.6	
BZ#123	mg/Kg	0.00003	0.00001	0.0042 U	0.17 U	
BZ#126	mg/Kg	0.1	0.1	0.0042 U	0.17 U	
BZ#156	mg/Kg	0.00003	0.0001	0.013	0.47	
BZ#157	mg/Kg	0.00003	0.0001	0.0042 U	0.17 U	
BZ#167	mg/Kg	0.00003	0.00001	0.0084 UJ	0.34 UJ	
BZ#169	mg/Kg	0.03	0.001	0.0042 U	0.17 U	
BZ#189	mg/Kg	0.00003	0.00001	0.0042 U	0.17 U	
Total PCB TEQ (ND=0) Mammalian	ng/kg	-	-	4	143	73
Total PCB TEQ (ND=0.5*RL) Mammalian	ng/kg	-	-	278	11268	5773
Total PCB TEQ (ND=0) Avian	ng/kg	-	-	4.9	243	124
Total PCB TEQ (ND=0.5*RL) Avian	ng/kg	-	-	742	30098	15420
TEQ Summary						
Total PCDD/PCDF TEQ (ND = 0) Mammalian	ng/kg	-	-	1.9	36	19
Total PCDD/PCDF TEQ (ND = RL) Mammalian	ng/kg	-	-	7.6	70	39
Total PCDD/PCDF TEQ (ND = 0) Avian	ng/kg	-	-	9.0	94	52
Total PCDD/PCDF TEQ (ND = RL) Avian	ng/kg	-	-	18	244	131
Total PCB TEQ (ND=0) Mammalian	ng/kg	-	-	3.5	143	73
Total PCB TEQ (ND=0.5*RL) Mammalian	ng/kg	-	-	278	11268	5773
Total PCB TEQ (ND=0) Avian	ng/kg	-	-	4.9	243	124
Total PCB TEQ (ND=0.5*RL) Avian	ng/kg	-	-	742	30098	15420
Total TEQ (ND=0) Mammalian	ng/kg	-	-	5.4	179	92
Total TEQ (ND=0) Avian	ng/kg	-	-	14	337	176
Total TEQ (ND=RL[DD/DF]; 0.5 RL[PCB]) Mammalian	ng/kg	-	-	286	11337	5812
Total TEQ (ND=RL[DD/DF]; 0.5 RL[PCB]) Avian	ng/kg	-	-	760	30343	15551
Contribution of BZ#126 to Total TEQ (ND=0)	%	-	-	0	0	0
Contribution of BZ#126 to Total TEQ (ND=RL[DD/DF]; 0.5 RL [PCB]) mammalian	%	-	-	73	75	74
Contribution of BZ#126 to Total TEQ (ND=RL[DD/DF]; 0.5 RL [PCB]) Avian				28	28	28

Table D-1. Cont.

Notes:

Data are from the RI (ENVIRON 2013)

Toxic Equivalency Factors (TEFs) are from EPA (U.S. EPA 2008) and Van den Berg et al. (2006)

Total TEQ is the summation of Total Dioxin TEQ and Total PCB TEQ.

U = not detected

J = Estimated

RL = Reporting limit

UY = not detected; peak exceeds expected retention time (from internal standard)

UXA = not detected; peak does not meet ratio criteria and has resulted in an elevated detection limit

UXB = not detected, diphenylether interference present caused dibenzofuran to become a "not detected"

Table D-2. Avian receptor exposure parameters

Parameter	Aquatic Herbivore		Aerial-Feeding Insectivore		Aquatic Invertivore		Aquatic Omnivore	
	Mallard		Tree Swallow		Spotted Sandpiper		Pied-Billed Grebe	
Composition of Diet (%)								
Sediment	6%	Beyer et al. (1994)	0%	Assumed to be negligible based on feeding strategy.	18%	Beyer et al. (1994), average of four sandpiper values.	6%	Mallard value assumed as a surrogate.
Aquatic Emergent and Flying Insects	0%		100%	Robertson et al. (1992)	50%		5%	
Aquatic Plants	80%	Herbivorous diet was chosen in order to evaluate mallard as an herbivorous receptor. Diet is based on professional judgment, supported by Dillon 1959 (in USEPA 1993) of a plant-based mallard diet in coastal Louisiana.	0%	--	0%	Diet adapted from Oring et al. (1997) using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.	10%	Diet adapted from Wetmore 1924 (in Muller and Storer 1999), using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.
Reptiles/Amphibians	0%		0%	--	0%		10%	
Benthic Invertebrates	10%		0%	--	50%		53%	
Crayfish	0%		0%	--	0%		20%	
Mollusk	10%		0%	--	0%		2%	
Body Weight (kg)	1.2	Average of non-breeding, adult birds (Drilling et al. 2002).	0.021	Robertson et al. (1992)	0.043	USEPA (1993), average of reported values.	0.42	Average of both sexes (Muller and Storer 1999).
Food Ingestion Rate (kg/kg bw/d) (dw)	0.087	Chukwudebe et al. (1988)	0.24	Nagy (2001), allometric equation for insectivores.	0.18	Nagy (2001), allometric equation for insectivores.	0.071	Nagy (2001), allometric equation for omnivores

Notes:

Exposure parameters are reproduced from SERA Table 4-2 (ARCADIS 2013)
-- = not applicable
dw = dry weight
kg = kilogram
kg/kg bw/d = kg/kg body weight per day
OU = Operable Unit
PCB = polychlorinated biphenyl
USEPA = U.S. Environmental Protection Agency

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Table D-3. Mammalian receptor exposure parameters

Parameter	Herbivore Muskrat		Mammalian Aerial-Feeding Insectivore Little Brown Bat		Mammalian Omnivore Raccoon	
Composition of Diet (%)						
Sediment	9%	Beyer et al. (1994), muskrat used as surrogate.	0%	Assumed to be negligible for aerial-feeding insectivores.	9%	Beyer et al. (1994)
Aquatic Emergent and Flying Insects	0%		100%	Belwood and Fenton (1976), as cited in Sample and Suter (1994).	0%	
Aquatic Plants	90%		0%	--	44%	
Amphibian (e.g., frogs)	0%	Diet adapted from USEPA 1993, using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2. Primarily herbivorous, but small invertebrates taken incidentally.	0%		10%	Diet adapted from USEPA 1993, using professional judgment to adjust based on food items available within Snow Creek portion of OU-1/OU-2.
Reptile (e.g., snakes)	0%		0%		5%	
Aquatic Invertebrates	5%		0%	--	13%	
Crayfish	0%		0%	--	15%	
Mollusk	5%		0%	--	13%	
Body Weight (kg)	1.1	Average of values given in Reid (2006).	0.01	Nagy (2001), allometric equation for little brown bat.	5.6	USEPA (1993), average of adult and juvenile means values.
Food Ingestion Rate (kg/kg bw/d) (dw)	0.07	Nagy (2001), allometric equation for Rodentia.	0.18	Nagy (2001), allometric equation for little brown bat.	0.03	Nagy (2001), allometric equation for Omnivores.

Notes:

Exposure parameters are reproduced from SERA Table 4-3 (ARCADIS 2013)
-- = not applicable
dw = dry weight
kg = kilogram
kg/kg bw/d = kg/kg body weight per day
OU = Operable Unit
PCB = polychlorinated biphenyl
USEPA = U.S. Environmental Protection Agency

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Table D-4. Summary of sediment to aquatic BAFs

	Sediment to Emergent Insects BAF_2	Sediment to Aquatic Plants BAF_3	Sediment to/ Amphibians (e.g., frogs) BAF_4	Sediment to Reptiles (e.g., snakes) BAF_5	Sediment to Benthic Invertebrates BAF_6	Sediment to Crayfish BAF_7	Sediment to Mollusks BAF_8
tPCB	3.82	0.42	3.40	26.91	0.92	0.75	6.50

Notes:

BAFs are reproduced from SERA Table 4-1 (ARCADIS 2013)

BAF = bioaccumulation factor

tPCB = total polychlorinated biphenyl

Table D-5. Parameters for the calculation of risk-based TEQ values for avian species

Symbol	Definition	Dabbling Duck	Tree Swallow	Spotted Sandpiper	Pied Billed Grebe
TH	Target Hazard (unitless)	1	1	1	1
TRV	Toxicity Reference Value (ng/kg bw-d)	143.4	143.4	143.4	143.4
IR	Ingestion Rate (kg/kg bw-d)	0.087	0.24	0.178	0.07
Cd_i	**Composition of Diet (%)**				
CD_1	Sediment (%)	6	0	18	6
CD_2	Emergent and Flying Insects (%)	0	100	50	5
CD_3	Aquatic Plants (%)	80	0	0	10
CD_4	Reptiles/Amphibians (%)	0	0	0	10
CD_5	Benthic Invertebrates (%)	10	0	50	53
CD_6	Crayfish (%)	0	0	0	20
CD_7	Mollusk (%)	10	0	0	2
BAF_i	**Bioaccumulation Factor**				
BAF_1	Sediment	0.3	0.3	0.3	0.3
BAF_2	Emergent and F lying Insects	3.82	3.82	3.82	3.82
BAF_3	Aquatic Plants	0.42	0.42	0.42	0.42
BAF_4	Reptiles/Amphibians	3.4	3.4	3.4	3.4
BAF_5	Benthic Invertebrates	0.92	0.92	0.92	0.92
BAF_6	Crayfish	0.75	0.75	0.75	0.75
BAF_7	Mollusk	6.5	6.5	6.5	6.5

Note:
Ingestion rates and dietary proportions are from Tables 2 and 3, for birds and mammals, respectively.
BAFs are from Table 4.

Table D-6. Parameters for the calculation of risk-based TEQ values for mammalian species

Symbol	Definition	Muskrat	Little Brown Bat	Raccoon
TH	Target Hazard (unitless)	1	1	1
TRV	Toxicity Reference Value (ng/kg bw-d)	25	25	25
IR	Ingestion Rate (kg/kg bw-d)	0.0682	0.178	0.03
CD_i	**Composition of Diet (%)**			
CD_1	Sediment (%)	9.4	0	9.4
CD_2	Emergent and Flying Insects (%)	0	100	0
CD_3	Aquatic Plants (%)	90	0	44
CD_4	Amphibians e.g., frogs (%)	0	0	10
CD_5	Reptiles e.g., snakes (%)	0	0	5
CD_6	Benthic Invertebrates (%)	5	0	13
CD_7	Crayfish (%)	0	0	15
CD_8	Mollusk (%)	5	0	13
BAF_i	**Bioaccumulation Factor**			
BAF_1	Sediment	0.3	0.3	0.3
BAF_2	Emergent and Flying Insects	3.82	3.82	3.82
BAF_3	Aquatic Plants	0.42	0.42	0.42
BAF_4	Amphibians e.g., frogs	3.4	3.4	3.4
BAF_5	Reptiles e.g., snakes	26.91	26.91	26.91
BAF_6	Benthic Invertebrates	0.92	0.92	0.92
BAF_7	Crayfish	0.75	0.75	0.75
BAF_8	Mollusk	6.5	6.5	6.5

Table D-7. Site-specific risk-based concentrations and species-specific parameters

	SSRBC for TEQ in Sediment (ng/kg)	Ingestion Rates (kg food/kg bw-d)	Body Weight (kg)
Avian Receptors			
Dabbling duck	1,504	0.087	1.17
Tree swallow	156	0.24	0.021
Sandpiper	332	0.18	0.043
Pied-billed grebe	1,508	0.07	0.416
Mammalian Receptors			
Muskrat	472	0.068	1.1
Little brown bat	37	0.18	0.0075
Raccoon	280	0.03	5.6

Note:
Ingestion rates and body weights are from Tables D-2 and D-3, for birds and mammals, respectively
SSRBC: Site-specific risk-based concentration