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BASELINE ECOLOGICAL RISK ASSESSMENT WORK PLAN FOR OPERABLE UNITS 2 & 3 OF THE SMURFIT-STONE/FRENCHTOWN MILL SITE LOCATED IN MISSOULA COUNTY, MONTANA

February 2018

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LIST OF ACRONYMS AND ABBREVIATIONS

BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
CFR	Clark Fork River
COPEC	Contaminants of Potential Ecological Concern
CSM	Conceptual Site Model
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EPC	Exposure Point Concentration
HDPT	High Density Pulp Tank
HQ	Hazard Quotient
LOAEL	Lowest-observed-adverse-effect-level
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish, Wildlife and Parks
NOAEL	No-observed-adverse-effect-level
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzo-p-furan
PEC	Probably Effect Concentration
RP	Responsible Party
RIWP	Remedial Investigation Work Plan
RP	Responsible Parties
SAP	Sampling and Analysis Plan
SLERA	Screening Level Ecological Risk Assessment
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzo-p-furan
TEC	Threshold Effect Concentration
TEF	Toxicity Equivalence Factor
TEQ	TCDD Toxicity Equivalent value
TRV	Toxicity Reference Value
TSB	Transformer Storage Building
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WMW	Wilcoxon-Mann-Whitney

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1.0 INTRODUCTION

1.1 Purpose and Scope of this Document

This document is a Work Plan that presents the approach and rationale for conducting the baseline ecological risk assessment (BERA) for the Smurfit-Stone/Frenchtown Mill site in Missoula County, Montana. The overall objectives of this Work Plan are to 1) describe how the problem formulation in the BERA will be further developed and refined beyond the problem formulation presented in the Screening Level Ecological Risk Assessment (SLERA), 2) outline the technical approach and methods that will be applied in the BERA for characterizing ecological exposures and risks, and 3) identify data gaps that may limit confidence in the risk characterization results in the BERA.

1.2 Site Overview

The Smurfit-Stone/Frenchtown Mill site encompasses approximately 3,150 acres of the northwestern portion of the Missoula Valley (herein referred to as "the Site"). A pulp mill operated at the Site from 1957 to 2010. The core industrial footprint of the Mill Site covers about 100 acres. Over 900 acres of the Site consist of a series of unlined ponds used to store treated and untreated wastewater effluent from the Mill, as well as primary sludge recovered from untreated wastewater. Some ponds initially used to store wastewater were drained and used for the landfilling of solid wastes generated from the Mill. Most of the pulp was used to produce un-bleached linerboard, but a small fraction (about 6 percent) of the total pulp produced from 1960-1999 was used to create white linerboard or sold as bleached pulp.

Various hazardous substances were used or produced at the Site during the time of operation. Numerous site investigations and monitoring events have been completed at the Site to evaluate the presence of contaminants of potential concern (COPCs) in environmental media (soil, groundwater, sediment, surface water). USEPA (2012) identified dioxins/furans, metals, polychlorinated hydrocarbons (PCBs), semi-volatile organic chemicals (SVOCs) and volatile organic chemicals (VOCs) as COPCs at the Site. Additional details on the historical mill operations, physical setting, ecological setting, and previous site investigations are presented in the Remedial Investigation Work Plan (RIWP) (NewFields 2015), the draft Screening Level Ecological Risk Assessment (SLERA) (USEPA 2017a), and on USEPA's Superfund Page for the Site[1].

[1] Smurfit-Stone Mill Frenchtown, Missoula, MT webpage: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0802850

For assessment and management purposes, the USEPA, the Montana Department of Environmental Quality (MDEQ) and the Responsible Parties (RPs) have agreed to divide the Site into three operable units (OUs) based on historic use and the nature of the potential environmental concerns (Figure 1-1). Ecological risks from OU1 have been evaluated previously (USEPA 2017b). This Work Plan focuses on OU2 (the former industrial area) and OU3 (the former wastewater treatment and holding ponds area, and parts of the Clark Fork River [CFR] floodplain, including the CFR itself).

1.3 Habitats and Biological Communities

1.3.1 OU2 Industrial Area

OU2 encompasses approximately 255 acres and includes the core industrial footprint of the former operational area. In OU2, there are a few buildings and other facilities and structures currently not in use, paved roads and parking areas, the wood chip staging area, and locations where recovery boilers, lime kilns and other equipment were once located but have been decommissioned. Many areas within OU2 do not currently provide good ecological habitat (gravel roads and/or paved areas). The plant community consists of hearty weeds, other forbs, and grasses. Wildlife that may use OU2 in its current state are those adapted to developed or disturbed areas (e.g., pigeons, swallows, crows, and small mammals). There is one area within OU2 that was formerly used as a borrow pit, and is now fed by groundwater, that may be considered surface water habitat in OU2. Although future land uses are expected to be mixed use or commercial/industrial, the lack of zoning restrictions means that OU2 could evolve into or be developed to provide improved ecological habitat in the future.

1.3.2 OU3 Uplands, Floodplain, and the Clark Fork River

OU3 encompasses approximately 1,700 acres and includes areas of the Site where solid and liquid wastes were treated and stored. OU3 currently includes multiple habitat types including upland meadows, several ponds in areas formerly used for treated water holding ponds and infiltration basins, and both forested and shrubby riparian areas adjacent to Lavalle and O'Keefe Creeks, the CFR, and side channels.

The upland meadows are occupied by both native forbs and shrubs and invasive weeds. Birds recently observed in this area include a variety of common passerines (e.g., sparrows, wrens, magpies), and small falcons as well as northern harriers, red-tailed hawks, and eagles perched in nearby snags or on poles or fences. Coyotes and deer have been observed in open areas of OU3 (elk have been observed in OU1), and parts of OU3 are currently used for cattle grazing. Numerous Columbia squirrels were observed in OU3 during a site visit in June 2017. Some

areas of the OU3 uplands were settling basins or landfills during mill operations. These occur closer to OU2, are covered with soil or wood chips and are sparsely vegetated.

Ponds in OU3 are fed by groundwater and surface water runoff. Because they do not have a surface hydrological connection to the river, they are not expected to be occupied or used by fish. Ponds containing water for most or all of the year currently are occupied by early successional stage wetland plant communities, including algae, and some floating and some emergent aquatic plants. Ponds are used by a variety of ducks, geese, and other waterfowl (e.g., grebes). They may also seasonally attract wading birds and shorebirds, amphibians, and reptiles.

O'Keefe Creek runs along the southern edge of OU3, and is joined by Lavalle Creek just before the confluence of Lavalle with the Clark Fork River. O'Keefe Creek is a ditch for much of its length. It is surrounded by emergent wetland vegetation (e.g., cattails, sedges, grasses) in some areas, and passes through culverts in several places along its length. Lavalle Creek is heavily impacted by grazing above the confluence with O'Keefe Creek. Both have very sparse riparian vegetation consisting mainly of grasses and forbs; shrubs and trees are largely absent on portions of the creeks that run through the Site. Beaver are active at the confluence of Lavalle Creek with the CFR, and signs of other aquatic mammals (e.g., river otters) have also been observed in this area. Waterfowl can be expected to use the creeks at times for foraging, but the lack of vegetative cover limits the creeks as breeding areas for birds.

Forested riparian areas adjacent to the CFR have an open understory and sparsely distributed Ponderosa pines with shrubby vegetation in some portions directly adjacent to the CFR. Large snags provide perches for eagles and osprey. Great blue herons, kingfisher, a variety of passerines and waterfowl have been observed along the shoreline of the river. Larger mammals using the upland portion of the Site can also be expected to visit the riparian habitat.

2.0 SCREENING LEVEL RISK ASSESSMENT

In accordance with the 8-step process used by USEPA (1997) to conduct ecological risk assessments (ERAs), a SLERA was previously conducted for the Site (USEPA 2017a). The SLERA identified the exposure media, exposure pathways, ecological receptor groups, and chemicals of potential ecological concern (COPECs) that require further assessment in the BERA. In brief, the SLERA identified a number of potentially significant exposure pathways, including:

- Direct contact of aquatic receptors with on-site surface water
- Direct contact of aquatic receptors with surface water in the CFR
- Direct contact of aquatic receptors with on-site sediments
- Direct contact of aquatic receptors with sediments in the CFR
- Direct contact of terrestrial plants and soil invertebrates with OU2 surface soil
- Direct contact of terrestrial plants and soil invertebrates with OU3 upland surface soil
- Direct contact of terrestrial plants and soil invertebrates with OU3 floodplain surface soil
- Ingestion of soil, food items, surface water and sediment by birds and mammals

Based on available data from analyses of samples of surface soil, sediment and surface water, the SLERA identified the following COPECs in site-media:

OU2 Surface Soil	OU3 Upland Surface Soil	Floodplain Surface Soil	CFR Flood Fringe Soil (a)	CFR Bed Sediment	On-site Surface Water	CFR Surface Water
TEQ (b)	TEQ	TEQ	TEQ	TEQ	No data	TEQ
Aroclor-1254	Aluminum	Aluminum	Aluminum	Copper		
Aroclor-1260	Antimony	Antimony	Arsenic	Manganese		
Aluminum	Arsenic	Arsenic	Cadmium	Mercury		
Arsenic	Barium	Barium	Chromium	Zinc		
Barium	Cadmium	Cadmium	Copper			
Cadmium	Chromium	Chromium	Lead			
Chromium	Copper	Copper	Manganese			
Copper	Lead	Lead	Mercury			
Lead	Manganese	Manganese	Vanadium			
Manganese	Mercury	Mercury	Zinc			
Mercury	Nickel	Silver				
Selenium	Selenium	Vanadium				
Vanadium	Vanadium	Zinc				
Zinc	Zinc					

(a) Floodplain soil is representative of historical pond sediments. No data on sediments collected from on-site ponds holding water were available.

(b) Data for dioxin and furan congeners were converted a 2,3,7,8-tetrachlorodibenzodioxin (TCDD) toxicity equivalent value (TEQ) by computing the sum across congeners of the product of the congener-specific concentration and relative Toxicity Equivalence Factor (TEF) for mammals (USEPA 2010) and birds (Van den Berg et al. 1998).

3.0 MANAGEMENT GOALS FOR THE BERA

The management goal for the Site is to ensure adequate protection of ecological receptors that may utilize aquatic or terrestrial habitat within the Site boundaries. Adequate protection is defined as protection of growth, reproduction, and survival of local populations. That is, the focus is on ensuring sustainability of local populations of ecological receptors, rather than on protection of every individual member of a population.

4.0 APPROACH FOR DEVELOPING THE BERA PROBLEM FORMULATION

The baseline problem formulation within the BERA will be developed by updating and expanding upon the screening level problem formulation presented in the SLERA (USEPA 2017a). Specific changes will include COPEC refinement, refinement of the CSMs, and refinement of assessment endpoints, as described below.

4.1 COPEC Refinement

The SLERA identified COPECs by comparing maximum detected concentrations of contaminants in Site media to conservative risk-based concentrations (USEPA 2017a). Because the COPEC selection process presented in the SLERA is inherently conservative, it is generally useful to refine the COPEC list prior to further focus assessment efforts (USEPA 2001). One strategy for COPEC refinement is a comparison of site data to an appropriate "background" data set. This is because USEPA does not require remedial action or further investigation of contaminants that are not elevated above background (non-site related) levels (USEPA 2002). Comparing site data to background data as an early step in the BERA and excluding COPECs that are not elevated provides a means for focusing the assessment.

Accordingly, as part of the problem formulation within the BERA, a statistical comparison of OU2 and OU3 data to available background data will be performed for the COPECs identified in the SLERA (USEPA 2017a). This will be done in accordance with the guidance provided in USEPA (2002). If a COPEC is observed to be present in Site media at a level higher than would otherwise be expected based on background data, then that contaminant will be retained for further assessment. If a COPEC is present in Site media at concentrations that are not statistically higher than the level that would be expected for that contaminant based on background levels, then it will be concluded that the Site-related contribution for that contaminant is sufficiently minor that further quantitative evaluation in the BERA is not needed. If data are inadequate to perform a reliable comparison of Site data to background, then the COPEC will be retained.

Available background data that will be used when performing the comparisons include the following:

Soil: The MDEQ has evaluated background concentrations of dioxins and inorganics in un-impacted soils across Montana (MDEQ 2011, 2013). These data are based on surface soil (0-2 inch depth) samples collected at sites with no known point sources.

Sediment and Surface Water: To support RI activities, NewFields previously collected sediment and surface water samples from locations within the CFR upstream of the Site. These samples were analyzed for dioxins/furans, PCBs (as Aroclors), metals, and SVOCs. Additional surface water and sediment data from locations within the CFR upstream of the Site are available from U.S. Geological Survey (USGS) monitoring stations located upstream of Missoula (Station ID 12340500), at Turah (Station ID 12334550), and near Drummond (Station ID 12331800) (Dodge et al. 2017). The USGS data are limited to select metals (arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel and zinc).

Fish: Fish have not been collected upstream of the Site as part of the RI investigation. In the absence of tissue data for fish collected within the CFR upstream of the Site, data from a national fish tissue study conducted by the USEPA (2016) will be used in the background comparison. USEPA (2016) collected adult fish from 1,924 randomly selected urban and non-urban river and stream sites in the conterminous United States. Predator fish species (e.g., bass or trout) ranging in length from 101-683 mm were collected. Composite fillet samples were analyzed for mercury and selenium (and other contaminants that are not of interest at the OU3 Site).

Because fish samples from USEPA (2016) were not analyzed for dioxins and Aroclors, the USEPA (2009) National Study of Chemical Residues in Lake Fish Tissue was also considered as a potential background fish tissue dataset. USEPA (2009) collected adult predator fish species (e.g., bass or trout) ranging in length from 122-840 mm. Composite skin-on fillet (scales removed and belly flap attached) samples were analyzed for mercury, PCBs as Aroclors, and dioxins/furans. Given that persistent organic pollutants like dioxins and PCBs accumulate in fat, using skin-on fillets with belly flap attached are not ideal for comparing dioxin and PCB concentrations measured in skinless fillets (MTFWP fish tissues). Additionally, there is uncertainty in the representativeness of using a background dataset based on fish collected from lakes to compare to fish collected from a river environment. Such a comparison may not account for potential influences of differing ecological variables that could influence contaminant uptake, absorption, and distribution.

The only other background information on concentrations of dioxins/furans in fish tissues that was found, comes from older studies that collected fish from areas within the CFR upstream of the Site (USEPA 1992b; TetraTech 1998). These data were limited to a point estimate based on a fillet composite sample (5 fish/composite) for brown trout collected from Warm Springs (USEPA 1992b) and a point estimate based on a whole-body composite sample (5 fish/composite) for mountain whitefish collected from the CFR just upstream of the Site (TetraTech 2998). These data are not adequate for performing statistical analyses and will not be used.

4.2 Refined CSM

The Draft SLERA presented CSMs for OU2 and OU3 based on Site knowledge at the time (USEPA 2017a). Because no exposure pathways were eliminated by the SLERA, the OU2 and OU3 CSMs developed for the BERA will be generally similar. However, the CSMs will be refined to include aquatic plants and herptiles (amphibians) as potential aquatic receptors. Additionally, the OU3 CSM will be expanded to include evaluation of exposures by ecological receptors to COPECs in O'Keefe and Lavalle Creeks. Figures 4-1 and 4-2 reflect these changes. Further refinement to the OU2 and OU3 CSMs may be made in the BERA based on the results of subsequent field investigations.

4.3 Identification of Assessment and Measurement Endpoints

An assessment endpoint is defined in Guidelines for Ecological Risk Assessment (U.S. EPA, 1998a) as "an explicit expression of the environmental value to be protected, operationally defined as an ecological entity and its attributes." Selection of appropriate assessment endpoints focuses the BERA on components of the ecosystem that could be adversely affected by the COPECs associated with the Site. In accordance with the general management goals identified above, the assessment endpoints selected for this Site include the survival, growth and reproduction of aquatic organisms (benthic macroinvertebrates, fish, and herptiles), terrestrial organisms (plants and soil invertebrates), and birds and mammals, as follows:

- Adequate protection of populations of aquatic receptors (fish, benthic invertebrates, aquatic plants, herptiles), including species of special concern (e.g., bull trout), from the deleterious effects of acute and chronic exposures to Site-related contaminants in surface water and sediment.

- Adequate protection of terrestrial plant and soil organism populations and communities by protecting them from the deleterious effects of exposures to Site-related contaminants in soil.

- Adequate protection of mammal and bird populations, including threatened and endangered species, by protecting them from the deleterious effects of acute and chronic exposures to Site-related contaminants in soils, sediments, waters, and prey items.

Measures of exposure and effects (also called measurement endpoints) represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (USEPA 1992a, 1997). Risk characterization in the BERA will be performed by calculating a hazard quotient (HQ) as the ratio of the estimated exposure of a receptor at the Site to a "benchmark" exposure that is believed to be without significant risk of unacceptable adverse effect on survival, growth, or reproduction, as follows:

HQ = Exposure / Benchmark

Exposure may be expressed in a variety of ways, including:

- Concentration in an environmental medium (water, sediment, soil, and diet)
- Concentration in the tissues of an exposed receptor
- Amount of chemical ingested by a receptor

In all cases, the benchmark toxicity value must be of the same type as the exposure estimate. When a receptor is exposed to a chemical by more than one pathway, HQs for that chemical for each exposure pathway will be added across pathways resulting in a "Total HQ" (HQ_t) for each chemical. In accordance with U.S. EPA guidance, HQ_ts for different chemicals are not added unless reliable data are available to indicate that the two (or more) chemicals act on the same target tissue by the same mode of action.

If the value of an HQ is less than or equal to 1, risks to exposed organisms are thought to be minimal. If the HQ exceeds 1, the risk of adverse effects in exposed organisms may be of potential concern, with the probability and/or severity of adverse effect tending to increase as the value of the HQ increases.

5.0 RISK EVALUATION APPROACH FOR THE BERA

5.1 Exposure Assessment

5.1.1 Wildlife Receptors

Although a wide range of wildlife receptors may occur at the Site, it is not feasible or necessary to evaluate exposures and risks for each avian and mammalian species potentially present at the Site. Rather, receptors may be grouped into feeding guilds (groups species with generally similar exposure potential), and one or more representative species within the guild can be used as a representative surrogate. Relevant receptor surrogates may also include species at higher trophic levels that forage on and off the Site.

Factors considered in the choice of the representative species included trophic level, feeding habits, and the availability of life history information. The bird and mammal species selected to serve as receptor surrogates for OU2 are presented below:

Feeding Guild	Receptor Surrogate	
	Avian	Mammalian
Terrestrial Invertivore	American robin Gray catbird	Vagrant shrew
Aerial Insectivore	Tree swallow	Bat
Herbivore	Blue grouse	White-tail deer Montane vole
Carnivore	American kestrel	Red Fox
Omnivore	Mallard Northern flicker Clark's nutcracker	Deer mouse

The species selected to serve as receptor surrogates for OU3 are presented below:

Feeding Guild	Receptor Surrogate	
	Avian	Mammalian
Terrestrial Invertivore	American robin Gray catbird	Vagrant shrew
Aerial Insectivore	Tree swallow	-- (a)
Aquatic Insectivore	American dipper	-- (a)
Herbivore	Blue grouse	White-tail deer Montane vole
Carnivore	American kestrel	Red Fox American mink
Piscivore	Belted kingfisher	River otter
Omnivore	Mallard Northern flicker Clark's nutcracker	Deer mouse

(a) This class of receptor does not occur in this area

5.1.2 Exposure Units

Aquatic Receptors

For the BERA, surface water and sediment data in the CFR and its smaller tributaries will be grouped into the following reaches:

- Clark Fork River upstream of the Site (reference area)
- Clark Fork River adjacent to and downstream of the Site
- O'Keefe Creek
- Lavalle Creek

For aquatic receptors exposed in these water bodies, each sample of water or sediment may be viewed as representing an environmental exposure location in which one or more organisms may be exposed. Thus, exposures of aquatic receptors to surface water or sediment will be evaluated on a sample-by-sample basis. However, concentrations within on-site ponds are assumed to homogenous. Under this assumption, on-site ponds will be evaluated as individual exposure areas.

Terrestrial Plants and Soil Invertebrates

Exposures of terrestrial plants and soil invertebrates to Site soils will be evaluated separately for the following areas:

- OU2
- OU3 upland
- OU3 holding pond areas within the 100-year floodplain
- OU3 floodplain area (FP) north of holding ponds that was not utilized as part of the historical wastewater treatment system (reference)

Because plants and soil invertebrates are not highly mobile, exposures to Site soils will be quantified on a sample-by-sample basis, rather than on an average concentration over some larger area.

Wildlife

For semi-aquatic terrestrial receptors that are exposed primarily along the river, creeks or wetlands (mallard, kingfisher, and tree swallow), the CFR and its smaller tributaries will be stratified into the following reaches:

- Clark Fork River upstream of the mill site (reference)
- Clark Fork River adjacent to and downstream of the mill site
- O'Keefe Creek
- Lavalle Creek
- Upland wetlands
- Floodplain wetlands

For terrestrial receptors, exposure areas will be defined according to the size of the home range of the receptor:

- Although it is anticipated that large home range receptors may be exposed across all of OU3 and potentially within OU2 (or at least consuming prey items exposed in OU2), exposures will be evaluated consistent with the assessment of the Site by OU to account for contaminant differences related to historical use. Thus, exposure areas for large home range receptors with home ranges that are on the same scale as the Site, will be all of OU2 and all of OU3.

- For receptors with intermediate size home ranges (10-1,000 acres), exposures will be evaluated separately for OU2, OU3 upland, OU3 floodplain, and the CFR floodplain downstream of the holding ponds that was never used for industrial purposes (reference). Within each of these areas, a medium home range will be evaluated as an area roughly 80-100 acres in size.

- For receptors with small home ranges (<10 acres), exposures will be evaluated on a sample-by-sample basis.

5.1.3 Exposure Point Concentrations

For evaluation of direct contact exposures by aquatic and terrestrial receptors, and small home range receptors, each sample of the abiotic exposure medium (surface water, sediment, or surface soil) may be viewed as representing an environmental exposure location in which one or more organisms may be exposed. For this reason, individual samples of surface water, sediment or soil are considered adequate to characterize the exposure of these receptors to COPECs.

The exposure of mobile receptors that have home ranges that are similar in size or larger than an exposure unit are best characterized based on the average exposure concentration within the exposure unit. Because the true average exposure concentration within an exposure unit can only be estimated from a finite set of measurements, USEPA generally uses the statistical upper confidence limit (UCL) on the average as a conservative estimate of the true average concentration. The most appropriate method for computing the UCL depends on the number of samples and the attributes (variance, skewness, degree of censoring) of each data set, so USEPA has developed software called ProUCL to help with this process (USEPA 2013). All UCL values used to evaluate exposure of mobile receptors will be derived using ProUCL.

5.1.4 Exposure Parameters

Exposure of aquatic receptors, plants and soil organisms will be evaluated based on the concentrations of a COPEC in the water or soil, where these receptors are living, so exposure factors are not needed for these groups.

Exposures of birds and mammals will be characterized in terms of the total ingested dose from each contaminated environmental media (e.g., soil, food and water) in accord with the following general equation:

$$\text{Daily Dose (mg/kg bw-day)} = ((FIR \times C_{food} \times RBA_{food}) + (WIR \times C_{water}) + SIR \times C_{soil} \times RBA_{soil})) \times AUF$$

where:

FIR = food ingestion rate (kg food dw/kg bw-day)
C_{food} = concentration in the overall diet (mg/kg food dw)
RBA_{food} = bioavailable fraction absorbed from ingested prey items (unitless)
WIR = water ingestion rate (L water/kg bw-day)
C_{water} = concentration in water (mg/L water)
SIR = sediment or soil ingestion rate (kg sediment dw/kg bw-day)
C_{soil} = concentration in sediment or soil (mg/kg dw)
RBA_{soil} = bioavailable fraction absorbed from ingested sediment or soil (unitless)
AUF = area use factor (unitless); fraction of time that a receptor spends at the Site relative to the entire home range.

If there are multiple types of foods consumed by the receptor, the portion of the dose derived from the diet incorporates the proportion of each prey type within a typical diet for that receptor. This is done by weighting the COPEC concentration in each component of the diet by the fraction of the total diet consisting of that prey type.

The USEPA has compiled exposure factors for a number of common birds and mammals that are presented in the Wildlife Exposure Factors Handbook (USEPA 1993). Published literature will also be reviewed to identify relevant exposure parameter values as needed. Wildlife exposure factors will be selected to represent average year-round adult exposures. In cases where no quantitative data are available, professional judgement will be used to select appropriate exposure parameters.

The exposure parameters selected for each wildlife receptor surrogate identified for evaluation in the BERA are detailed in Appendix A.

5.1.5 Food Web Exposure

Exposures of birds and mammals through the food chain is often of particular importance for contaminants that tend to bioaccumulate. The SLERA identified dioxins/furans and mercury as bioaccumulative COPECs at the Site. Measured or estimated concentrations of these COPECs in forage and prey items will be used in the estimate of ingested dose for each wildlife receptor surrogate.

Fish

In the case of fish tissues, available data in fish fillets (see Section 6.1.5.1) will first be used to model whole body concentrations using equations from Bevelhimer et al. (1997). These

estimated whole-body concentrations will then be used to estimate dietary exposure of piscivorous receptors.

Other Prey Items

Site-specific tissue concentrations in other prey items (terrestrial plants, aquatic invertebrates, terrestrial invertebrates, small mammals) are not currently available or are not adequate to support estimation of wildlife ingestion exposures in the BERA. In the absence of the collection of additional tissue data (see Section 6), estimation of tissue concentrations and exposure of receptors through the food web pathway will be addressed in a phased approach, as follows.

First, conservative screening-level calculations will be conducted using high-end measured concentration values in abiotic media along with readily available, conservative, upper end accumulation factors. This procedure is intended to be highly conservative. That is, it is expected that predicted estimates derived from this modeling approach will tend to overestimate actual risks. If predicted risks derived using conservative screening calculations are below a level of concern, then this suggests that additional biotic data and further refinement of risk calculations are not needed.

However, if the conservative screening calculations indicate a potentially unacceptable risk via food web exposure, USEPA will consider the need for additional data collection of paired biotic-abiotic data that can be used to develop both empirically derived exposure estimates (in which site-specific tissue concentrations are measured, see Section 6) and, if necessary, site-specific uptake models.

The details of biotic uptake model development cannot be specified *a priori*, but will depend on the data values. In general, it is necessary to test several different forms of uptake model to determine which best characterizes the relationship between abiotic and biotic concentration levels. This includes testing of simple linear models (e.g., $C_{tissue} = k*C_{abiotic}$) and a range of non-linear models (e.g., $\ln(C_{tissue}) = a + b * \ln(C_{abiotic})$). For simplicity, initial parameter estimation will be based on ordinary least squares regression, but final parameterization may employ alternative methods (e.g., maximum likelihood estimation) that do not assume homoscedasticity of errors, and may account for measurement errors both in the dependent variable (C_{tissue}) and in the independent variable ($C_{abiotic}$). All modeling efforts and results will be detailed in an appendix to the BERA.

For evaluation of dioxin/furan uptake into the food web, two alternative strategies will be investigated. The first will seek to develop an uptake model for each congener, and the TEQ content of the tissue will be computed from the predicted congener concentration in the tissue.

The second approach will determine if tissue TEQ can be reliably calculated from TEQ in the source medium. The most appropriate strategy will be determined how well each approach characterizes the observed data.

5.2 Toxicity Reference Values (TRVs)

Ecological Toxicity Reference Values (TRVs) are chemical-specific estimates of exposure that identify an exposure level that is believed to be without any risk of effect (no observed effect concentration [NOEC] or no observed adverse effect level [NOAEL]) or identify the lowest exposure level that may cause an adverse effect (lowest observed effect concentration [LOEC] or lowest observed adverse effect level [LOAEL]). Both types of these TRVs will be used in the BERA. Three different types of TRVs will be used in the BERA:

- **Concentration-based** TRVs are expressed as a concentration of a chemical in abiotic media. These will be used when evaluating risks to receptors that have direct contact with contaminated medium (e.g., fish in water, plants in soil) and are expressed in units of mg/unit medium.

- **Dose-based** TRVs are expressed as an ingested dose. These will be used to estimate exposure of individual wildlife via ingestion and are expressed in units of mg/kg-day.

- **Tissue-based** TRVs are expressed in units of mg/kg tissue in the exposed receptor. This type of TRV is often referred to as Critical Tissue Residue (CTR). Most CTRs that are applicable to ecological risk assessment are expressed as whole body tissue concentrations.

Application of these TRVs to estimate ecological risks within the BERA is described in further detail below.

5.2.1 Concentration-Based TRVs

Concentration-based TRVs will be used in the BERA to evaluate direct exposures of aquatic and terrestrial receptors to surface water, sediment and soils at the Site.

Surface Water TRVs for Aquatic Receptors

Surface water benchmark values for the protection of aquatic life from direct contact with contaminants in surface water are available from several sources as described in Appendix B. In brief, USEPA acute and chronic National Ambient Water Quality Criteria (NAWQC) values

for the protection of aquatic communities (EPA 2002a) will be used whenever available. If NAWQC values are not available, Montana water quality standards will be used (MDEQ 2017), followed by the Great Lake Water Quality Initiative (GLWQI) Tier II criteria derived in Suter and Tsao (1996). For chemicals without NAWQC or GLWQI Tier II values (magnesium, potassium and sodium), Oak Ridge National Laboratory (ORNL) lowest chronic values and EC20 values for fish, daphnids, and non-daphnid invertebrates (Suter and Tsao 1996) will be used. If available, both acute and chronic surface water TRVs will be utilized in the BERA.

Sediment TRVs for Benthic Macroinvertebrates

Sediment toxicity benchmark values for the protection of benthic macroinvertebrate communities are available from several sources as described in Appendix B. In brief, two types of sediment benchmarks will be used in the BERA to evaluate exposure and risk to benthic invertebrates:

- A threshold effect concentration (TEC)
- A probable effect concentration (PEC)

Sediment toxicity is expected to be absent or minimal at concentrations below the TEC (a NOEC equivalent benchmark), while effects are predicted to occur at concentrations above the PEC (a LOEC equivalent benchmark). Exposures at concentrations between the TEC and the PEC may result in some effects, but it is considered likely the effects will be of relatively low ecological significance.

Soil TRVs for Terrestrial Plants and Soil Invertebrates

Toxicity benchmark values for the protection of terrestrial plants and soil invertebrates from direct contact with soil are available from several sources as described in Appendix B. In general, values are based on the EPA-recommended Ecological Soil Screening Levels (EcoSSLs) where available, and otherwise based on Oak Ridge National Laboratory (ORNL) Benchmark values.

5.2.2 Dose-Based TRVs

In general, wildlife TRVs used in the BERA will be selected to represent relevant toxicity endpoints for population sustainability (growth, reproduction, and survival). Both NOAEL and LOAEL values will be used.

Ideally, TRVs will be selected for each bird or mammal receptor surrogate that is evaluated.

TRVs will be derived for each COPEC retained for evaluation in the BERA. To derive TRVs, a literature search will be conducted to identify studies on the toxicity of COPECs to ecological receptors. Available studies will be evaluated based on study design (complete description of methodologies, quantification of doses, measures of effects) and reporting. Measured endpoints need to be ecologically relevant (growth, reproduction or survival) and statistical analyses must be clearly described. In the absence of species-specific TRVs, available generic TRVs based on all birds or all mammals will be used.

Appendix C includes a description of the methods that will be used to select TRVs for the BERA.

5.2.3 Tissue-Based TRVs

Currently, the only tissue data collected at the Site are on concentrations of dioxins/furans, Aroclors, mercury and selenium in fish fillets. The USEPA has not yet established standard tissue-based benchmarks for use in ecological risk assessment, but some values can be identified from published literature. One resource that will be used for identification of tissue-based benchmarks in fish for the BERA is the Environmental Residue-Effects Database (ERED)[2]. This database was developed and is maintained by the U.S. Army Engineer Research and Development Center and includes a collection of residue-effects data obtained from peer-reviewed literature and reports submitted by U.S. government agencies.

Although CTRs are generally not used in risk assessments for metals (Meador et al. 2011), they are commonly used in risk assessments for dioxins and furans. Steevens et al. (2005) derived species sensitivity distributions for toxicity of dioxins and furans to fish using a number of quality studies on sensitive fish species. This paper also identified the ranges of concentrations in eggs (ng/kg lipid) associated with different levels of protectiveness, including a concentration protective of 95 percent of fish species. These CTR values could be used in BERA to compare predicted whole-body fish tissue concentrations derived from the available fillet data.

5.3 Risk Characterization

As noted above, the assessment endpoints for this Site are survival, growth and reproduction of potentially exposed ecological receptors, and the potential for adverse effects on these endpoints will evaluated in the BERA by calculating HQ values using available concentration data and appropriate toxicity values.

[2] https://ered.el.erdc.dren.mil/

5.3.1 Aquatic and Terrestrial Receptors

For evaluation of direct contact exposures by aquatic and terrestrial receptors, HQ values will be calculated by comparing COPEC concentrations in individual samples to appropriate NOEC and LOEC benchmark concentrations. Sample-specific HQs will be evaluated based on the frequency and magnitude of exceedances. For threatened species such as the bull trout, risk characterization would be based on the max HQ. The HQ value for an appropriate reference area will also be provided for comparison to Site exposure areas, to help estimate the contribution of site-related COPECs.

5.3.2 Avian and Mammalian Wildlife

Because wildlife receptors are exposed to more than one environmental medium, the total hazard quotient (HQ_t) for a receptor from a specific contaminant is calculated as the sum of HQs for that contaminant across all relevant media:

$$HQ_{t\,i,j,r} = \sum HQ_{i,j,r}$$

where:

$HQt_{i,j,r}$ = Total Hazard Quotient of receptor "r" to chemical "i" in all media (e.g., soil, sediment, surface water, food items, etc.)

$HQ_{i,j,r}$ = HQ for exposure of receptor "r" to chemical "i" in medium "j"

For small home range receptors, HQs will be calculated on a sample-by-sample basis and evaluated by consideration of the frequency and magnitude of HQ values that exceed 1 in each exposure unit. The fraction of the population that must have HQ values below a value of 1 in order for the population to remain stable depends on the species being evaluated and on the toxicological endpoint underlying the toxicity benchmark. Consequently, reliable characterization of the impact of a chemical stressor on an exposed population risks requires knowledge of population size, birth rates, and death rates, as well as immigration and emigration rates. Because this type of detailed knowledge of population dynamics is generally not available on a site-specific basis, extrapolation from a distribution of individual risks to a characterization of population-level risks is generally uncertain. However, if all or nearly all of the HQs for individuals in a population of receptors are below 1, it is very unlikely that adverse, population-level effects will occur in the exposed population. Conversely, if many or all of the individual receptors have HQs that are above 1, then adverse effects on the exposed population are likely, especially if the HQ values are large. If only a small portion of the exposed population has HQ values that exceed 1, some individuals may be impacted, but population-level effects are not likely to occur. As the fraction of the population with HQ values above 1 increases, and as the

magnitude of the exceedances increases, risk that a population-level effect will occur also increases. The distribution of HQ values for appropriate reference areas will also be provided for comparison, to help estimate the contribution of site-related COPECs.

For medium or large home range receptors, one HQ value will be calculated for each exposure unit. The potential for adverse effects is considered minimal if each pathway-specific HQ and the HQ_t is equal to or below 1 based on the NOAEL TRV. If any pathway-specific HQ or the HQ_t is above 1 based on the NOAEL but is equal to or less than 1 based on the LOAEL, it is considered that adverse effects are possible, but they are likely to be low in extent and/or severity. If any pathway-specific HQ or the HQ_t is above 1 based on the LOAEL TRV, it is considered possible that some adverse effects will occur, with the frequency and/or severity of effects tending to increase as the LOAEL-based HQ value increases. Based on this, risk levels are assigned qualitative descriptions as follows:

Findings	Risk Characterization
NOAEL-based $HQ_t \leq 1$	Minimal
LOAEL-based $HQ_t \leq 1$, NOAEL-based $HQ_t > 1$	Low
LOAEL-based HQ_t 2-5	Moderate
LOAEL-based $HQ_t > 5$	High

5.4 Uncertainty Analysis

In interpreting HQ values and distributions of HQ values, it is always important to bear in mind that the values are estimates, based on predictive models, and are subject to the uncertainties that are inherent in both the estimates of exposure and the estimates of toxicity benchmarks. The BERA will include discussions of both qualitative and quantitative uncertainties that may limit confidence in the risk characterization.

6.0 DATA GAP ANALYSIS

Data gaps were assessed based on reviewing the results of the SLERA in context of the proposed approach outlined above for evaluating exposures and risks to ecological receptors in the BERA.

6.1 Data Gaps Analysis for the Hazard Quotient Approach

This section identifies site media where additional data may be needed to supplement existing data in order to reliably characterize ecological exposures and/or decrease uncertainty in calculated HQ values in the BERA. The need for additional data is generally recognized in cases where HQ calculations based on existing data are sufficiently uncertain that it is difficult to make confident risk management decisions. Consequently, the identification of data gaps is often achieved in a phased approach, first evaluating HQ values based on available data, and then determining if more data are needed.

Existing concentration data include soil measurements collected in OU2 and OU3 in 2014, 2015 and 2016 as well as surface water and sediment measurements collected from O'Keefe Creek, Lavalle Creek and the CFR in 2015. Additionally, fish samples were previously collected in the spring of 2013 in the CFR just downstream of the Site. Details of these previous sampling efforts are provided in the 2015 Remedial Investigation Work Plan (RIWP) and the Preliminary Data Summary Report (NewFields 2015, 2016) and the Montana Fish, Wildlife and Parks (MTFWP) 2013 Preliminary Investigation report (MTFWP 2013). The existing data were previously summarized in the Draft SLERA (USEPA 2017a) and are referenced in brief by media below. Key details of additional sampling activities (type, number and location of additional samples, analytical methods and requirements) will be presented subsequently in Sampling and Analysis Plans (SAPs) as appropriate.

6.1.1 Surface Soil

6.1.1.1 Operable Unit 2

Existing Surface Soil Data for OU2

Surface soil samples were collected in OU2 in April 2014 and November/December 2015 as 5-point composites collected from a 1 square meter area. Surface soil sampling in OU2 was focused on potential source locations identified based on-Site knowledge of historic activities. Samples were collected from 0 to 2.4 inches below ground surface (bgs) to evaluate aerial deposition. One composite sample was analyzed from each location. Figure 6-1 presents the sampling locations and Table 6-1 summarizes the data. Additional focused soil sampling for PCBs (reported as Aroclor mixtures) was completed at the High Density Pulp Tank Foundation

(HDPT) and the Transformer Storage Building (TSB) (see Figure 6-2) in August 2016 (NewFields 2017a). These samples consisted of 5-point vertical composites collected from boreholes at a depth of 0-1 foot bgs. Since that time, additional removal and delineation sampling activities have been conducted at these two specific locations; these data have not been reported at the time of this Work Plan.

Surface Soil Data Gaps for Operable Unit 2

The available surface soil data set for OU2 is limited by two considerations:

1. The sample locations cover only a small fraction of the area of OU2 (255 acres), and there are large areas that are un-sampled.
2. The sample depth (0-2.4 inches) does not fully characterize the depths to which plant roots and soil invertebrates may be exposed to site contamination. USEPA considers the top six inches to adequately represent the biologically active zone.

For these reasons, additional surface soil samples collected from a depth of 0-6 inches using a systematic (grid) approach are needed to provide more complete (and less biased) spatial coverage.

6.1.1.2 Operable Unit 3

Existing Soil Data for OU3 Upland

Surface soil samples were collected in the OU3 upland area (outside of the floodplain) in April 2014 and November/December 2015 as 5-point composites collected from a 1 square meter area. OU3 consists of a series of ponds and basins used historically for treatment and storage of aqueous or solid wastes from the on-site activities. Previous surface soil sampling was conducted within these historic pond areas (e.g., aeration basin-1, north polishing pond, settling pond-3). This was done because historic uses associated with wastewater treatment and storage indicate that the presence of contaminants likely varies based on the purpose of each pond (primary treatment, secondary treatment, storage of treated water). Some samples were collected from one location at depths from 0 to 2 inches and from 5 to 7 inches bgs. Some samples were collected at other locations from 0 to 2.4 inches bgs. Other samples were also collected from 0 to 6 inches below the surface in opportunistic test pits at potential source locations. One composite sample was analyzed from each sampling location. Figure 6-3 presents the sampling locations and Table 6-2 summarizes the data from OU3 upland areas.

Data Gaps for OU3 Upland Basins

The existing surface soil data set for the OU3 upland is limited by the following considerations:

1. Surface soil samples have not been collected from all historic upland pond areas.
2. The OU3 upland area encompasses roughly 480 acres of land. Samples collected to date represent only a small area (1 square meter) of each pond. Although sampling locations were selected with the intent of focusing on areas most likely to be contaminated, there is uncertainty as to whether this was achieved.
3. Due to differing historic uses, concentration levels in different ponds may vary substantially. Hence, large area averages that span multiple ponds may not accurately reflect the contamination levels within a specific pond.
4. The sample depth of some samples (0-2.4, 0-2 and 5-7 inches) does not fully characterize the depths to which plant roots and soil invertebrates may be exposed to site contamination. USEPA considers the top six inches to adequately represent the biologically active zone.
5. In some historic ponds/basins, only subsurface soil samples have been collected at depths greater than 1-foot bgs.

For these reasons, additional surface soil samples collected from a depth of 0-6 inches using a systematic (grid) approach are needed to provide more complete spatial coverage. In order to assess exposures for small home range receptors that do not move between multiple historic pond areas, surface soil samples are also needed within the boundaries of individual pond/basin areas where previous sampling was limited or lacking, or where future grid sampling may be within a grid that spans multiple historic ponds/basins.

Existing Soil Data for OU3 Floodplain

Surface soil sampling in the OU3 floodplain area has been conducted in April 2014 and December 2015 within historic pond areas (e.g., holding pond 13, holding pond 2). Historic use of these ponds to hold and store treated wastewater may have resulted in residual contaminants settling into sediments at the base of these ponds. The treated effluent chemistry was reportedly consistent throughout the holding ponds within the CFR floodplain. During mill operations these ponds were inundated with water, but surface soil sampling conducted to date occurred at a time when these ponds were dry. In general, two to three 5-point composite soil samples have been collected within a 1 square meter area in each historic holding pond.

Figure 6-4 shows sampling locations and Table 6-3 summarizes the data

Data Gaps for OU3 Upland Basins

The existing data set for OU3 floodplain samples is limited by the following:

1. The OU3 floodplain area encompasses over 1,000 acres of land. Samples collected to date represent only a small area (1 square meter) of each pond. Although sampling locations were selected with the intent of focusing on areas most likely to be contaminated, there is uncertainty as to whether this was achieved.
2. There are roughly 360 acres of the CFR floodplain within the site boundary downstream of the holding ponds that have not been sampled.

For these reasons, additional sampling using a systematic (grid) approach is needed to address more complete spatial coverage. Also, surface soil samples are needed within the floodplain area that was not used for industrial purposes. This area may represent an appropriate reference area for risk characterization purposes in the BERA.

6.1.2 Subsurface Soil

Subsurface data are available from locations in OU2 and OU3 (see Figures 6-1 to 6-4). However, consistent with the CSM presented in the SLERA, exposures of ecological receptors to subsurface soils will not be evaluated in the BERA. Thus, no data gap has been identified for subsurface soils.

6.1.3 Sediment and Surface Water

6.1.3.1 Existing Sediment and Surface Water Data

Co-located sediment and surface water data were collected from O'Keefe Creek, Lavalle Creek and the CFR in November/December 2015 at locations shown in Figure 6-5. Sediment sampling has focused on collecting fine grain sediment at depths of 0 to 6 inches from depositional areas.

Additionally, sediment samples have been collected from the "flood fringe" at locations identified to be representative of past sediment deposition along the banks of the CFR during flood events. Three flood fringe samples have been collected adjacent to and extending approximately two to three miles downstream of the Site. These samples were collected from dry areas not under water, thus more representative of surface soil samples collected along the banks of the CFR.

Tables 6-4 through 6-6 present summary statistics for bed sediment data in O'Keefe Creek, Lavalle Creek and the CFR, respectively. Table 6-7 presents summary statistics for flood fringe data in the CFR. Tables 6-8 through 6-10 present summary statistics for surface water data in O'Keefe Creek, Lavalle Creek and the CFR, respectively.

6.1.3.2 Sediment and Surface Water Data Gaps in Operable Unit 2

No sediment or surface water data have been collected in OU2. There are low-lying areas within OU2 that may form intermittent ponds and/or puddles during precipitation events, but these generally represent temporary exposure areas that are generally surrounded by pavement, gravel, or wood-chip fill. These areas are not considered to represent viable habitat and will not be evaluated in the BERA. However, a pond has been observed in an area just west of the main plant building close to the TSB. On-site observations have indicated that water remains in this pond for a significant portion of the year, thus providing potential wetland habitat to ecological receptors in the area. As no surface water or sediment data have been collected from this location, this is identified as a data gap for which samples are needed to characterize potential ecological exposures.

6.1.3.3 Sediment and Surface Water Data Gaps in Operable Unit 3

Current On-site Pond Areas

Wastewater treatment and storage ponds in OU3 were historically inundated with water during mill operations. Currently, only discrete, low-lying areas retain water at varying amounts for varying periods of time. Current data include floodplain surface soils that were collected from dry areas in the historic ponds representative of historic on-site sediments. However, as described in the SLERA (USEPA 2017a), standing water has been observed at varying amounts for at least several months of the year, if not year-round, in low-lying ponded areas within the larger historic pond/basin areas of P5, P17, IBJ, NPP, HP2, HP7, HP12, HP13, HP13a, and HP18. These ponds have been identified as suitable wetland habitat to which ecological receptors may be exposed. Additionally, standing water is present within the Clarifier ditches within OU3 and additional wetland habitat is also present along the cooling water ditch that runs north/northwest from OU2. Given that no sediment or surface water samples have been collected from the Clarifier ditches, cooling water ditch or any of the on-site ponds to date, this is identified as a data gap.

Although these ponds may be formed in part from the intersection of the regional water table with pond bottom elevations, using available groundwater data to characterize ecological risks in the BERA is not recommended. There are several reasons why the concentrations in pond

surface water may not be the same as in groundwater, including: 1) pond water may be derived in part by surface water runoff from the Site, which may contain differing levels of contaminants that groundwater; 2) contaminant concentrations in groundwater may be altered by dissolution or sorption to sediments that occurs as groundwater wells up through the sediments at the bottom of the ponds, and 3) as pond water stands in the ponds, concentration levels may change due to a variety of physical/chemical and biological fate and transport processes that may be occurring. Therefore, sampling of sediment and surface water in on-site ponds is needed to adequately characterize exposures to benthic invertebrates, as well as waterfowl and shorebirds that prey upon BMI, consume water and incidentally ingest sediment.

Clark Fork River

Six sediment samples have been collected adjacent to and extending approximately two to three miles downstream of the Site. Surface water was also collected from three of these locations. Upstream sediment samples were collected along the CFR beyond the confluence with the Blackfoot River upstream of Missoula. All sediment samples were collected at a single time point. Because sediment can be carried and deposited in depositional areas of the river over time, it is possible that contamination related to site operations, including persistent dioxin-like contaminants, have migrated farther downstream than was sampled and been deposited within depositional areas including lower floodplain areas, pointbars, islands, backwater areas, oxbows and reservoirs. Additionally, because sediment and surface water concentrations may vary over time, samples collected at a single time point may not provide a clear understanding of the range of concentrations that may occur over time. Thus, additional sediment and surface water sampling in the CFR upstream, adjacent to, and downstream of the Site is needed to reduce uncertainty in exposure estimates, better characterize areas of sediment deposition and temporal variability, and support statistical comparisons to background.

Evaluation of the hydrology of the CFR downstream of the Site suggests that the segment of the CFR between the Site and Alberton, Montana would be where sediments potentially impacted by site-related activities may have deposited. This segment of the CFR is relatively low gradient and includes meandering/braided channels. Beyond Alberton, the stretch of the CFR stretching to Superior is a high gradient, scouring reach characterized by steep canyon walls, whitewater, and few to no depositional features. Just downstream of Superior there appears to be sediment deposition features where sediment scoured out of the previous reach is likely deposited. From this location downstream to the confluence with the Flathead River, the CFR is high gradient with few sediment depositional features. The Flathead River significantly increases the flow of the CFR as it joins and dramatically changes the characteristics of the river at this point. Thus, sediment sampling in the CFR downstream of the Site in the reach between the Site and Alberton is needed to better characterize areas of sediment deposition.

O'Keefe Creek

Three bed sediment samples have been collected from O'Keefe Creek, including one location upstream of the Site, one location just within the site boundary prior to flowing through the Site (see Figure 6-5), and one location taken from the pooling area where O'Keefe and Lavalle Creeks converge. Surface water was also collected from the location upstream of the site boundary. Data for these samples were evaluated in the OU1 ERA, and no concentrations of COPECs were identified to be present at concentrations above concentrations in the section of the CFR upstream of the Site (USEPA 2017b). However, samples were collected from a single time point, and measured site concentrations included data from the location on O'Keefe Creek located upstream of the Site near Interstate 90. Additional sediment and surface water sampling in O'Keefe Creek is needed to help to reduce uncertainty in exposure estimates and provide a clearer understanding of the range of concentrations that may occur over time.

Lavalle Creek

Three bed sediment samples have been collected from Lavalle Creek at locations shown in Figure 6-5. One surface water sample was also collected at the upstream location. The OU1 ERA did not observe significant concentrations of COPECs within Lavalle Creek above concentrations in the section of the CFR upstream of the Site (USEPA 2017b). However, samples were collected from a single time point, and only one surface water sample was collected. Given that sediment and surface water concentrations may vary over time, samples collected at a single time point may not provide a clear understanding of the range of concentrations that may occur over time. Thus, additional sediment and surface water sampling in Lavalle Creek is needed to provide a better estimate of exposure for ecological receptors and a clearer understanding of the range of concentrations that may occur over time.

6.1.4 Sediment Porewater

Adverse effects of contamination in bulk sediment on benthic species may be mediated in large degree by exposure of the organisms to contaminants that exist in the porewater of the sediment. For this reason, samples of porewater may provide a better basis for estimating exposure and risks to BMI than measurements of contaminant levels in sediment. Since no porewater data are presently available, porewater data is identified as a data gap. However, USEPA intends to apply a tiered evaluation of ecological risks to receptors exposed to sediment whereby the first tier involves the analysis of additional abiotic (bulk sediment) and biotic (macroinvertebrate) data. The results of this evaluation will inform the need to move on to the second tier of conducting porewater sampling to further evaluate ecological effects related to site contamination.

6.1.5 Biotic Tissue

6.1.5.1 Existing Biotic Tissue Data

The MTFWP collected and analyzed fish (skinless) fillet tissue (northern pike and rainbow trout) in the spring of 2013 from backwaters, sloughs and margins of the CFR along a 10-km reach just downstream of the site as shown in Figure 6-6. No other biotic tissue data have been collected.

Table 6-11 presents summary statistics for the MTFWP fish fillet samples collected just downstream of the Site.

6.1.5.2 Biotic Tissue Data Gaps

Benthic Invertebrates

No benthic macroinvertebrate samples have been collected from on-site ponds or from Lavalle or O'Keefe Creeks. Additionally, no tissue concentration data are available for macroinvertebrates collected from the CFR upstream, adjacent to, or downstream of the Site. Because it is difficult to accurately predict the tissue concentrations of such macroinvertebrates, the lack of benthic macroinvertebrate tissue data is identified as a data gap for on-site ponds, Lavalle and O'Keefe Creeks, and the CFR. Collection and analysis of invertebrate tissues from these aquatic environments within OU3 is needed to minimize uncertainty in the estimation of ecological risks to receptors that prey on pond invertebrates. USEPA intends to confer with field experts to determine the optimum locations and times to collect samples of benthic macroinvertebrates at the Site, but recommends the collection of paired abiotic (sediment) and biotic samples from locations within on-site ponds, Lavalle and O'Keefe Creeks, and the CFR inclusive of the upstream reaches (as a reference location) to address this data gap.

Fish in On-Site Ponds and Lavalle and O'Keefe Creeks

No fish data are available for on-site ponds or O'Keefe or Lavalle Creeks. However, available site information suggests that reproducing fish populations are generally limited or absent from these water bodies, so this is not considered to be a significant data gap.

Fish from the CFR

No fish tissue samples from an upstream (reference) location on the CFR were collected to facilitate a background comparison. The fish samples collected from the CFR downstream of the Site by MTFWP were filleted with skin removed and analyzed for select contaminants for the

purposes of evaluating risks for human consumption. Because ecological receptors generally consume the whole bodies of fish, the MTFWP data are not optimal for evaluating ecological exposures. In addition, other species of general ecological concern (e.g., peamouth, northern pikeminnow, longnose dace, redside shiner, longnose sucker, largescale sucker, and sculpin) were not sampled.

Additional fish sampling within the CFR could address this data gap. However, USEPA first recommends additional evaluation of existing data to determine the extent that additional fish sampling is needed to support risk characterization in the BERA. USEPA will use available sediment data to estimate concentrations of bioaccumulative COPECs in aquatic food items using conservative uptake models. These results will be used to help inform whether collection and analysis of fish tissues is warranted. Also, if additional data are obtained on paired measurements of sediment and macroinvertebrate tissues from the CFR upstream of the Site, adjacent to the Site and downstream of the Site, these data will be evaluated to determine if observed impacts related to site contamination warrant additional fish sampling.

Terrestrial Forage and Prey Items

No samples of terrestrial food items (plants, terrestrial invertebrates) have been collected from areas within OU2 or OU3. Given that bioaccumulatives have been identified as COPECs at the Site, the lack of terrestrial biotic tissue limits the ability to confidently characterize uptake of these contaminants in the food web. Thus, this is identified as a data gap.

Although measured data of concentrations in terrestrial forage and prey items is identified as a data gap, USEPA intends to apply a tiered approach to determining the need for additional tissue sampling. Under this approach, USEPA will first use available soil data to estimate concentrations of bioaccumulative COPECs in terrestrial food items using conservative uptake models. These results will be used to determine if collection and analysis of terrestrial food items is warranted. If the data evaluation indicates the need for additional tissue sampling, soil concentration data will be utilized to inform the selection of locations for future biotic sampling that should occur during or as near to the time of peak abundance.

6.2 Data Gaps Analysis for Other Lines of Evidence

Because of the uncertainties associated with the Hazard Quotient approach for risk characterization, it is often helpful to obtain and evaluate data from other lines of evidence that help clarify the nature and magnitude of site-related ecological risks which may exist. The most common of these other lines of evidence are:

- Site-specific toxicity testing
- Site-specific population surveys

Site-Specific Toxicity Tests

Site-specific toxicity tests compare the response of receptors that are exposed to site media to the response in receptors exposed to laboratory control media or media collected from one or more reference locations. The chief advantage of this approach is that site-specific conditions which can influence toxicity are usually accounted for. A potential disadvantage is that, if adverse effects are observed when test organisms are exposed to a site medium, it is usually not possible to specify which chemical or combination of chemicals is responsible for the effect since the site medium typically contains a mixture of site-related contaminants. In addition, it is often difficult to test the full range of environmental conditions which may occur at the Site across time and space, either in the field or in the laboratory, so these studies are not always adequate to establish an exposure-response relationship or to identify the boundary between exposures that are acceptable and those that are not.

Site-Specific Population Surveys

Field observations on the populations and communities present at the Site help to inform the current status of an ecosystem using measures of population or community density and diversity. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity of an ecological population depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (non-impacted) abundance and diversity of an ecological population should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the Site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the Site. However, it is sometimes quite difficult to locate reference areas that are truly a good match for all of the important habitat variables at the Site, so comparisons based on this approach do not

always establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a receptor population.

At OU2 and OU3, no data are presently available to support measurement endpoints other than calculating HQ values. After the BERA is performed using the Hazard Quotient approach, if the results do not allow for confident risk management decision making, consideration will then be given to the collection of data to support additional lines of evidence (i.e., site-specific toxicity tests, population surveys).

6.3 Data Gap Summary and Next Steps

Existing data for OU2 and OU3 are not sufficient in all cases to support reliable characterization of ecological risks, and a number of data gaps have been identified where collection and analysis of additional samples would help improve confidence and decrease uncertainty in the BERA as follows:

Location	Media	Sub-Location	Basis
OU2	Surface soils (0-6 inches)	All of OU2	Inadequate spatial representation [1]
	Sediment	Cooling water ditch	Lack of data
	Surface Water		
	Biotic Tissue		
OU3	Surface soils (0-6 inches)	All of OU3	Inadequate spatial representation [1]
	Sediment and surface water	On-site ponds and clarifier ditches	Lack of data in ponds with water
		Lavalle and O'Keefe Creeks	Limited data; inadequate spatial or temporal representation
		CFR	Inadequate characterization of areas of primary sediment deposition downstream. Lack of data to provide sufficient confidence in risk estimates and inadequate temporal representation of areas upstream, adjacent to, and downstream of the Site.

	Biotic tissue (macroinvertebrates, fish)	Aquatic habitat (CFR; O'Keefe and Lavalle Creeks; on-site ponds)	Lack of data
OU2/OU3	Biotic tissue (terrestrial insects, terrestrial plants, and small birds and mammals)	Terrestrial habitat	Lack of data
[1] Additional soil sampling was conducted at the Site in October 2017 as per Addendum 7 of the RIWP (NewFields 2017b). These data address the data gap identified in this table regarding spatial representation of surface soil data.			

Next steps include the development of Data Quality Objectives (DQOs) to direct future sampling intended to address the data gaps described above. USEPA has developed a seven-step process for establishing DQOs to help maximize the likelihood that data collected in the field will be sufficient for the intended purpose (USEPA 2006). The goals of the studies should be to collect data that allow confident evaluation of hazards to ecological receptors from exposures to site-related COPECs in site media. To do this, a set of reliable measurements of COPEC concentrations are needed that address the identified data gaps. Data should be collected to minimize decision errors. In evaluating ecological hazards from exposures to COPECs, two types of decision errors are possible:

> Type I error: In this case, it is concluded that hazard is within acceptable limits, when in fact the true exposure exceeds acceptable limits.
>
> Type II error: In this case, it is concluded that hazard is above acceptable limits, when in fact the true exposure is within acceptable limits.

USEPA is primarily concerned with minimization of the chances for a Type I error, since an error of this type could result in a failure to address exposures that are of potential ecological concern. In general, USEPA has a goal that the probability of making a Type I error should not exceed 5%. This goal is generally achieved by using the 95% upper confidence bound on the mean for each exposure area.

Type II errors are of lesser concern, since a Type II error does not result in unacceptable ecological hazards. However, Type II errors may result in the unnecessary expenditure of resources to address hazards that are actually within acceptable limits. Consequently, USEPA typically seeks to limit the probability of Type II errors to within a reasonable tolerance. Although there is no standard rule for Type II errors, a value of 20-30% is often identified as a goal. This goal is achieved by collecting sufficient data that uncertainty around the mean (often

expressed as the ratio of the upper confidence limit [UCL] to the mean) is small enough that the range does not overlap the decision criterion.

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TABLES

Table 6-1. OU2 Surface Soil* Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ	Avian TEQ (ND=0)	20	20	100%	4.10E-06	4.79E-06	1.55E-05	--
	Avian TEQ (ND=1/2 MDL)	20	20	100%	4.12E-06	4.78E-06	1.55E-05	--
	Mammalian TEQ (ND=0)	20	20	100%	4.10E-06	5.17E-06	2.22E-05	--
	Mammalian TEQ (ND=1/2 MDL)	20	20	100%	4.11E-06	5.16E-06	2.22E-05	--
PCBs (Aroclors)	Aroclor-1016	13	0	0%	4.77E-03	1.80E-03	--	9.54E-03
	Aroclor-1221	13	0	0%	6.36E-03	1.29E-03	--	1.27E-02
	Aroclor-1232	13	0	0%	6.33E-03	2.58E-03	--	1.27E-02
	Aroclor-1242	13	0	0%	5.16E-03	2.96E-03	--	1.03E-02
	Aroclor-1248	13	0	0%	4.19E-03	1.26E-03	--	8.38E-03
	Aroclor-1254	13	2	15%	8.41E-02	2.47E-01	8.93E-01	8.67E-03
	Aroclor-1260	13	8	62%	6.59E-01	2.06E+00	7.49E+00	9.52E-03
	Aroclor-1262	13	0	0%	4.87E-03	1.78E-03	--	9.74E-03
	Aroclor-1268	13	0	0%	2.95E-03	8.11E-04	--	5.89E-03
Metals	Aluminum	22	22	100%	1.18E+04	6.88E+03	2.84E+04	6.15E+00
	Antimony	1	1	100%	2.00E-01	--	2.00E-01	1.00E-01
	Arsenic	22	22	100%	4.26E+00	2.02E+00	1.14E+01	1.35E-01
	Barium	22	22	100%	2.68E+02	2.05E+02	1.08E+03	1.22E-01
	Beryllium	1	1	100%	1.20E+00	--	1.20E+00	8.90E-02
	Cadmium	22	21	95%	4.67E-01	7.17E-01	3.50E+00	3.08E-02
	Calcium	1	1	100%	6.65E+03	--	6.65E+03	4.08E+01
	Chromium	22	22	100%	1.25E+01	5.47E+00	3.18E+01	2.08E-01
	Cobalt	22	22	100%	4.85E+00	1.43E+00	8.00E+00	2.72E-01
	Copper	22	22	100%	2.75E+01	2.00E+01	8.63E+01	3.69E-01
	Iron	22	22	100%	1.31E+04	4.35E+03	2.35E+04	2.73E+01
	Lead	22	22	100%	1.29E+01	7.94E+00	3.88E+01	4.66E-02
	Magnesium	1	1	100%	7.70E+03	--	7.70E+03	1.44E+01
	Manganese	22	22	100%	5.35E+02	6.14E+02	3.04E+03	3.17E-01
	Mercury	22	7	32%	1.50E-02	2.06E-02	9.00E-02	8.29E-03
	Nickel	22	22	100%	9.52E+00	3.33E+00	1.88E+01	1.68E-01
	Potassium	1	1	100%	4.14E+03	--	4.14E+03	7.98E+01
	Selenium	1	1	100%	1.80E+00	--	1.80E+00	3.20E-01
	Silver	22	1	5%	9.93E-02	1.45E-01	7.40E-01	1.37E-01
	Sodium	1	1	100%	1.10E+02	--	1.10E+02	2.78E+01
	Thallium	22	11	50%	1.03E-01	1.19E-01	5.50E-01	4.63E-02
	Vanadium	22	22	100%	1.37E+01	4.88E+00	2.62E+01	2.89E-01
	Zinc	22	22	100%	1.08E+02	9.90E+01	4.46E+02	1.48E+00
PAHs	Acenaphthene	19	0	0%	4.70E-04	1.01E-03	--	9.40E-04
	Acenaphthylene	19	0	0%	4.41E-04	9.47E-04	--	8.81E-04
	Anthracene	19	0	0%	3.99E-04	8.60E-04	--	7.99E-04
	Benzo(a)anthracene	19	4	21%	1.57E-03	3.82E-03	1.56E-02	4.77E-04
	Benzo(a)pyrene	19	1	5%	2.15E-03	8.22E-03	3.60E-02	5.16E-04
	Benzo(b)fluoranthene	19	3	16%	3.97E-03	9.01E-03	3.38E-02	9.09E-04
	Benzo(g,h,i)perylene	19	1	5%	1.46E-03	4.43E-03	1.93E-02	9.21E-04
	Benzo(k)fluoranthene	19	0	0%	5.21E-04	1.12E-03	--	1.04E-03
	Chrysene	19	2	11%	2.83E-03	7.51E-03	2.42E-02	6.38E-04
	Dibenzo(a,h)anthracene	19	0	0%	5.57E-04	1.20E-03	--	1.11E-03
	Fluoranthene	19	9	47%	5.59E-03	7.89E-03	3.07E-02	5.68E-04
	Fluorene	19	0	0%	4.01E-04	8.60E-04	--	8.02E-04
	Indeno(1,2,3-cd)pyrene	19	0	0%	5.01E-04	1.08E-03	--	1.00E-03
	Naphthalene	19	0	0%	4.81E-04	1.03E-03	--	9.63E-04
	Phenanthrene	19	0	0%	3.23E-04	6.97E-04	--	6.46E-04
	Pyrene	19	1	5%	1.67E-03	5.91E-03	2.59E-02	6.26E-04

Table 6-1. OU2 Surface Soil* Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
VOCs	1,1,1,2-Tetrachloroethane	1	0	0%	3.90E-04	--	--	7.80E-04
	1,1,1-Trichloroethane	1	0	0%	1.05E-03	--	--	2.10E-03
	1,1,2,2-Tetrachloroethane	1	0	0%	3.55E-04	--	--	7.10E-04
	1,1,2-Trichloroethane	1	0	0%	4.15E-04	--	--	8.30E-04
	1,1-Dichloroethane	1	0	0%	5.00E-04	--	--	1.00E-03
	1,1-Dichloroethene	1	0	0%	9.50E-04	--	--	1.90E-03
	1,1-Dichloropropene	1	0	0%	9.50E-04	--	--	1.90E-03
	1,2,3-Trichlorobenzene	1	0	0%	3.20E-04	--	--	6.40E-04
	1,2,3-Trichloropropane	1	0	0%	9.50E-04	--	--	1.90E-03
	1,2,4-Trichlorobenzene	1	0	0%	3.35E-04	--	--	6.70E-04
	1,2,4-Trimethylbenzene	1	0	0%	2.65E-04	--	--	5.30E-04
	1,2-Dibromo-3-chloropropane	1	0	0%	1.50E-03	--	--	3.00E-03
	1,2-Dibromoethane	1	0	0%	4.70E-04	--	--	9.40E-04
	1,2-Dichlorobenzene	1	0	0%	3.05E-04	--	--	6.10E-04
	1,2-Dichloroethane	1	0	0%	3.65E-04	--	--	7.30E-04
	1,2-Dichloropropane	1	0	0%	5.50E-04	--	--	1.10E-03
	1,3,5-Trimethylbenzene	1	0	0%	3.70E-04	--	--	7.40E-04
	1,3-Dichlorobenzene	1	0	0%	3.40E-04	--	--	6.80E-04
	1,3-Dichloropropane	1	0	0%	3.35E-04	--	--	6.70E-04
	1,4-Dichlorobenzene	1	0	0%	2.95E-04	--	--	5.90E-04
	2,2-Dichloropropane	1	0	0%	1.00E-03	--	--	2.00E-03
	Acetone	1	0	0%	3.55E-03	--	--	7.10E-03
	Allyl chloride	1	0	0%	6.00E-04	--	--	1.20E-03
	Benzene	1	0	0%	7.00E-04	--	--	1.40E-03
	Bromobenzene	1	0	0%	6.50E-04	--	--	1.30E-03
	Bromochloromethane	1	0	0%	2.80E-04	--	--	5.60E-04
	Bromoform	1	0	0%	3.15E-04	--	--	6.30E-04
	Bromomethane	1	0	0%	1.10E-03	--	--	2.20E-03
	Carbon tetrachloride	1	0	0%	1.55E-04	--	--	3.10E-04
	Chlorobenzene	1	0	0%	3.90E-04	--	--	7.80E-04
	Chloroethane	1	0	0%	7.50E-04	--	--	1.50E-03
	Chloroform	1	0	0%	4.20E-04	--	--	8.40E-04
	Chloromethane	1	0	0%	7.50E-04	--	--	1.50E-03
	cis-1,2-Dichloroethylene	1	0	0%	4.75E-04	--	--	9.50E-04
	cis-1,3-Dichloropropylene	1	0	0%	1.15E-04	--	--	2.30E-04
	Cumene	1	0	0%	4.85E-04	--	--	9.70E-04
	Dibromochloromethane	1	0	0%	4.80E-04	--	--	9.60E-04
	Dichlorobromomethane	1	0	0%	4.50E-04	--	--	9.00E-04
	Dichlorodifluoromethane	1	0	0%	1.05E-03	--	--	2.10E-03
	Dichlorofluoromethane	1	0	0%	7.00E-04	--	--	1.40E-03
	Ethyl ether	1	0	0%	4.55E-04	--	--	9.10E-04
	Ethylbenzene	1	0	0%	4.40E-04	--	--	8.80E-04
	Hexachlorobutadiene	1	0	0%	1.05E-03	--	--	2.10E-03
	Methyl ethyl ketone	1	0	0%	2.55E-03	--	--	5.10E-03
	Methyl isobutyl ketone	1	0	0%	1.60E-03	--	--	3.20E-03
	Methylene bromide	1	0	0%	3.05E-04	--	--	6.10E-04
	Methylene chloride	1	1	100%	3.27E-01	--	3.27E-01	1.68E-02
	MTBE (Methyl tert-butyl ether)	1	0	0%	3.10E-04	--	--	6.20E-04
	Naphthalene	1	0	0%	3.05E-04	--	--	6.10E-04
	n-Butyl benzene	1	0	0%	5.00E-04	--	--	1.00E-03
	n-Propyl benzene	1	0	0%	5.50E-04	--	--	1.10E-03
	o-Chlorotoluene	1	0	0%	3.90E-04	--	--	7.80E-04
	p-Chlorotoluene	1	0	0%	1.60E-04	--	--	3.20E-04
	p-Isopropyltoluene	1	0	0%	4.70E-04	--	--	9.40E-04
	sec-Butyl benzene	1	0	0%	6.00E-04	--	--	1.20E-03
	Styrene	1	0	0%	2.75E-04	--	--	5.50E-04
	tert-Butyl benzene	1	0	0%	5.00E-04	--	--	1.00E-03
	Tetrachloroethylene	1	0	0%	7.50E-04	--	--	1.50E-03
	Tetrahydrofuran	1	0	0%	3.00E-03	--	--	6.00E-03
	Toluene	1	0	0%	3.05E-04	--	--	6.10E-04
	trans-1,2-Dichloroethylene	1	0	0%	7.50E-04	--	--	1.50E-03
	trans-1,3-Dichloropropylene	1	0	0%	9.00E-05	--	--	1.80E-04
	Trichloroethylene	1	0	0%	6.50E-04	--	--	1.30E-03
	Trichlorofluoromethane	1	0	0%	1.90E-03	--	--	3.80E-03
	Trichlorotrifluoroethane	1	0	0%	2.70E-04	--	--	5.40E-04
	Vinyl chloride	1	0	0%	2.45E-04	--	--	4.90E-04
	Xylenes (total)	1	0	0%	8.50E-04	--	--	1.70E-03

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls; PAH = polyaromatic hydrocarbons; VOC = volatile organic compounds.

*OU2 surface soil samples include 7 samples collected from 0-1 ft bgs in 2016 from the HDPT (n=3) and TSB (n=4) analyzed for aroclors. All other surface samples were collected at depths from 0-2.4 inches bgs.

[a]Non-detects evaluated at 1/2 MDL.

Table 6-2. OU3 Upland Surface Soil Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ	Avian TEQ (ND=0)	28	28	100%	7.57E-05	2.88E-04	1.53E-03	--
	Avian TEQ (ND=1/2 MDL)	28	28	100%	7.57E-05	2.88E-04	1.53E-03	--
	Mammalian TEQ (ND=0)	28	28	100%	3.98E-05	1.42E-04	7.56E-04	--
	Mammalian TEQ (ND=1/2 MDL)	28	28	100%	3.98E-05	1.42E-04	7.56E-04	--
PCBs (Aroclors)	Aroclor-1016	19	0	0%	8.46E-03	4.10E-03	--	1.69E-02
	Aroclor-1221	19	0	0%	5.30E-03	1.43E-03	--	1.06E-02
	Aroclor-1232	19	0	0%	9.51E-03	2.96E-03	--	1.90E-02
	Aroclor-1242	19	0	0%	8.42E-03	3.19E-03	--	1.68E-02
	Aroclor-1248	19	0	0%	5.01E-03	1.42E-03	--	1.00E-02
	Aroclor-1254	19	0	0%	7.33E-03	1.94E-03	--	1.47E-02
	Aroclor-1260	19	0	0%	7.07E-03	4.99E-03	--	1.41E-02
	Aroclor-1262	19	0	0%	7.94E-03	2.82E-03	--	1.59E-02
	Aroclor-1268	19	0	0%	4.83E-03	1.17E-03	--	9.66E-03
Metals	Aluminum	27	27	100%	1.00E+04	5.33E+03	1.89E+04	5.95E+00
	Antimony	19	15	79%	1.04E+00	1.15E+00	3.90E+00	1.19E-01
	Arsenic	27	27	100%	6.65E+00	7.91E+00	4.07E+01	2.89E-01
	Barium	27	27	100%	4.78E+02	3.11E+02	1.45E+03	2.38E-01
	Beryllium	19	10	53%	2.94E-01	3.11E-01	1.10E+00	1.07E-01
	Cadmium	27	25	93%	1.76E+00	2.36E+00	8.30E+00	5.12E-02
	Calcium	19	19	100%	1.37E+05	1.64E+05	4.98E+05	6.60E+01
	Chromium	27	27	100%	2.00E+01	1.25E+01	5.82E+01	2.45E-01
	Cobalt	27	26	96%	3.13E+00	1.77E+00	8.50E+00	3.42E-01
	Copper	27	27	100%	2.98E+01	2.14E+01	8.94E+01	1.04E+00
	Iron	27	27	100%	8.19E+03	5.38E+03	2.08E+04	3.43E+01
	Lead	27	27	100%	1.47E+01	1.90E+01	1.04E+02	3.25E-02
	Magnesium	19	19	100%	8.12E+03	6.66E+03	2.93E+04	2.33E+01
	Manganese	27	27	100%	7.90E+02	8.63E+02	2.70E+03	2.85E-01
	Mercury	27	21	78%	4.94E-01	9.40E-01	8.00E+00	1.10E-02
	Nickel	27	27	100%	1.35E+01	8.22E+00	3.79E+01	3.49E-01
	Potassium	19	15	79%	1.63E+03	2.19E+03	9.21E+03	8.59E+01
	Selenium	19	10	53%	6.57E-01	5.01E-01	1.40E+00	3.80E-01
	Silver	27	13	48%	5.34E-01	5.49E-01	1.70E+00	3.03E-01
	Sodium	19	18	95%	2.81E+03	3.11E+03	8.89E+03	4.51E+01
	Thallium	27	24	89%	1.67E-01	1.64E-01	6.80E-01	2.72E-02
	Vanadium	27	27	100%	2.45E+01	2.68E+01	1.19E+02	1.22E-01
	Zinc	27	27	100%	1.56E+02	1.62E+02	6.86E+02	1.68E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls.

[a]Non-detects evaluated at 1/2 MDL.

Table 6-3. OU3 Floodplain Surface Soil Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ	Avian TEQ (ND=0)	19	19	100%	3.91E-05	4.31E-05	1.69E-04	--
	Avian TEQ (ND=1/2 MDL)	19	19	100%	3.92E-05	4.31E-05	1.69E-04	--
	TEQ (ND=0)	19	19	100%	2.82E-05	2.99E-05	1.02E-04	--
	TEQ (ND=1/2 MDL)	19	19	100%	2.82E-05	2.99E-05	1.02E-04	--
PCBs (Aroclor)	Aroclor-1016	2	0	0%	5.40E-03	5.66E-04	--	1.08E-02
	Aroclor-1221	2	0	0%	5.40E-03	5.66E-04	--	1.08E-02
	Aroclor-1232	2	0	0%	1.01E-02	1.10E-03	--	2.03E-02
	Aroclor-1242	2	0	0%	9.43E-03	1.03E-03	--	1.89E-02
	Aroclor-1248	2	0	0%	4.05E-03	4.24E-04	--	8.10E-03
	Aroclor-1254	2	0	0%	7.43E-03	8.13E-04	--	1.49E-02
	Aroclor-1260	2	0	0%	3.38E-03	3.89E-04	--	6.75E-03
	Aroclor-1262	2	0	0%	8.78E-03	9.55E-04	--	1.76E-02
	Aroclor-1268	2	0	0%	4.73E-03	5.30E-04	--	9.45E-03
Metals	Aluminum	19	19	100%	1.26E+04	4.26E+03	2.15E+04	4.76E+00
	Antimony	2	1	50%	2.49E-01	2.85E-01	4.50E-01	9.45E-02
	Arsenic	19	19	100%	5.94E+00	3.84E+00	1.49E+01	1.51E-01
	Barium	19	19	100%	8.17E+02	6.51E+02	2.84E+03	5.57E-01
	Beryllium	2	2	100%	6.05E-01	4.88E-01	9.50E-01	8.45E-02
	Cadmium	19	19	100%	1.52E+00	1.43E+00	5.10E+00	3.54E-02
	Calcium	2	2	100%	1.21E+04	1.41E+04	2.20E+04	7.85E+00
	Chromium	19	19	100%	2.19E+01	9.78E+00	4.52E+01	2.33E-01
	Cobalt	19	19	100%	3.75E+00	1.55E+00	7.10E+00	3.03E-01
	Copper	19	19	100%	5.97E+01	4.66E+01	2.08E+02	4.23E-01
	Iron	19	19	100%	1.09E+04	4.37E+03	2.29E+04	3.05E+01
	Lead	19	19	100%	1.73E+01	8.93E+00	3.53E+01	5.06E-02
	Magnesium	2	2	100%	5.65E+03	4.22E+03	8.63E+03	2.75E+00
	Manganese	19	19	100%	6.01E+02	5.76E+02	1.80E+03	5.18E-01
	Mercury	19	19	100%	1.03E+00	1.32E+00	5.10E+00	2.66E-02
	Nickel	19	19	100%	9.90E+00	3.23E+00	1.45E+01	1.85E-01
	Potassium	2	2	100%	2.80E+03	1.85E+03	4.11E+03	1.53E+01
	Selenium	2	1	50%	2.48E-01	1.31E-01	3.40E-01	3.05E-01
	Silver	19	5	26%	3.54E-01	5.08E-01	1.80E+00	1.61E-01
	Sodium	2	2	100%	9.75E+02	1.22E+03	1.84E+03	5.30E+00
	Thallium	19	14	74%	1.34E-01	7.44E-02	2.20E-01	4.98E-02
	Vanadium	19	19	100%	2.30E+01	1.17E+01	4.62E+01	3.09E-01
	Zinc	19	19	100%	1.77E+02	1.09E+02	4.05E+02	1.65E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls.

[a]Non-detects evaluated at 1/2 MDL.

Table 6-4. Clark Fork River Bed Sediment Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ	Avian TEQ (ND=0)	6	6	100%	9.98E-08	1.04E-07	2.81E-07	--
	Avian TEQ (ND=1/2 MDL)	6	6	100%	1.52E-07	9.80E-08	3.18E-07	--
	Mammalian TEQ (ND=0)	6	6	100%	2.67E-07	2.01E-07	5.53E-07	--
	Mammalian TEQ (ND=1/2 MDL)	6	6	100%	3.02E-07	1.97E-07	5.79E-07	--
PCBs (Aroclors)	Aroclor-1016	2	0	0%	5.63E-03	5.30E-04	--	1.13E-02
	Aroclor-1221	2	0	0%	1.31E-02	1.24E-03	--	2.62E-02
	Aroclor-1232	2	0	0%	5.83E-03	5.30E-04	--	1.17E-02
	Aroclor-1242	2	0	0%	1.50E-02	1.41E-03	--	2.99E-02
	Aroclor-1248	2	0	0%	9.65E-03	9.19E-04	--	1.93E-02
	Aroclor-1254	2	0	0%	3.63E-03	3.18E-04	--	7.25E-03
	Aroclor-1260	2	0	0%	3.70E-03	3.54E-04	--	7.40E-03
	Aroclor-1262	2	0	0%	4.93E-03	4.60E-04	--	9.85E-03
	Aroclor-1268	2	0	0%	3.38E-03	3.18E-04	--	6.75E-03
Metals	Aluminum	6	6	100%	4.33E+03	1.17E+03	6.04E+03	8.60E+00
	Arsenic	6	6	100%	6.17E+00	1.34E+00	7.70E+00	2.53E-01
	Barium	6	6	100%	1.20E+02	2.19E+01	1.50E+02	1.65E-01
	Cadmium	6	6	100%	4.63E-01	2.35E-01	7.60E-01	5.62E-02
	Chromium	6	6	100%	5.28E+00	1.23E+00	7.10E+00	3.93E-01
	Cobalt	6	6	100%	2.68E+00	4.31E-01	3.30E+00	5.10E-01
	Copper	6	6	100%	5.31E+01	2.47E+01	8.33E+01	6.70E-01
	Iron	6	6	100%	6.86E+03	1.06E+03	8.24E+03	5.14E+01
	Lead	6	6	100%	1.42E+01	5.30E+00	2.13E+01	9.05E-02
	Manganese	6	6	100%	4.12E+02	2.78E+02	8.32E+02	4.23E-01
	Mercury	6	5	83%	1.55E-01	1.00E-01	3.00E-01	1.65E-02
	Nickel	6	6	100%	4.37E+00	7.63E-01	5.40E+00	3.15E-01
	Silver	6	0	0%	1.22E-01	5.19E-02	--	2.43E-01
	Thallium	6	0	0%	4.53E-02	2.06E-02	--	9.05E-02
	Vanadium	6	6	100%	9.37E+00	1.74E+00	1.20E+01	5.63E-01
	Zinc	6	6	100%	1.43E+02	3.82E+01	1.92E+02	2.77E+00
SVOCs	1,2,4-Trichlorobenzene	2	0	0%	1.65E-01	1.64E-01	--	3.31E-01
	1,2-Dichlorobenzene	2	0	0%	6.46E-02	6.42E-02	--	1.29E-01
	1,2-Diphenylhydrazine	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	1,3-Dichlorobenzene	2	0	0%	6.32E-02	6.27E-02	--	1.26E-01
	1,4-Dichlorobenzene	2	0	0%	6.70E-02	6.65E-02	--	1.34E-01
	1-Methylnaphthalene	2	0	0%	1.73E-01	1.72E-01	--	3.46E-01
	2,4,5-Trichlorophenol	2	0	0%	1.20E-01	1.19E-01	--	2.40E-01
	2,4,6-Trichlorophenol	2	0	0%	1.29E-01	1.28E-01	--	2.58E-01
	2,4-Dichlorophenol	2	0	0%	1.89E-01	1.88E-01	--	3.78E-01
	2,4-Dimethylphenol	2	0	0%	1.88E-01	1.87E-01	--	3.76E-01
	2,4-Dinitrophenol	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	2,4-Dinitrotoluene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	2,6-Dinitrotoluene	2	0	0%	8.58E-02	8.52E-02	--	1.72E-01
	2-Chloronaphthalene	2	0	0%	1.57E-01	1.56E-01	--	3.14E-01
	2-Chlorophenol	2	0	0%	2.34E-01	2.33E-01	--	4.68E-01
	2-Methylnaphthalene	2	0	0%	1.80E-01	1.78E-01	--	3.59E-01
	2-Nitroaniline	2	0	0%	1.09E-01	1.08E-01	--	2.17E-01
	2-Nitrophenol	2	0	0%	1.72E-01	1.70E-01	--	3.43E-01
	3,3`-Dichlorobenzidine	2	0	0%	1.40E-01	1.39E-01	--	2.80E-01
	3-Nitroaniline	2	0	0%	1.03E-01	1.02E-01	--	2.05E-01
	4,6-Dinitro-o-cresol	2	0	0%	2.00E-01	1.98E-01	--	3.99E-01
	4-Bromophenyl phenyl ether	2	0	0%	1.07E-01	1.06E-01	--	2.13E-01
	4-Chloro-3-methylphenol	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	4-Chlorophenyl phenyl ether	2	0	0%	1.15E-01	1.15E-01	--	2.31E-01
	4-Nitroaniline	2	0	0%	8.78E-02	8.72E-02	--	1.76E-01
	4-Nitrophenol	2	0	0%	1.05E-01	1.04E-01	--	2.10E-01
	Acenaphthene	2	0	0%	1.16E-01	1.15E-01	--	2.31E-01
	Acenaphthylene	2	0	0%	1.31E-01	1.30E-01	--	2.63E-01
	Anthracene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Benzo(a)anthracene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Benzo(a)pyrene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Benzo(b)fluoranthene	2	0	0%	1.27E-01	1.26E-01	--	2.54E-01
	Benzo(g,h,i)perylene	2	0	0%	1.22E-01	1.21E-01	--	2.44E-01
	Benzo(k)fluoranthene	2	0	0%	1.28E-01	1.27E-01	--	2.57E-01

	bis(2-chloroethoxy)methane	2	0	0%	1.96E-01	1.94E-01	--	3.92E-01
	bis(2-chloroethyl)ether	2	0	0%	6.99E-02	6.94E-02	--	1.40E-01
	Bis(2-chloroisopropyl)ether	2	0	0%	2.32E-01	2.30E-01	--	4.64E-01
	Bis(2-ethylhexyl)phthalate	2	0	0%	1.72E-01	1.70E-01	--	3.43E-01
	Butyl benzyl phthalate	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Carbazole	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Chrysene	2	0	0%	1.35E-01	1.34E-01	--	2.69E-01
	Dibenzo(a,h)anthracene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Dibenzofuran	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Dibutyl phthalate	2	0	0%	1.39E-01	1.38E-01	--	2.78E-01
	Diethyl phthalate	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Dimethyl phthalate	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Di-n-octyl phthalate	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Fluoranthene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Fluorene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
SVOCs	Hexachlorobenzene	2	0	0%	1.32E-01	1.31E-01	--	2.64E-01
	Hexachlorobutadiene	2	0	0%	8.46E-02	8.40E-02	--	1.69E-01
	Hexachloroethane	2	0	0%	6.38E-02	6.33E-02	--	1.28E-01
	Indeno(1,2,3-cd)pyrene	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Isophorone	2	0	0%	1.60E-01	1.59E-01	--	3.20E-01
	m & p-cresols	2	0	0%	2.01E-01	1.99E-01	--	4.01E-01
	Naphthalene	2	0	0%	1.88E-01	1.87E-01	--	3.76E-01
	Nitrobenzene	2	0	0%	2.03E-01	2.01E-01	--	4.06E-01
	N-Nitrosodimethylamine	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	N-Nitrosodi-n-propylamine	2	0	0%	1.37E-01	1.36E-01	--	2.73E-01
	N-Nitrosodiphenylamine	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	o-Cresol	2	0	0%	2.17E-01	2.16E-01	--	4.34E-01
	p-Chloroaniline	2	0	0%	1.54E-01	1.53E-01	--	3.08E-01
	Pentachlorophenol	2	0	0%	5.02E-01	4.99E-01	--	1.00E+00
	Phenanthrene	2	0	0%	1.43E-01	1.42E-01	--	2.87E-01
	Phenol	2	0	0%	2.19E-01	2.18E-01	--	4.38E-01
	Pyrene	2	0	0%	1.26E-01	1.25E-01	--	2.53E-01

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls; SVOC = semi-volatile organic compounds.

[a]Non-detects were evaluated at 1/2 the method detection limit (MDL).

Table 6-5. Clark Fork River Flood Fringe Soil Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg)[a]	Standard Deviation (mg/kg)[a]	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ[b]	TEQ, mammalian ND=0	3	3	100%	3.40E-07	1.26E-07	4.22E-07	--
	TEQ, mammalian ND=1/2 MDL	3	3	100%	3.75E-07	1.24E-07	4.55E-07	--
	TEQ, avain ND=0	3	3	100%	7.05E-07	5.39E-07	1.29E-06	--
	TEQ, avian ND=1/2 MDL	3	3	100%	7.51E-07	5.37E-07	1.33E-06	--
Metals	Aluminum	3	3	100%	1.14E+04	1.78E+03	1.32E+04	4.90E+00
	Arsenic	3	3	100%	1.76E+01	8.29E+00	2.72E+01	1.43E-01
	Barium	3	3	100%	2.44E+02	1.55E+01	2.59E+02	9.40E-02
	Cadmium	3	3	100%	1.63E+00	3.51E-01	2.00E+00	3.20E-02
	Chromium	3	3	100%	1.29E+01	1.75E+00	1.47E+01	2.23E-01
	Cobalt	3	3	100%	6.93E+00	7.51E-01	7.70E+00	2.90E-01
	Copper	3	3	100%	2.07E+02	9.45E+01	3.13E+02	3.87E-01
	Iron	3	3	100%	1.59E+04	2.15E+03	1.80E+04	2.92E+01
	Lead	3	3	100%	4.36E+01	9.70E+00	5.32E+01	5.13E-02
	Manganese	3	3	100%	6.41E+02	1.70E+02	7.68E+02	5.93E-01
	Mercury	3	3	100%	2.33E-01	1.40E-01	3.90E-01	9.67E-03
	Nickel	3	3	100%	1.20E+01	1.45E+00	1.34E+01	1.80E-01
	Silver	3	2	67%	7.12E-01	5.77E-01	1.20E+00	1.40E-01
	Thallium	3	3	100%	2.07E-01	2.52E-02	2.30E-01	5.13E-02
	Vanadium	3	3	100%	1.86E+01	1.85E+00	2.04E+01	3.27E-01
	Zinc	3	3	100%	4.01E+02	4.77E+01	4.56E+02	1.60E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit.

[a]Non-detects were evaluated at 1/2 the method detection limit (MDL).

Table 6-6. Clark Fork River Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
TEQ[b]	Avian TEQ (ND=0)	3	3	100%	7.45E-10	1.61E-10	8.79E-10	--
	Avian TEQ (ND=1/2 MDL)	3	3	100%	4.23E-07	1.61E-10	4.23E-07	--
	Mammalian TEQ (ND=0)	3	3	100%	2.24E-09	4.84E-10	2.64E-09	--
	Mammalian TEQ (ND=1/2 MDL)	3	3	100%	3.30E-07	4.84E-10	3.30E-07	--
PCBs (Aroclors)	Aroclor-1016	2	0	0%	2.25E-02	0.00E+00	--	4.50E-02
	Aroclor-1221	2	0	0%	9.75E-03	3.54E-04	--	1.95E-02
	Aroclor-1232	2	0	0%	1.83E-02	3.54E-04	--	3.65E-02
	Aroclor-1242	2	0	0%	1.40E-02	0.00E+00	--	2.80E-02
	Aroclor-1248	2	0	0%	6.00E-03	0.00E+00	--	1.20E-02
	Aroclor-1254	2	0	0%	7.75E-03	3.54E-04	--	1.55E-02
	Aroclor-1260	2	0	0%	7.50E-03	0.00E+00	--	1.50E-02
	Aroclor-1262	2	0	0%	2.10E-02	0.00E+00	--	4.20E-02
	Aroclor-1268	2	0	0%	1.15E-02	0.00E+00	--	2.30E-02
Metals (Total)	Aluminum	3	0	0%	1.50E+00	0.00E+00	--	3.00E+00
	Arsenic	3	3	100%	2.17E+00	5.77E-02	2.20E+00	1.10E-01
	Barium	3	3	100%	9.65E+01	2.89E+00	9.82E+01	8.10E-02
	Cadmium	3	0	0%	1.20E-02	0.00E+00	--	2.40E-02
	Chromium	3	0	0%	8.50E-02	1.32E-09	--	1.70E-01
	Cobalt	3	0	0%	6.50E-02	9.31E-10	--	1.30E-01
	Copper	3	1	33%	7.37E-01	1.09E+00	2.00E+00	2.10E-01
	Iron	3	1	33%	2.19E+01	2.60E+01	5.19E+01	1.37E+01
	Lead	3	2	67%	1.01E-01	6.83E-02	1.50E-01	4.60E-02
	Manganese	3	3	100%	1.29E+01	1.91E+00	1.51E+01	2.40E-01
	Mercury	3	0	0%	1.10E-02	0.00E+00	--	2.20E-02
	Nickel	3	0	0%	8.00E-02	1.32E-09	--	1.60E-01
	Silver	3	0	0%	7.50E-02	1.32E-09	--	1.50E-01
	Thallium	3	0	0%	7.50E-03	1.16E-10	--	1.50E-02
	Vanadium	3	0	0%	1.40E-01	0.00E+00	--	2.80E-01
	Zinc	3	0	0%	1.20E+00	2.11E-08	--	2.40E+00
Metals (Dissolved)	Aluminum	3	1	33%	3.70E+00	3.81E+00	8.10E+00	3.00E+00
	Arsenic	3	3	100%	2.10E+00	3.46E-01	2.50E+00	1.10E-01
	Barium	3	3	100%	9.84E+01	1.27E+01	1.13E+02	8.10E-02
	Cadmium	3	0	0%	1.20E-02	0.00E+00	--	2.40E-02
	Calcium	3	3	100%	3.15E+04	1.53E+02	3.17E+04	6.70E+01
	Chromium	3	3	100%	2.80E-01	8.89E-02	3.80E-01	1.70E-01
	Cobalt	3	3	100%	5.60E-01	1.66E-01	6.80E-01	1.30E-01
	Copper	3	3	100%	9.07E-01	8.14E-02	1.00E+00	2.10E-01
	Iron	3	1	33%	9.70E+00	4.94E+00	1.54E+01	1.37E+01
	Lead	3	2	67%	1.14E-01	1.28E-01	2.60E-01	4.60E-02
	Magnesium	3	3	100%	8.61E+03	3.06E+01	8.64E+03	2.00E+01
	Manganese	3	3	100%	9.87E+00	2.11E+00	1.23E+01	2.40E-01
	Nickel	3	3	100%	2.20E-01	6.93E-02	3.00E-01	1.60E-01
	Potassium	3	3	100%	1.94E+03	5.57E+01	2.00E+03	1.26E+02
	Silver	3	0	0%	7.50E-02	1.32E-09	--	1.50E-01
	Sodium	3	3	100%	7.64E+03	1.96E+02	7.82E+03	3.33E+01
	Thallium	3	0	0%	7.50E-03	1.16E-10	--	1.50E-02
	Vanadium	3	3	100%	5.30E-01	1.73E-02	5.50E-01	2.80E-01
	Zinc	3	1	33%	1.67E+00	8.08E-01	2.60E+00	2.40E+00

Table 6-6. Clark Fork River Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	1,2,4-Trichlorobenzene	2	0	0%	9.50E-01	0.00E+00	--	1.90E+00
	1,2-Dichlorobenzene	2	0	0%	9.50E-01	0.00E+00	--	1.90E+00
	1,2-Diphenylhydrazine	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	1,3-Dichlorobenzene	2	0	0%	8.00E-01	0.00E+00	--	1.60E+00
	1,4-Dichlorobenzene	2	0	0%	9.50E-01	0.00E+00	--	1.90E+00
	1-Methylnaphthalene	2	0	0%	1.05E+00	0.00E+00	--	2.10E+00
	2,4,5-Trichlorophenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	2,4,6-Trichlorophenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	2,4-Dichlorophenol	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	2,4-Dimethylphenol	2	0	0%	3.40E+00	0.00E+00	--	6.80E+00
	2,4-Dinitrophenol	2	0	0%	1.40E+00	0.00E+00	--	2.80E+00
	2,4-Dinitrotoluene	2	0	0%	1.05E+00	0.00E+00	--	2.10E+00
	2,6-Dinitrotoluene	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	2-Chloronaphthalene	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	2-Chlorophenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	2-Methylnaphthalene	2	0	0%	1.05E+00	0.00E+00	--	2.10E+00
	2-Nitroaniline	2	0	0%	1.40E+00	0.00E+00	--	2.80E+00
	2-Nitrophenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	3,3`-Dichlorobenzidine	2	0	0%	2.45E+00	0.00E+00	--	4.90E+00
	3-Nitroaniline	2	0	0%	2.50E+00	0.00E+00	--	5.00E+00
	4,6-Dinitro-o-cresol	2	0	0%	1.75E+00	0.00E+00	--	3.50E+00
	4-Bromophenyl phenyl ether	2	0	0%	1.20E+00	0.00E+00	--	2.40E+00
	4-Chloro-3-methylphenol	2	0	0%	8.00E-01	0.00E+00	--	1.60E+00
	4-Chlorophenyl phenyl ether	2	0	0%	7.00E-01	0.00E+00	--	1.40E+00
	4-Nitroaniline	2	0	0%	2.20E+00	0.00E+00	--	4.40E+00
	4-Nitrophenol	2	0	0%	1.70E+00	0.00E+00	--	3.40E+00
	Acenaphthene	2	0	0%	8.00E-01	0.00E+00	--	1.60E+00
	Acenaphthylene	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	Anthracene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Benzo(a)anthracene	2	0	0%	2.55E+00	0.00E+00	--	5.10E+00
	Benzo(a)pyrene	2	0	0%	1.20E+00	0.00E+00	--	2.40E+00
	Benzo(b)fluoranthene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Benzo(g,h,i)perylene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Benzo(k)fluoranthene	2	0	0%	1.40E+00	0.00E+00	--	2.80E+00
	bis(2-chloroethoxy)methane	2	0	0%	7.50E-01	0.00E+00	--	1.50E+00
	bis(2-chloroethyl)ether	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Bis(2-chloroisopropyl)ether	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Bis(2-ethylhexyl)phthalate	2	0	0%	1.20E+00	0.00E+00	--	2.40E+00
	Butyl benzyl phthalate	2	0	0%	9.50E-01	0.00E+00	--	1.90E+00
	Carbazole	2	0	0%	1.35E+00	0.00E+00	--	2.70E+00
	Chrysene	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Dibenzo(a,h)anthracene	2	0	0%	9.00E-01	0.00E+00	--	1.80E+00
	Dibenzofuran	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Dibutyl phthalate	2	0	0%	1.20E+00	0.00E+00	--	2.40E+00
	Diethyl phthalate	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Dimethyl phthalate	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Di-n-octyl phthalate	2	0	0%	8.50E-01	0.00E+00	--	1.70E+00
	Fluoranthene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Fluorene	2	0	0%	1.20E+00	0.00E+00	--	2.40E+00
	Hexachlorobenzene	2	0	0%	1.30E+00	0.00E+00	--	2.60E+00
	Hexachlorobutadiene	2	0	0%	8.50E-01	0.00E+00	--	1.70E+00
	Hexachloroethane	2	0	0%	8.50E-01	0.00E+00	--	1.70E+00
	Indeno(1,2,3-cd)pyrene	2	0	0%	9.00E-01	0.00E+00	--	1.80E+00
	Isophorone	2	0	0%	8.00E-01	0.00E+00	--	1.60E+00
	m & p-cresols	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	Naphthalene	2	0	0%	1.00E+00	0.00E+00	--	2.00E+00
	Nitrobenzene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	N-Nitrosodimethylamine	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	N-Nitrosodi-n-propylamine	2	0	0%	1.15E+00	0.00E+00	--	2.30E+00
	N-Nitrosodiphenylamine	2	0	0%	1.95E+00	0.00E+00	--	3.90E+00

Table 6-6. Clark Fork River Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	o-Cresol	2	0	0%	1.00E+00	0.00E+00	--	2.00E+00
	p-Chloroaniline	2	0	0%	1.80E+00	0.00E+00	--	3.60E+00
	Pentachlorophenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	Phenanthrene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00
	Phenol	2	0	0%	1.10E+00	0.00E+00	--	2.20E+00
	Pyrene	2	0	0%	1.25E+00	0.00E+00	--	2.50E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls; SVOC = semi-volatile organic compounds.

[a]Non-detects were evaluated at 1/2 the method detection limit (MDL).

[b]The only congener reported as detected was 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD).

Table 6-7. O'Keefe Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
TEQ[b]	Avian TEQ (ND=0)	1	1	100%	5.14E-09	--	5.14E-09	--
	Avian TEQ (ND=1/2 MDL)	1	1	100%	4.27E-07	--	4.27E-07	--
	Mammalian TEQ (ND=0)	1	1	100%	3.91E-08	--	3.91E-08	--
	Mammalian TEQ (ND=1/2 MDL)	1	1	100%	3.64E-07	--	3.64E-07	--
PCBs (Aroclors)	Aroclor-1016	1	0	0%	2.25E-02	--	--	4.50E-02
	Aroclor-1221	1	0	0%	9.50E-03	--	--	1.90E-02
	Aroclor-1232	1	0	0%	1.80E-02	--	--	3.60E-02
	Aroclor-1242	1	0	0%	1.40E-02	--	--	2.80E-02
	Aroclor-1248	1	0	0%	6.00E-03	--	--	1.20E-02
	Aroclor-1254	1	0	0%	7.50E-03	--	--	1.50E-02
	Aroclor-1260	1	0	0%	7.00E-03	--	--	1.40E-02
	Aroclor-1262	1	0	0%	2.05E-02	--	--	4.10E-02
	Aroclor-1268	1	0	0%	1.10E-02	--	--	2.20E-02
Metals (Total)	Aluminum	1	1	100%	1.32E+03	--	1.32E+03	3.00E+00
	Arsenic	1	1	100%	1.70E+00	--	1.70E+00	1.10E-01
	Barium	1	1	100%	2.62E+02	--	2.62E+02	8.10E-02
	Cadmium	1	0	0%	1.20E-02	--	--	2.40E-02
	Chromium	1	0	0%	8.50E-02	--	--	1.70E-01
	Cobalt	1	0	0%	6.50E-02	--	--	1.30E-01
	Copper	1	0	0%	1.05E-01	--	--	2.10E-01
	Iron	1	0	0%	6.85E+00	--	--	1.37E+01
	Lead	1	0	0%	2.30E-02	--	--	4.60E-02
	Manganese	1	1	100%	1.99E+01	--	1.99E+01	2.40E-01
	Mercury	1	0	0%	1.10E-02	--	--	2.20E-02
	Nickel	1	0	0%	8.00E-02	--	--	1.60E-01
	Silver	1	0	0%	7.50E-02	--	--	1.50E-01
	Thallium	1	0	0%	7.50E-03	--	--	1.50E-02
	Vanadium	1	0	0%	1.40E-01	--	--	2.80E-01
	Zinc	1	1	100%	5.00E+00	--	5.00E+00	2.40E+00
Metals (Dissolved)	Aluminum	1	1	100%	4.19E+01	--	4.19E+01	3.00E+00
	Arsenic	1	1	100%	1.30E+00	--	1.30E+00	1.10E-01
	Barium	1	1	100%	2.19E+02	--	2.19E+02	8.10E-02
	Cadmium	1	0	0%	1.20E-02	--	--	2.40E-02
	Calcium	1	1	100%	2.87E+04	--	2.87E+04	6.70E+01
	Chromium	1	1	100%	3.30E-01	--	3.30E-01	1.70E-01
	Cobalt	1	1	100%	9.80E-01	--	9.80E-01	1.30E-01
	Copper	1	1	100%	7.90E-01	--	7.90E-01	2.10E-01
	Iron	1	1	100%	3.74E+01	--	3.74E+01	1.37E+01
	Lead	1	1	100%	5.70E-02	--	5.70E-02	4.60E-02
	Magnesium	1	1	100%	1.35E+04	--	1.35E+04	2.00E+01
	Manganese	1	1	100%	1.06E+01	--	1.06E+01	2.40E-01
	Nickel	1	1	100%	4.90E-01	--	4.90E-01	1.60E-01
	Potassium	1	1	100%	1.74E+03	--	1.74E+03	1.26E+02
	Silver	1	0	0%	7.50E-02	--	--	1.50E-01
	Sodium	1	1	100%	2.29E+04	--	2.29E+04	3.33E+01
	Thallium	1	1	100%	2.50E-02	--	2.50E-02	1.50E-02
	Vanadium	1	1	100%	3.60E-01	--	3.60E-01	2.80E-01
	Zinc	1	0	0%	1.20E+00	--	--	2.40E+00

Table 6-7. O'Keefe Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	1,2,4-Trichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1,2-Dichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1,2-Diphenylhydrazine	1	0	0%	1.25E+00	--	--	2.50E+00
	1,3-Dichlorobenzene	1	0	0%	8.00E-01	--	--	1.60E+00
	1,4-Dichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1-Methylnaphthalene	1	0	0%	1.05E+00	--	--	2.10E+00
	2,4,5-Trichlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2,4,6-Trichlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2,4-Dichlorophenol	1	0	0%	1.15E+00	--	--	2.30E+00
	2,4-Dimethylphenol	1	0	0%	3.40E+00	--	--	6.80E+00
	2,4-Dinitrophenol	1	0	0%	1.40E+00	--	--	2.80E+00
	2,4-Dinitrotoluene	1	0	0%	1.05E+00	--	--	2.10E+00
	2,6-Dinitrotoluene	1	0	0%	1.15E+00	--	--	2.30E+00
	2-Chloronaphthalene	1	0	0%	1.10E+00	--	--	2.20E+00
	2-Chlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2-Methylnaphthalene	1	0	0%	1.05E+00	--	--	2.10E+00
	2-Nitroaniline	1	0	0%	1.40E+00	--	--	2.80E+00
	2-Nitrophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	3,3`-Dichlorobenzidine	1	0	0%	2.45E+00	--	--	4.90E+00
	3-Nitroaniline	1	0	0%	2.50E+00	--	--	5.00E+00
	4,6-Dinitro-o-cresol	1	0	0%	1.75E+00	--	--	3.50E+00
	4-Bromophenyl phenyl ether	1	0	0%	1.20E+00	--	--	2.40E+00
	4-Chloro-3-methylphenol	1	0	0%	8.00E-01	--	--	1.60E+00
	4-Chlorophenyl phenyl ether	1	0	0%	7.00E-01	--	--	1.40E+00
	4-Nitroaniline	1	0	0%	2.20E+00	--	--	4.40E+00
	4-Nitrophenol	1	0	0%	1.70E+00	--	--	3.40E+00
	Acenaphthene	1	0	0%	8.00E-01	--	--	1.60E+00
	Acenaphthylene	1	0	0%	1.10E+00	--	--	2.20E+00
	Anthracene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(a)anthracene	1	0	0%	2.55E+00	--	--	5.10E+00
	Benzo(a)pyrene	1	0	0%	1.20E+00	--	--	2.40E+00
	Benzo(b)fluoranthene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(g,h,i)perylene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(k)fluoranthene	1	0	0%	1.40E+00	--	--	2.80E+00
	bis(2-chloroethoxy)methane	1	0	0%	7.50E-01	--	--	1.50E+00
	bis(2-chloroethyl)ether	1	0	0%	1.15E+00	--	--	2.30E+00
	Bis(2-chloroisopropyl)ether	1	0	0%	1.15E+00	--	--	2.30E+00
	Bis(2-ethylhexyl)phthalate	1	0	0%	1.20E+00	--	--	2.40E+00
	Butyl benzyl phthalate	1	0	0%	9.50E-01	--	--	1.90E+00
	Carbazole	1	0	0%	1.35E+00	--	--	2.70E+00
	Chrysene	1	0	0%	1.15E+00	--	--	2.30E+00
	Dibenzo(a,h)anthracene	1	0	0%	9.00E-01	--	--	1.80E+00
	Dibenzofuran	1	0	0%	1.15E+00	--	--	2.30E+00
	Dibutyl phthalate	1	0	0%	1.20E+00	--	--	2.40E+00
	Diethyl phthalate	1	0	0%	1.25E+00	--	--	2.50E+00
	Dimethyl phthalate	1	0	0%	1.15E+00	--	--	2.30E+00
	Di-n-octyl phthalate	1	0	0%	8.50E-01	--	--	1.70E+00
	Fluoranthene	1	0	0%	1.25E+00	--	--	2.50E+00
	Fluorene	1	0	0%	1.20E+00	--	--	2.40E+00
	Hexachlorobenzene	1	0	0%	1.30E+00	--	--	2.60E+00
	Hexachlorobutadiene	1	0	0%	8.50E-01	--	--	1.70E+00
	Hexachloroethane	1	0	0%	8.50E-01	--	--	1.70E+00
	Indeno(1,2,3-cd)pyrene	1	0	0%	9.00E-01	--	--	1.80E+00
	Isophorone	1	0	0%	8.00E-01	--	--	1.60E+00
	m & p-cresols	1	0	0%	1.15E+00	--	--	2.30E+00
	Naphthalene	1	0	0%	1.00E+00	--	--	2.00E+00
	Nitrobenzene	1	0	0%	1.25E+00	--	--	2.50E+00
	N-Nitrosodimethylamine	1	0	0%	1.15E+00	--	--	2.30E+00
	N-Nitrosodi-n-propylamine	1	0	0%	1.15E+00	--	--	2.30E+00
	N-Nitrosodiphenylamine	1	0	0%	1.95E+00	--	--	3.90E+00

Table 6-7. O'Keefe Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	o-Cresol	1	0	0%	1.00E+00	--	--	2.00E+00
	p-Chloroaniline	1	0	0%	1.80E+00	--	--	3.60E+00
	Pentachlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	Phenanthrene	1	0	0%	1.25E+00	--	--	2.50E+00
	Phenol	1	0	0%	1.10E+00	--	--	2.20E+00
	Pyrene	1	0	0%	1.25E+00	--	--	2.50E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls; SVOC = semi-volatile organic compounds.

[a]Non-detects were evaluated at 1/2 the method detection limit (MDL).

[b]The only congeners reported as detected were 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD) and 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD).

Table 6-8. LaValle Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
TEQ[b]	Avian TEQ (ND=0)	1	1	100%	3.61E-08	--	3.61E-08	--
	Avian TEQ (ND=1/2 MDL)	1	1	100%	4.57E-07	--	4.57E-07	--
	Mammalian TEQ (ND=0)	1	1	100%	9.21E-08	--	9.21E-08	--
	Mammalian TEQ (ND=1/2 MDL)	1	1	100%	4.16E-07	--	4.16E-07	--
PCBs (Aroclors)	Aroclor-1016	1	0	0%	2.30E-02	--	--	4.60E-02
	Aroclor-1221	1	0	0%	1.00E-02	--	--	2.00E-02
	Aroclor-1232	1	0	0%	1.85E-02	--	--	3.70E-02
	Aroclor-1242	1	0	0%	1.40E-02	--	--	2.80E-02
	Aroclor-1248	1	0	0%	6.50E-03	--	--	1.30E-02
	Aroclor-1254	1	0	0%	8.00E-03	--	--	1.60E-02
	Aroclor-1260	1	0	0%	7.50E-03	--	--	1.50E-02
	Aroclor-1262	1	0	0%	2.10E-02	--	--	4.20E-02
	Aroclor-1268	1	0	0%	1.15E-02	--	--	2.30E-02
Metals (Total)	Aluminum	1	0	0%	1.50E+00	--	--	3.00E+00
	Arsenic	1	1	100%	1.60E+00	--	1.60E+00	1.10E-01
	Barium	1	1	100%	2.50E+02	--	2.50E+02	8.10E-02
	Cadmium	1	0	0%	1.20E-02	--	--	2.40E-02
	Chromium	1	0	0%	8.50E-02	--	--	1.70E-01
	Cobalt	1	0	0%	6.50E-02	--	--	1.30E-01
	Copper	1	0	0%	1.05E-01	--	--	2.10E-01
	Iron	1	0	0%	6.85E+00	--	--	1.37E+01
	Lead	1	1	100%	3.40E-01	--	3.40E-01	4.60E-02
	Manganese	1	1	100%	7.30E+00	--	7.30E+00	2.40E-01
	Mercury	1	0	0%	1.10E-02	--	--	2.20E-02
	Nickel	1	0	0%	8.00E-02	--	--	1.60E-01
	Silver	1	0	0%	7.50E-02	--	--	1.50E-01
	Thallium	1	0	0%	7.50E-03	--	--	1.50E-02
	Vanadium	1	0	0%	1.40E-01	--	--	2.80E-01
	Zinc	1	0	0%	1.20E+00	--	--	2.40E+00
Metals (Dissolved)	Aluminum	1	0	0%	1.50E+00	--	--	3.00E+00
	Arsenic	1	1	100%	1.40E+00	--	1.40E+00	1.10E-01
	Barium	1	1	100%	2.44E+02	--	2.44E+02	8.10E-02
	Cadmium	1	0	0%	1.20E-02	--	--	2.40E-02
	Calcium	1	1	100%	5.23E+04	--	5.23E+04	6.70E+01
	Chromium	1	1	100%	2.80E-01	--	2.80E-01	1.70E-01
	Cobalt	1	1	100%	9.20E-01	--	9.20E-01	1.30E-01
	Copper	1	1	100%	2.80E-01	--	2.80E-01	2.10E-01
	Iron	1	0	0%	6.85E+00	--	--	1.37E+01
	Lead	1	0	0%	2.30E-02	--	--	4.60E-02
	Magnesium	1	1	100%	2.23E+04	--	2.23E+04	2.00E+01
	Manganese	1	1	100%	6.20E+00	--	6.20E+00	2.40E-01
	Nickel	1	1	100%	2.60E-01	--	2.60E-01	1.60E-01
	Potassium	1	1	100%	2.13E+03	--	2.13E+03	1.26E+02
	Silver	1	0	0%	7.50E-02	--	--	1.50E-01
	Sodium	1	1	100%	8.21E+03	--	8.21E+03	3.33E+01
	Thallium	1	0	0%	7.50E-03	--	--	1.50E-02
	Vanadium	1	1	100%	9.40E-01	--	9.40E-01	2.80E-01
	Zinc	1	0	0%	1.20E+00	--	--	2.40E+00

Table 6-8. LaValle Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	1,2,4-Trichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1,2-Dichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1,2-Diphenylhydrazine	1	0	0%	1.25E+00	--	--	2.50E+00
	1,3-Dichlorobenzene	1	0	0%	8.50E-01	--	--	1.70E+00
	1,4-Dichlorobenzene	1	0	0%	9.50E-01	--	--	1.90E+00
	1-Methylnaphthalene	1	0	0%	1.05E+00	--	--	2.10E+00
	2,4,5-Trichlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2,4,6-Trichlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2,4-Dichlorophenol	1	0	0%	1.15E+00	--	--	2.30E+00
	2,4-Dimethylphenol	1	0	0%	3.45E+00	--	--	6.90E+00
	2,4-Dinitrophenol	1	0	0%	1.40E+00	--	--	2.80E+00
	2,4-Dinitrotoluene	1	0	0%	1.10E+00	--	--	2.20E+00
	2,6-Dinitrotoluene	1	0	0%	1.15E+00	--	--	2.30E+00
	2-Chloronaphthalene	1	0	0%	1.15E+00	--	--	2.30E+00
	2-Chlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	2-Methylnaphthalene	1	0	0%	1.05E+00	--	--	2.10E+00
	2-Nitroaniline	1	0	0%	1.40E+00	--	--	2.80E+00
	2-Nitrophenol	1	0	0%	1.15E+00	--	--	2.30E+00
	3,3`-Dichlorobenzidine	1	0	0%	2.50E+00	--	--	5.00E+00
	3-Nitroaniline	1	0	0%	2.55E+00	--	--	5.10E+00
	4,6-Dinitro-o-cresol	1	0	0%	1.80E+00	--	--	3.60E+00
	4-Bromophenyl phenyl ether	1	0	0%	1.20E+00	--	--	2.40E+00
	4-Chloro-3-methylphenol	1	0	0%	8.00E-01	--	--	1.60E+00
	4-Chlorophenyl phenyl ether	1	0	0%	7.00E-01	--	--	1.40E+00
	4-Nitroaniline	1	0	0%	2.20E+00	--	--	4.40E+00
	4-Nitrophenol	1	0	0%	1.70E+00	--	--	3.40E+00
	Acenaphthene	1	0	0%	8.50E-01	--	--	1.70E+00
	Acenaphthylene	1	0	0%	1.15E+00	--	--	2.30E+00
	Anthracene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(a)anthracene	1	0	0%	2.55E+00	--	--	5.10E+00
	Benzo(a)pyrene	1	0	0%	1.20E+00	--	--	2.40E+00
	Benzo(b)fluoranthene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(g,h,i)perylene	1	0	0%	1.25E+00	--	--	2.50E+00
	Benzo(k)fluoranthene	1	0	0%	1.40E+00	--	--	2.80E+00
	bis(2-chloroethoxy)methane	1	0	0%	8.00E-01	--	--	1.60E+00
	bis(2-chloroethyl)ether	1	0	0%	1.15E+00	--	--	2.30E+00
	Bis(2-chloroisopropyl)ether	1	0	0%	1.15E+00	--	--	2.30E+00
	Bis(2-ethylhexyl)phthalate	1	0	0%	1.20E+00	--	--	2.40E+00
	Butyl benzyl phthalate	1	0	0%	9.50E-01	--	--	1.90E+00
	Carbazole	1	0	0%	1.35E+00	--	--	2.70E+00
	Chrysene	1	0	0%	1.15E+00	--	--	2.30E+00
	Dibenzo(a,h)anthracene	1	0	0%	9.00E-01	--	--	1.80E+00
	Dibenzofuran	1	0	0%	1.15E+00	--	--	2.30E+00
	Dibutyl phthalate	1	0	0%	1.25E+00	--	--	2.50E+00
	Diethyl phthalate	1	0	0%	1.25E+00	--	--	2.50E+00
	Dimethyl phthalate	1	0	0%	1.20E+00	--	--	2.40E+00
	Di-n-octyl phthalate	1	0	0%	8.50E-01	--	--	1.70E+00
	Fluoranthene	1	0	0%	1.25E+00	--	--	2.50E+00
	Fluorene	1	0	0%	1.20E+00	--	--	2.40E+00
	Hexachlorobenzene	1	0	0%	1.30E+00	--	--	2.60E+00
	Hexachlorobutadiene	1	0	0%	8.50E-01	--	--	1.70E+00
	Hexachloroethane	1	0	0%	8.50E-01	--	--	1.70E+00
	Indeno(1,2,3-cd)pyrene	1	0	0%	9.00E-01	--	--	1.80E+00
	Isophorone	1	0	0%	8.00E-01	--	--	1.60E+00
	m & p-cresols	1	0	0%	1.15E+00	--	--	2.30E+00
	Naphthalene	1	0	0%	1.00E+00	--	--	2.00E+00
	Nitrobenzene	1	0	0%	1.25E+00	--	--	2.50E+00
	N-Nitrosodimethylamine	1	0	0%	1.15E+00	--	--	2.30E+00
	N-Nitrosodi-n-propylamine	1	0	0%	1.15E+00	--	--	2.30E+00
	N-Nitrosodiphenylamine	1	0	0%	2.00E+00	--	--	4.00E+00

Table 6-8. LaValle Creek Surface Water Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (ug/L)[a]	Standard Deviation (ug/L)[a]	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	o-Cresol	1	0	0%	1.00E+00	--	--	2.00E+00
	p-Chloroaniline	1	0	0%	1.85E+00	--	--	3.70E+00
	Pentachlorophenol	1	0	0%	1.10E+00	--	--	2.20E+00
	Phenanthrene	1	0	0%	1.30E+00	--	--	2.60E+00
	Phenol	1	0	0%	1.15E+00	--	--	2.30E+00
	Pyrene	1	0	0%	1.25E+00	--	--	2.50E+00

TEQ = toxicity equivalence; ND = non-detect; MDL = method detection limit; PCB = polychlorinated biphenyls; SVOC = semi-volatile organic compounds.

[a]Non-detects were evaluated at 1/2 the method detection limit (MDL).

[b]The only congeners reported as detected were 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD) and 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD).

Table 6-9. Fish Tissue Summary Statistics

Analysis	Analyte	N Samples	N Detected Samples	Detection Frequency	Average Concentration (mg/kg ww)[a,b]	Standard Deviation (mg/kg ww)[a,b]	Maximum Detected Concentration (mg/kg ww)	Average DL[b] (mg/kg ww)
TEQ[c]	Mammalian TEQ, Dioxins/Furans (ND=0)	7	7	100%	7.5E-08	5.9E-08	1.8E-07	--
	Mammalian TEQ, Dioxins/Furans (ND=1/2DL)	7	7	100%	1.6E-07	5.1E-08	2.4E-07	--
	Avian TEQ, Dioxins/Furans (ND=0)	7	7	100%	3.7E-07	3.0E-07	9.6E-07	--
	Avian TEQ, Dioxins/Furans (ND=1/2DL)	7	7	100%	4.7E-07	2.9E-07	1.1E-06	--
PCBs	Aroclor 1016	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1221	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1232	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1242	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1248	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1254	7	2	29%	2.4E-02	1.8E-02	6.4E-02	3.3E-02
	Aroclor 1260	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1262	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
	Aroclor 1268	7	0	0%	1.6E-02	9.3E-04	0.0E+00	3.3E-02
Metals	Mercury	7	7	100%	1.1E-01	9.0E-02	2.5E-01	1.3E-02
	Selenium	7	6	86%	1.2E-01	2.9E-02	1.4E-01	9.3E-02

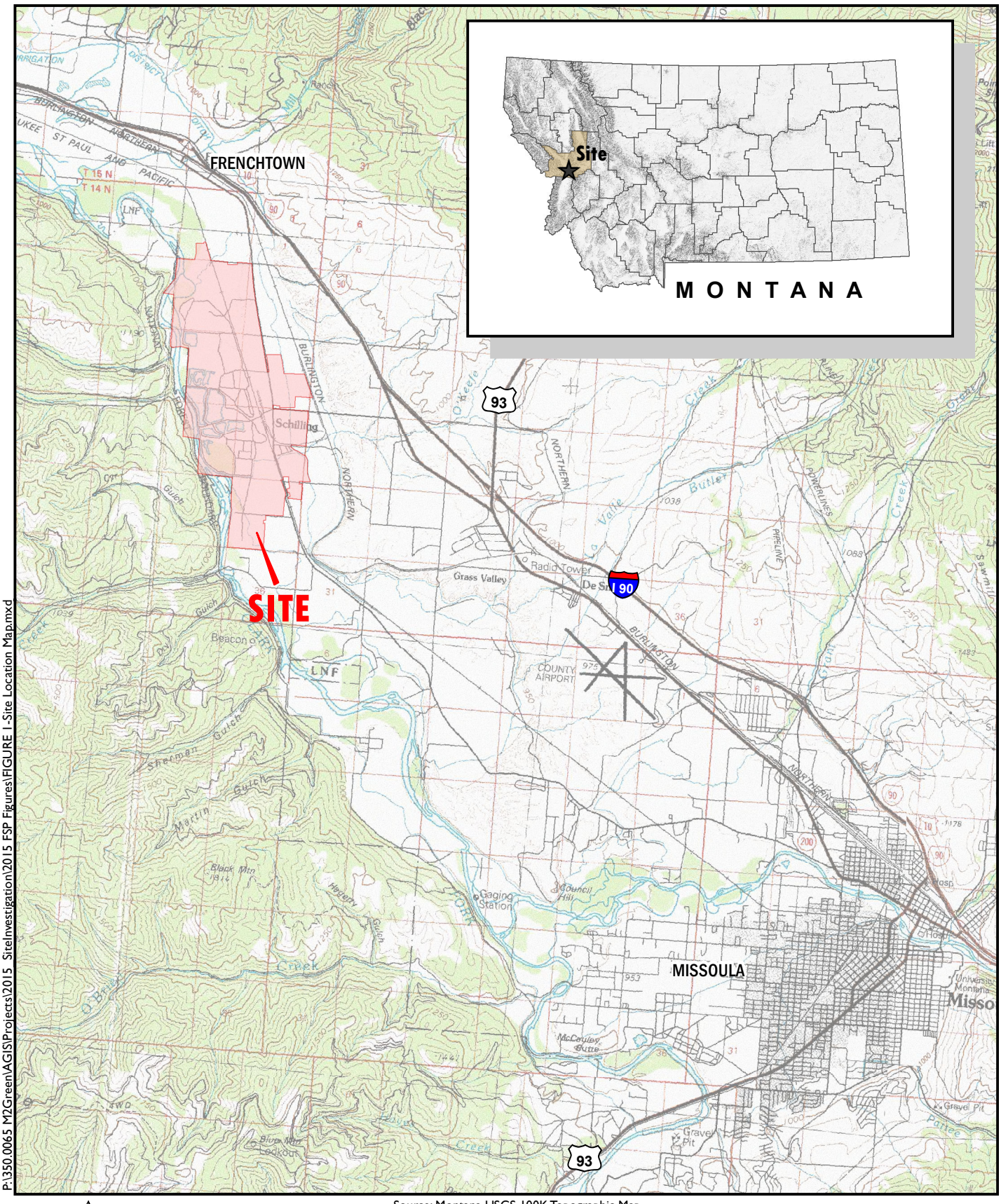
PCB=polychlorinated biphenyl; ND=non-detect; DL=detection limit; DL-PCB=dioxin like PCB

[a]Non-detects were evaluated at 1/2 the DL.

[b]The Estimated Detection Limit (EDL) was used as the DL for dioxins, the Reporting Limit (RL) was used to evaluate NDs for the other contaminants.

[c]TEQ values were calculated using TEFs for mammals from USEPA (2010) and using TEFs for birds from van Den Berg et al. (1998).

FIGURES



P:\350.0065 M2Green\AGIS\Projects\2015 SiteInvestigation\2015 FSP Figures\FIGURE 1-Site Location Map.mxd

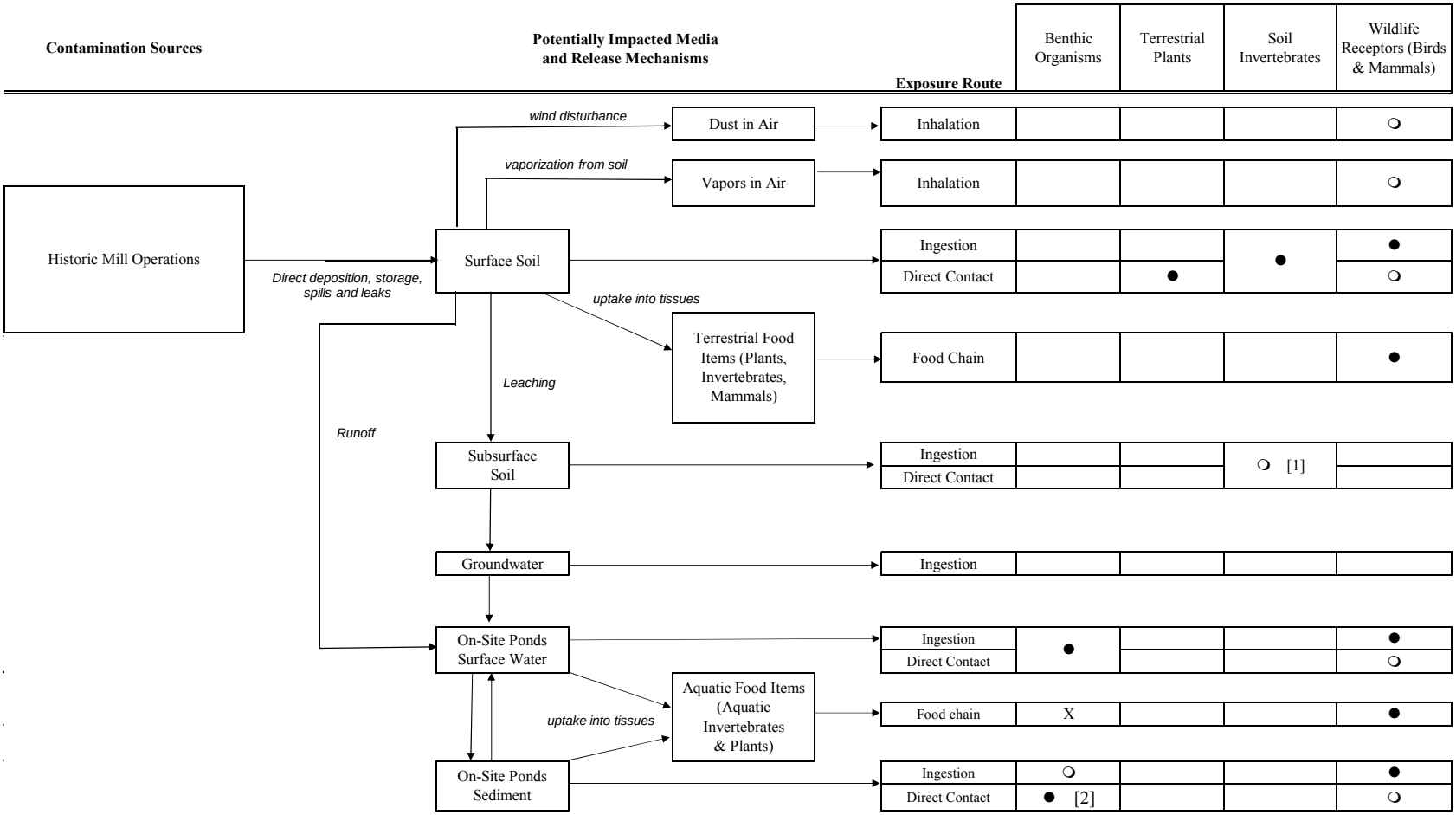
Source: Montana USGS 100K Topographic Map

0 Feet 10,000

NewFields

Site Location Map
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 1-1

Figure 4-1 Conceptual Site Model for Ecological Exposure at OU2



LEGEND

●	Pathway is complete and might be significant.
❍	Pathway is complete, but is relatively minor.
X	Pathway is complete and may be significant, but insufficient data (exposure or toxicity) are available for quantitative evalution.
	Pathway is not complete.

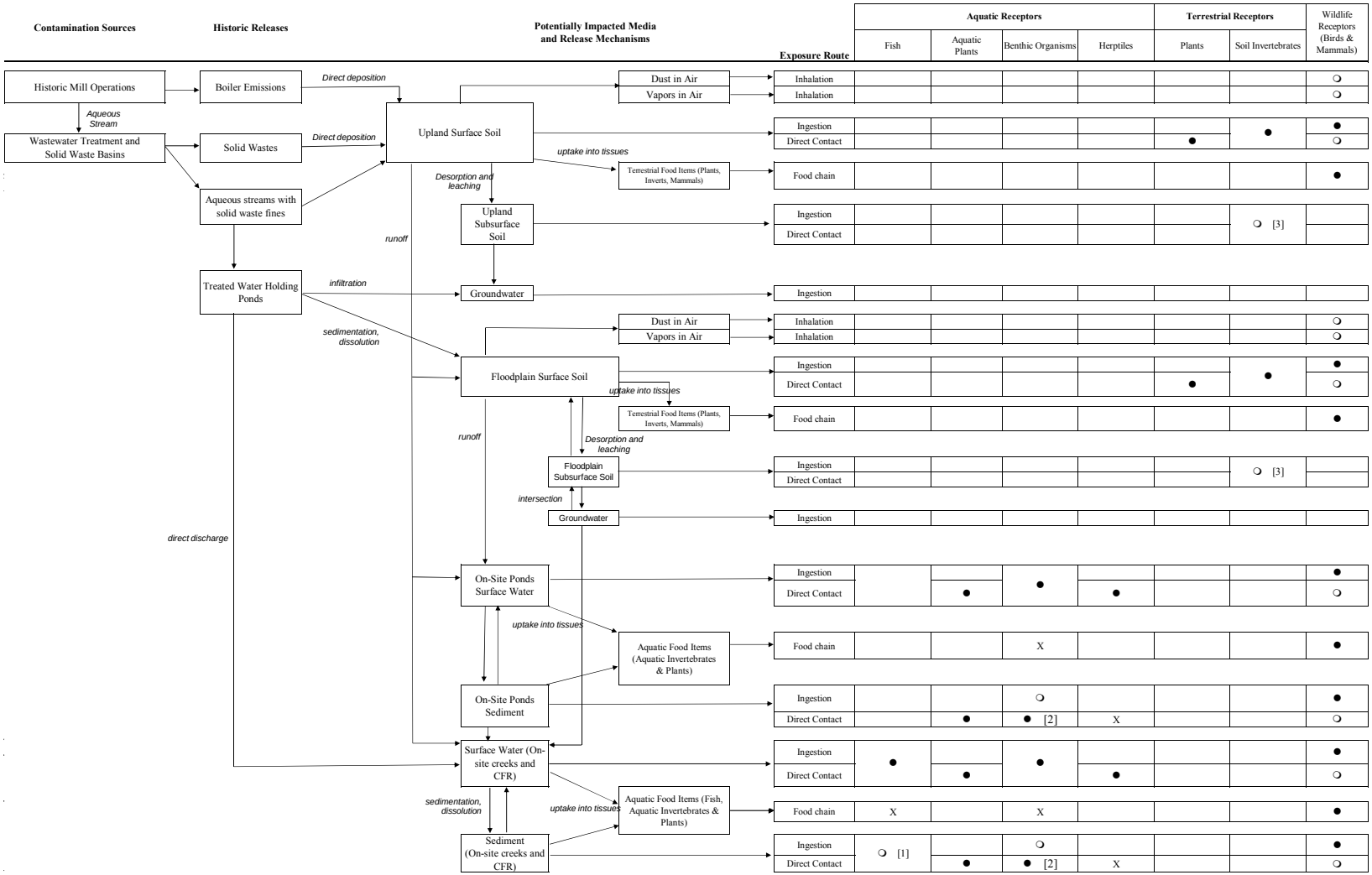
NOTES

Direct contact exposures include dermal contact, root uptake, respiration, and/or osmotic exchange.

[1] USEPA (2015) guidance recommends sampling to a depth of approximately 25-30 cm to capture the average biologically active zone (soil biota). Surface soil samples have been collected at 0-7 inches (0-18 cm). Subsurface samples have been collected at depths greater than 1 foot below ground surface. However, statistical testing has found that concentrations in surface soils are comparable or higher than concentrations in subsurface samples (alpha = 0.05). Thus, quantification of ecological exposures to surface soils is expected to be representative and/or protective of exposures to subsurface soils.

[2] In most cases, toxicity values for exposure of BMI to sediments likely include at least some contribution from the ingestion pathway, so direct contact and ingestion of benthic macroinvertebrates are usually evaluated together.

Figure 4-2. Conceptual Site Model for Ecological Exposures at OU3



LEGEND

●	Pathway is complete and might be significant; quantitative evaluation.
❍	Pathway is complete, but is relatively minor; semi-quantitative evaluation.
X	Pathway is or may be complete, however, data for quanitative evaluation may be lacking.
	Pathway is not complete; no evaluation required.

NOTES

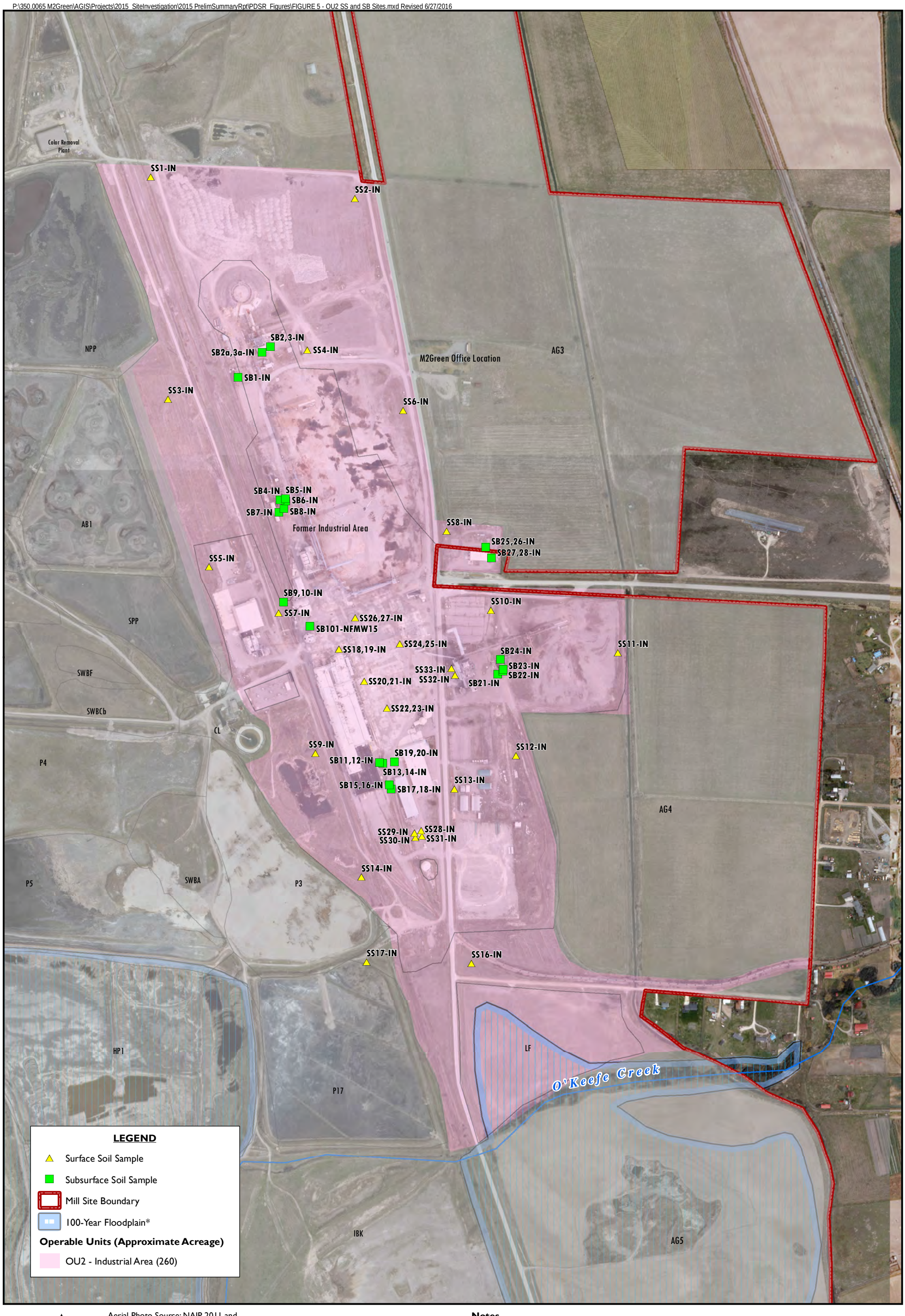
Direct contact exposures include dermal contact, root uptake, respiration, and/or osmotic exchange.

[1] Believed to be a minor pathway compared to risks from direct contact with surface water, but may be important for contaminants that bioaccumulate.

[2] In most cases, toxicity values for exposure of BMI to sediments likely include at least some contribution from the ingestion pathway, so direct contact and ingestion of benthic macroinvertebrates are usually evaluated together.

[3] USEPA (2015) guidance recommends sampling to a depth of approximately 25-30 cm to capture the average biologically active zone (soil biota). Surface soil samples have been collected at 0-7 inches (0-18 cm). Subsurface samples have been collected at depths greater than 1 foot below ground surface. However, statistical testing has found that concentrations in surface soils are comparable or higher than concentrations in subsurface samples (alpha = 0.05). Thus, quantification of ecological exposures to surface soils is expected to be representative and/or protective of exposures to subsurface soils.

P:\350.0065 M2Green\AGIS\Projects\2015_SiteInvestigation\2015 PrelimSummaryRpt\PDSR_Figures\FIGURE 5 - OU2 SS and SB Sites.mxd Revised 6/27/2016



Aerial Photo Source: NAIP 2011 and Newfields 2016 (Within Site Boundary)

*Floodplain Source:
As defined by the Federal Emergency Management Agency (FEMA) 2013 Digital Flood Insurance Rate Map (DFIRM). (NFIP 2013)

0 Feet 600

NewFields

Notes

AG - Agricultural Land
AB - Aeration Stabilization Basin
CFR - Clark Fork River
CL - Clarifier
FP - Flood Plain
HP - Holding or Storage Pond
IB - Rapid Infiltration Basin
NPP - North Polishing Pond
P - Settling Pond
SB - Spoils Basin
SPP - South Polishing Pond
SWB - Solid Waste Basin
WR - West of River

Surface and Subsurface Soil Sampling Locations in OU2
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 6-1

P:\350.0065 M2Green\AGIS\Projects\2016 RIWP Addendum\FIGURE 2 - Proposed Sample Areas.mxd Revised 5/17/2016

Aerial Photo Source: Newfields 2016

N

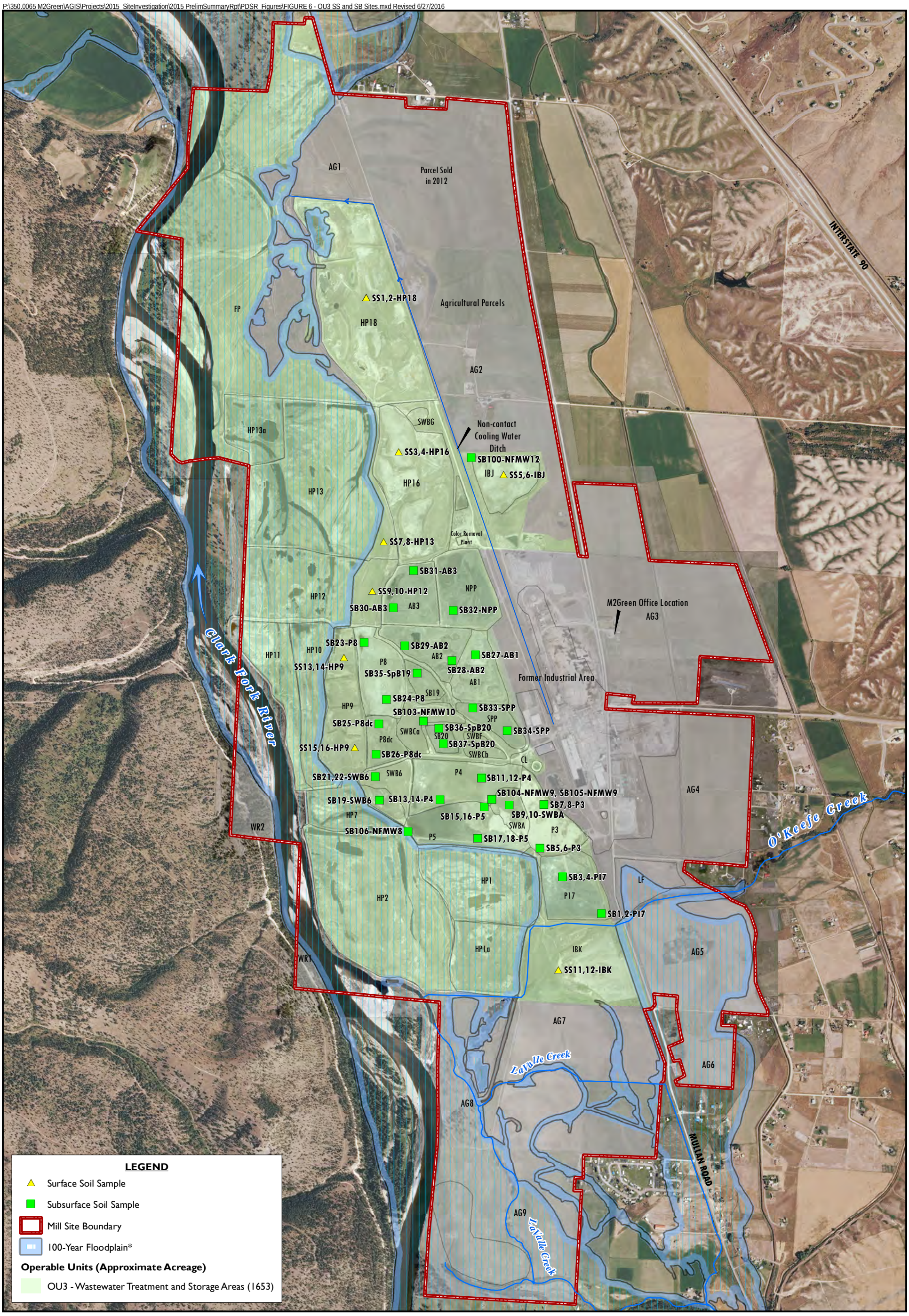
0 Feet 200

OU2 - Industrial Area Boundary

NewFields

Soil Sample Areas (OU2)
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 6-2

P:\350.0065 M2Green\AGIS\Projects\2015_SiteInvestigation\2015 PrelimSummaryRpt\PDSR_Figures\FIGURE 6 - OU3 SS and SB Sites.mxd Revised 6/27/2016



Aerial Photo Source: NAIP 2011 and Newfields 2016 (Within Site Boundary)

0 1,600 Feet

*Floodplain Source:
As defined by the Federal Emergency Management Agency (FEMA) 2013 Digital Flood Insurance Rate Map (DFIRM). (NFIP 2013)

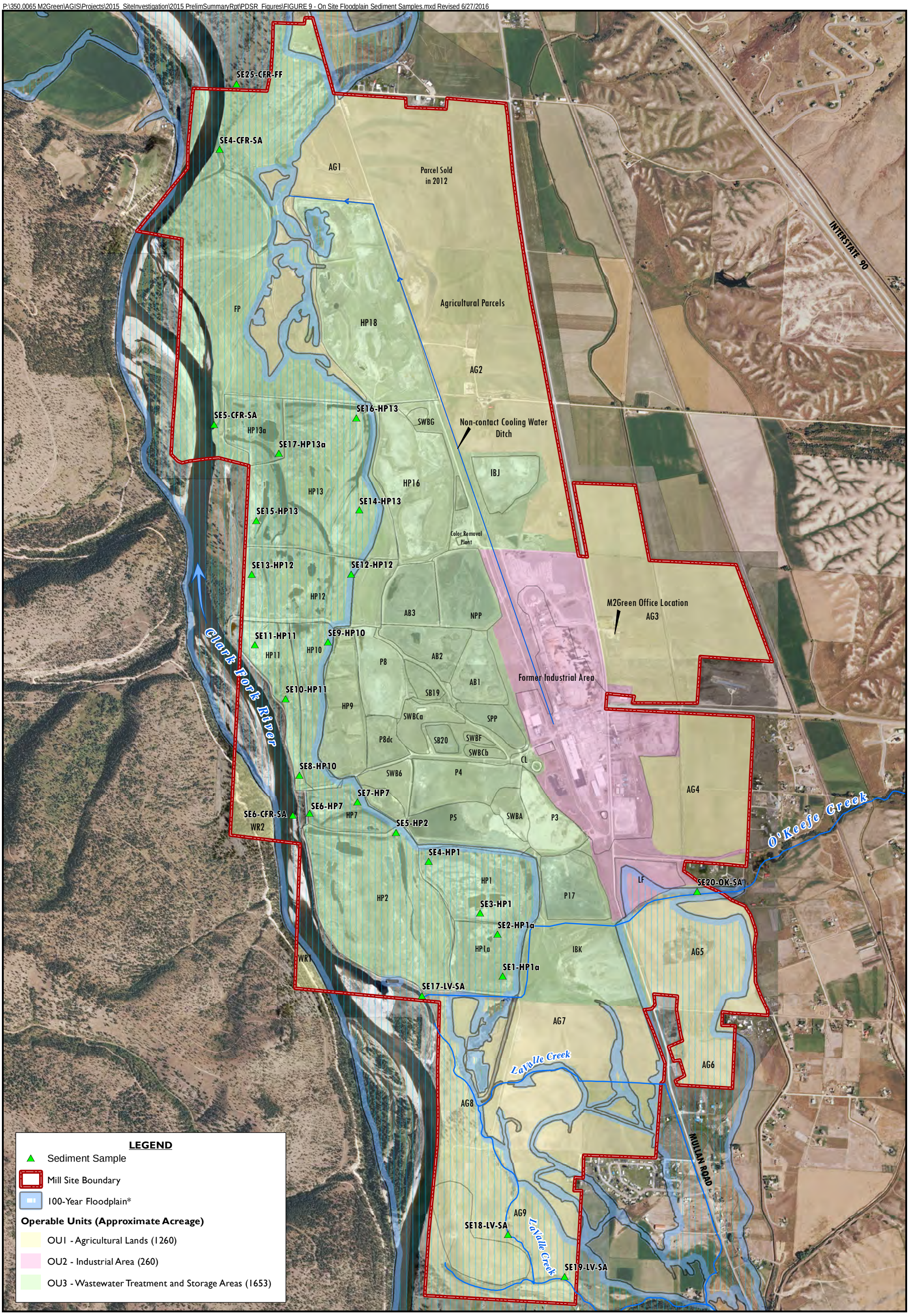
Notes

AG - Agricultural Land
AB - Aeration Stabilization Basin
CFR - Clark Fork River
CL - Clarifier
FP - Flood Plain
HP - Holding or Storage Pond
IB - Rapid Infiltration Basin
NPP - North Polishing Pond
P - Settling Pond
SB - Spoils Basin
SPP - South Polishing Pond
SWB - Solid Waste Basin
WR - West of River

NewFields

Surface and Subsurface Soil Sampling Locations in OU-3
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 6-3

P:\350.0065 M2Green\AGIS\Projects\2015_SiteInvestigation\2015 PrelimSummaryRpt\PDSR_Figures\FIGURE 9 - On Site Floodplain Sediment Samples.mxd Revised 6/27/2016



LEGEND

- Sediment Sample
- Mill Site Boundary
- 100-Year Floodplain*

Operable Units (Approximate Acreage)

- OU1 - Agricultural Lands (1260)
- OU2 - Industrial Area (260)
- OU3 - Wastewater Treatment and Storage Areas (1653)

0 Feet 1,600

Aerial Photo Source: NAIP 2011 and Newfields 2016 (Within Site Boundary)

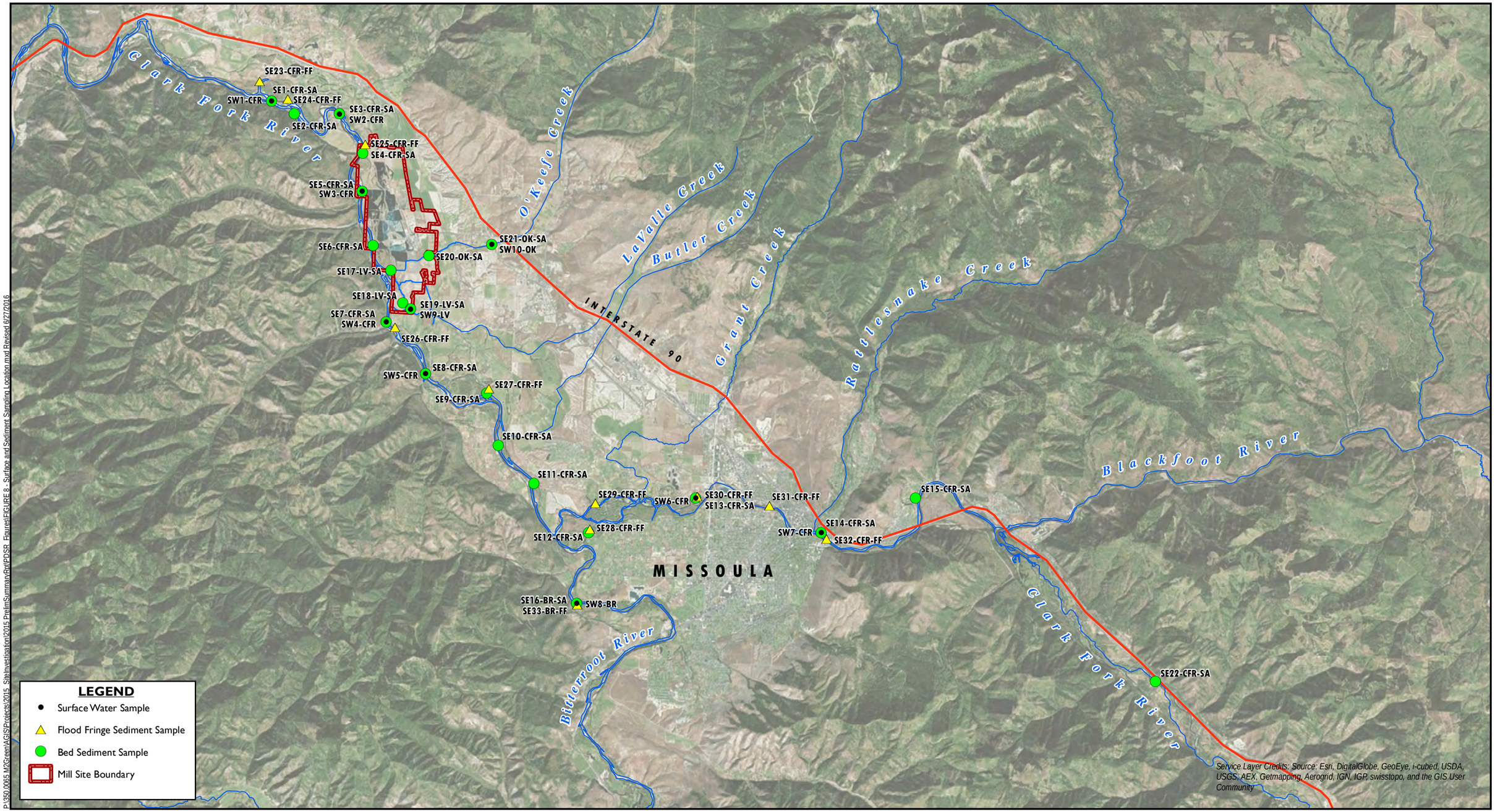
*Floodplain Source:
As defined by the Federal Emergency Management Agency (FEMA) 2013 Digital Flood Insurance Rate Map (DFIRM). (NFIP 2013)

Notes

AG - Agricultural Land
AB - Aeration Stabilization Basin
CFR - Clark Fork River
CL - Clarifier
FP - Flood Plain
HP - Holding or Storage Pond
IB - Rapid Infiltration Basin
NPP - North Polishing Pond
P - Settling Pond
SB - Spoils Basin
SPP - South Polishing Pond
SWB - Solid Waste Basin
WR - West of River

NewFields

On-Site Floodplain Sediment Sampling Locations
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 6-4



P:\350\0065 M2\Geen\AGIS\Projects\2015_SiteInvestigation\2015 PrelimSummaryRpt\PDSR_Figures\FIGURE 8 - Surface and Sediment Sampling Location.mxd Revised 6/27/2016

0 Feet 12,000

NewFields

Surface Water and Sediment
Sampling Locations
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 6-5

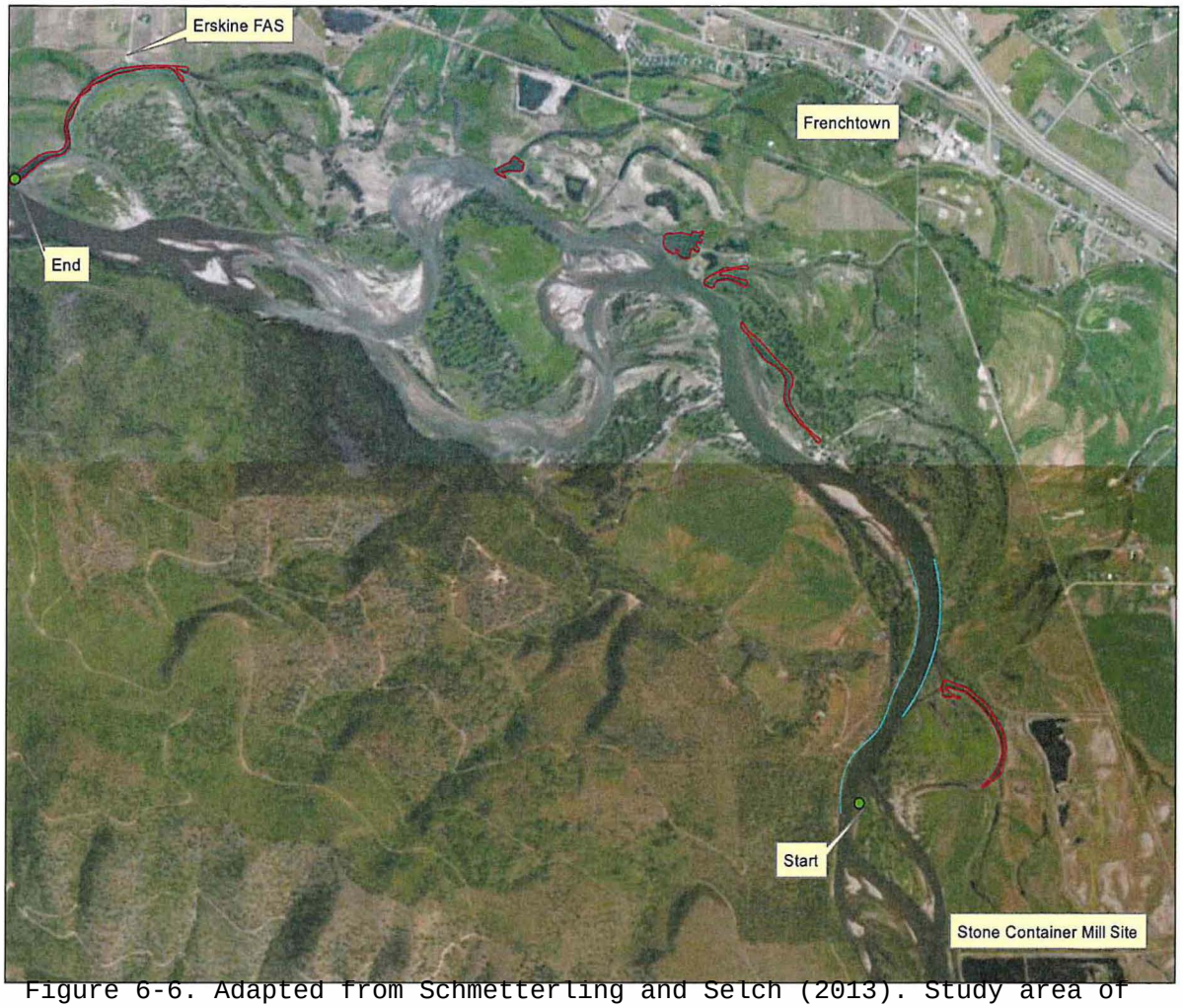


Figure 6-6. Adapted from Schmetterling and Selch (2013). Study area of the Clark Fork River downstream of the Smurfit-Stone/Frenchtown Mill site. The red lines depict sampling locations of northern pike and blue lines show where rainbow trout were captured.

APPENDICES

APPENDIX A
WILDLIFE EXPOSURE PARAMETERS

American Robin
Turdus migratorius

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	0.077 Mean (kg) - adults - Pennsylvania 0.086 Mean (kg) - adult male nonbreeders - New York 0.084 Mean (kg) - adult female nonbreeders - New York 0.077 Mean (kg) - adult female breeders - New York 0.081 Mean (kg) - adult male breeders - New York	USEPA, 1993	Average of reported means: **0.081 kg**
Food Ingestion Rate	IR_{food}	0.89 Mean (g ww/g BW-day) - breeding free-living male & females - California 1.52 Mean (g ww/g BW-day)- free-living adults - Kansas	USEPA, 1993	Average of reported means: **1.205 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from avian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: *IR (L/day) = [0.059 * BW (kg ww) 0.67] / BW (kg) =* **0.011 L/day or 0.136 L/kgBW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; fraction of soil in the diet is assumed to be 10% (Hansen et al. 2011) Assumes 20% dry matter in food (CF = 0.20 kg food dw / kg food ww).	Hansen et al. 2011 Assumption	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}$ *(kg ww/kg BW/day) * soil in diet * CF (dw/ww)* **0.025 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Western United States: Spring: fruit 17%; invertebrates 83% Summer: fruit 29%; invertebrates 71% Fall: fruit 63%; invertebrates 37% Winter: fruit 70%; invertebrates 30%	USEPA, 1993	**50% plants, 25% terrestrial invertebrate, 25% earthworm**
Home Range Size	HR	0.15 Mean (ha) - adults with nestlings, foraging home range in summer 0.81 Mean (ha) - adults with fledglings, foraging home range in summer 0.13 ha - nesting territory 0.11 ha - nesting territory 0.33 (mean) ha -- breeding territory, 1971 0.55 (mean) ha - breeding territory, 1972 0.38 (mean) ha - breeding territory, 1974 0.51 (mean) ha - breeding territory, 1975 0.45 (mean) ha - breeding territory, 1976 0.34 (mean) ha - breeding territory, 1977 0.35 (mean) ha - breeding territory, 1980	USEPA, 1993 Wauer 1999 Howell 1942 Pitts 1984 Pitts 1984 Pitts 1984 Pitts 1984 Pitts 1984 Pitts 1984 Pitts 1984 Pitts 1984	Average of reported means: **0.37 hectares**
Seasonal Area Use Factor	AUF	Migratory in northern portion of range. Leave breeding grounds from September to November returning from February to April.	USEPA, 1993	

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Gray Catbird
Dumetella carolinensis

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	38.3 Mean (g) of range 31.9-48.7 g, adult males 40.9 Mean (g) of range 31.6-54.5 g, adult females	Raynor, 1979	Average of reported means: **0.0396 kg**
Food Ingestion Rate	IR_{food}	Estimated from allometric equation for passerines: *FIR (g ww/day) = 2.438 (BW) $^{0.607}$, BW in g*	Nagy 2001	Estimated from allometric equation for order passeriformes: 22.74 g ww/day **0.574 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from avian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: *IR (L/day) = [0.059 * BW (kg ww) 0.67] / BW (kg) =* **0.171 L/kgBW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; fraction of soil in the diet is assumed to be 10% (Hansen et al. 2011) Assumes 20% dry matter in food (CF = 0.20 kg food dw / kg food ww).	Hansen et al. 2011 Assumption	Based on fraction of soil in the diet: *IR_{soil} = IR_{food} (kg ww/kg BW/day) * soil in diet * CF (dw/ww)* **0.025 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Mostly insects and berries. Beetles, ants, caterpillars, grasshoppers, crickets, true bugs, spiders and millipedes. More than half the annual diet of adults may be vegetable matter (primarily berries). Rarely catches small fish.	National Audubon Society	**50% plants; 50% terrestrial invertebrates**
Home Range Size	HR	Assumed value 0.38 hectares	Assumption	**0.38 ha**
Seasonal Area Use Factor	AUF	Migratory bird. Spring migration ranges from March to May, and in the fall ranges from late August to November. Normally present on breeding grounds in May.		

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Tree Swallow
Tachycineta bicolor

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	0.020 kg	USEPA 1999	**0.020 kg**
Food Ingestion Rate	IR_{food}	0.0046 kg/day	USEPA 1999 (a)	**0.228 kg ww/kg BW/day** (calculated)
Water Ingestion Rate	IR_{water}	0.0044 L/day	USEPA 1999	**0.22 L/kg BW/day** (calculated)
Soil Ingestion Rate	IR_{soil}	1%	USEPA 1999	**0%**
Dietary Composition	DF	Mainly flying insects	USEPA 1999	**90% flying insects** **10% crawling invertebrates**
Home Range	HR	300,000 m2	USEPA 1999	**30 Ha**
Seasonal Area Use factor	AUF	Migrates north relatively early in spring. Southward migration begins as early as July, peaks in early fall.	National Audubon Society	

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(a) Food intake rates (kg/day) presented in Table A12-2 of USEPA1999 utilize an incorrect coefficient. The value shown in uin this table is calculated in accord with the equation and correct coefficent reported in the primary source doccument (Nagy 1987)

American Dipper
Cinclus mexicanus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	Average 57 g; range 50 - 61; males	Armstrong and O'Clair 2008	Average of reported means:
		Average 51 g; range 44 -59; females	Armstrong and O'Clair 2008	
		Average 53.7 g; range 48.7 -70; females	Lovett	**0.056 kg**
		Average 58.2 g; range 53 -63; females	Lovett	
		Average 58.4 g; range 54 -61; sex undetermined	Lovett	
		Average 60 g; range 53.5 - 67; males; *C.m.mexicanus*	Wilson and Kingery 2011	
		Average 61 g; range 57 - 66; males; *C.m. unicolor*	Wilson and Kingery 2011	
		Average 53.6 g; range 48.5 - 62.5; females; *C.m.mexicanus*	Wilson and Kingery 2011	
		Average 54.6 g; range 43-65; females; *C.m. unicolor*	Wilson and Kingery 2011	
		Average 56.2 g; n = 25	Price and Bock 1983	
		Average 58.5 g; n = 31	Price and Bock 1983	
		Average 57.2; 61 males	Green et al. 2009	
		Average 48.6; 27 females	Green et al. 2009	
Food Ingestion Rate	IR_{food}	Estimated from allometric equation for passerines:	Nagy 2001	Estimated from allometric equation for order passeriformes:
		FIR (g ww/day) = 2.438 (BW) $^{0.607}$, BW in g		28.04 g ww/day
				0.502 kg ww/kg BW/day
Water Ingestion Rate	IR_{water}		USEPA, 1993	Estimated from allometric equation:
				*IR (L/day) = [0.059 * BW (kg ww) $^{0.67}$] / BW (kg)*
				0.0086 L/day = 0.154 L/kg BW/day
Soil Ingestion Rate	IR_{soil}	5.2%; common goldeneye; 4.7% lesser scaup -- IRsoil = 4.95%	Assumption	Based on fraction of soil in the diet:
		$IR_{soil} = IR_{food}*0.2*I_{soil}$ Where 0.2 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 20% dry matter in food:	SIR similar to other birds with diet primarily aquatic invertebrates (lesser scaup, goldeneye; Beyer 1998)	**0.005 kg dw/kg BW/day**
Dietary Composition	DF	42% fish, 58% invertebrates; Chilliwack River residents; stable isotope analysis	Morrissey et al. 2004	**90% benthic macroinvertebrates, 5% aerial invertebrates, 5% fish**
		22% fish, 78% invertebrates; tributary residents	Morrissey et al. 2004	
		30% fish. 70% invertebrates; males; n = 20	Morrissey et al. 2004	
		37.4% fish, 62.2% invertebrates; females; n = 11	Morrissey et al. 2004	
		100% invertebrates, primarily Trichoptera, Ephemeroptera, Diptera; % by number	Willson and Kingery 2011	
		100% invertebrates, primarily Trichoptera and Ephemeroptera; % by number	Feck and Hall 2004	
Home Range Size	HR	400 -4000 m stream length (midpoint 2200 m)	Lovett	Average of reported means:
		45 - 950 m stream length; winter territory (midpoint 498 m)	Bakus 1959	
		320 m stream length; maximum breeding territory	Bakus 1959	
		1504 m; polygynous males	Price and Bock 1983	
		944 m; monogamous males	Price and Bock 1983	**1115 m stream length**
		759 m; monogamous males	Wilson and Kingery 2011	
		1406 - 2070 m (midpoint 1738 m)	Wilson and Kingery 2011	
		502 - 1378 m (midpoint 940 m)	Wilson and Kingery 2011	
Seasonal Area Use Factor	AUF	Does not migrate but moves to lower altitudes in fall	Terres, 1991	

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Blue Grouse
Dendragapus obscurus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	Average, 1279.3 g, range 1175 - 1375; males	Redfield 1973	Average of reported means:
		Average 868.9 g; range 773 - 1132; females	Redfield 1973	
		Average 1287 g, 17 males	Lewis and Zwickel 1981	
		Average 1293 g, 39 males	Lewis and Zwickel 1981	**1.160 kg**
		Average 1273 g; 482 males	Zwickel and Bendell 2004	
		Average 839 g; 223 females	Zwickel and Bendell 2004	
		Average 1171 g, n = 41, *D.o.pallidus* , Washington	Zwickel and Bendell 2004	
		Average 1271 g, n = 29, *D.o.pallidus* , Montana	Zwickel and Bendell 2004	
Food Ingestion Rate	IR_{food}	187.7 g ww/day; males	Zwickel and Bendell 2005	Average of reported means:
		151.3 g ww/day; females		**169.5 g ww/day; 0.146 kg/kg BW/day**
Water Ingestion Rate	IR_{water}	Estimated from allometric equation:	USEPA, 1993	
		$IR\ (L/day) = [0.059 * BW\ (kg\ ww)^{0.67}] / BW\ (kg)$		**0.065 L/day or 0.056 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	Ingestion of soil (I_{soil}) as percentage of food intake (kg soil dry weight/kg food dry weight) is not available. Assumed to be equal to 2%. Where 0.33 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 33% dry matter	Assumption	$IR_{soil} = IR_{food} * 0.33 * I_{soil}$ in food: **0.00096 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	% volume	35.9% conifer needles, 22.5% green leaves, 22.4 % fruits and seeds; 17% other plant, 2.2% invertebrates	Stewart 1944	**100% plants**
	% weight	44% conifer needles, 15.5% leaves, 5.3% flowers. 22.4% fruits, 0.2% invertebrates; males	King 1968	
	% weight	17% conifer needles, 20.4% leaves, 8.5% flowers. 29.3% fruits, 0.5% invertebrates; females	King 1968	
	% weight	13% leaves, 18.5% flowers. 36% fruits,22% invertebrates; chicks	King 1968	
Home Range Size	HR	Average 16.8 ha; range 3 to 42.5 ha	Hines 1986	Average of reported means:
		Average 0.63 ha; range 0.26 - 0.93 ha; breeding period	Lewis 1985	
		Average 1.07 ha; range 0.16 - 2.14 ha; post-breeding period	Lewis 1985	**4.96 ha**
		Average 0.6 ha; range 0.2 - 0.9 ha; males	Zwickel and Bendell 2005	
		Average 17.4 ha, breeding females	Zwickel and Bendell 2005	
		average 2.3 ha; females, laying period	Zwickel and Bendell 2005	
		average 6.4 ha; females, pre-incubation	Zwickel and Bendell 2005	
		average 0.8 ha; range 0.5 - 1.1 ha; males	Zwickel and Bendell 2005	
		average 1.5 ha; range 1.2 -1.9 ha; males	Zwickel and Bendell 2005	
		average 2.1 ha; range 0.4 - 5.2; males	Zwickel and Bendell 2005	
Seasonal Area Use Factor	AUF	Short migration. During the winter, inhabits mountainous pine forests; nesting time begins in spring.		

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American Kestrel
Falco sparvarius

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	115 g; female, fall 132 g; female, winter 103 g; male, fall 114 g; male, winter 124 g; female, laying 127 g; female, fall 138 g; female, winter 108 g; male, incubating 111 g; male fall 119 g, male, winter	USEPA, 1993	Average of reported means: **119.1 g**
Food Ingestion Rate	IR_{food}	43 g/day ww; males 48.6 g/day ww, females 35 g/day; females 32.5 g/day ww; females 34.16 g/day ww; females 38.4 g/day ww; both sexes	Fernie and Bird 1999 Fernie and Bird 1999 Anderson et al. 1993 Anderson et al. 1993 Koplin et al. 1980 Lacombe et al. 1994	Average of reported means: **38.6 g ww/day; 0.324 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	Estimated from allometric equation: $IR\ (L/day) = [0.059 * BW\ (kg\ ww)^{0.67}] / BW\ (kg)$	USEPA, 1993	**0.0014 L/day; 0.012 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.01 (1%) based on professional judgement. Assumes 32% dry matter in food (CF = 0.32 kg food dw / kg food ww).	Assumption	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.001 kg dw/kg BW/day**
Dietary Composition (% biomass)	DF	79.1% mammals, 8% birds, 2.4% reptiles, 10.5% invertebrates; females Oct - March 22.8% mammals, 37.9% reptiles, 39.3% invertebrates; females March - Sept 45.9% mammals, 51.8% birds, 0.5% reptiles, 1.8% invertebrates 30.4% mammals, 62.1% birds, 5.4% reptiles, 2.1% invertebrates 36.9% mammals, 7.04% birds, 19.3% reptiles, 36.7% invertebrates	Collopy and Koplin 1983 Collopy and Koplin 1983 Smith and Murphy 1973 Smith and Murphy 1973 Koplin et al. 1980	Average of reported %iles: 43% mammals. 13 % reptiles, 32% birds, 18% invertebrates. Only site-specific small mammal and invertebrate tissue data available. **60% small mammals, 40% invertebrates**
Home Range Size	HR	109.4 ha; breeding 80.29 ha; pair 67.34 ha; pair 41.44 ha; individual Average 31.6 ha; range 18.7 - 42 ha; female Average 13.1 ha; range 9.7 -14.8 ha; male	Balgooyen 1976 Smith and Murphy (1973) Smith and Murphy (1973) Smith and Murphy (1973) Meyer and Balgooyen 1987 Meyer and Balgooyen 1987	Average of reported means: **57.2 ha**
Seasonal Area Use Factor	AUF	Migratory over the northern-most portions of its range.	USEPA, 1993	

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Belted Kingfisher
Ceryle alcyon

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	0.148 Mean (kg) - adults - Pennsylvania 0.136 Mean (kg) - adults - Pennsylvania 0.1436 Mean (kg) - adult males - Minnesota 0.1516 Mean (kg) - adult females - Minnesota 0.158 Mean (kg) - adults - Ohio	USEPA, 1993 USEPA, 1993 Hamas 1994 Hamas 1994 USEPA, 1993	Average of reported means: **0.147 kg**
Food Ingestion Rate	IR_{food}	56.2 g ww /day 61.5 g ww/day 54.6 g ww/day	Kelly 1998 Alexander 1977 Vessel 1977	Average of reported means: 57.4 **kg ww/day** **0.390 kg ww /kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from allometric equation: $IR\ (L/day) = [0.059 * BW\ (kg\ ww)^{0.67}] / BW\ (kg)$	USEPA, 1993	**0.016 L/day or 0.109 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.01 (1%) based on professional judgement. Assumes 27% dry matter in food (CF = 0.27 kg food dw / kg food ww).	Assumption	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.0014 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Michigan/trout streams: Game fish: 43% Forage fish: 15% Unidentified fish: 1% Invertebrates: 41%	USEPA, 1993	**DF_{fish} = 100%**
Home Range Size	HR	389.29 m stream length; non-breeding territory 1030 m stream length; breeding territory 1566.25 m stream length; range 923 - 2908 m; breeding territory 2185 m stream length; Pennsylvania 1028 m stream length; Ohio	Davis 1982 Davis 1982 Mazeika et al. 2006 Brooks and Davis 1987 Brooks and Davis 1987	Average of reported means: **1240 m stream length**
Seasonal Area Use Factor	AUF	Migratory in northern portion of range. Leave breeding grounds from October to December returning from February to April.	USEPA, 1993	

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Mallard
Anas platyrhynchos

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	1.225 Mean (kg) - adult males, North America 1.043 Mean (kg) - adult females, North America 1.246 Mean (kg) - adult males in winter, Mississippi 1.095 Mean (kg) - adult females in winter, Mississippi 1.237 Mean (kg) - adult males in winter, Texas 1.088 Mean (kg) - adult females in winter, Texas 1.197 Mean (kg) - adult females in spring, North Dakota	USEPA, 1993	Average of reported means: **1.162 kg**
Food Ingestion Rate	IR_{food}	No measured values available; estimated from avian allometric equation for food ingestion provided in USEPA (1993). Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation (converted to ww): IR(kg ww/day) = [0.621*BW (g)0.564] / [CF (dw/ww) * BW (kg) * 1000 (g/kg)] **0.31 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = [0.099 * BW\ (kg\ ww)^{0.90}] / BW\ (kg)$ **0.056 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	Estimated fraction of sediment in the diet is 0.049 (4.9%). Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	Beyer et al., 1998	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.0027 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	North Dakota, prairie potholes 75% total invertebrates: average in spring 25% total plants: average in spring	USEPA, 1993	No measured data and cannot estimate concentrations in aquatic plants, therefore benthic concentrations are used as a surrogate for aquatic plant concentrations. **Dfbenthics = 100%**
Home Range Size	HR	111 Mean (ha) - adult females, laying - North Dakota, prairie potholes 210 Mean (ha) - adult females, Minnesota 240 Mean (ha) - adult males, Minnesota 135 Mean (ha) - adult females, pre-nesting, Minnesota 70 Mean (ha) - adult females, laying, Minnesota 127 Mean (ha) - brood rearing, range 4 - 623 ha, California 62 Mean (ha) - brood rearing, range 4.5 - 268 ha, California	Dwyer et al. 1979 Gilmer et al. 1975 Gilmer et al. 1975 Gilmer et al. 1975 Gilmer et al. 1975 Mauser et al. 1994 Mauser et al. 1994	Average of reported means: **136 hectares**
Seasonal Area Use Factor	AUF	Migratory in northern portion of range. Leave breeding grounds from September to November returning in spring.	USEPA, 1993	

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Northern Flicker
Colaptes auratus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	Average 140 g; Range 131 - 144 g, n = 4 males 112.8, n = 5 Average 161.1 g; range 131 -187 g, n = 703 males Average 153.7 g; range 124 -182 g, n = 707 females 121.8, n = 2 males 131.1, n = 1 female average 139.59 , range 129 - 154 g, n = 17 males; yellow-shafted average 131.83 g, range 117 - 150 g, n = 20 females; yellow-shafted average 156.45, range 143 - 167 g, 9 males; red-shafted average 139.17, range 130 - 145 g, n = 6 females; red-shafted	Royall and Bray 1980 Szaro and Balda 1979 Wiebe and Moore 2008 Wiebe and Moore 2008 Stegeman 1955 Stegeman 1955 Short 1965 Short 1965 Short 1965 Short 1965	Average of reported means: **138.8 g**
Food Ingestion Rate	IR_{food}	Estimated from allometric equation for insectivorous b irds: *FIR (g ww/day) = 1.633 (BW) $^{0.705}$, BW in g*	Nagy 2001	**52.9 g ww/day; 0.381 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	Estimated from allometric equation: *IR (L/day) = [0.059 * BW (kg ww) $^{0.67}$] / BW (kg)*	USEPA, 1993	**0.0157 L/day; 0.113 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of soil in the diet is assumed to be equal to that of the American woodcock 0.104 (10.4%). Assumes 20% dry matter in food (CF = 0.20 kg food dw / kg food ww).	Beyer et al., 1994 Assumption	Based on fraction of soil in the diet: *IR_{soil} = IR_{food} (kg ww/kg BW/day) * soil in diet * CF (dw/ww) =* **0.0079 kg dw/kg BW/day**
Dietary Composition	DF	60.9 % invertebrates, 39.1 % plant; yellow-shafted flicker 67.7 % invertebrates, 32.3 % plant; red-shafted flicker	Beal 1911 as cited in Moore; not stated whether % volume or food item counts	70% invertebrates, 30% plants
Home Range Size	HR	16 ha; breeding pair in confier forest 25 ha; range 5 - 109 ha; n = 52 101 ha; individual male 91 ha; individual male 53 ha; individual male 48 ha; individual male	Lawrence 1967 Wiebe and Moore 2008 Royall and Bray 1980 Royall and Bray 1980 Royall and Bray 1980 Royall and Bray 1980	Average of reported means: **55 ha**
Seasonal Area Use Factor	AUF		USEPA, 1993	

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Clark's Nutcracker
Nucifraga columbiana

Parameter	Symbol		Reported Values	Reference	Values Identified for BERA
Body Weight	BW	124	Average 124 g; range 111 - 136 g; n = 7	Lorenz and Aubry 2011	Average of reported means:
		135	Average 135 g; range 121 -151 g; n = 13	Lorenz and Aubry 2011	
		136	Average 136 g; n = 51 males	Giuntoli and Mewaldt 1978	
		149	Average 149 g; n = 48 males	Giuntoli and Mewaldt 1978	
		122	Average 122 g; n = 30 females	Giuntoli and Mewaldt 1978	**133.3 g**
		134	Average 134 g; n = 27 females	Giuntoli and Mewaldt 1978	
Food Ingestion Rate	IR_{food}		Estimated from allometric equation for passerines:	Nagy 2001	
			FIR (g ww/day) = 2.438 (BW) $^{0.607}$ *, BW in g*		**47.5 g ww/day; 0.356 g ww/kg BW/day**
Water Ingestion Rate	IR_{water}		Estimated from allometric equation:	USEPA, 1993	
			*IR (L/day) = [0.059 * BW (kg ww)* $^{0.67}$ *] / BW (kg)*		**0.015 L/day; 0.1147 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}		Ingestion of soil (I_{soil}) as percentage of food intake (kg soil dry weight/kg food dry weight) is not available. Assumed to be equal to 2%.	Assumption	Based on fraction of soil in the diet:
			Assumes 37% dry matter in food (Nagy 2001); CF = 0.37		$IR_{soil} = IR_{food}$ *(kg ww/kg BW/day) * soil in diet * CF (dw/ww)* **0.0026 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF		83% conifer seeds, 13.3 % arthropods, 3.1 % carrion (mammals)	Giuntoli and Mewaldt	85% seeds [plants], 15% invertebrates
Home Range Size	HR		Average 440 ha; range 140 - 2070 ha; non-floaters; n = 13	Lorenz and Aubry 2011	Average of reported means:
		440	Average 413.2 ha; range 138.6 - 5207.4 ha; n = 18	Lorenz et al 2011	
		413.2	Average 315 ha; range 182 - 477 ha; n = 5. Core range	McMurray (2008)	473 ha
		315	Average 318.4 ha; range 157 - 547 ha; n = 5. summer range	McMurray (2008)	
		318.4	Average 879.6 ha; range 318 - 1357 ha; n = 5. Autumn range	McMurray (2008)	
		879.6			
Seasonal Area Use Factor	AUF			USEPA, 1993	

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Vagrant Shrew
Sorex vagrans

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	4.6 Mean (g) of reported range 3.5-6.1 g (subadult males) 6.3 Mean (g) of reported range 4.9-7.8 g (adult males) 4.4 Mean (g) of reported range 3.4-5.7 g (subadult females) 5.5 Mean (g) of reported range 4.2-7.7 g (adult females)	Hooven et al., 1975 (as cited in Mammalian Species; No. 744)	Average of reported means: **0.0052 kg**
Food Ingestion Rate	IR_{food}	No measured values available; estimated from mammalian (rodent) allometric equation for food ingestion provided in USEPA (1993). Assumes 32% dry matter in food (CF = 0.32 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation (converted to ww): IR(kg ww/day) = [0.621*BW (g)$^{0.564}$] / [CF (dw/ww) * BW (kg) * 1000 (g/kg)] **0.95 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = [0.099 * BW\ (kg\ ww)^{0.90}] / BW\ (kg)$ **0.17 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of soil in the diet is assumed to be equal to that of the short-tailed shrew 0.13 (13%). Assumes 32% dry matter in food (CF = 0.32 kg food dw / kg food ww).	Talmage & Walton, 1993	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.040 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Diet consists of earthworms, spiders, crickets, caterpillars, moths, slugs, snails, June beetles and larvae, ladybird beetles, centipedes, ants, craneflies, aphids, Hemipterans, grasshoppers, bees, and wasps. Also reported to eat fungi, flower parts, seeds and other vegetation.	Whitaker et al. 1983	**DFterrestrial invertebrates = 50%** **DFworms = 50%**
Home Range Size	HR	Home ranges are largest during the breeding season. 4,343 m^2 (males; breeding season in British Columbia) 2,233 m^2 (females; breeding season in British Columbia) 1,039 m^2 (males and females; non-breeding season in British Columbia)	Hawes, 1977	Average of reported values: **0.25 Ha**
Seasonal Area Use Factor	AUF	No information available		

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White-tailed Deer
Odocoileus virginianus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	68 kg (males) 45 kg (females) 56.5 kg (mean males and females)	Sample & Suter, 1994	Average of reported means: **56.5 kg**
Food Ingestion Rate	IR_{food}	1.74 kg/d wet weight	Sample & Suter, 1994	Reported value (adjusted for bw): **0.03 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	3.7 L/d	Sample & Suter, 1994	Reported value (adjusted for bw): **0.065 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	Assuming 2% soil and 1.74 kg/day food consumption rates	Sample & Suter, 1994	Reported value: **0.0348kg dw/day; 0.0006 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	White-tailed deer are exclusively herbivores with a diverse diet dependant on the availability of food. Major foods include buds and twigs of trees and shrubs, grasses and forbs (summer), masts and fruits (fall).	Sample *et al.* 1997	DFplant = 100%
Home Range Size	HR	16.2 Ha (minimum home range; Georgia) 1,526 Ha (maximum home range; Florida) 62 Ha (mean, Georgia, based on minimum polygon method) 85 Ha (mean, Florida and Alabama, minimum home range method) 270 Ha (mean, Florida, minimum home range method) 90 Ha (mean, Alabama, minimum home range method) 518 Ha (mean, Arkansas, minimum area method) 71 Ha (mean, Texas, grid method) 178 Ha (mean, Wisconsin, minimum polygon method) 362 Ha (mean, Florida, minimum home range method) 171 Ha (mean, South Carolina, minimum home range method) 130-659 Ha (Pennsylvania, method not stated)	Marshall & Whittington, 1969 Smith, 1970 Marshall & Whittington, 1969 Marchinton, 1968 Bridges, 1968 Byford, 1970 Cartwright, 1975 Hood, 1971 Larson et al., 1978 Smith, 1970 Sweeney, 1970 Merritt, 1987	Average of mean values: **236 Ha**
Seasonal Area Use Factor	AUF	Active year round and do not hibernate; often migrate from high mountainous areas in the summer to lower elevations in the winter to avoid deep snow.	Sample & Suter, 1994	

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Montane Vole
Microtus montanus

Parameter	Symbol	Reported Values	References	Values Identified for BERA
Body Weight	BW	47.9 Mean (g) - males from 9 populations 46.9 Mean (g) - females from 8 populations	Innes and Millar, 1994	Average of reported means (converted to kg): **0.047** **kg ww**
Food Ingestion Rate	IR_{food}	No measured values available; estimated from mammalian (rodent) allometric equation for food ingestion provided in USEPA (1993). Assumes 32% dry matter in food (CF = 0.32 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation (converted to ww): IR(kg ww/day) = [0.621*BW (g)$^{0.564}$] / [CF (dw/ww) * BW (kg) * 1000 (g/kg)] **0.36 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: *IR (L/day) = [0.099 * BW (kg ww)$^{0.90}$] / BW (kg)* **0.13 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of soil in the diet is <0.024 (2.4%). Assumes 20% dry matter in diet.	Beyer et al., 1994 USEPA, 1993	Based on assumed fraction of soil in the diet: *IR_{soil} = IR_{food} (kg ww/kg BW/day) * soil in diet * CF (dw/ww)* **0.00023** **kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	In Colorado, leaves and forbs accounted for 85% of the diet and grasses only 9%.	Vaughan, 1974	**DFplant = 100%**
Home Range Size (ha)	HR	0.019 Mean (ha) - adult males in summer - Virginia/old field 0.0069 Mean (ha) - adult females in summer - Virginia/old field 0.014 Mean (ha) - adult males and females in summer - Montana/alluvial bench 0.0002 Mean (ha) - adult males and females in winter - Montana/alluvial bench 0.083 Mean (ha) - adult males in summer - Massachusetts/grassy meadow 0.037 Mean (ha) - adult females in summer - Massachusetts/grassy meadow	USEPA, 1993	Based on data for a Meadow Vole (*Microtus pennsylvanicus*) Average of reported means: **0.027** **ha**
Seasonal Area Use Factor	AUF	No information available.		

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Red Fox
Vulpes vulpes

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	5.25 Mean (kg) - adult males in spring - Illinois 4.13 Mean (kg) - adult females in spring - Illinois 4.82 Mean (kg) - adult males in fall - Iowa 3.92 Mean (kg) - adult females in fall - Iowa	USEPA, 1993	Average of reported means: **4.53 kg**
Food Ingestion Rate	IR_{food}	Estimated from allometric equation for carnivorous mammals: *FIR (g ww/day) = 0.348 (BW)* $^{0.859}$*, BW in g*	Nagy 2001	**481 g ww /day; 0.106 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: *IR (L/day) = [0.099 * BW (kg ww)* $^{0.90}$ *] / BW (kg)* **0.085 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	Estimated fraction of soil in the diet is 0.028 (2.8%). Assumes 27% dry matter in food (CF = 0.27 kg food dw/kg food ww	Beyer *et al.* 1994	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}$ *(kg ww/kg BW/day) * soil in diet * CF (dw/ww)* **0.0008 kgdw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Nebraska, winter: (fraction wet volume) mammals 77.4%, birds 19.6%, other 3.0% Illinois, farm/woods (ranges across all seasons) mammals 37.1% - 92.2%, birds 0.2% - 43.2%, plants 4.6% - 31.1% Missouri (ranges across all seasons) mammals 18.3% - 69.4%, birds 11.6% - 45.0%, plants 2.1% - 6.9% Maryland, fall & winter: mammals 81.4%, birds 4.8%, plants 7.0%, other 6.8%	USEPA, 1993	**No measured data and cannot estimate concentrations in birds,** therefore mammal concentrations are used as representative of bird concentrations. **Dfmammal = 75%** **Df plants = 25%**
Home Range Size	HR	1611 Mean (ha) -adult both sexes - British Columbia 1967 Mean (ha) - adult male - British Columbia 1137 Mean (ha) - adult female - British Columbia hectares 699 Mean (ha) - adult female - spring - Minnesota 717 Mean (ha) - adult male - Wisconsin 96 Mean (ha) - adult female - Wisconsin	USEPA, 1993	Average of reported means: **1038 hecatres**
Seasonal Area Use Factor	AUF	No information available		

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Mink
Neovison vison

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	Average 552 g; range 454 - 680 g; n = 6; females; Indiana	Mumford and Whitaker 1982	Average of reported means:
		Average 891 g; range 790 - 1200 g; n = 6; females; Alaska	Marshall 1936	
		Average 596 g; range 496 - 790 g; n = 5; females; Georgia	Grinnell et al. 1937	
		Average 542 g; n = 11; females; coastal habitat	Clode et al. 1995	
		Average 753 g; n = 6; females; riverine habitat	Clode et al. 1995	**1007 g**
		Average 1112 g; range 997 - 1362 g; n = 11; males; Indiana	Mumford and Whitaker 1982	
		Average 1150 g; range 875 - 1475; males; Montana	Mitchell 1961	
		Average 2070 g; range 1680 - 2310 g; n = 5; males; Alaska	Marshall 1936	
		Average 1221 g; range 1000 - 1451 g; n = 10; males; California	Grinnell et al. 1937	
		Average 955 g; n = 15; males; coastal habitat	Clode et al. 1995	
		Average 1240 g; n = 16; males; riverine habitat	Clode et al. 1995	
Food Ingestion Rate	IR_{food}	217.2 g/day, males	Bleavins and Aulerich 1981	Average of reported means:
		134.5 g/day, females	Bleavins and Aulerich 1981	
		175 g/day	Wamberg et al. 1996	
		261 g/day	Heaton et al.	**199 g ww/day; 0.198 kg ww/kgBW/day**
		238.2 g/day; males	Bucci et al. 1992	
		169.1 g/day; females	Bucci et al. 1992	
Water Ingestion Rate	IR_{water}	65 ml/day; fasting period	Wamberg et al 1996	Average of reported means:
		49 ml/day; feeding period		
		69 ml/day; non-breeding	Tauson et al. 1998	**0.0664 L/day**
		84 ml/day; late gestation		
		65 ml/day; lactating		
Soil Ingestion Rate	IR_{soil}	No measured values available; assumed estimated fraction of soil in the diet is similar to red fox (2.8%).	Beyer et al., 1994	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}$ (kg ww/kg BW/day) * soil in diet * CF (dw/ww)
		Assumes 27% dry matter in food (CF = 0.27 kg food dw / kg food ww).		**0.0015 kg dw/kgBW/day**
Dietary Composition (fraction wet volume)	DF	55.6 % mammals, 5.7% birds; 18.4% fish; 8% crustaceans; 2.3 % insects, winter	Dearborn 1932	Approximate average across all studies:
		17% mammals, 61% fish, 5% amphibians, 11% crustaceans; 2% insects; spring/summer	Alexander 1977	
		6% mammals, 85% fish, 3% amphibians, 4% crustaceans	Alexander 1977	**25% terrestrial (small mammal), 75% aquatic (fish)**
		37.6% mammals, 5.6% birds, 19.9% fish, 24.9% amphibians, 9.3 % crustaceans	Schwartz 1981	
		36.2% mammals, 4.6% birds, 22.3% fish, 23% amphibians, 12.2 % crustaceans, 0.5 % insects; winter	Korschgen 1958	
Home Range Size	HR	Average 770 ha; male	Arnold 1987	Average of reported means:
		Average 646 ha; range 316 - 1626 ha; male	Arnold and Fritzell 1990	
	7519	average 7.72 ha; female	Mitchell 1961	
	6800	Average 20.16 ha; female	Mitchell 1961	**290 ha**
	2610	Average 8.1 ha; female	Marshall 1936	
	1350	Average 7519 m stream length; range 5663 - 11038 m; male	Stevens et al. 1997	**4570 m stream length**
		Average 6800 m stream length; male	Yamaguchi et al. 2004	
		Average 2610 m stream length, female	Yamaguchi et al. 2004	
		Average 1350 m stream length. Male	Dunstone and Birks 1983	
Seasonal Area Use Factor	AUF	No information available		

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River Otter
Lutra canadensis

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	9.20 Mean (kg) adult males - wc Idaho 7.90 Mean (kg) adult females -wc Idaho	USEPA, 1993	Average of reported means: **8.55 kg**
Food Ingestion Rate	IR_{food}	1351 g/d ww (estimated food consumption with bioenergetics model; based on measured daily energy expenditure) 1225 g/d ww 1253 g/d ww 1258 g/d ww 1233 g/d ww 1264 g/d ww 1392 g/d ww 1438 g/d ww 1485 g/d ww 1522 g/d ww 1594 g/d ww 1755 g/d ww	Dekar et al, 2010	Average of reported values: **1,397 g ww/d; 163 g ww/kg-bw/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = [0.099 * BW\ (kg\ ww)^{0.90}] / BW\ (kg)$ **0.08 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.01 (1%) based on professional judgement. Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	Assumption	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.0003 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	nw Montana/lakes and streams (based on percent frequency of occurrence in scats) Spring: 91.4% fish; Summer: 92.9% fish; Fall/Winter: 100% fish Invertebrates: 26% in winter - 44% in summer Frogs: 9% in winter - 19.6% in spring; birds and mammals wc Idaho mountain streams and lakes (percent frequency of occurrence in scats) Spring: 100% fish; Summer: 93% fish; Fall: 97% fish; Winter: 99% fish Invertebrates: 2% in spring - 12% in winter	USEPA, 1993	**DF_{fish} = 100%**
Home Range Size	HR	Shape of the home range varies by habitat type; near rivers it may be a long strip along the shoreline (km) wc Idaho/river drainage (no trends seen with season) 43 km yearling males 32 km yearling females 31 km adult females 28 km BB In marshes or areas with many small streams, may resemble a polygon (ha) 2,900 - 5,700 ha - Colorado (fall-spring) 400 - 1,900 ha - Missouri/marsh, streams	USEPA, 1993	Average of reported means in km: **33.5 km stream length** Midpoint of area ranges in ha: 2,700 ha
Seasonal Area Use Factor	AUF	No information available		

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Deer Mouse
Peromyscus maniculatus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	0.0220 Mean (kg) - adult males - North America USEPA, 1993 Average of reported means: 0.0200 Mean (kg) - adult females - North America 0.0157 Mean (kg) - adult males, austerus spp. 0.0148 Mean (kg) - adult females, austerus spp. 0.0223 Mean (kg) - adult males, blandus spp. 0.0211 Mean (kg) - adult females, blandus spp. 0.0196 Mean (kg) - both sexes - New Hampshire 0.0203 Mean (kg) - adult females, nonbreeding, borealus spp. 0.0315 Mean (kg) - adult females, gestation, borealus spp. 0.0245 Mean (kg) - adult females, lactation, borealus spp.	USEPA, 1993	Average of reported means: **0.021 kg**
Food Ingestion Rate	IR_{food}	0.19 Mean (g/g BW-day) - adult females - Canada 0.18 Mean (g/g BW-day) - adult females - Canada 0.45 Mean (g/g BW-day) - lactating females - Canada 0.38 Mean (g/g BW-day) - lactating females - Canada 0.19 Mean (g/g BW-day) - nonbreeding females - Virginia lab 0.22 Mean (g/g BW-day) - nonbreeding males - Virginia lab	USEPA, 1993	Average of reported means: **0.268 kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = [0.099 * BW\ (kg\ ww)^{0.90}] / BW\ (kg)$ **0.15 L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; estimated fraction of soil in the diet is assumed to be equal to that of the white-footed mouse 0.012 (1.2%). Assumes 55% dry matter in food (CF = 0.55 kg food dw / kg food ww).	Assumption	Based on fraction of soil in the diet: $IR_{soil} = IR_{food}\ (kg\ ww/kg\ BW/day) * soil\ in\ diet * CF\ (dw/ww)$ **0.0018 kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Colorado, short grass prairie: USEPA, 1993 Spring - plants/seeds 35.0%, invertebrates 58.6% Summer - plants/seeds 39.9%, invertebrates 45.2% Fall - plants/seeds 66.0%, invertebrates 21.7% Winter - plants/seeds 77.1%, invertebrates 9.5%	USEPA, 1993	Approximate average across all seasons: **DFplant = 50%** **DFsurface invertebrates = 50%**
Home Range Size	HR	The home range of female deer mice encompass both their foraging areas and their nests. Male home ranges are larger and overlap those of the females. 0.039 Mean (ha) - adult males, summer, Utah subalpine meadow 0.027 Mean (ha) - adult females, summer, Utah subalpine meadow 0.100 Mean (ha) - adult males, Oregon ponderosa pines 0.075 Mean (ha) - adult females, Oregon ponderosa pines 0.128 Mean (ha) - adult males, Idaho desert 0.094 Mean (ha) - adult females, Idaho desert	USEPA, 1993	Average of reported means: **0.077 hectares**
Seasonal Area Use Factor	AUF	Torpor reported in winter in northern parts of range.	USEPA, 1993	

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

Big Brown Bat

Eptesicus fuscus

Parameter	Symbol	Reported Values	Reference	Values Identified for BERA
Body Weight	BW	22 Mean (g) of reported range (14-30g) 14 Mean (g) of reported range (11-17g) Females 5% larger than males	Animal Diversity website Peterson, 1976 Collett and Zeveloff, 1988	Average of reported means: **0.018** **kg ww**
Food Ingestion Rate	IR_{food}	No measured values available; estimated from mammalian (rodent) allometric equation for food ingestion provided in USEPA (1993). Assumes 40% dry matter in food (CF = 0.40 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation (converted to ww): $IR(g\ ww/day) = [0.621*BW(g\ ww)^{0.564}] / [CF\ (dw/ww)* BW\ (kg) * 1000\ (g/kg)]$ **0.44** **kg ww/kg BW/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR(L/day) = [0.099 * BW(kg\ ww)^{0.90}] / BW(kg)$ **0.15** **L/kg BW/day**
Soil Ingestion Rate	IR_{soil}	No measured values available; as aerial insectivore assumed to be negligible.	Sample and Suter, 1994	Based on professional judgement: **0** **kg dw/kg BW/day**
Dietary Composition (fraction wet volume)	DF	Mostly flying insects, beetles, and infrequently moths	Collett and Zeveloff, 1988	**DFaerial invertebrates = 100%**
Home Range Size	HR	Estimated home range of 111 km² (43 mi²)	Beer 1955	**11,100** **hectares**
Seasonal Area Use Factor	AUF	Some migrate, some hibernate in Utah mines and caves. Do not feed in winter, but depend on fat reserves for energy.	Collett and Zeveloff, 1988	

References:

Animal Diversity website: http://animaldiversity.ummz.umich.edu/accounts/eptesicus/e._fuscus$narrative.html#physical_characteristics

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APPENDIX B
Toxicity Benchmarks for Ecological Receptors

Overview

The purpose of the screening level risk assessment is to identify COPECs based on comparison of site-related concentrations to appropriate benchmarks of toxicity. The benchmarks identified for this assessment are concentration-based (e.g., the concentration in soil, sediment, or surface water). Each benchmark is contaminant-specific, receptor-specific and is usually medium-specific.

For this SLERA, all toxicity benchmarks are based on values developed by various regulatory agencies and published in the literature. For this assessment, values were chosen to be consistent with other recent and/or ongoing regional ecological risk assessments. This appendix describes the various sources of benchmark values reviewed for this risk assessment, and identifies the hierarchy used to prioritize values when more than one value was available.

This appendix is organized into the following sections:

Aquatic Receptors

C-1 Benchmarks for Direct Contact with Surface Water
C-2 Benchmarks for Direct Contact with Sediment

Terrestrial Receptors

C-3 Benchmarks for Direct Contact with Surface Soils

Aquatic Receptors

B-1 Benchmarks for Direct Contact with Surface Water

B-1a Aquatic Receptors (Fish & Benthic Macroinvertebrates)

Toxicity values used in this risk assessment were chosen to be consistent with other recent regional ecological risk assessments. Toxicity values for the protection of aquatic life from contaminants in surface water are available from several sources. Each of these sources is described briefly below.

National Ambient Water Quality Criteria

The USEPA has established acute and chronic National Ambient Water Quality Criteria (NAWQC) values for surface waters for the protection of aquatic communities (USEPA 2002a). The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect on growth, reproduction, or survival. The NAWQC values are not species-specific, but are designed to protect 95% of the aquatic species for which toxicity data are available (USEPA 1985).

Great Lake Water Quality Initiative Tier II Values

The approach used for the derivation of Great Lake Water Quality Initiative (GLWQI) Tier II secondary acute values (SAVs) and secondary chronic values (SCVs) is similar to that used to derive NAWQC. USEPA (1995) describes how to calculate the GLWQI Tier II values. Data and detailed methods and are described in Appendix B of Suter and Tsao (1996). In brief, a secondary acute value is derived by taking the lowest genus mean acute value (GMAV) and dividing it by the Final Acute Value Factor (FAVF). The FAVF is based on the number of studies and types of species used to derive the FAV. Once an SAV is calculated, the geometric mean of each of the secondary acute-chronic ratios (SACR) is found. The SCV is calculated by dividing the SAV by the SACR.

USEPA Region 4 Screening Values

Screening level freshwater benchmarks are also available from USEPA Region 4 (USEPA, 2002b). The Region 4 acute and chronic screening values are equal to the lowest effect level (LEL) divided by 10 to protect for sensitive species. If no chronic LEL is available, the chronic screening value is equal to the lowest acute median lethal concentration (LC50) or median effective concentration (EC50) divided by 10.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 has derived ecological screening levels (ESLs) for RCRA Appendix IX Hazardous Constituents in soil, surface water, sediment, and air (USEPA 2003). The surface water ESL is based on either an aquatic benchmark, which is protective of direct contact exposures, or a wildlife receptor-specific benchmark, which is protective of ingestion exposures in the mink and belted kingfisher.

Canadian Water Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) have established water quality guidelines (WQG) for the protection of aquatic life in Canadian waters (CCME, 1991, 2001). The protocol for deriving water quality guidelines is similar to the NAWQC procedure. Protocol details are available on the CCME WQG website. In brief, the guideline is equal to the most sensitive lowest observed effect level (LOEL) from a chronic exposure study divided by a safety factor of 10. If a chronic LOEL is not available, the WQG is equal to the acute LC50 divided by the acute/chronic ratio (ACR). The CCME WQG is designed to be protective of "100% of the aquatic life species, 100% of the time".

Oak Ridge National Laboratory Lowest Chronic Values and EC20 Values

Oak Ridge National Laboratory (ORNL) has compiled summary tables of the lowest chronic values (LCVs) in surface water for fish, daphnids, non-daphnid invertebrates, aquatic plants, and aquatic populations (Suter and Tsao, 1996). In some instances, the LCVs were extrapolated from LC50 and EC50 data using fish and daphnid-specific equations. ORNL also summarized EC20 data for fish, daphnids, sensitive species, and aquatic populations. The EC20s are based on a level of biological effect; they are benchmarks derived by using mathematical models to evaluate a dose-response relationship, such as a concentration estimated to correspond to a 20% reduction in fish production (Suter and Tsao, 1996).

Office of Solid Waste and Emergency Response (OSWER) Ecotox Thresholds

The OSWER Ecotox Thresholds (ETs) were presented in a USEPA ECO Update Bulletin (USEPA, 1996). The bulletin provided an overview of the development and use of ecological benchmarks for surface water and sediment. For surface water, the ET is based on either the chronic NAWQC or the GLWQI Tier II value.

The OSWER ETs were excluded because they are based on primary sources (NAWQC, GLWQI Tier II) that had been previously reviewed. For the remaining sources, selection of the surface water toxicity benchmarks for aquatic receptors was based on the following hierarchy:

- National Ambient Water Quality Criteria (NAWQC)
- Great Lake Water Quality Initiative (GLWQI) Tier II Values
- USEPA Region 4 Screening Values
- USEPA Region 5 ESLs
- Canadian Water Quality Guidelines
- Oak Ridge National Laboratory (ORNL) LCVs and EC20s

NAWQCs were selected preferentially over other benchmark sources because these surface water quality criteria are derived using a well-documented derivation approach which incorporates toxicity data from multiple studies, receptors, and endpoints that has undergone extensive review and approval by EPA. GLWQI Tier II values were selected next in the hierarchy because toxicity values are derived using a derivation procedure that is similar to NAWQC, but allows for derivation of toxicity benchmarks for data sets that are too limited to meet NAWQC requirements. USEPA Region 4 screening values, the Canadian WQG, the ORNL LCVs and EC20s, and USEPA Region ESLs are last in the hierarchy because they are often based on extremely limited data sets (i.e., only 1 or 2 studies), and these toxicity benchmarks tend to incorporate safety factor adjustments to account for limitations in the underlying data sets. USEPA Region 4 screening values and USEPA Region 5 ESLs were selected in preference over the Canadian WQG and the ORNL values because they have undergone Regional EPA review.

The surface water benchmark values from these sources are shown in Table C-1, along with the values selected for use in the risk assessment.

The water quality values for Se of 20 ug/L (EPA 2002b) and 5 ug/L (EPA 2002a) for acute and chronic exposures, respectively are considered uncertain for use in this risk assessment. Since the issuance of these criterion values, considerable data have demonstrated that diet is the primary pathway of selenium exposure to aquatic life, and traditional methods for predicting toxicity on the basis of exposure to dissolved concentrations in water are not appropriate for selenium (EPA 2004; Chapman et al. 2009).

B-1b Herptiles

Pauli et al. (2000) performed a comprehensive literature review to identify literature reports on the toxicity of a wide variety of environmental toxicants on herptiles (reptiles and amphibians). The data are conveniently summarized in a report generally referred to as the RATL (Reptile and Amphibian Toxicity Literature) database. This database includes benchmarks that are useful for evaluating potential risks from exposures of herptiles to metals.

Acute Benchmarks

The RATL database summarizes literature reports that were located on the acute toxicity of toxicants on herptiles under laboratory conditions. In all cases, the endpoint of acute toxicity is mortality, and reported values include LC_{50} values following exposure durations of 24 hours up

to seven days. Only studies of exposure to a single contaminant were utilized, while studies of exposure to laboratory of environmental mixtures were excluded. Data for all species, all life stages, and all exposure durations were retained. Studies that did not provide a clear quantitative metric of acute toxicity were excluded.

Immersion Exposure
Most studies on RATL utilize the "immersion" route of exposure. In this type of study, the organisms are placed in water containing the toxicant. Given the set of all values for a metal, the benchmark concentration was identified by finding the 10_{th} percentile of the LC_{50} values, and then dividing by a factor of 2 to extrapolate from an LC_{50} to an LC_{low} (Stephan et al. 1985).

Oral Exposure
No studies of acute mortality from oral exposure to metals were identified.

Non-Acute Benchmarks

The RATL database also summarizes literature reports on laboratory toxicity studies with herptiles that were located classified as "non-acute". Exposure durations were generally not specified.

Only studies that included observations on mortality, reproduction, developmental effects, or hatching success were considered. Only studies of exposure to a single metal were utilized, while studies of exposure to laboratory of environmental mixtures were excluded. Studies that did not provide a clear quantitative metric of effect or no-effect toxicity were excluded.

Immersion Exposure
Given the set of all values for a metal, the benchmark concentration was identified by finding the 10_{th} percentile of the non-acute values.

Oral Exposure
Although four reports were located on oral exposure, none were considered to be adequate to identify a reliable oral TRV.

References:

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U.S. EPA. (2016). Aquatic Life Ambient Water Quality Criterion for Selenium -- Freshwater 2016. U.S. Environmental Protection Agency, Office of Water. EPA-822-R-16-006. https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_-_freshwater_2016.pdf.

B-2 Benchmarks for Direct Contact with Sediment

Toxicity values for the protection of benthic macroinvertebrates from contaminants in freshwater sediment are available from several sources. Each of these sources is described briefly below.

Consensus-Based Sediment Quality Guidelines

MacDonald et al. (2000) issued consensus-based sediment quality guidelines (SQGs) for 28 chemicals of concern, in an effort to focus on agreement among the various sediment quality guidelines. For each chemical of concern, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified based on available sediment toxicity literature. The consensus-based TECs were calculated by determining the geometric mean of all threshold effect values from the literature. The consensus-based PECs were calculated by determining the geometric mean of all probable effect values from the literature. A summary of the types of sediment effect concentrations included in the TEC and PEC calculations is provided in MacDonald et al. (2000).

The predictive reliability of these values was also evaluated. The predictive ability analyses were focused on the ability of each SQG when applied alone to classify samples as either toxic or non-toxic. Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the PEC. Individual TECs were considered reliable if more than 75% of the sediment samples were correctly predicted to be non-toxic. Similarly, the individual PEC was considered reliable if greater than 75% of the sediment samples were correctly predicted to be toxic. The SQGs were considered to be reliable only if a minimum of 20 samples were included in the predictive ability evaluation (MacDonald et al. 2000).

Because field collected sediments contain a mixture of chemicals, a second analysis was completed to investigate whether the toxicity of a sediment could be predicted based on the average of the PEC ratios for the sediment, using only the PEC values that were found to be reliable. It was found that 92% of sediment samples with a mean PEC quotient > 1.0 were toxic to one or more species of aquatic organisms. The mean PEC quotient was found to be highly correlated with incidence of toxicity ($R^2 = 0.98$) (MacDonald et al. 2000).

ARCS Sediment Effect Concentrations

As part of the Assessment and Remediation of Contaminated Sediment (ARCS) Project, Ingersoll et al. (1996) compiled freshwater sediment toxicity data from nine different sites in the United States and identified a series of sediment effect concentrations (SECs) for metals in sediment. The SECs are defined as the concentrations of individual contaminants in sediment below which toxicity is rarely observed and above which toxicity is frequently observed. The database was compiled to classify toxicity data for Great Lakes sediment samples and is segregated into “effect” data and “no effect” data.

Ingersoll et al. (1996) derived five different SECs; effect range low (ERL), effect range median (ERM), threshold effect level (TEL), probable effect level (PEL) and no effect concentration (NEC). The derivation of each of these SECs is presented below:

- effect range low (ERL) = 10^{th} percentile of adverse effect data
- effect range median (ERM) = 50^{th} percentile (median) of adverse effect data
- no effect range median (NERM) = 50^{th} percentile (median) of no effect data
- no effect range high (NERH) = 85^{th} percentile of no effect data
- threshold effect level (TEL) = geometric mean of ERL and NERM
- probable effect level (PEL) = geometric mean of ERM and NERH
- no effect concentration (NEC) = maximum of no effect data

The ERL is defined as the concentration below which adverse effects are unlikely to occur. The ERM is defined as the concentration of a chemical above which effects are frequently or always observed or predicted among most species. The NEC is the maximum concentration of a chemical in sediment that does not significantly adversely affect the particular response when compared to the control.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 Ecological Screening Levels (ESLs) for sediment were developed based on available federal freshwater sediment criteria and state-promulgated sediment quality guidelines (USEPA 2003). If no freshwater guidelines were available, marine criteria were used. For those chemicals for which no guidelines were available, an interim ESL was developed using the equilibrium partitioning approach. These interim guidelines were developed for both nonpolar and polar organic constituents. The equilibrium partitioning method is generally only applied to nonpolar organics, however, it was assumed to be a satisfactory method for organics for use on a screening level approach (USEPA 2003). The ESL was derived from the lowest federal, state or interim water quality guideline and assumes a total organic carbon content of 1%.

NOAA Sediment Effect Concentrations

The National Oceanic and Atmospheric Administration (NOAA) compiled sediment data from studies performed in both freshwater and saltwater (originally presented in NOS OMA Technical Memo 52, Long and Morgan 1990).The NOAA ERL and ERM were developed using the same procedures as outlined for the ARCS Project (Ingersoll et al. 1996). The NOAA ERL is defined as the concentration of a chemical in sediment below which adverse effects are rarely observed or predicted among sensitive species. The NOAA ERM is representative of concentrations above which effects frequently occur. The original data set used by Long and Morgan (1990) has since been supplemented with additional saltwater data, therefore these additional marine reports are not applicable (ie: Long et al. 1995).

USEPA Region 4 Screening Levels

The USEPA Region 4 Screening Levels are derived from three different sediment effects data sets including NOAA freshwater and marine data from Long and Morgan (1990), additional NOAA marine data from Long et al. (1995), and Florida State Department of Environmental Protection marine data from MacDonald et al. (1996). The sediment effect level is based on the reported ERL from each study. In instances when the USEPA Contract Laboratory Program (CLP) practical quantitation limit (PQL) is above the effect level, the screening value is equal to the CLP PQL (USEPA 2002).

CCME Sediment Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) derived sediment quality guidelines to support protection and management strategies for freshwater, estuarine, and marine ecosystems (CCME 1995). Guideline derivation protocols are detailed in CCME (1995) and are similar to the procedures described previously for the ARCS Project (Ingersoll et al. 1996). Separate guidelines were derived for freshwater and marine sediments (CCME 2001). The freshwater interim sediment quality guideline (ISQG) was equal to the TEL and is representative of the concentration below which adverse effects are not anticipated for aquatic life associated with bed sediments (CCME 1995). A PEL was also calculated to establish concentrations above which adverse effects are likely to occur.

Ontario Sediment Effect Levels

Persaud et al. (1993) derived sediment effect levels for the protection of aquatic organisms in Ontario, Canada. Three types of sediment quality guidelines were developed; a No Effect Level (NEL; no toxic effects), a Low Effect Level (LEL; tolerable by benthic species), and a Severe Effect Level (SEL; detrimental to most benthic species). A summary and review of the available approaches to sediment guideline development and the protocol for the derivation of the Ontario values is described in detail in Persaud et al. (1993). Briefly, the NEL is obtained through a chemical equilibrium approach using water quality standards. Because the equilibrium partitioning approach is only predictive for nonpolar organics, a No Effect Level is not derived for metals and polar organics. The LEL and SEL are based on the 5^{th} and 95^{th} percentiles of all effects data for bulk sediment analysis, respectively. For non-polar organics these concentrations were normalized for total organic carbon.

U.S. EPA Region 3 Screening Benchmarks

The Region 3 screening benchmarks were derived based on the following hierarchy:

- Preference was given to benchmarks based on chronic direct exposure, non-lethal endpoint studies designed to be protective of sensitive species.
- Values derived by statistical or consensus-based evaluation of multiple studies were given first priority.
- Equilibrium partitioning values were selected for contaminants with 2.0 < log Kow< 6.0 if empirical values based on multiple studies were not available.
- Absent consensus or equilibrium partitioning values, single study toxicity values were selected.

Marine values were used for freshwater only if a suitable freshwater value was not available.

Of these sources, the following are excluded from use in this risk assessment due to inadequate documentation of derivation methodology, use of site-specific assumptions, use of marine or estuarine sediments, use of inappropriate receptors, or errors in benchmark derivation.

USEPA Region 5 Screening Levels
USEPA Region 4 Screening Levels
CCME Sediment Quality Guidelines (ISQG/PEL)
Ontario Sediment Effect Levels (Low/Severe)
ORNL EqP Guidelines

Of the remaining sources, a benchmark selection hierarchy is established as follows:

Consensus-based TEC (MacDonald et al., 2000)
ARCs TEL (Ingersoll et al., 1996)
NOAA ERL (Long and Morgan, 1990)
U.S. EPA Region 3 Screening Benchmarks

The consensus-based SQGs presented in MacDonald et al. (2000) were selected as the first preference in the hierarchy because they utilized a derivation procedure that incorporated toxicity data from numerous sources. ARCs TEL (Ingersoll et al. 1996) and NOAA ERL (Long and Morgan 1990) rank after the consensus-based SQGs because they are derived from toxicity data from a limited number of studies (i.e., only 1-2 studies). The ARCs TELs and NOAA ERLs were both developed using similar derivation procedures. ARCs TELs were selected in preference to NOAA ERLs because the ARCs data set included only freshwater studies, while the NOAA data set included both freshwater and saltwater studies. A summary of all selected sediment toxicity benchmarks is shown in Table C-2.

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Terrestrial Receptors

B-3 Benchmarks for Direct Contact with Surface Soils

Toxicity values for the protection of terrestrial plants, soil invertebrates and wildlife from contaminants in surface soils are available from several sources. Each of these sources is described briefly below.

Ecological Soil Screening Levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern (COPCs) in soils requiring further evaluation in a baseline ecological risk assessment (ERA). Eco-SSLs are derived separately for four groups of ecological receptors, plants, soil invertebrates, birds and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. The lower of the values for plants and soil invertebrates is used preferentially as the soil screening benchmark.

The Eco-SSL derivation process represents a three year collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry and academic participants led by the USEPA, Office of Emergency and Remedial Response (OERR) (USEPA, 2002b). The USEPA issued the final guidance for Eco-SSLs and interim final Eco-SSL values for several contaminants in 2003.

Oak Ridge National Laboratory Plants/Soil Organisms/Microbes

Oak Ridge National Laboratory (ORNL) reviewed data on the toxicity of contaminants in soil on a wide range of plants, soil organisms, and microbes, and determined the lowest observed effect concentration (LOEC) (Efroymson et al. 1997a,b). The LOEC is defined as the lowest applied concentration of the chemical causing a greater than 20% reduction in the measured response. In some cases, the LOEC is the lowest concentration tested or the only concentration reported (EC50 or ED50 data). The LOECs for a series of different plants and soil organisms are rank ordered and a value selected that approximated the 10th percentile. When a benchmark is based on a lethality endpoint, the benchmark value is divided by 5 to approximate an effects concentration for growth and reproduction. The factor is selected based on the author's judgement (Efroymson et al. 1997a,b). The benchmark values are then rounded to one significant figure.

Dutch Target and Intervention Values

The Dutch Target and Intervention Values are derived from available data on ecotoxicological effects of contaminants in soil to terrestrial species and soil microbial processes (Swartjes 1999). The Target Values for soil are related to negligible risk for soil ecosystems (95% protection). The Intervention Values are defined as the hazardous

concentration for 50% of the soil ecosystem population and are not protective of sensitive species. The Dutch benchmarks are developed by reviewing available literature to determine the lowest no observed effect concentration (NOEC). When there is a LOEC but no NOEC, the NOEC is estimated from the LOEC according to the effect level observed at the LOEC, as follows:

LOEC Effect Range	NOEC
10% - 20%	LOEC / 2
20% - 50%	LOEC / 3
50% - 80%	LOEC / 10

The ecotoxicological data are selected according to the criteria established in Crommenentujin et al. (1994) and are normalized for soil characteristics such as organic matter and clay content. If not enough data is available for terrestrial species and microbial processes, aquatic data (adjusted by an uncertainty factor of 10) are used to derive the benchmark values (Swartjes 1999).

CCME Soil Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) established effects-based environmental soil quality guidelines (SQG_E) designed to be clean-up goals to protect ecological receptors from direct contact and ingestion exposures to soil-based contaminants. From the available soil toxicity literature, CCME compiled an adverse effect data set and a no effect data set. Several SQG_Es are calculated based on land use types (agricultural-A, residential/parkland-R/P, commercial/industrial-C/I). Based on the amount of toxicity data available, different derivation methods are used to calculate the land use SQG_E. Each of these methods are detailed in CCME (1999) and described briefly below.

Weight-of Evidence Method
A, R/P Land Uses = threshold effects concentration (TEC), 25th percentile of effect and no effect data sets divided by an uncertainty factor
C/I Land Use = effects concentration low (ECL), 25th percentile of effect data set

Lowest-Observed-Effect Concentration (LOEC) Method
A, R/P Land Uses = lowest available LOEC divided by an uncertainty factor
C/I Land Use = geometric mean of available LOEC data

Median Effects Method
A, R/P Land Uses = lowest available EC50 or LC50 divided by an uncertainty factor

C/I Land Use = no guideline calculated

In addition to calculating an SQG_E, CCME also derived SQGs for human health (SQG_{HH}). The final soil guideline is the minimum of the SQG_E and the SQG_{HH}.

USEPA Region 4 Ecological Screening Levels

The USEPA Region 4 compiled soil toxicity screening benchmarks from several sources including ORNL (Efroymson et al. 1997a,b), CCME (CCME 1997), and Dutch values (Crommenentujin et al. 1994). From these sources, screening levels are selected based on contaminant levels associated with ecological effects (USEPA 2002b). These screening values do not take into account area or regional background levels.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 reviewed and evaluated soil quality criteria from international, federal, and state sources (USEPA 1999). A default soil ecological screening level (ESL) is selected based on the lowest receptor-specific ESL for terrestrial (plant/soil organisms) and wildlife receptors found during a review of existing toxicological information. The ESL is derived from the concentration which resulted in no observed adverse effects (NOAEL) for chronic exposure of the target species. When a chronic value is not available, the most relevant toxicological result is adjusted by division with uncertainty factors as appropriate to approximate the chronic NOAEL for the selected receptor (USEPA 1999).

Because the CCME final SQGs do not make a distinction between ecological and human health benchmarks, they are not included as a benchmark source. The Region 4 benchmarks are also excluded because they are based on primary sources that had been previously reviewed. For the remaining sources, selection of the surficial soil toxicity benchmarks for terrestrial receptors is based on the following hierarchy:

Eco-SSLs
ORNL benchmarks
Region 5 ESLs

Benchmarks for soil microbes were not included for the purposes of performing screening level risk calculations (see Attachment 1-2 of the Eco-SSL guidance document for additional information on the exclusion of microbes). The soil benchmark values for all chemicals analyzed in surface soils are shown in Table C-3.

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Table B-1. Surface Water Toxicity Benchmarks

Analyte Type	Analyte	NAWQC - Acute (ug/L) [1]	GLWQI Tier II SAV (ug/L) [2]	USEPA R4 - Acute (ug/L) [2]	**Surface Water Acute Benchmark (ug/L)**	NAWQC - Chronic (ug/L)	GLWQI Tier II SCV (ug/L)	USEPA R4 - Chronic (ug/L)	USEPA R5 (ug/L)	Other (ug/L)	**Surface Water Chronic Benchmark (ug/L)**
Inorganics	Aluminum	750	--	750	750	87	--	87	--	75 EC20 Sensitive Species	87
	Arsenic	340	--	360	340	150	--	190	148	5 CCME WQG	150
	Barium	50,000 a	110	--	50,000	5,000 a	4	--	220	--	5,000
	Cadmium	2 b	--	3.92	2.01	0.25 b	--	1.13	--	--	0.25
	Calcium	--	--	--	no benchmark	--	--	116,000	--	116,000 LCV Daphnids	116,000
	Chromium III	570 b	--	1,740	570	74 b	--	207	--	--	74
	Chromium VI	16 b	--	16	16	11 b	--	11	--	--	11
	Cobalt	--	1,500	--	1,500	--	23	--	24	--	23
	Copper	13 b	--	17.7	13	9 b	--	11.8	1.58	--	9
	Iron	--	--	--	no benchmark	1,000	--	1,000	--	300 CCME WQG	1,000
	Lead	65 b	--	81.6	65	2.5 b	--	3.18	1.17	--	2.5
	Magnesium	--	--	--	no benchmark	--	--	82,000	--	82,000 LCV Daphnids	82,000
	Manganese	--	2,300	--	2,300	--	120	--	--	--	120
	Mercury	1	--	2.4	1.2	0.65	1.3	0.012	0.0013	--	0.65
	Nickel	468 b	--	1420	468	52 b	--	158	28.9	--	52
	Potassium	--	--	--	no benchmark	--	--	53,000	--	53,000 LCV Daphnids	53,000
	Silver	3 a	--	4.06	3	0.3 a	0.36	0.012	0.12	--	0.3
	Sodium	--	--	--	no benchmark	--	--	680,000	--	680,000 LCV Daphnids	680,000
	Thallium	--	110	140	110	--	12	4	10	--	12
	Vanadium	--	280	--	280	--	20	--	12	--	20
	Zinc	117 b	--	117	117	118 b	--	106	65.7	--	118
TEQ	2,3,7,8-TCDD	--	--	--	no benchmark	--	--	--	--	--	no benchmark

(a) Only acute NAWQC available; chronic NAWQC is equal to acute / 10.
(b) Metal toxicity is hardness-dependent; values shown are calculated based on a hardness of 100 mg/L.

NAWQC = National Ambient Water Quality Criteria
GLQWI = Great Lakes Water Quality Initiative
SAV/SCV = Secondary Acute/Chronic Value
CCME = Canadian Council of Ministers of the Environment
WQG = Water Quality Guidelines
LCV = Lowest Chronic Value
EC20 = Effect Concentration Causing Less Than 20% Reduction

Table B-2. Sediment Toxicity Benchmarks

		Threshold Effect Concentrations (TEC)[1]					Probable Effect Concentrations (PEC)[1]				
Analyte	**Analyte**	**Consensus-Based TEC (mg/kg) [a]**	**ARCS TEL (mg/kg) [b]**	**Other (mg/kg)**		**Sediment Screening Benchmark (mg/kg)**	**Consensus-Based PEC (mg/kg) [a]**	**ARCS PEL (mg/kg) [b]**	**Other (mg/kg)**		**Sediment Screening Benchmark (mg/kg)**
TEQ	2,3,7,8-TCDD	--	--	8.5E-07	USEPA Region 3	8.5E-07	--	--	--		no benchmark
Metals	Aluminum	--	25,519	--		25,519	--	59,572	--		59,572
	Arsenic	9.8	11	--		9.8	33	33	--		33
	Barium	--	--	--		no benchmark	--	--	--		no benchmark
	Cadmium	0.99	0.58	--		0.99	4.98	--	--		4.98
	Chromium	43	36	--		43	111		--		111
	Cobalt	--	--	--		no benchmark	--	--	--		no benchmark
	Copper	32	28	--		32	149		--		149
	Iron	--	188,400	--		188,400	--	247,600	--		247,600
	Lead	36	37	--		36	128		--		128
	Manganese	--	631	--		631	--	1,184	--		1184
	Mercury	0.18	--	--		0.18	1.10	--	--		1.10
	Nickel	23	20	--		23	49		--		49
	Silver	--	--	1.0	NOAA ERL [c]	1	--	--	4.0	NOAA ERM [c]	4
	Thallium	--	--	--		no benchmark	--	--	--		no benchmark
	Vanadium	--	--	--		no benchmark	--	--	--		no benchmark
	Zinc	121	98	--		121	459		--		459

Notes:

1 The TEC encompasses several types of sediment quality guidelines including the Lowest Effect Level (LEL), the Threshold Effect Level (TEL), the Effect Range Low (ERL), the TEL for Hyalella azetca in 28 day tests (TEL-HA28), and the Minimum Effect Threshold (MET).

2 The PEC encompasses several types of sediment quality guidelines including the Severe Effect Level (SEL), the Probable Effect Level (TEL), and the Effect Range Median (ERM).

Sources Hierarchy:

a MacDonald et al. (2000); consensus-based threshold effect concentration (TEC) and probable effect concentration

b Ingersoll, et al. (1996); Threshold Effect Level (TEL) and Probable Effect Level (PEL) for total extraction of sediment (BT) samples from *Hyalella azteca* 28-day (HA28) tests.

c Long and Morgan (1990); NOAA Effect Range Low (ERL) and Effect Range Median (ERM).

d U.S. EPA Region 3. 2009. Ecological Risk Assessment. Freshwater Screening Benchmarks. http://www.epa.gov/reg3hscd/risk/eco/btag/sbv/fw/screenbench.htm

Table B-3. Soil Toxicity Benchmarks

Analyte	Plants		Soil Invertebrates		Birds	Mammals	
	EcoSSL	ORNL	EcoSSL	ORNL	EcoSSL	EcoSSL	Benchmark
Aluminum		50					50
Antimony		5	78			0.27	0.27
Arsenic	18	10		60	43	46	10
Barium		500	330			2000	330
Beryllium		10	40			21	10
Cadmium	32	4	140	20	0.77	0.36	0.36
Chromium (III)		1		0.4	26	34	0.4
Chromium (VI)						130	130
Cobalt	13	20			120	230	13
Copper	70	100	80	50	28	49	28
Lead	120	50	1700	500	11	56	11
Manganese	220	500	450		4300	4000	220
Mercury		0.3		0.1			0.1
Nickel	38	30	280	200	210	130	30
Selenium	0.52	1	4.1	70	1.2	0.63	0.52
Silver	560	2			4.2	14	2
Thallium		1					1
Vanadium		2			7.8	280	2
Zinc	160	50	120	200	46	79	46
Aroclor-1254		40					40
2,3,7,8-TCDD (a)							0.119

All values shown are in units of mg/kg.
EcoSSL = Ecological Soil Screening Level; ORNL = Oak Ridge National Laboratory
HMW = high molecular weight; LMW = low molecular weight
(a) Based on EPA Region 5 ESL for 2,3,7,8-Tetrachlorodibenzo-p-dioxin

APPENDIX C
Identifying Wildlife Toxicity Benchmarks

1.0. METHODS FOR DERIVING TOXICITY REFERENCE VALUES

Toxicity reference values (TRVs) for the Smurfit Baseline Ecological Risk Assessment (BERA) will be derived using a variety of methods, depending on the availability of technically defensible source information and relevant guidance. The process used to derive TRVs will result in determination of no-observed-adverse-effect levels (NOAELs) and/or lowest-observed-adverse-effect levels (LOAELs) for each chemical of potential ecological concern (COPEC) in each medium of interest to the BERA investigation. Methods to derive TRVs (e.g., a dose-response curve or species sensitivity distribution) and the supporting toxicity information are described in this appendix. The U.S. Environmental Protection Agency (USEPA) intends to confer with technical experts to identify toxicity studies that should be included in the BERA.

1.1 Primary Literature Review

In general, the derivation of wildlife TRVs begins with a literature search to identify studies on the toxicity of the COPECs to ecological receptors. In preparing the draft BERA work plan, USEPA performed a preliminary review of available wildlife TRVs used at other Region 8 sites. In addition to these TRVs, there are several well-established compendiums of TRV and toxicity data for birds, mammals, and aquatic life including the following:

- The ecological soil screening levels (EcoSSLs) developed by USEPA (2005) (plants, soil invertebrates, birds and mammals)
- Sample et al. (1996) (birds and mammals)
- USEPA ambient water quality criteria (aquatic life).

In addition, searches of other recent and comprehensive ecological risk assessments (e.g., Portland Harbor BERA [Windward 2011]) and toxicity studies in the primary literature may also be used to find information less readily available, to obtain the most recent information, and for chemicals for which it is necessary to evaluate toxicity in greater depth (e.g., dioxins and furans, mercury). When conducting a primary literature review, abstracts will be reviewed to determine if an article reports survival, growth, or reproductive endpoints for the relevant taxonomic group. Articles addressing these endpoints may be evaluated according to the acceptability criteria described in Section 1.2.

1.2 Toxicity Data Acceptability Criteria

The toxicity literature reflects a wide range of investigator objectives, most of which were not associated with ecological risk assessment. As a result, the technical quality of toxicological studies potentially available for risk assessment varies widely. Some of the available literature is not acceptable for use in a BERA. Because most studies, especially older research, provide imperfect ecotoxicological information, guidelines to evaluate the acceptability of literature used to derive TRVs are needed.

1.2.1 Minimal Requirements

The use of basic standards for data quality ensures that the meaning and uses of the reported information are clear. The following are among the most important considerations for inclusion of toxicity data in the BERA:

- Methods must be clearly presented and complete (e.g., inclusion of negative control).
- The test subjects should not have been exposed to toxicants other than the toxicant under study prior to or during the investigation, unless the pre-existing exposure is addressed by the study. For field studies in which test subjects have been exposed to other chemicals, NOAELs can be derived.
- The measured endpoints of the study have to be ecologically relevant (growth, reproduction, or survival).
- Exposure doses must be quantified and effects measured and reported (e.g., ECx, LOAEL, NOAEL).
- The statistical design must employ an appropriate number of replicates, treatments need to be randomized, and the level of significance must be reported for differences in response from controls.
- There should be no obvious confounding factors, such as limited feeding of tested specimens, which could affect the test endpoint.

The above acceptability criteria represent the minimal standards a study must meet to be included in the derivation of the final TRV. Studies that do not meet these minimal criteria would contribute significantly to the uncertainty in the risk evaluation.

1.2.2 Additional Guidelines

In addition to the above criteria, preference is given to toxicity studies with the following characteristics:

- Both a LOAEL and a NOAEL are reported.
- The form of the test chemical is reported, and is a form commonly found in the environment.
- Tissue residue-based TRVs report concentrations for whole-body samples (because concentrations of individual organs and isolated tissues such as liver or gill tissue of receptors at the Site cannot be reliably predicted and were not measured), or for eggs where the basis of the reported concentration (dry or wet weight) is clearly stated.
- Concentrations in exposure media or tissue are measured, not estimated.
- Exposure duration is clearly reported, and effects of chronic exposures are evaluated. Multi-generational studies are preferred.
- A standard or peer-reviewed study protocol is used.

Though these guidelines are not a requirement for selection of a study, they distinguish the studies of high quality.

1.2.3 Uncertainty Factors

The preferred approach for selecting TRVs is to find values that meet the above minimal and additional guidelines. Weight-of-evidence, dose-response, and/or species sensitivity distribution methods for deriving benchmark TRVs preclude the need for uncertainty factors, because these methods inherently require data of higher quality and are not based on a single study. However, data may not be available for a given taxon or effect level of interest (e.g., a LOAEL may be reported without a NOAEL). In the case where other more applicable studies are not available and only a single LOAEL study is available, application of an uncertainty factor to conservatively estimate the NOAEL TRV may be considered.

In a review of the types and uses of uncertainty factors, Chapman et al. (1998) conclude that an uncertainty factor should account for the uncertainty in the extrapolation, but should not be so large that it renders the resultant value meaningless for assessing risk. Chapman et al.'s (1998) review emphasizes the importance of evaluating the substance and context of the uncertainty. They caution against the extrapolation of LOAELs to NOAELs because there can be substantial uncertainty in moving from effects to no-effects concentrations. They provide several examples that support the use of uncertainty factors of 10 or less for individual extrapolations.

Uncertainty factors may be estimated directly from paired NOAEL and LOAEL concentrations for a given chemical. If insufficient data are available to derive a chemical- and receptor-specific uncertainty factor, and only a single study is available for a given chemical and

receptor, then a factor of 10 or less may be used for extrapolations (Amdur and Klaasen 1996; Sample et al. 1996).

1.4 Methods for Aggregation of Toxicity Data and Deriving Final TRVs

For most COPECs, reasonably conservative TRVs from the literature are compared directly to site-specific exposure estimates. In these cases, the TRV reflects results of a study or studies of acceptable quality to provide the best representation of the receptor on the basis of taxonomy and sensitive life stages of the site-specific receptor.

Possible methods for aggregation of toxicity data include 1) critical study selection; whereby the study providing the lowest TRV for a given receptor group and endpoint is selected, 2) weight-of-evidence approach including geometric mean and threshold effect calculation methods, 3) species sensitivity distributions, or 4) dose-response methods. Selection of the appropriate toxicity data aggregation method depends in part on the quality and quantity of available studies. For example, to derive a dose-response relationship, a given study must have at least three exposure levels plus a control in addition to meeting the above minimal data acceptability criteria.

Ideally, TRVs should be developed using methods that represent a thorough understanding of the underlying mechanism of toxicity, which can best be represented by dose-response curves (Allard et al. 2010). Use of an exposure-response derived effect concentration (e.g., ECx) allows for a quantitative understanding of the magnitude and effect of an exposure for risk estimation. However, not all toxicity data are conducive to dose-response evaluation; thus, the quality of the data should be evaluated.

Therefore, the most appropriate initial approach will be to calculate TRVs using a weight-of-evidence approach that considers the acceptability criteria outlined above. Many studies used to derive wildlife TRVs were not conducted using standard methods. Studies that do not have identical exposure durations, exposure and test conditions are not directly comparable. Many of the wildlife toxicity studies utilized a limited number of exposure concentrations or test organisms. Determination of statistical significance for an experiment depends not only on toxicity, but also on study design (the dose levels tested and number of replicates per dose) and the particular statistical procedure chosen to compare the treatment and control responses, all of which affect the statistical power of the comparison. Poorly designed studies with low statistical power result in higher NOAELs and LOAELs compared with more rigorous studies with higher statistical power. Additionally, although several studies may evaluate reproductive effects, different endpoints may be measured. If a single study meets study criteria, it is used as the basis for the TRV. If two studies meet study criteria, a weight-of-evidence approach is used. When

there is higher confidence in one study over the other, the study with higher confidence is selected for the TRV.

If multiple studies are weighted equally, and multiple NOAELs are available, the geometric mean can be calculated. Mathematically, the geometric mean is equivalent to the *n*th root of the product of the *n* values:

$$GM = (x_1 \times x_2 \times \cdots x_n)^{1/n}$$

However, a geometric mean of LOAEL values will not be calculated. Calculating a geometric mean of LOAELs measured using different test species, experimental methods, and measurement endpoints is not a valid method to derive a protective low adverse effect level. Additionally, no data quality screening step is incorporated into the proposed geometric mean calculation for LOAEL TRVs; all of the studies that report a LOAEL will be utilized to calculate the proposed TRV. Some studies report a LOAEL at the lowest tested dose, which may be higher than the dose range tested in later studies. Use of the mid-point of a variety of low adverse effect levels or a geometric mean low effect level results in an under-protective "LOAEL" and is not consistent with developing the range of concentrations that bound the potential for adverse ecological effects described above (ERAGS 1997). In the case of aggregating multiple LOAEL values, the minimum value is used as the basis for the TRV.

If sufficient data are available of acceptable quality, dose-response or species sensitivity distribution methods should be additionally evaluated as an alternative to point-estimate NOAEL/LOAEL-based TRVs.

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