7. RISKS TO TERRESTRIAL WILDLIFE

Risks from radionuclides and nonradionuclides (e.g., organic and inorganic chemicals) were estimated for small mammals and wide-ranging wildlife species within the WOCW. Because the methods for risk estimation differ between radionuclide and nonradionuclide contaminants, each is addressed separately. Risks from exposure to radionuclides are discussed in Chapter 9.

7.1 EXPOSURE ASSESSMENT

Wildlife may be exposed to contaminants through ingestion of food, soil and water. In this assessment, exposure through ingestion of food, soil, and water was estimated using exposure models (described in the following paragraphs). Exposure through water for terrestrial wildlife was assessed by comparing unfiltered water concentrations to water benchmarks for wildlife (see Sect 7.2.1). Contaminant exposure through ingestion was estimated for small mammals (short-tailed shrew and white-footed mouse) and wide-ranging species (white-tailed deer, wild turkey, red-tailed hawk, red fox, and mink). Soil-related ingestion exposures and combined watershed-wide water- and soil-related exposures for mink are addressed in this section; water-related ingestion exposures for mink are addressed with the other piscivores in Sec. 8. Exposure estimates were calculated using soil and soil-biota uptake factors for small mammals, earthworms, and plants. Uptake factors for small mammals and plants were derived from data from 15 locations within the Bear Creek watershed (four within BCOU1 and 11 within the Bear Creek floodplain). Uptake factors for earthworms were derived from data from Bear Creek, WAG 5 and 2 locations within WAG 2. When measured data on uptake factors were unavailable, values were derived from available literature.

7.1.1 Oral Ingestion Exposure Model

Oral exposure to contaminants experienced by terrestrial wildlife may come from multiple sources. They may consume contaminated food (either plant or animal), drink contaminated water, or ingest soil or sediment. Soil or sediment ingestion may be incidental while foraging or grooming or purposeful to meet nutrient needs. The total oral exposure experienced by an individual is the sum of the exposures attributable to each source and may be described as:

$$E_{total} \approx E_{food} + E_{water} + E_{soil} \qquad (1)$$

where:

E_{total} = total exposure from all pathways
E_{food} = exposure from food consumption
E_{water} = exposure from water consumption
E_{soil} = exposure from soil consumption

For exposure estimates to be useful in the assessment of risk to wildlife, they must be expressed in terms of a body weight-normalized daily dose or mg contaminant per kg body weight per day (mg/kg/d). Exposure estimates expressed in this manner may then be compared to toxicological benchmarks for wildlife, such as those derived by Sample et al. (1996a), or to doses reported in the toxicological literature. Estimation of the daily contaminant dose an individual may receive from a particular medium for a particular contaminant may be calculated using the following equation:

$$E_j = \sum_{i=1}^{m} p_{ik}\left(\frac{IR_i \ x \ C_{ijk}}{BW}\right) \qquad (2)$$

where:

E_j	=	total exposure to contaminant (j) (mg/kg/d)
m	=	total number of ingested media (e.g., food, soil, or water)
IR_i	=	consumption rate for medium (i) (kg/d or L/d)
p_{ik}	=	proportion of type (k) of medium (i) consumed (unitless)
C_{ij}	=	concentration of contaminant (j) in type (k) of medium (i) (mg/kg or mg/L)
BW	=	body weight of endpoint species (kg)

Exposure estimates were calculated for all contaminants detected in soil or water from the WOCW. Because wildlife are mobile, their exposure is best represented by the mean contaminant concentration in media. To be conservative, the lower of the 95% upper confidence limit (UCL) and the maximum detected concentration was used in exposure estimates. These data were used in the initial exposure estimates. Exposure estimates for contaminants that may potentially present a risk to wildlife (based upon comparisons to LOAELs) were reevaluated using Monte Carlo simulations.

7.1.2 Uptake Factors

Contaminant concentrations in biota were not available for the WOCW. To estimate contaminant concentrations in biota, soil-to-tissue uptake factors developed as part of the Bear Creek Valley RI were used. Uptake factors for small mammals and plants were developed exclusively with data from the Bear Creek assessment. In addition to the Bear Creek data, data from two samples in WAG 2 and 6 from WAG 5 were used to develop the earthworm uptake factors Uptake factors for plants are available in Efroymson et al. (1996b); uptake factors for earthworms and small mammals are available in Sample et al. (1996b). When ORR-specific uptake factors were available from Efroymson et al. (1996b) or Sample et al. (1996b), contaminant concentrations in biota were estimated by multiplying the biota type-specific uptake factor by the soil concentration:

$$C_{tissue} = UF_i \quad C_{soil} \qquad (3)$$

where:

UF_i	=	Soil-to-tissue uptake factor for plant, worm, or wildlife receptor (unitless)
C_{soil}	=	Concentration of chemical *i* in soil (mg/kg)

When ORR-specific soil-to-tissue uptake factors were unavailable, literature-derived uptake factors were used. For plants and soil invertebrates, equation 3 was used to estimate tissue concentrations. However, literature-derived uptake factors for small mammals were food-to-tissue uptake factors, not soil-to-tissue. Therefore, small mammal tissue concentrations were estimated by multiplying the food-to-tissue uptake factor by the concentration in plant or invertebrate food consumed by the small mammal:

$$C_{tissue} = BAF_i \ (C_{ij} \quad P_j + C_{soil} \quad P_{soil}) \qquad (4)$$

where:

BAF_i	=	Food-to-tissue uptake factor for chemical *i*. (mg/kg tissue over mg/kg food)
C_{ij}	=	Concentration of chemical *i* in food type *j* (mg/kg)
P_j	=	Proportion of food type *j* in small mammal's diet (unitless)
C_{soil}	=	Concentration of chemical *i* in surface soil.

P_{soil} = Proportion of soil in small mammal diet. (unitless)

Uptake factors used in this assessment are provided in Table 7.1. It was assumed that contaminant uptake from ingested food and soil was similar.

7.1.3 Contaminant Concentrations in Media

Soil and water data were aggregated into subbasins within the WOCW. Subbasins were identified based on drainage patterns and relation to potential sources. Figure 1.1 portrays the relative location of all identified subbasins within the watershed. Summary statistics for contaminants detected in soil from each subbasin in the WOCW are presented in Table 5.2 and in Attachment A of Appendix B of this RI report. Surface water data are also presented in Attachment A of Appendix B.

7.1.4 Exposure Modeling using Point-Estimates

Initial estimates of exposure of terrestrial wildlife to contaminants were performed for each of the subbasins using point estimates of parameters in the exposure model. Species-specific parameters necessary to estimate exposure using Eq. 2 are listed in Tables 7.2 through 7.8.

To estimate contaminant exposure experienced by short-tailed shrew, the following assumptions were made:

- body weight = 0.015 kg
- food consumption = 0.009 kg/d (fresh weight)
- soil consumption = 0.00117 kg/d (dry weight)
- water consumption = 0.033 L/d
- diet consists 100% of earthworms or soil invertebrates.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by white-footed mouse, the following assumptions were made:

- body weight = 0.022 kg
- food consumption = 0.0034 kg/d (fresh weight)
- soil consumption = 0.000068 kg/d (dry weight)
- water consumption = 0.0066 L/d
- diet consists 50% of earthworms or soil invertebrates and 50% herbaceous plant material.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by white-tailed deer, the following assumptions were made:

- body weight = 56.5 kg
- food consumption = 1.74 kg/d (fresh weight)
- soil consumption = 0.0348 kg/d (dry weight)
- water consumption = 3.7 L/d

To estimate contaminant exposure experienced by red fox, the following assumptions were made:

- body weight = 4.5 kg
- food consumption = 0.45 kg/d (fresh weight)
- soil consumption = 0.0126 kg/d (dry weight)
- water consumption = 0.38 L/d
- diet consists 80.8% of small mammals and birds, 10.4% plant material, and 8.8% earthworms or other invertebrates
- contaminant concentration in small mammals is representative of that in other vertebrate prey.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by red-tailed hawk, the following assumptions were made:

- body weight = 1.126 kg
- food consumption = 0.109 kg/d (fresh weight)
- soil consumption = 0 kg/d (dry weight)
- water consumption = 0.064 L/d
- diet consists 100% of small mammals and other vertebrates
- contaminant concentration in small mammals is representative of that in other vertebrate prey.

To estimate contaminant exposure experienced by mink, the following assumptions were made:

- body weight = 1 kg
- food consumption = 0.137 kg/d (fresh weight)
- water consumption = 0.099 L/d
- diet consists 54.6% of fish or other aquatic prey and 45.4% small mammals.
- contaminant concentration in small mammals is representative of that in other terrestrial vertebrate prey.
- contaminant concentration in fish is representative of that in other aquatic prey.

To estimate contaminant exposure experienced by wild turkey, the following assumptions were made:

- body weight = 5.8 kg
- food consumption = 0.174 kg/d (fresh weight)
- soil consumption = 0.0162 kg/d (dry weight)
- water consumption = 0.19 L/d
- diet consists 90.3% of plant material, and 9.7% invertebrates
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

Using Equation 2 and the assumptions and data described above, point estimates of exposure to contaminants within each of the subbasins within the watershed were estimated for each endpoint (Tables 7.9 through 7.15).

7.1.5 Exposure Modeling using Monte Carlo Simulations

Employing point estimates for the input parameters in the exposure model does not take into account the variation and uncertainty associated with the parameters and therefore may over- or underestimate the contaminant exposure that endpoints may receive. In addition, calculating the model using point estimates produces a point estimate of exposure. This estimate provides no information concerning the distribution of exposures or the likelihood that individuals within the watershed will actually experience potentially hazardous exposures. To incorporate the variation in exposure parameters and to provide a better estimate of the potential exposure experienced by wildlife in the WOCW, the exposure model was re-calculated using Monte Carlo simulations.

Monte Carlo simulation is a resampling technique frequently used in uncertainty analysis in risk assessment (Hammonds et al. 1994). In practice, distributions are assigned to input parameters in a model, and the model is recalculated many times to produce a distribution of output parameters (e.g., estimates of contaminant exposure). Each time the model is recalculated, a value is selected from within the distribution assigned for each input parameter. As a result, a distribution of exposure estimates is produced that reflects the variability of the input parameters.

For all endpoints, Monte Carlo simulations were performed for the entire WOCW area. The percentiles of the resulting exposure distributions represent the likelihood that an individual within the modeled area will experience a given exposure level. It was assumed that each subbasin contributed equally to the overall mean exposure (i.e., individuals within the watershed do not preferentially forage at any one location within a subbasin). While this assumption is not likely to be ecologically correct (foraging effort and therefore exposure is likely to be biased toward those locations with the most abundant food), data were not available to estimate preferential use among subbasins. For short-tailed shrews and white-footed mice, species with small home ranges for which an individual subbasin is a relevant scale to address populations, Monte Carlo simulations were performed for individual subbasins.

Simulations were performed for each contaminant where comparison of point estimates of exposure to LOAELs produced HQs$\geq$1 for at least one subbasin (LOAELs are discussed in Sect 7.2.; results of screening of exposure estimates against LOAELs are discussed in Sect. 7.3.).

Distributions were used for the following parameters in the exposure model: contaminant concentrations in soil and soil-biota uptake factors. Distributions for soil contaminant concentrations were identified as normal or lognormal using the UNIVARIATE procedure in SAS (SAS 1990). When sample sizes were adequate (>6 observations), the Shapiro-Wilk test (Shapiro and Wilk 1965) was used to determine whether a normal or lognormal distribution provided the best fit of the data. For small sample sizes or data with no variation, a normal distribution was assumed. Distributions for soil-to-biota uptake factors were obtained from Efroymson et al. (1996b) and Sample et al. (1996b).

Monte Carlo simulations were performed using Crystal Ball software (Decisioneering 1996). Samples from each distribution were selected using latin hypercube sampling. The number of model iterations performed for each exposure estimate was set at 1000.

7.2 CHEMICAL EFFECTS ASSESSMENT FOR WILDLIFE

7.2.1 Single Chemical Toxicity Data

Single chemical toxicity data consist of no observed adverse effects levels (NOAELs) and lowest observed adverse effects levels (LOAELs) of toxicity studies reported in the literature. NOAELs and LOAELs for wildlife endpoints were estimated from these data using the allometric methods outlined in Sample et al. (1996a). This methodology for toxicity extrapolation is equivalent to that the EPA uses in their carcinogenicity assessments and Reportable Quantity documents for adjusting from animal data to an equivalent human dose. Using the allometric scaling factor recommended in EPA (1995), the equation for estimating mammalian LOAELs was:

$$LOAEL_w = LOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4} \quad (5)$$

where $LOAEL_t$ and $LOAEL_w$ represent LOAELs for a mammalian test species and a wildlife species, respectively. Toxicity values for birds were estimated using the scaling factor derived from Mineau (1996) where:

$$LOAEL_w = LOAEL_t \left(\frac{bw_t}{bw_w} \right)^{0} = LOAEL_t\ (1) = LOAEL_t \quad (6)$$

To evaluate the potential risk that contaminants in water may present, water benchmarks were derived according to the methods outlined in Sample et al. (1996a). Water benchmarks represent the concentration of a contaminant in water (C_w, in mg/L) that would result in a dose equivalent to a $NOAEL_w$ or $LOAEL_w$. NOAEL's and LOAEL's and water benchmarks were derived for all seven endpoints. Experimental information used to estimate avian and mammalian benchmarks and NOAEL's and LOAEL's for avian and mammalian endpoints are available in Sample et al. (1996a).

Toxicological profiles for analytes of concern are provided in the attachment of this appendix.

7.2.2 Biological Surveys

7.2.2.1 Mink survey

Stevens (1995) investigated bioaccumulation of mercury in mink on the ORR in 1993 through 1995. The methods used in the mink survey, while indicating that mink are present on the Reservation, cannot be used to estimate abundance or density of mink on the ORR. A total of four male mink were live-trapped over the course of 6073 trapnights (trapnight=1 trap set for 24 h). One juvenile was captured along East Fork Poplar Creek, two adults were captured along Bear Creek, and one adult was captured along WOC. Captured mink were fitted with an intraperitoneal radio transmitter (to monitor movements and home range) and released. Prior to release samples of hair were collected for metals analysis. An additional 8 roadkilled mink (5 male and 3 female) were collected from the ORR and surrounding areas of Roane and Anderson counties. While one roadkill sample (a male) was collected on a bridge over Bear Creek and was assumed to be a resident of Bear Creek, all others were collected off the ORR and were used as references. Results of metals analysis are presented in Table 7.16.

Radiotelemetry data on home ranges and movements were obtained for 3 mink - one each from the East Fork Poplar Creek, Bear Creek, and WOC watersheds. Mean (± standard deviation) home range for these three individuals was found to be 7.5±3 km of stream. The home range of the WOC mink included all of WOC from the headwater tributaries to the Clinch River, including the X-10 facility. This individual was observed to use dens within the X-10 facility and moved through the facility on several occasions.

7.3 CHARACTERIZATION OF CHEMICAL RISKS TO WILDLIFE

Risk Characterization integrates the results of the exposure assessment (Sect. 7.1) and effects assessment (Sect. 7.2) to estimate risks (the likelihood of effects given the exposure) based on each line of evidence, and then applies a weight of evidence inference logic to determine the best estimate of risk to each assessment endpoint. In an ideal risk assessment there are three lines of evidence: literature-derived single chemical toxicity data (which indicate the toxic effects of the concentrations measured in site media); biological surveys of the affected system (these indicate the actual state of the receiving environment); and toxicity tests with ambient media (these indicate the toxic effects of the concentrations measured in site media). With the exception of the biosurvey data for mink (Sect 7.2.2), only one line of evidence, single chemical toxicity data, was available to assess risk to wildlife in the WOCW.

7.3.1 Single Chemical Toxicity Data

Exposure estimates generated by the exposure model (see Sect. 7.1) produced by both point estimates of parameter values and Monte Carlo simulation represent exposure at the individual level. The exposure estimates using point estimates of parameter values at each subbasin are used to identify COPECs and locations that contribute significantly to risk. In contrast, the WOCW-wide exposure distributions generated by Monte Carlo simulation represent the likelihood that an individual within the watershed will experience a particular exposure.

Two types of single chemical toxicity data are available with which to evaluate wildlife contaminant exposure: NOAELs and LOAELs. In this baseline assessment, the evaluation is based on comparison to LOAELs. LOAELs are compared to the exposure distribution generated by the Monte Carlo simulation. If the LOAEL is lower than the 80th percentile of the exposure distribution, there is a >20% likelihood that individuals within the modeled location are experiencing contaminant exposures that are likely to produce adverse effects. By combining measured or literature-derived population density data with the likelihood or probability of exceeding the LOAEL, the magnitude of population-level impacts may be estimated.

7.3.1.1 Screening point estimates of exposure

To determine if the contaminant exposures experienced by wildlife in each subbasin and throughout the WOCW are potentially hazardous, the dietary contaminant exposure estimates (generated using point estimates of parameter values) were compared to estimated NOAELs and LOAELs for these species (Sample et al. 1996a). To quantify the magnitude of hazard, a hazard quotient (HQ) was calculated where: HQ = exposure/LOAEL. Hazard quotients greater than 1 indicate that individuals may be experiencing exposures that are in excess of LOAELs. While exceeding the NOAEL suggests that adverse effects are possible, exceeding the LOAEL suggests that adverse effects are likely. Hazard quotients for all endpoints are presented along with the point estimates of exposure in Tables 7.9 through 7.15 for all instances where the NOAEL- or LOAEL-based HQ was greater than 1.0.

Mercury was the dominant contaminant presenting risks to terrestrial wildlife in the WOCW. Mercury exposure in the WOCW exceeded LOAELs for all endpoints within at least one subbasin and in as many as six subbasins for the shrew (Tables 7.17 through 7.23). The next most important contaminants presenting risks were PCBs, presenting risks to shrews, mice, and fox (Table 7.17 through 7.19). Other analytes presenting likely risks were chromium (shrew, mouse, fox); barium (shrew, fox, deer); arsenic (shrew and mouse); zinc (shrew, hawk); nickel (shrew, mouse, fox, hawk, deer, turkey, and mink); and cadmium, copper, molybdenum, and selenium (shrew). With the exception of short-tailed shrews, only one to at most five contaminants were identified as presenting risks to any endpoint. In the case of shrews, 12 contaminants resulted in potentially significant risks (Table 7.17).

Tables 7.17 through 7.23 display the sum of the LOAEL-based HQs (e.g., sum of toxic units or HI) for those contaminants where at least one LOAEL-based HQ>1 was obtained. For all endpoint species, the greatest risks were identified in the mainstem of WOC. The highest HIs are in the Intermediate Holding Pond subbasin. The WOC and Lower WOC subbasins also result in relatively high HIs, all primarily due to mercury contamination. The HF-2 subbasin in the HFIR basin along Melton Branch results in high HIs due to chromium, barium, and zinc. HIs decline with increasing distance downstream in the mainstem of WOC (Intermediate Holding Pond > WOC > Lower WOC). The high HI for SWSA 4 Main is caused by the extremely high nickel concentrations at WAG 4 Seep 6 and probably represents a hot spot rather than widespread contamination.

The following paragraphs in this subsection provide a subbasin by subbasin description of risk results for exposure of terrestrial wildlife to contaminants in surface soil.

HFIR BASIN

HF-2 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the HF-2 subbasin. Likely risks were identified for short-tailed shrews, white-footed mice, red fox, white-tailed deer, and red-tailed hawk (Tables 7.17 through 7.21). Inorganics contributed 100% of the HI for all receptors. HQs exceeding one were estimated for four (chromium, barium, zinc, and molybdenum) for shrews, two (chromium and barium) for foxes, and one for mice, deer, and hawks (chromium, barium, and zinc, respectively). With the exception of chromium, most exceedances of toxicological benchmarks were relatively low (less than a factor of 3.8). This subbasin was not a major contributor to the estimated watershed-wide population effects for shrews exposed to molybdenum.

Chromium was the primary risk driver for shrews, mice, and foxes, contributing 51-99% of the HI for each. Chromium was detected in both of the soil samples collected at HF-2, but at levels higher than background in only one, and then at a concentration only about twice as high (168 mg/kg for HF-2 versus 78 mg/kg background). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors.

SWSA 5 Seep A Basin

Seep A Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep A subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews (HI = 6.9), but no risks were identified for any other receptors (HIs < 1). Inorganics contributed >90% of the HI for all receptors. HQs exceeding one were estimated for two analytes (selenium and zinc) for shrews (Table 7.17). This subbasin was the major contributor to the estimated watershed-wide population effects for shrews exposed to selenium.

HRE

Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the HRE subbasin. Likely risks were identified for shrews and mice (Tables 7.17 and 7.18). HQs exceeding one were estimated for three analytes for shrews (barium, chromium, and PCBs) and one for mice (chromium). Barium and PCBs were not predicted to result in population level effects within the subbasin for shrews or mice, but chromium was predicted to result in population level effects on shrews and mice within the subbasin and in watershed-wide effects on shrews. However, while chromium was the primary risk driver in this subbasin, it was detected at only 1.3 times background. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995a), but in most soils chromium (VI) is likely to be reduced to chromium (III). The toxicological benchmarks used in this assessment were based on chromium (VI) studies. The use of benchmarks for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of risks. Exposures were below NOAELs for chromium (III) for all receptors. Therefore, while risks to individuals are possible in this subbasin due to barium, chromium, and PCBs, these analytes probably do not represent a significant concern at the population level.

SWSA 5 Seep B Basin

Seep B West Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep B West subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, and mink (Table 7.17 through 7.19, 7.21, and 7.23). Inorganics contributed >99% of the HI for all receptors. HQs exceeding one were estimated for three analytes for shrews (mercury, selenium, and molybdenum) and one (mercury) for mice, fox, hawk, and mink. While not as significant as the Intermediate Holding Pond, this subbasin was a significant contributor to estimated watershed-wide risks to shrews and foxes from exposure to mercury. It is also a contributor to estimated watershed-wide risks to shrews from exposure to selenium.

Seep B East Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep B East subbasin. Likely risks from nonradionuclides were only identified for short-tailed shrews (Table 7.17). While PCB-1260 contributed >72% of the HI for the shrew and was the only analyte resulting in a HQ exceeding one, this subbasin was not a major contributor to estimated watershed-wide risks to shrews from exposure to PCB-1260.

SWSA 5 Drainage D-2

SWSA 5 Drainage D-2 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 Drainage D-2 subbasin. Likely risks were identified for short-tailed shrews, white-footed mice, and red fox from exposure to nonradionuclides (Table 7.17 through 7.19). The organic PCB-1260 was the risk driver for all three receptors, contributing >90% of the HI. The PCB-1260 HQ for the shrew was 19.0. This subbasin was the primary contributor to the watershed-wide risks estimated for shrews from exposure to PCB-1260. PCB-1260 was detected in 2 of 5 samples within the subbasin.

SWSA 5 Seep C Basin

Seep C Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep C subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews

(Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for three inorganics for shrews (molybdenum, barium, and selenium). This subbasin was the primary contributor to estimated watershed-wide risks to shrews from exposure to molybdenum.

MWOC/East Basin

SWSA 5 Tributary 1. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA5 Trib-1 subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews and red fox (Table 7.17 and 7.19). Inorganics contributed >84% of the HI for both receptors. HQs exceeding one were estimated for two inorganics for shrews (mercury and selenium) and one for red fox (mercury). Mercury was the primary risk driver for all receptors, accounting for 40% of the shrew HI, and 73% of the fox HI.

SWSA 5 WOC. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 WOC subbasin. Likely risks were identified for short-tailed shrews (Table 7.17) from exposure to nonradionuclides. Inorganics contributed >86% of the HI. HQs exceeding one were estimated for two inorganics (mercury and selenium) for shrews. Exceedances of toxicological benchmarks were relatively low (less than a factor of 1.2).

SWSA 5 N WOC. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 N WOC subbasin. Likely risks were identified for short-tailed shrews from exposure to nonradionuclides (Table 7.17). Inorganics contributed >99% of the HI. Only selenium resulted in a HQ exceeding one for the shrew, and the exceedance of the toxicological benchmark was low (HQ = 1.8), but this subbasin was an important contributor to the estimated watershed-wide risks to shrews from exposure to selenium in soil.

MWOC/West Basin

Intermediate Pond. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Intermediate Pond subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, white-tailed deer, red-tailed hawk, wild turkey, and mink (Tables 7.17 through 7.23). Inorganics contributed >98% of the HI for all receptors. HQs exceeding one were estimated for four inorganics for shrews (mercury, molybdenum, nickel, and zinc) and one (mercury) for mice, fox, deer, hawk, turkey, and mink. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 4.6. The Intermediate Holding Pond was the primary contributor to estimated watershed-wide risks to shrews and foxes from exposure to mercury. It is also an important contributor to estimated watershed-wide risks to shrews from exposure to PCB-1260 and molybdenum.

SWSA 4 Main. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the SWSA 4 Main subbasin. Likely risks were identified for all receptors (Tables 7.17 through 7.23). HQs exceeding one were estimated for three analytes for shrews (barium, nickel, and selenium) and one for all other receptors (nickel). Barium, nickel, and selenium were all predicted to result in population level effects on shrews within the subbasin, and nickel was predicted to result in within basin population level effects for mice. This subbasin was the primary reason for a predicted watershed-wide effect on shrews from exposure to nickel and an important contributor to predicted watershed-wide effects on shrews from exposure to selenium.

While nickel was the primary risk driver for wildlife in the subbasin, it should be noted that the results are driven by the high nickel concentration (7860 mg/kg) at one sample location

(WAG4Seep6). The highest concentration at two other locations in the subbasin was 49.6 mg/kg, suggesting that risks from nickel are spatially limited within the subbasin. Therefore, watershed-wide effects on shrews from exposure to nickel are not likely.

WAG 7 WOC. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the WAG 7 WOC subbasin. No risks were identified for wildlife receptors; estimated exposures were below LOAELs for all receptors.

WOC Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the WOC subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, wild turkey, and mink (Tables 7.17 through 7.19 and 7.21 through 7.23). Inorganics contributed >89% of the HI for all receptors. HQs exceeding one were estimated for five inorganics for shrews (mercury, zinc, molybdenum, copper, and selenium), two for red-tailed hawks (mercury and zinc), and one (mercury) for mice, fox, turkey, and mink. This subbasin was second to the Intermediate Holding Pond in contribution to estimated watershed-wide risks to shrews and foxes from exposure to mercury. Mercury accounted for >65% of the HI for wildlife receptors. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 4.1 and accounting for 11% of the shrew HI.

West Seep Basin

West Seep Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the West Seep subbasin. No analytes resulted in HQs >1.0 for any receptors, thereby indicating that risks to wildlife are negligible in this subbasin.

East Seep Basin

East Seep Subbasin. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the East Seep subbasin. Likely risks were identified only for shrews (Tables 7.17). HQs exceeding one were estimated for three analytes for shrews (barium, selenium, and thallium). Although HQs were low (<1.5), selenium and thallium were predicted to result in population level effects on shrews within the subbasin. This subbasin was a minor contributor to predicted watershed-wide effects on shrews from exposure to selenium. Watershed-wide effects were not predicted for thallium or barium.

SWSA 6 BASIN

W6MS3 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the WAG6MS3 subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. Only arsenic resulted in an HQ exceeding one for shrews. Exceedance of the toxicological benchmark was relatively low (HQ = 1.8).

W6MS1 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the W6MS1 subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for only two analytes for shrews (arsenic and nickel). The nickel HQ was only 1.2 while the arsenic HQ was 4.3.

White Oak Lake, Creek, and Floodplain Basin

Lower WOC Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Lower WOC subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, wild turkey, and mink (Table 7.17 through 7.19 and 7.21 through 7.23). Inorganics contributed >95% of the HI for all receptors. HQs exceeding one were estimated for five inorganics for shrews (mercury, chromium, zinc, molybdenum, and selenium), two for mice and foxes (mercury and chromium), and one (mercury) for hawks, turkeys, and mink. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 2.3. This subbasin was third behind Intermediate Holding Pond and WOC subbasins in contribution to watershed-wide risks to shrews and foxes exposed to mercury. Hazard quotients for mercury were as high as 23.2 for shrews. Chromium was a significant risk driver for shrews, mice, and foxes, but the UCL95 of the chromium concentration only exceeded background by 1.1x. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors.

SWSA 6 South Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 6 SOUTH subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews and white-footed mice (Tables 7.17 and 7.18). Inorganics contributed 100% of the HI for both receptors as benchmarks were unavailable for the three organics detected in the single sample from the subbasin. Only arsenic resulted in a HQ exceeding one for shrews and mice. The shrew HQ of 8.1 was the highest HQ for arsenic for any wildlife receptor at any of the subbasins.

SWSA 6 East Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in SWSA 6 East subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics accounted for >99% of the HI. HQs exceeding one were estimated for only two analytes for shrews (nickel and cadmium). Exceedances of toxicological benchmarks were less than 1.2 for both analytes. Relative to other subbasins within the watershed, the SWSA 6 East subbasin presents a minor risk of adverse effects.

Pit 4 South Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Pit 4 South subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for three inorganics for shrews (molybdenum, selenium, and barium). Exceedances of toxicological benchmarks were low (less than a factor of 1.8) for all analytes.

NHF Basin

NHF Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the NHF subbasin. No risks were identified for exposure of terrestrial biota to nonradionuclides in soil. Exposures for all receptors were below toxicological benchmarks for all analytes.

7.3.1.2 Screening Monte Carlo simulation estimates of exposure

To incorporate the variation present in the parameters employed in the exposure model, Monte Carlo simulations were performed for the exposure estimates of each species to analytes where at least one LOAEL-based HQ>1 was observed. For all endpoints, simulations were performed only at the watershed-wide level.

By superimposing NOAEL and LOAEL values on the exposure distributions generated from the Monte Carlo simulation, the likelihood of an individual experiencing potentially hazardous exposures can be estimated and the magnitude of risk may be determined. An interpretation of the comparison of exposure distributions to NOAELs and LOAELs is given in Table 7.24.

To evaluate the likelihood and magnitude of population-level effects on wildlife, literature-derived population density data (expressed as number of individuals/ ha or km of stream) were combined with hectares of suitable habitat (within the WOCW) to estimate the number of individuals of each endpoint species expected to be present in the watershed. For the terrestrial species (shrew, mice, deer, fox, turkey and hawk) habitat preferences follow those reported in the Preliminary Reservation-wide Ecological Risk Assessment (Sample et al. 1995). These habitat preferences were compared to the habitat types identified in WAGs within the WOCW in Washington-Allen et al. (1995) and extrapolated to address the entire Melton Valley area of the WOCW. Because streams are the preferred habitats for mink, the length of WOC was assumed to represent suitable habitat. The estimated abundance of wildlife endpoint species is reported in Table 7.25.

The number of individuals within the WOCW likely to experience exposures >LOAELs can be estimated using cumulative binomial probability functions (Dowdy and Wearden 1983). Binomial probability functions are estimated using the following equation:

$$b(y;n;p) = \binom{n}{y} p^{y} (1-p)^{n-y} \qquad (7)$$

where:

y = the number (or percent) of individuals experiencing exposures > LOAEL
n = total number (or percent) of individuals within the watershed
p = probability of experiencing an exposure in excess of the LOAEL
b (y; n; p) = probability of y individuals out of a total of n, experiencing an exposure > LOAEL, given the probability of exceeding the LOAEL=p.

By solving Equation 8 for y=0 to y=n, a cumulative binomial probability distribution may be generated that can be used to estimate the number of individuals within the WOCW that are likely to experience adverse effects.

Binomial probability distributions were generated only for contaminant-endpoint combinations where the percent of the exposure distribution exceeding the LOAEL was 20% to 80% (these values are reported in Table 7.26). If the percent of the exposure distribution exceeding the LOAEL was <20%, it was assumed that no individuals within the area of interest were experiencing adverse effects. Conversely, if the percent of the exposure distribution exceeding the LOAEL was >80%, it was assumed that all individuals within the area of interest were experiencing adverse effects. Exposure estimates for 5 contaminant-endpoint combinations met the 20% to 80% exceedance criterion at the watershed level: PCB, mercury, molybdenum, and selenium exposure to shrews, and mercury exposure to fox. The total numbers of individuals for each endpoint species estimated to be experiencing adverse effects within the WOCW are summarized in Table 7.26.

Based on the Monte Carlo analysis and binomial distribution analysis, the following conclusions may be made:

1. Because < 20% of the WOCW populations are estimated to be experiencing exposures >LOAEL, the following contaminants do not present significant risks:

Endpoint	Analytes
Short-tailed shrew	As, Ba, Cd, Cu, Tl, and Zn
White-footed mouse	Aroclor 1260, As, Cr, Hg, and Ni
Red fox	Aroclor 1260, Ba, and Ni
White-tailed deer	Ba, Hg, and Ni
Red-tailed hawk	Hg, Zn, and Ni
Wild turkey	Hg and Ni
Mink	Aroclor 1260, Hg, and Ni (soil-related exposures only)

2. Because >20% of the WOCW shrew population is estimated to be experiencing exposures >LOAEL, Aroclor-1260, chromium, mercury, molybdenum, nickel, and selenium present significant watershed-wide risks to shrews;

3. Because >20% of the population was estimated to be experiencing exposures >LOAEL, mercury presents a significant watershed-wide risk to red fox.

4. Because >20% of the population within some subbasins was estimated to experience exposures >LOAEL, arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc present significant risks to shrews at the subbasin scale. Table 7.27 identifies the subbasin/analyte combinations presenting significant risks.

5. Because >20% of the population within the subbasins was estimated to experience exposures >LOAEL, chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

6. Because <20% of the individuals in the mink population were likely to experience combined water- and soil-related exposures >LOAELs, mercury and PCBs are not expected to present significant watershed-wide risks to mink.

While significant watershed-wide and within subbasin population-level risks to shrews were predicted for chromium, it should be noted that chromium risks are based on comparison to the benchmark for chromium (VI). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors. In addition, chromium was detected above background in only two subbasins (HF-2 and Lower WOC/WHITE OAK LAKE) and then at a concentration only about twice as high.

Watershed-side effects on shrews from exposure to nickel may also be overestimated bacause a single sample location, WAG 4 Seep 6, in the SWSA 4 Main subbasin drives the analysis. The concentration at WAG 4 Seep 6 is two orders of magnitude higher than at other locations in the subbasin, suggesting the area of high contamination is spatially limited.

7.3.1.3 Screening point estimates of exposure: surface water

To evaluate the potential risk that contaminants in surface water present to wildlife, the 95% UCLs for concentrations in unfiltered water were compared to LOAEL water benchmarks for all species. Surface water data for this comparison included both mainstem and seep/small tributary data. HQs (water concentration/benchmark value) were calculated for all species.

Potential risks to white-tailed deer exposed to thallium by drinking surface water were identified for three subbasins (WOC, HF-2, and SWSA 5 Trib-1). Risks were not identified for any other receptors, and thallium was the only analyte which exceeded the LOAEL for deer. However, it is unlikely that thallium in drinking water poses a risk to deer. The thallium benchmark is conservative, based on a reduction in sperm motility, and was derived using a subchronic to chronic uncertainty factor of 10. In addition, the frequency of detection was low (3 of 8, 1 of 9, and 1 of 8 samples) in all three subbasins.

7.3.2 Effects of Retained Contaminants

Chromium

For the purposes of this assessment, it was assumed that 100% of the chromium to which wildlife are exposed consists of chromium (VI). This is a very conservative assumption. The mammalian NOAEL for chromium was based on a study of rats fed Cr^{+6} in water for one year (Mackenzie et al. 1958). No adverse effects were observed at the highest dose of 3.28 mg/kg-d. The 3.28 mg/kg-d exposure was considered to be a chronic NOAEL. The mammalian LOAEL for chromium was based on a study of rats fed Cr^{+6} in water for 3 months (Steven et al. 1976). Mortality significantly increased among rats consuming 131.4 mg/kg-d. The study was considered to represent a subchronic exposure, therefore a 0.1 subchronic-chronic correction factor was employed. The 13.14 mg/kg-d exposure was considered to be a chronic LOAEL. Based on the results of Steven et al. (1976), shrews experiencing exposure ≥ LOAEL are likely to display increased mortality.

Mercury

For the purposes of this assessment, it was assumed that 100% of the mercury to which wildlife are exposed consists of methylmercury. The fox and mink NOAELs and LOAELs for mercury were derived from a study of mink fed methyl mercury for 93 d (Wobeser et al. 1976). While consumption of 0.247 mg/kg-d methyl mercury resulted in significant mortality, weight loss, and behavioral impairment, no effects were observed at the 0.15 mg/kg-d exposure level. The 0.15 mg/kg-d exposure was considered to be a NOAEL and the 0.247 mg/kg-d exposure was considered to be a LOAEL. Because the study was subchronic in duration (<1 yr), a subchronic-chronic correction factor was applied (NOAEL=0.015, LOAEL=0.025). Based on the results of Wobeser et al. (1976), shrews and fox experiencing exposures ≥ LOAEL are likely to display increased mortality, weight loss, and behavioral impairment.

Molybdenum

The mammalian NOAEL and LOAEL for molybdenum were derived from a study of mice given molybdate in water and food for three generations (Schroeder and Mitchner 1971). Total exposure of 2.58 mg/kg/d resulted in reduced reproductive success and a high incidence of runts. This dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1. Based on the results of Schroeder and Mitchner (1971), shrews experiencing exposures ≥ LOAEL are likely to reduced reproductive success.

PCBs

The mammalian NOAEL and LOAEL for PCBs were derived from a study of mink fed Aroclor 1254 for 4.5 mo. (Aulerich and Ringer 1977). While consumption of 0.69 mg/kg-d Aroclor 1254 reduced kit survivorship, no effects were observed at the 0.14 mg/kg-d exposure level. The 0.14 mg/kg-d exposure was considered to be a chronic NOAEL; the 0.69 mg/kg-d exposure was considered to be a chronic LOAEL Based on the results of Aulerich and Ringer (1977), shrews experiencing exposure ≥ LOAEL are likely to display reduced survivorship of young.

Selenium

The mammalian NOAELs and LOAELs for selenium were derived from a study of mice fed Se for 3 generations. (Schroeder and Mitchner 1971). Consumption of 0.76 mg/kg-d selenium resulted in reduced reproductive success, increased incidence of runts, and failure to breed. Only one dose level was tested. The study was considered to represent a chronic exposure. A NOAEL was estimated using a LOAEL-NOAEL correction factor of 0.1. The 0.076 mg/kg-d exposure was considered to be a chronic NOAEL; the 0.76 mg/kg-d exposure was considered to be a chronic LOAEL Based on the results of Schroeder and Mitchner (1971), shrews experiencing exposure ≥ LOAEL are likely to display impaired reproduction.

7.3.3 Biological Surveys

Mink survey

Results of the mink survey (see Sect. 7.2.2) indicate that mink are present on the ORR and within the WOCW, have large home ranges, and do not avoid the industrial facilities on the ORR. The methods employed in the study do not allow numbers or density of mink to be determined. Concentrations of metals in hair of the single mink collected from the WOCW were comparable to that from mink collected offsite.

7.3.4 Weight of Evidence

7.3.4.1 Short-tailed shrews

One line of evidence, literature toxicity data, was available to evaluate potential risk to short-tailed shrews in the WOCW. Point estimates of exposure indicated that 15 contaminants detected above background concentrations exceeded NOAELs with 12 also exceeding LOAELs (Table 7.9). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that Aroclor 1260, chromium, mercury, molybdenum, nickel, and selenium present significant watershed-wide risks to the shrew population in the WOCW. In addition, arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc present significant population-level risks within at least one subbasin (Table 7.27).

7.3.4.2 White-footed mice

One line of evidence, literature toxicity data, was available to evaluate potential risk to white-footed mice in the WOCW. Point estimates of exposure indicated that 10 contaminants exceeded NOAELs with 5 also exceeding LOAELs (Table 7.10). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant watershed-wide risk to the mouse population in the WOCW. However, chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

7.3.4.3 Red fox

One line of evidence, literature toxicity data, was available to evaluate potential risk to red fox in the WOCW. Point estimates of exposure indicated that 10 contaminants exceeded NOAELs with 5 also exceeding LOAELs (Table 7.11). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that only mercury presents a significant risks to the fox population in the WOCW.

7.3.4.4 White-tailed deer

One line of evidence, literature toxicity data, was available to evaluate potential risk to white-tailed deer in the WOCW. Point estimates of exposure indicated that 5 contaminants exceeded NOAELs with 3 also exceeding LOAELs (Table 7.12). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the deer population in the WOCW.

7.3.4.5 Red-tailed hawk

One line of evidence, literature toxicity data, was available to evaluate potential risk to red-tailed hawk in the WOCW. Point estimates of exposure indicated that 5 contaminants exceeded NOAELs with 3 also exceeding LOAELs (Table 7.13). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the hawk population in the WOCW.

7.3.4.6 Wild turkey

One line of evidence, literature toxicity data, was available to evaluate potential risk to wild turkey in the WOCW. Point estimates of exposure indicated that 4 contaminants exceeded NOAELs with 2 also exceeding LOAELs (Table 7.14). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the turkey population in the WOCW.

7.3.4.7 Mink

Two lines of evidence, biological survey data and literature toxicity data, were available to evaluate potential risks to mink within The WOCW. The biological survey data indicate that mink are present within the WOCW, but due to the sampling methods employed, estimates of the abundance of the mink population cannot be made from these data. Residue analysis indicates that mink in the WOCW have contaminant concentrations in hair similar to that in mink from offsite.

Point estimates of exposure indicated that 3 contaminants exceeded NOAELs with 2 also exceeding LOAELs (Tables 7.15). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the mink population in the WOCW.

7.3.5 Summary of Risks to Terrestrial Wildlife

Ecological risks were evaluated for terrestrial wildlife exposed to nonradionuclide contaminants in surface soil within each subbasin in the watershed for which surface soil data were available (radionuclide exposures are discussed in Chapter 9). Nonradiological data were available from 22 subbasins. Only one formal line of evidence, single chemical toxicity data, was available to evaluate potential risks for terrestrial wildlife receptors with the exception of biological surveys for mink.

Likely risks to short-tailed shrews were identified for 20 subbasins, 9 for white-footed mice, 10 for red fox, 3 for white-tailed deer, 6 for red-tailed hawks, 4 for wild turkeys, and 5 for mink (Table 7.17 through 7.23). The Intermediate Pond resulted in the highest risks for all receptors due to high soil mercury concentrations.

LOAELs for at least one wildlife receptor (short-tailed shrew, white-footed mouse, red fox, white-tailed deer, red-tailed hawk, wild turkey, or mink) were exceeded in at least one subbasin as a result of arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, selenium, thallium, zinc, and PCB-1260 (Tables 7.17 through 7.23). However, only mercury, molybdenum, nickel, selenium, and PCB-1260 for the shrew and mercury for the fox were predicted to result in potential watershed-wide effects. Fewer than 20% of the individuals in populations within the watershed were likely to exceed LOAELs for all other receptor-contaminant combinations. The Intermediate Pond was the primary contributor to mercury exposures; the average mercury concentration there was an order of magnitude higher than in any other subbasin. The WOC, Lower WOC/White Oak Lake, and Seep B subbasins were also major contributors to high mercury exposures. The SWSA 5 Drainage D-2 subbasin was the primary contributor to PCB-1260 exposures, followed by the Intermediate Pond and WOC subbasins. Seep C subbasin was the most significant contributor to molybdenum exposures. Selenium exposures were highest in the Seep A, Pit 4 South, and SWSA 5 N/WOC subbasins. Significant population-level risks within at least one subbasin from exposure to arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc were identified for short-tailed shrews (see Table 7.27 for list of subbasin/analyte combinations). Chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

7.4 UNCERTAINTIES CONCERNING RISKS TO WILDLIFE

7.4.1 Bioavailability of Contaminants

Bioavailability of contaminants was assumed to be comparable between soil and water from the WOCW and the diets used in the literature toxicity tests. Because bioavailability may not be comparable, exposure estimates based upon the contaminant concentrations may either under- or overestimate the actual contaminant exposure experienced.

7.4.2 Extrapolation from Published Toxicity Data

While published toxicity studies are available for mink, there are no published data for the other endpoints. To estimate toxicity of contaminants at the site, it was necessary to extrapolate from studies performed on test species (i.e., mallard ducks, ring-necked pheasant, and rats). While it was assumed that toxicity could be estimated as a function of body size, the accuracy of the estimate is not known. For example, hawks may be more or less sensitive to contaminants than ducks or pheasants, due to factors other than metabolic rate.

Additional extrapolation uncertainty exists for those contaminants for which data consisted of only LOAELs or tests were subchronic in duration. For either case, an uncertainty factor of 10 was employed to estimate NOAELs or chronic data. The uncertainty factor of 10 may either over- or underestimate the actual LOAEL-NOAEL or subchronic-chronic relationship.

Toxicity of PCBs to piscivorous wildlife was evaluated using toxicity data from studies on Aroclor 1254. Because toxicity of PCB congeners can vary dramatically, the applicability of data for Aroclor 1254 is unknown.

7.4.3 Variable Food Consumption

While food consumption by wildlife was assumed to be similar to that reported for the same or related species in other locations, the validity of this assumption cannot be determined. Food consumption by wildlife in the WOCW may be greater or less than that reported in the literature, resulting in either an increase or decrease in contaminant exposure.

7.4.4 Single Contaminant Tests vs Exposure to Multiple Contaminants in the Field

While wildlife in the WOCW are exposed to multiple contaminants concurrently, published toxicological values only consider effects experienced by exposures to single contaminants. Because some contaminants to which wildlife are exposed can interact antagonistically, single contaminant studies may overestimate their toxic potential. Similarly, for those contaminants that interact additively or synergistically, single contaminant studies may underestimate their toxic potential.

7.4.5 Inorganic Forms or Species Present in the Environment

Toxicity of metal species varies dramatically depending upon the valence state or form (organic or inorganic) of the metal. For example, arsenic (III), chromium (VI), and methyl mercury are more toxic than arsenic (V), chromium (III), and inorganic mercury, respectively. The available data on the contaminant concentrations in media do not report which species or form of contaminant was observed. Because benchmarks used for comparison represented the more toxic species/forms of the metals (particularly for arsenic, chromium, and mercury), if the less toxic species/form of the metal was actually present in media from the WOCW, potential toxicity at the sites may be overestimated.

7.4.6 Uptake Factors

Soil to biota uptake factors specific to the WOCW were unavailable. Therefore it was assumed that the uptake factors developed as part of the Bear Creek assessment were applicable. Due to the differing geologies and histories between the WOCW and Bear Creek, the Bear Creek uptake factors may over- or under estimate the actual biota concentrations in the WOCW. Uncertainties associated with literature-derived uptake factors may also result in over- or underestimates of actual biota concentrations.

7.4.7 Contaminant Concentrations in Unanalyzed Food Types

Uptake factors were not available for all food types consumed by the endpoint species. It was assumed that the uptake factors for food types for which we had data were representative of that for those without data. Due to different life histories among food types, contaminant burdens are likely to differ from the measured data. Therefore, assuming comparability among food types may either over- or underestimate exposure.

7.4.8 Monte Carlo Simulation

To perform Monte Carlo simulations, distributions must be assigned to parameters. Distributions for uptake factors and soil concentrations were determined using available data, but sample sizes within some subbasins were limited. The distributions used may or may not accurately reflect the actual distribution of these parameters within the WOCW.

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)
1,1,1-Trichloroethane	2.5	3.47E-01	o,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j	
1,1,2,2-Tetrachloroethane	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j	
1,1,2-Trichloroethane	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
1,1-Dichloroethane	1.8	8.82E-01	f,g	5.00E-02	m	1.58E-06	i	1.58E-06	f,j	
1,1-Dichloroethene	1.8	8.82E-01	f,g	5.00E-02	m	1.58E-06	i	1.58E-06	f,j	
1,2-Benzenedicarboxylic acid				5.00E-02	m					
1,2-Dichloroethane	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j	
1,2-Dichloroethene	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j	
1,2-Dichloropropane	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
2,4-D	2.5	3.47E-01	f,g	5.00E-02	m	4.79E-06	i	4.79E-06	f	
2,4-Dichlorophenol	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j	
2,4-Dimethyl-2-pentanol				5.00E-02	m					
2,4-Dimethyl-3-heptanone				5.00E-02	m					
2,4-Dinitrophenol	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j	
2,4-Dinitrotoluene	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
2,5-Hexanedione				5.00E-02	m					
2,6-Dinitrotoluene	1.7	1.01E+00	f,g	5.00E-02	m	1.26E-06	i	1.26E-06	f,j	
2-Butanone	0.27	6.76E+00	f,g	5.00E-02	m	4.68E-08	i	4.68E-08	f,j	
2-Chlorophenol	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j	
2-Cyclohexen-1-one				5.00E-02	m					
2-Heptanol acetate				5.00E-02	m					
2-Hexanone	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j	
2-Methylnaphthalene	3.9	5.39E-02	f,g	5.00E-02	m	2.00E-04	i	2.00E-04	f,j	
2-Methylphenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
2-Nitroaniline	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j	
3,3'-Dichlorobenzidine	3.5	9.18E-02	f,g	5.00E-02	m	7.94E-05	i	7.94E-05	f,j	
3-Methylpentane				5.00E-02	m					
4,4'-DDD	5.8	4.30E-03	f,g	5.00E-02	m	1.26E-02	i	1.26E-02	f	
4,4'-DDE	5.7	2.62E-02	f	5.00E-02	m	4.90E-02	i	4.90E-02	f	
4,4'-DDT	6.36	3.96E-03	f	5.00E-02	m	2.82E-02	i	2.82E-02	f	
4-Chloro-3-methylphenol				5.00E-02	m					
4-Chlorobenzenamine	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j	
4-Chlorophenylphenylether				5.00E-02	m					
4-Hydroxy-4-methyl-2-pentanone				5.00E-02	m					
4-Methyl-2-pentanone	1.2	1.96E+00	f,g	5.00E-02	m	3.98E-07	i	3.98E-07	f,j	
4-Methylphenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
4-Nitrophenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
5-Methyl-2-hexanone				5.00E-02	m					

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
5-Methyl-5-hexen-2-one				5.00E-02	m						
6-(Acetyloxy)-2-hexanone				5.00E-02	m						
Acenaphthene	4.33	3.04E-02	f,g	5.00E-02	m	5.37E-04	i	5.37E-04	f,j		
Acenaphthylene	4.07	4.30E-02	f,g	5.00E-02	m	2.95E-04	i	2.95E-04	f,j		
Acetone	-0.24	1.33E+01	f,g	5.00E-02	m	1.45E-08	i	1.45E-08	f,j		
Aldol Condensation Product				5.00E-02	m						
Aldrin	3	5.34E-03	f	5.60E+00	k	8.51E-02	i	8.51E-02	f		
alpha BHC	3.8	9.73E-02	f, o	2.60E+00	n	1.66E-02	i, o	1.66E-02	f, o		
alpha-Chlordane	5.5	3.87E-03	f, p	5.00E-02	m	7.41E-03	i, p	7.41E-03	f, p		
Aluminum		3.00E-02	b	1.18E-01	a	1.50E-03	i	1.50E-03	e	1.40E-02	a
Anthracene	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Antimony		1.00E-02	d			1.00E-03	i	1.00E-03	e		
Arsenic		3.20E-02	b	8.11E-01	a	2.00E-03	i	2.00E-03	e	8.00E-03	a
Barium		2.37E-01	b	1.60E-01	a	9.00E-03	c	1.50E-04	e	6.10E-02	a
Benz(A)Anthracene	5.7	4.91E-03	f,g	4.32E-02	l	1.26E-02	i	1.26E-02	f,j		
Benzene	2.1	5.92E-01	f,g	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Benzenemethanol	1.1	2.24E+00	f,g	5.00E-02	m	3.16E-07	i	3.16E-07	f,j		
Benzidine	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Benzo(A)Pyrene	6	1.41E-02	f	5.44E-02	l	2.51E-02	i	2.51E-02	f,j		
Benzo(B)Fluoranthene	5	1.25E-02	f,g	3.36E-02	l	2.51E-03	i	2.51E-03	f,j		
Benzo(ghi)peryline	6.6	1.48E-03	f,g	5.00E-02	m	1.00E-01	i	1.00E-01	f,j		
Benzo(K)Fluoranthene	5	1.25E-02	f,g	3.36E-02	l	2.51E-03	i	2.51E-03	f,j		
Benzoic Acid	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j		
Beryllium		4.00E-02	b	1.18E+00	a	1.00E-03	i	1.00E-03	e		
beta BHC	3.8	9.73E-02	f, o	2.60E+00	n	1.66E-02	i, o	1.66E-02	f, o		
Bis(2-Chloroethyl)Ether	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Bis(2-Chloroisopropyl)Ether Technical	2.1	5.92E-01	f,g,h	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Bis(2-Ethylhexyl)Phthalate	5.1	1.09E-02	f,g	5.00E-02	m	3.16E-03	i	3.16E-03	f,j		
Boron		1.00E+00	e			8.00E-04	i	8.00E-04	e		
Bromodichloromethane	2.1	5.92E-01	f,g	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Bromoform	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j		
Bromomethane	1.2	1.96E+00	f,g	5.00E-02	m	3.98E-07	i	3.98E-07	f,j		
Butyl 2-methylpropyl phthalate				5.00E-02	m						
Butylbenzylphthalate	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
C14H22O				5.00E-02	m						
Cadmium		1.12E+00	b	6.41E+00	a	8.00E-01	c	5.50E-04	e	1.32E-01	a
Calcium		3.87E+00	b	1.90E+00	a	4.00E-02	c	7.00E-04	e	9.38E+00	a
Carbazole	3.8	6.16E-02	f,g	5.00E-02	m	1.58E-04	i	1.58E-04	f,j		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
Carbon disulfide	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j		
Carbon tetrachloride	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Cerium		2.00E-03	d			4.00E-03	c	7.50E-04	e		
Cesium		5.30E-02	c			1.00E+01	c	2.00E-02	e		
Chlordane	5.5	3.87E-03	f	5.00E-02	m	7.41E-03	i	7.41E-03	f		
Chlorobenzene	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Chloroethane	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
Chloroform	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j		
Chloromethane	0.91	2.88E+00	f,g	5.00E-02	m	2.04E-07	i	2.04E-07	f,j		
Chromium		6.70E-02	b	8.33E+00	a	5.50E-03	i	5.50E-03	e	2.21E-01	a
Chrysene	5.7	4.91E-03	f,g	5.00E-02	m	1.26E-02	i	1.26E-02	f,j		
cis-1,3-Dichloropropene	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
Cobalt		1.20E-02	b	2.91E-01	a	2.00E+00	c	2.00E-02	e	1.00E-02	a
Copper		3.81E-01	b	8.26E-01	a	5.00E-01	c	1.00E-02	e	7.40E-01	a
Cyanide	1.1	2.24E+00	f,g	5.00E-02	m	3.16E-07	i	3.16E-07	f,j		
delta-BHC	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Di-n-butylphthalate	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Di-n-octylphthalate	9.2	4.66E-05	f,g	5.00E-02	m	3.98E+01	i	3.98E+01	f,j		
Dibenz(a,h)anthracene	6.8	1.14E-03	f,g	5.00E-02	m	1.58E-01	i	1.58E-01	f,j		
Dibenzofuran				5.00E-02	m						
Dibromochloromethane	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j		
Dieldrin	4.6	2.44E-02	f	5.50E+00	n	7.94E-03	i	7.94E-03	f		
Diethylphthalate	2.5	3.47E-01	f,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j		
Dimethylbenzene	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j		
Dimethylphthalate	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
Dioctyl hexanedioate				5.00E-02	m						
Docosane				5.00E-02	m						
Endosulfan I				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endosulfan II				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endosulfan sulfate				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endrin	5.6	3.78E-03	f	1.90E+00	n	1.20E-02	i	1.20E-02	f		
Endrin aldehyde		3.78E-03	f, r	5.00E-02	m	1.20E-02	r	1.20E-02	r		
Endrin ketone		3.78E-03	f, r	5.00E-02	m	1.20E-02	r	1.20E-02	r		
Ethylbenzene	3.1	1.56E-01	f,g	5.00E-02	m	3.16E-05	i	3.16E-05	f,j		
Europium		2.00E-03	d			5.00E-03	i	5.00E-03	e		
Fluoranthene	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Fluorene	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Gallium		3.00E-03	d			5.00E-04	i	5.00E-04	e		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
gamma-Chlordane	5.5	3.87E-03	f, p	5.00E-02	m	7.41E-03	p	7.41E-03	p		
Gold		1.00E-01	d			8.00E-03	i	8.00E-03	e		
Hafnium		3.00E-03	r			1.00E-03	i	1.00E-03	e		
Heptachlor	4.3	8.28E-03	f	1.00E+00	n	1.55E-02	i	1.55E-02	f		
Heptachlor Epoxide	5.4	6.00E-03	f	1.00E+00	n	7.94E-02	i	7.94E-02	f		
Hexachlorobenzene	6.2	1.20E-01	f	5.00E-02	m	4.47E-02	i	4.47E-02	f		
Hexachlorobiphenyl				5.00E-02	m						
Hexachloroethane	3.8	6.16E-02	f,g	5.00E-02	m	1.58E-04	i	1.58E-04	f,j		
Hexadecanoic acid				5.00E-02	m						
Hexadecanoic acid ester				5.00E-02	m						
Hexanedioic acid ester				5.00E-02	m						
Hydrazobenzene	-1.1	4.19E+01	f,g	5.00E-02	m	2.00E-09	i	2.00E-09	f,j		
Indeno(1,2,3-Cd)Pyrene	6.6	1.48E-03	f,g	5.00E-02	m	1.00E-01	i	1.00E-01	f,j		
Iron		1.40E-02	b	7.80E-02	a	1.00E+00	c	2.00E-02	e	7.00E-03	a
Isobutanol	0.83	3.21E+00	f,g	5.00E-02	m	1.70E-07	i	1.70E-07	f,j		
Lanthanum		2.50E-03	e			1.00E-01	c	3.00E-04	e		
Lead		5.20E-02	b	1.64E-01	a	3.00E-04	i	3.00E-04	e	4.50E-02	a
Lindane	4.1	9.73E-02	f	2.60E+00	n	1.66E-02	i	1.66E-02	f		
Lithium		3.40E-02	b	2.17E-01	a	1.00E-02	i	1.00E-02	e	3.30E-02	a
Lutetium		2.50E-03	e			4.50E-03	i	4.50E-03	e		
Magnesium		1.70E+00	b	4.25E-01	a	5.00E-03	i	5.00E-03	e	8.75E-01	a
Manganese		3.62E-01	b	1.17E-01	a	5.00E-02	c	4.00E-04	e	5.00E-03	a
MCPA	2.3	4.53E-01	f,g	5.00E-02	m	5.01E-06	i	5.01E-06	f,j		
Mercury		9.50E-02	b	4.44E+00	a	3.00E-02	c	2.50E-01	e	7.47E-01	a
Methoxychlor	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Methylcyclopentane				5.00E-02	m						
Methylene chloride	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Methylpyrene				5.00E-02	m						
Molybdenum		8.50E-02	b	2.09E+00	a	1.00E+00	c	6.00E-03	e	1.00E-02	a
Mono(2-ethylhexyl) phthalate				5.00E-02	m						
N-Nitroso-di-n-propylamine	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
N-Nitrosodiphenylamine	3.1	1.56E-01	f,g	5.00E-02	m	3.16E-05	i	3.16E-05	f,j		
Naphthalene	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j		
Nickel		1.56E-01	b	5.78E+00	a	6.00E-03	i	6.00E-03	e	2.32E-01	a
Nitrobenzene	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j		
Nitrosodiethylamine, N-	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j		
Octamethylcyclotetrasiloxane				5.00E-02	m						
Osmium		3.75E-03	e			4.00E-01	i	4.00E-01	e		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
PCB-1016	5.9	3.76E-03	f,g	5.00E-02	m	2.00E-02	i	2.00E-02	f,j		
PCB-1221	4.1	4.13E-02	f,g	5.00E-02	m	3.16E-04	i	3.16E-04	f,j		
PCB-1232	3.2	1.37E-01	f,g	5.00E-02	m	3.98E-05	i	3.98E-05	f,j		
PCB-1242	4.1	4.13E-02	f,g	5.00E-02	m	3.16E-04	i	3.16E-04	f,j		
PCB-1248	5.8	4.30E-03	f,g	5.00E-02	m	1.58E-02	i	1.58E-02	f,j		
PCB-1254	6	4.25E-03	f	6.25E-01	a	5.25E-02	i	5.25E-02	f		
PCB-1260	7.1	7.62E-04	f,g	1.24E+01	a					5.22E+00	a
Pentachlorophenol	5.9	3.76E-03	f,g	5.00E-02	m	2.00E-02	i	2.00E-02	f,j		
Phenanthrene	4.6	2.12E-02	f,g	5.00E-02	m	1.00E-03	i	1.00E-03	f,j		
Phenol	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j		
Polychlorinated biphenyl	6	3.30E-03	f,g	5.00E-02	m	2.51E-02	i	2.51E-02	f,j		
Polycyclic aromatic hydrocarbon (PAH)				5.00E-02	m						
Potassium		9.24E+00	b	5.96E+00	a	2.00E-02	i	2.00E-02	e	5.11E+00	a
Prometon	2.3	4.53E-01	f,g	5.00E-02	m	5.01E-06	i	5.01E-06	f,j		
Propanoic acid, 2-methyl-, 1-(1				5.00E-02	m						
Pyrene	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Rubidium		2.25E-01	c			1.50E-02	i	1.50E-02	e		
Scandium		2.00E-03	d			1.50E-02	i	1.50E-02	e		
Selenium		6.00E-02	b	1.40E+00	a	9.00E+00	c	1.50E-02	e	2.31E-01	a
Silicon		8.75E-02	e			4.00E-03	i	4.00E-03	e		
Silver		4.90E-02	b	1.53E+01	a	2.00E+00	c	3.00E-03	e		
Sodium		6.18E-01	b	6.45E+01	a	5.50E-02	i	5.50E-02	e	1.02E+01	a
Strontium		1.82E-01	b	2.78E-01	a	8.00E-02	c	3.00E-04	e	2.60E-02	a
Styrene	2.9	2.04E-01	f,g	5.00E-02	m	2.00E-05		2.00E-05	f,j		
Sulfate											
Sulfide											
Terbium		2.50E-03	e			4.50E-03	i	4.50E-03	e		
Tetrachloroethene	2.6	3.04E-01	f,g	5.00E-02	m	1.00E-05	i	1.00E-05	f,j		
Thallium		2.30E-02	b			4.00E-02	i	4.00E-02	e		
Tin		3.00E-01	d			8.00E-02	i	8.00E-02	e		
Titanium		1.38E-03	e			3.00E-02	i	3.00E-02	e		
Toluene	2.7	2.66E-01	f,g	5.00E-02	m	1.26E-05	i	1.26E-05	f,j		
Totarol				5.00E-02	m						
Toxaphene	4.8	1.63E-02	f,g	5.00E-02	m	1.62E-03	i	1.62E-03	f		
trans-1,2-Dichloroethene	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j		
trans-1,3-Dichloropropene	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
trans-4-Chlorocyclohexanol				5.00E-02	m						
Trichloroethene	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
Trichlorofluoromethane	2.5	3.47E-01	f,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j		
Trimethylsilanol				5.00E-02	m						
Uranium		2.00E-03	b	6.30E-02	a	1.00E+00	c	2.00E-04	e		
Vanadium		8.40E-02	b	8.80E-02	a	2.50E-03	i	2.50E-03	e		
Vinyl acetate	0.73	3.66E+00	f,g	5.00E-02	m	1.35E-07		1.35E-07	f,j		
Vinyl Chloride	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
Ytterbium		2.50E-03	e			4.00E-03	i	4.00E-03	e		
Zinc		7.16E-01	b	6.48E+00	a	7.00E+00	c	1.00E-01	e	2.38E+00	a

[1] = All transfer factors based on wet tissue concentrations.

a = ES/ER/TM-197

b = ES/ER/TM-198

c = IAEA 1994

d = NCRP 1989

e = Baes et al., 1984

f = Travis and Arms 1988

g = Plant BAF calculated using the following equation presented
by Travis and Arms (1988) unless otherwise noted:
log (plant Uptake Factor) = 1.588 - 0.578 log Kow; if log Kow < 5,
BAF assumed to be 0.02 assuming plant are 80% water.

h = EPA 1990

i = surrogate mammal BAF was used

j = Mammal BAF calculated using the following equation presented
by Travis and Arms (1988): log BTF = log Kow - 7.6
where BAF = BTF * 50

k = Korschgen 1971.

l = Beyer and Stafford, 1993

m = Menzie et al., 1992

n = ABB, 1996

o = Used value for lindane

p = Used value for chlordane

q = Used value for endosulfan

r = Used value for endrin

Conversion factors:

wet wt = dry weight (1-%H20)

% H2O in mammals = 0.68

% H2O in Invertebrates = 0.84

% H2O in terrestrial dicots = 0.85

% H2O in terrestrial grass = 0.9

% H2O in terrestrial fodder = .81

% H2O in general plants using Travis and Arms equation = .75

Table 7.2. Life history parameters for the short-tailed shrew (*Blarina brevicauda*)

Parameter	Value[a]	Comments	Reference
Body Weight	**0.015** ± 0.00078 kg	New Hampshire (field)	Schlessinger and Potter 1974
Food Consumption Rate	0.01 kg/d	larch sawfly diet (lab)	Buckner 1964
	0.00795 ± 0.00017 kg/d	mealworm diet (lab)	Barrett and Stueck 1976
	mean = **0.009** kg/d		
Water Consumption Rate	0.223 ml/g bw/d		Chew 1951
	0.033 L/d	assuming a 0.015 kg bw	
Soil Consumption Rate	13% of diet		Talmage and Walton 1993
	0.00117 kg/d	assuming diet of 0.009 kg/d	
Diet Composition	earthworms 31.4% slugs/snails 27.1% soil/litter invert 13.2% fungi 8.4% misc. animals 8.1% coleoptera 5.9% vegetation 5.4%	percent volume in diet in summer in New York	Whitaker and Ferraro 1963
Home Range	**0.39** ± 0.036 ha	Manitoba bog	Buckner 1966
Habitat Requirements	broad and variable but requires >50% herbaceous cover		Miller and Getz 1977
	forest, wetlands, and grasslands. most abundant in hardwood forests with deep litter and humus.		van Zyll de Jong 1983
Population Density	2.3 /ha - winter 5.2 /ha - spring 9.3 /ha -summer 8.1 /ha - fall	Illinois - alfalfa, tallgrass, and bluegrass; means derived from graph.	Getz 1989
	2.5-45/ha	Depending on habitat	
Behavior	nocturnal, semifossorial, spends little time above surface		George et al. 1986
	active year-round - does not hibernate		EPA 1993a

Table 7.2 (continued)

Parameter	Value[a]	Comments	Reference
Other	appear to be unpalatable to most predators due to lateral gland		van Zyll de Jong 1983

[a] Suggested values for use in exposure assessment are in bold.

Table 7.3. Life history parameters for the white-footed mouse (*Peromyscus leucopus*)

Parameter	Value[a]	Comments	Reference
Body Weight	**0.022** kg		Green and Millar 1987
Food Consumption Rate	**0.0034** kg/d	lab study	Green and Millar 1987
Water Consumption Rate	**0.0066** L/d	nonreproductive ♀ (lab)	Oswald et al. 1993
Soil Consumption Rate	<2%		Beyer et al. 1994
	0.000068 kg/d	assuming diet of 0.0034 kg/d and a 2% soil consumption rate	
Diet Composition	omnivorous and opportunistic		
	arthropods - 57% seeds, fruit, vegetation - 34%	Virginia	Wolff et al. 1985
	arthropods - 30% seeds, fruit, vegetation - 67%	Indiana	Whitaker 1966
	arthropods - 50% seeds, fruit, vegetation - 48%	Illinois	Batzli 1977
Home Range	**0.059** ha	mean:♂+♀; Virginia, mixed deciduous forest	Wolff 1985
Habitat Requirements	wooded, brushy areas; sometimes open areas		Burt and Grossenheider 1976
Population Density	6 - 57 /ha	Virginia, mixed deciduous forest	Wolff 1985
Behavior	while semi-arboreal, spends most of time on ground.		Lackey et al. 1985
	primarily nocturnal		
	enters torpor to reduce metabolic demands in winter and during food stress		EPA 1993a

[a] Suggested values for use in exposure assessment are in bold.

Table 7.4. Life history parameters for red fox (*Vulpes fulva*)

Parameter	Value[a]	Comments	Reference
Body Weight	5.25 ± 0.18 kg (♂) 4.13 ± 0.11 kg (♀)	Illinois	Storm et al. 1976
	4.82 ± 0.081 kg (♂) 3.94 ± 0.079 kg (♀)	Iowa	
	4.5 kg	mean ♂+♀ for both Illinois and Iowa	
Food Consumption Rate	0.596 kg/d	see calculation below[b]	Vogtsberger and Barret 1973
	0.31 kg/d	0.069 g/g/d for nonbreeding adult times 4.5 kg bw	Sargent 1978
	0.45 kg/d	mean of both estimates	
Water Consumption Rate	**0.38** L/d	Estimated using allometric equation[c]; assuming 4.5 kg bw	Calder and Braun 1983
Soil Consumption Rate	2.8%		Beyer et al. 1994
	0.0126 kg/d	assuming diet of 0.45 kg/d	
Diet Composition	mammals - 68.8% birds - 12.0% plants - 10.4% insects - 0.9% misc. - 5.5%	Maryland, Appalachian region	Hockman and Chapman 1983
Home Range	699 ± 137 ha (♀ spring)	Minnesota - forest, field, swamp	Sargent 1972
	717 ha (♂ all year) 96 ha (♀ all year)	Wisconsin - multiple habitats	Ables 1969

Table 7.4 (continued)

Parameter	Value[a]	Comments	Reference
Habitat Requirements	wide and diverse - occur in many habitats prefer mixture of forest and open habitat		EPA 1993a Burt and Grossenheider 1976
Population Density	0.046 - 0.077 /ha	"good fox range" in North America	EPA 1993a
Behavior	active year round - does not hibernate		EPA 1993a

[a] Suggested values for use in exposure assessment are in bold.

[b] The following parameters were presented by Vogtsberger and Barret (1973):

food ingestion = 223 kcal/kg bw/d
energy content of vertebrate food = 5.606 kcal/g dry wt.
wet-dry weight conversion = 1 g wet wt = 0.3 g dry wt

therefore:

223 kcal/kg bw/d x 4.5 kg bw = 1003.5 kcal/d

1003.5 kcal/d x 1g dry wt./5.606 kcal = 179 g dry/d

179 g dry/d x 1 g wet/0.3 g dry (wet-dry conversion) = 596 g/d

[c] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.5. Life history parameters for white-tailed deer (*Odocoileus virginianus*)

Parameter	Value[a]	Comments	Reference
Body Weight	68 kg (♂) 45 kg (♀) **56.5 kg** (mean♂+♀)		Smith 1991
Food Consumption Rate	**1.74 kg/d**		Mautz et al. 1976
Water Consumption Rate	**3.7 L/d**	Estimated using allometric equation[b] assuming 56.5 kg bw	Calder and Braun 1983
Soil Consumption Rate	<2%		Beyer et al. 1994
	0.0348 kg/d	assuming 2% soil and 1.74 kg/d food consumption rates	
Diet Composition	exclusively herbivorous		
	diet diverse and variable, depends on availability.		Martin et al. 1951
	major foods: - buds and twigs of trees and shrubs - grasses and forbs (summer) - mast and fruits (fall)		Smith 1991
Home Range	59 - 520 ha		Marchinton and Hirth 1984
Habitat Requirements	uses a wide variety of habitats; favors forest-field-farmland mosaic; population density directly related to number and distribution of forest openings		Smith 1991
Population Density	0.06 /ha	eastern mixed deciduous forest - Tennessee	Barber 1984
	0.39 - 0.78 /ha	oak-hickory forest - midwest	Torgerson and Porath 1984
	0.1704/ha	(calculated based upon 2000 deer on the ORR and available habitat)	J. Evans (pers. comm., 1995)

Table 7.5 (continued)

Parameter	Value[a]	Comments	Reference
Behavior	generally crepuscular		Smith 1991
	active year-round; does not hibernate		

[a] Suggested values for use in exposure assessment are in bold.
[b] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.6. Life History parameters for red-tailed hawks (*Buteo jamaicensis*)

Parameter	Value[a]	Comments	Reference
Body Weight	1.028 kg (♂) 1.224 kg (♀) **1.126** kg (mean♂+♀)		Dunning 1984
Food Consumption Rate	**0.109** kg/d		Craighead and Craighead 1969
Water Consumption Rate	**0.064** L/d	Estimated using allometric equation[b]; assuming 1.126 kg bw	Calder and Braun 1983
Soil Consumption Rate	while some soil attached to prey may be ingested, amount is assumed to negligible		
Diet Composition	predominantly small mammals small mammal - 78.5 % bird - 8.5 % snake - 13.0 %	 Oregon - pasture and wheat fields	EPA 1993a Janes 1984
Home Range	233 ha 1936 ha (957 - 2465 ha range)	Oregon - pasture and wheat fields Colorado - prairie-pinyon/juniper woodland; mean of 4 birds; 95% ellipse and systematic relocation	Janes 1984 Anderson and Rongstad 1989
Habitat Requirements	use wide range of habitats. prefer landscapes containing mixture of oldfields, wetlands and pasture for foraging with trees interspersed for perching and nesting		EPA 1993a DeGraaf et al. 1981
Population Density	0.03 - >0.005 pairs/ha		EPA 1993a
Behavior	territorial throughout year northerly populations migrate; those in the south do not		Brown and Amadon 1968[b] National Geographic Society 1987

[a] Suggested values for use in exposure assessment are in bold.
[b] Allometric equation for estimation of water consumption by birds is:

$$W=0.059(bw)^{0.67}$$

Table 7.6 (continued)

where:	W	=	water consumption (L/d)
	bw	=	body weight (kg)

Table 7.7. Life History Parameters for the Wild Turkey (*Meleagris gallopavo*)

Parameter	Value[a]	Comments	Reference
Body Weight	7.400 kg (♂) 4.222 kg (♀) **5.8 kg** (mean♂+♀)		Dunning 1984
Food Consumption Rate	13.6 g/lb bw/d **0.174** kg/d	 assuming 5.8 kg bw	Korschgen 1967
Water Consumption Rate	**0.19** L/d	estimated using allometric equation[c] assuming 5.8 kg bw	Calder and Braun 1983
Soil Consumption Rate	9.3 % **0.0162** kg/d	 assuming 0.174 kg/d food consumption rates	Beyer et al. 1994
Diet Composition	plant material (mast, fruit, seeds, some foliage) - 90.3% animal material (insects, crayfish, snails, salamanders) - 9.7 %		Korschgen 1967
Home Range	150 - 190 ha		Pough 1951[b]
Habitat Requirements	mast-producing woodlands with associated fields and abundant water		Schorger 1966[b]
Population Density	0.03 /ha 0.06 - 0.076 /ha **0.0426 /ha** (calculated based on @ 500 turkey observed on ORR and suitable habitat)	West Virginia in 'ideal' habitat Oak Ridge Reservation	Uhling 1950[b] Pough 1951[b] Personal Communication, Jim Evans 1995
Behavior	forage primarily on the ground roost in trees at night year-round resident; does not migrate		National Geographic Society 1987

[a] Suggested values for use in exposure assessment are in bold.

[b] Cited in DeGraaf et al. 1981.

[c] Allometric equation for estimation of water consumption for birds is:

Table 7.7 (continued)

$$WIR = 0.059(BW)^{0.67}$$

where:

WIR= water ingestion rate (L water/individual/day).

Table 7.8. Life history parameters for mink

Parameter	Value	Comments	Reference
Body Weight	**1.0** kg (mean ♂+♀)		EPA 1993b
Food Consumption Rate	**0.137** kg/d (mean ♂+♀)		Bleavins and Aulerich 1981
Water Consumption Rate	**0.099** L/d	estimated using allometric equation[a] assuming 1.0 kg bw	Calder and Braun 1983
Diet Composition	Diverse diet includes: mammals, fish, aquatic invertebrates, amphibians, and birds		Hamilton 1940, Sealander 1943, Korschgen 1958, Burgess and Bider 1980 Alexander 1977
	Proportion of aquatic prey (fish, amphibians, inverts, etc.) = 0.546±0.21	Proportion represents means of values from five studies	
	fish sizes: 0-10 cm=72% 11-20 cm=28%		
Home Range	2.63 km (♂) 1.85 km (♀)	stream - Sweden	Gerell 1970
	770 ha (♂)	prairie potholes, Manitoba	Arnold and Fritzell 1987
		range size and shape depends on habitat - linear along streams, circular in marshes	EPA 1993a.
Habitat Requirements	aquatic habitats - streams, lakes, marshes;		Burt and Grossenheider 1976
Population Density	0.03 - 0.085 /ha	river - Montana	Mitchell 1961
	0.6/km	river - Michigan	EPA 1993a
Behavior	nocturnal active year-round, does not hibernate		EPA 1993a

[a] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.9. Exposure (mg/kg/d) and risk estimates for short-tailed shrews exposed to contaminants in surface soil subbasins in the White Oak Creek watershed

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 5 Seep A	Inorganics	Antimony	2/2	0.32	2.15	0.22
SWSA 5 Seep B East	Inorganics	Antimony	1/1	0.27	1.78	0.18
SWSA 5 Seep B West	Inorganics	Antimony	1/2	0.48	3.25	0.33
SWSA 5 Seep C	Inorganics	Antimony	3/6	0.80	5.38	0.54
SWSA 5 Trib 1	Inorganics	Antimony	2/5	0.26	1.72	0.17
SWSA 5 WOC	Inorganics	Antimony	2/9	0.27	1.79	0.18
SWSA 6 South	Inorganics	Arsenic	1/1	12.20	81.33	8.14
W6MS1	Inorganics	Arsenic	6/6	6.43	42.87	4.29
W6MS3	Inorganics	Arsenic	10/11	2.74	18.27	1.83
East Seep	Inorganics	Barium	3/3	53.80	4.56	1.24
HF-2	Inorganics	Barium	2/2	167.00	14.15	3.84
HRE	Inorganics	Barium	7/7	44.60	3.78	1.03
Intermediate Pond	Inorganics	Barium	15/15	31.90	2.70	0.73
Lower WOC	Inorganics	Barium	12/12	31.20	2.64	0.72
NHF	Inorganics	Barium	3/3	38.80	3.29	0.89
PIT 4 South	Inorganics	Barium	2/2	46.30	3.92	1.06
SWSA 4 Main	Inorganics	Barium	3/3	79.70	6.75	1.83
SWSA 5 Drainage D-2	Inorganics	Barium	5/5	36.90	3.13	0.85
SWSA 5 Seep C	Inorganics	Barium	15/15	47.90	4.06	1.10
SWSA 5 Trib 1	Inorganics	Barium	17/17	30.90	2.62	0.71
SWSA 5 WOC	Inorganics	Barium	22/22	35.10	2.97	0.81
SWSA6 East	Inorganics	Barium	4/4	38.80	3.29	0.89
West Seep	Inorganics	Barium	32/32	26.10	2.21	
SWSA 4 Main	Inorganics	Beryllium	3/3	2.13	1.47	
W6MS1	Inorganics	Beryllium	6/6	1.54	1.06	
HRE	Inorganics	Cadmium	3/7	9.71	4.58	0.46
Intermediate Pond	Inorganics	Cadmium	14/14	4.78	2.25	0.23
Lower WOC	Inorganics	Cadmium	12/12	2.75	1.30	0.13
SWSA 5 Seep A	Inorganics	Cadmium	2/5	3.23	1.52	0.15
SWSA 5 Seep B West	Inorganics	Cadmium	1/2	2.79	1.32	0.13
SWSA 5 Seep C	Inorganics	Cadmium	4/15	2.69	1.27	0.13
SWSA 6 South	Inorganics	Cadmium	1/1	12.60	5.94	0.59
SWSA6 East	Inorganics	Cadmium	4/4	21.60	10.19	1.02
W6MS1	Inorganics	Cadmium	6/6	17.80	8.40	0.84
W6MS3	Inorganics	Cadmium	10/11	11.90	5.61	0.56
West Seep	Inorganics	Cadmium	19/32	10.00	4.72	0.47
WOC	Inorganics	Cadmium	6/6	4.71	2.22	0.22
HF-2	Inorganics	Chromium	2/2	853.00	118.31	29.50
HRE	Inorganics	Chromium	7/7	334.00	46.32	11.50
Lower WOC	Inorganics	Chromium	12/12	446.00	61.86	15.40
WOC	Inorganics	Copper	6/6	59.40	1.78	1.35
Intermediate Pond	Inorganics	Mercury	14/14	98.00	1394.03	279.00
Lower WOC	Inorganics	Mercury	12/12	8.15	115.93	23.20
SWSA 5 Seep B West	Inorganics	Mercury	1/2	5.49	78.09	15.60
SWSA 5 Trib 1	Inorganics	Mercury	4/16	0.75	10.73	2.14
SWSA 5 WOC	Inorganics	Mercury	7/21	0.41	5.83	1.17
WOC	Inorganics	Mercury	6/6	8.80	125.18	25.00
HF-2	Inorganics	Molybdenum	2/2	3.86	12.49	1.25

Table 9 (continued)

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
Intermediate Pond	Inorganics	Molybdenum	15/15	5.61	18.16	1.81
Lower WOC	Inorganics	Molybdenum	12/12	4.56	14.76	1.47
PIT 4 South	Inorganics	Molybdenum	2/2	5.60	18.12	1.81
SWSA 5 Seep B West	Inorganics	Molybdenum	1/1	4.40	14.24	1.42
SWSA 5 Seep C	Inorganics	Molybdenum	4/4	9.73	31.49	3.15
WOC	Inorganics	Molybdenum	6/6	4.77	15.44	1.54
Intermediate Pond	Inorganics	Nickel	15/15	205.00	2.33	1.16
SWSA 4 Main	Inorganics	Nickel	3/3	27900.00	317.41	159.00
SWSA6 East	Inorganics	Nickel	4/4	213.00	2.42	1.21
W6MS1	Inorganics	Nickel	6/6	219.00	2.49	1.24
West Seep	Inorganics	Nickel	32/32	155.00	1.76	0.88
East Seep	Inorganics	Selenium	1/3	1.10	2.50	1.51
HF-2	Inorganics	Selenium	2/2	0.71	1.62	0.98
Intermediate Pond	Inorganics	Selenium	12/14	0.64	1.45	0.88
Lower WOC	Inorganics	Selenium	9/12	0.89	2.02	1.22
PIT 4 South	Inorganics	Selenium	2/2	1.10	2.50	1.51
SWSA 4 Main	Inorganics	Selenium	1/3	1.83	4.16	2.52
SWSA 5 N /WOC	Inorganics	Selenium	2/4	1.28	2.91	1.77
SWSA 5 Seep A	Inorganics	Selenium	5/5	3.43	7.80	4.73
SWSA 5 Seep B West	Inorganics	Selenium	2/2	1.19	2.70	1.64
SWSA 5 Seep C	Inorganics	Selenium	4/13	0.72	1.65	1.00
SWSA 5 Trib 1	Inorganics	Selenium	4/13	0.97	2.21	1.34
SWSA 5 WOC	Inorganics	Selenium	3/19	0.79	1.78	1.08
WOC	Inorganics	Selenium	2/6	0.98	2.22	1.34
East Seep	Inorganics	Thallium	1/3	0.20	11.89	1.19
Intermediate Pond	Inorganics	Thallium	13/15	0.07	4.11	0.41
Lower WOC	Inorganics	Thallium	12/12	0.06	3.96	0.40
PIT 4 South	Inorganics	Thallium	2/2	0.09	5.71	0.57
SWSA 5 Seep C	Inorganics	Thallium	5/14	0.08	4.72	0.47
SWSA 6 South	Inorganics	Thallium	1/1	0.08	4.76	0.48
WOC	Inorganics	Thallium	6/6	0.06	3.90	0.39
HF-2	Inorganics	Zinc	2/2	2300.00	6.53	3.27
HRE	Inorganics	Zinc	7/7	651.00	1.85	0.93
Intermediate Pond	Inorganics	Zinc	15/15	722.00	2.05	1.03
Lower WOC	Inorganics	Zinc	12/12	1100.00	3.13	1.56
SWSA 4 Main	Inorganics	Zinc	3/3	484.00	1.38	0.69
SWSA 5 Seep A	Inorganics	Zinc	6/6	749.00	2.13	1.06
SWSA6 East	Inorganics	Zinc	4/4	513.00	1.46	0.73
WOC	Inorganics	Zinc	6/6	2380.00	6.76	3.38
Intermediate Pond	Organics	PCB-1254	5/10	0.40	5.94	0.59
Intermediate Pond	Organics	PCB-1260	8/10	3.07	45.96	4.60
Lower WOC	Organics	PCB-1260	8/11	1.51	22.60	2.26
SWSA 5 Drainage D-2	Organics	PCB-1260	2/5	12.70	190.12	19.01
SWSA 5 Seep A	Organics	PCB-1260	3/6	0.40	5.94	0.59
SWSA 5 Seep B East	Organics	PCB-1260	2/3	1.05	15.72	1.57
SWSA 5 Trib 1	Organics	PCB-1260	5/17	0.50	7.51	0.75
SWSA 5 WOC	Organics	PCB-1260	6/19	0.34	5.09	0.51
WOC	Organics	PCB-1260	6/6	2.75	41.17	4.12

Table 9 (continued)

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL.
Only analytes whose concentrations were above backgound and resulted in NOAEL HQs > 1 are included in this table.

Table 7.10. Exposure (mg/kg/d) and risk estimates for white-footed mice exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 6 South	Arsenic	1/1	1.44	10.59	1.06
W6MS1	Arsenic	6/6	0.76	5.58	0.56
W6MS3	Arsenic	10/11	0.32	2.38	0.24
HF-2	Barium	2/2	31.00	2.87	0.78
SWSA 4 Main	Barium	3/3	14.80	1.37	
SWSA 6 East	Cadmium	4/4	3.21	1.66	0.17
W6MS1	Cadmium	6/6	2.65	1.37	0.14
HF-2	Chromium	2/2	109.00	16.64	4.16
HRE	Chromium	7/7	42.70	6.52	1.63
Lower WOC	Chromium	12/12	57.10	8.72	2.18
Intermediate Pond	Mercury	14/14	12.60	197.18	39.40
Lower WOC	Mercury	12/12	1.05	16.43	3.27
SWSA 5 Seep B West	Mercury	1/2	0.71	11.03	2.20
SWSA 5 Trib 1	Mercury	4/16	0.10	1.51	0.30
WOC	Mercury	6/6	1.13	17.68	3.53
HF-2	Molybdenum	2/2	0.49	1.75	0.18
Intermediate Pond	Molybdenum	15/15	0.71	2.54	0.25
Lower WOC	Molybdenum	12/12	0.58	2.06	0.21
PIT 4 South	Molybdenum	2/2	0.71	2.54	0.25
SWSA 5 Seep B West	Molybdenum	1/1	0.56	1.99	0.20
SWSA 5 Seep C	Molybdenum	4/4	1.24	4.41	0.44
WOC	Molybdenum	6/6	0.61	2.16	0.22
SWSA 4 Main	Nickel	3/3	3620.00	45.31	22.70
SWSA 5 Seep A	Selenium	5/5	0.43	1.07	0.65
HF-2	Zinc	2/2	323.00	1.01	0.51
WOC	Zinc	6/6	334.00	1.04	0.52
Intermediate Pond	PCB-1260	8/10	0.39	6.46	0.65
Lower WOC	PCB-1260	8/11	0.19	3.18	0.32
SWSA 5 Drainage D-2	PCB-1260	2/5	1.62	26.69	2.67
SWSA 5 Seep B East	PCB-1260	2/3	0.13	2.21	0.22
SWSA 5 Trib 1	PCB-1260	5/17	0.06	1.06	0.11
WOC	PCB-1260	6/6	0.35	5.78	0.58

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL.
Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.11. Exposure (mg/kg/d) and risk estimates for red fox exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 5 South	Arsenic	1/1	0.24	6.56	0.66
W6MS1	Arsenic	6/6	0.12	3.44	0.35
W6MS3	Arsenic	10/11	0.05	1.47	0.15
East Seep	Barium	3/3	3.58	1.26	
HF-2	Barium	2/2	11.10	3.91	1.07
HRE	Barium	7/7	2.98	1.05	
Pit 4 South	Barium	2/2	3.09	1.09	0.30
SWSA 4 Main	Barium	3/3	5.31	1.87	
SWSA 5 Seep C	Barium	15/15	3.20	1.13	0.31
HF-2	Chromium	2/2	15.90	9.19	2.29
HRE	Chromium	7/7	6.22	3.60	0.90
Lower WOC	Chromium	12/12	8.31	4.80	1.20
Intermediate Pond	Mercury	14/14	3.69	358.25	215.00
Lower WOC	Mercury	12/12	0.31	29.81	17.90
SWSA 5 Seep B West	Mercury	1/2	0.21	20.10	12.00
SWSA 5 Trib 1	Mercury	4/16	0.03	2.76	1.65
SWSA 5 WOC	Mercury	7/21	0.02	1.50	0.90
WOC	Mercury	6/6	0.33	32.14	19.30
Intermediate Pond	Molybdenum	15/15	0.10	1.30	0.13
Lower WOC	Molybdenum	12/12	0.08	1.05	0.11
Pit 4 South	Molybdenum	2/2	0.10	1.29	0.13
SWSA 5 Seep B West	Molybdenum	1/1	0.08	1.02	0.10
SWSA 5 Seep C	Molybdenum	4/4	0.17	2.25	0.23
WOC	Molybdenum	6/6	0.08	1.10	0.11
SWSA 4 Main	Nickel	3/3	582.00	27.58	13.80
SWSA 5 Seep A	Selenium	5/5	0.13	1.22	0.74
East Seep	Thallium	1/3	0.01	1.93	0.19
HF-2	Zinc	2/2	150.00	1.78	0.89
WOC	Zinc	6/6	156.00	1.85	0.92
Intermediate Pond	PCB-1260	8/10	0.22	2.27	0.46
Lower WOC	PCB-1260	8/11	0.11	1.11	0.23
SWSA 5 Drainage D-2	PCB-1260	2/5	0.90	9.38	1.90
WOC	PCB-1260	6/6	0.20	2.03	0.41

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.12. Exposure (mg/kg/d) and risk estimates for white-tailed deer exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 6 South	Arsenic	1/1	0.03	1.46	0.15
East Seep	Barium	3/3	2.35	1.56	
HF-2	Barium	2/2	7.30	4.83	1.31
HRE	Barium	7/7	1.95	1.29	
NHF	Barium	3/3	1.69	1.12	0.30
PIT 4 South	Barium	2/2	2.02	1.34	0.36
SEEP C	Barium	15/15	2.09	1.38	0.38
SWSA 4 Main	Barium	3/3	3.48	2.30	
SWSA 5 Drainage D-2	Barium	5/5	1.61	1.07	0.29
SWSA 5 WOC	Barium	22/22	1.53	1.01	0.28
SWSA 6 East	Barium	4/4	1.69	1.12	0.30
Intermediate Pond	Mercury	14/14	0.12	12.81	2.57
Lower WOC	Mercury	12/12	0.01	1.07	0.21
WOC	Mercury	6/6	0.01	1.15	0.23
SWSA 4 Main	Nickel	3/3	40.10	3.58	1.79
East Seep	Thallium	1/3	0.00	1.21	0.12

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL.

Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.13. Exposure (mg/kg/d) and risk estimates for red-tailed hawks exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
HRE	Chromium	7/7	1.41	1.41	0.28
Intermediate Pond	Mercury	14/14	2.58	403.13	40.40
Lower WOC	Mercury	12/12	0.22	33.59	3.35
SWSA 5 Seep B West	Mercury	1/2	0.15	22.66	2.26
SWSA 5 Trib 1	Mercury	4/16	0.02	3.11	0.31
SWSA 5WOC	Mercury	7/21	0.01	1.69	0.17
WOC	Mercury	6/6	0.23	36.25	3.62
SWSA 4 Main	Nickel		177.00	2.29	1.65
HF-2	Zinc	2/2	133.00	9.17	1.02
HRE	Zinc	7/7	37.80	2.61	0.29
Intermediate Pond	Zinc	15/15	41.90	2.89	0.32
Lower WOC	Zinc	12/12	63.70	4.39	0.49
SWSA 4 Main	Zinc	3/3	28.10	1.94	0.21
SWSA 5 Seep A	Zinc	6/6	43.40	2.99	0.33
SWSA 5WOC	Zinc	22/22	18.10	1.25	0.14
SWSA 6 East	Zinc	4/4	29.80	2.06	0.23
WOC	Zinc	6/6	138.00	9.52	1.05
Intermediate Pond	PCB-1260	8/10	0.21	1.15	0.12
SWSA 5 Drainage D-2	PCB-1260	2/5	0.85	4.74	0.47
WOC	PCB-1260	6/6	0.19	1.03	0.10

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL.

Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.14. Exposure (mg/kg/d) and risk estimates for wild turkeys exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
HRE	Chromium	7/7	1.96	1.96	0.39
Intermediate Pond	Mercury	14/14	0.68	105.47	10.50
Lower WOC	Mercury	12/12	0.06	8.77	0.88
SWSA Seep B West	Mercury	1/2	0.04	5.91	0.59
WOC	Mercury	6/6	0.06	9.47	0.95
SWSA 4 Main	Nickel	3/3	193.00	2.49	1.80
HF-2	Zinc	2/2	24.20	1.67	0.19
WOC	Zinc	6/6	25.10	1.73	0.19

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.15. Exposure (mg/kg/d) and risk estimates for mink exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
Intermediate Pond	Inorganics	Mercury	14/14	1.66	110.67	66.40
Lower WOC	Inorganics	Mercury	12/12	0.14	9.20	5.52
SWSA 5 Seep B,West	Inorganics	Mercury	1/2	0.09	6.19	3.72
WOC	Inorganics	Mercury	6/6	0.15	9.93	5.96
SWSA4 Main	Inorganics	Nickel	3/3	113.00	3.67	1.84
SWSA 5 Drainage D-2	Organics	PCB-1260	2/5	0.55	3.91	0.79

[a] See section 7.1 for methods used to estimate total exposure. The exposure estimate for mink is based on terrestrial exposures (ingestion of small mammal prey) only. Aquatic exposure are addressed separately.

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.16. Metal Concentrations in Hair of Mink from the ORR and from Offsite Reference Samples[a]

Site	N	Hg	Se	As	Cd	Pb
East Fork Poplar Creek	1	104	0.69	ND[b]	ND	0.33
Bear Creek	3	10.97±3.42	1.88±.1.41	0.15±0.09	0.04±.0.02	0.97±1.28
WOC	1	8.8	1	ND	ND	0.37
Offsite	7	5.15±3.43	1.11±0.25	0.22±0.31	0.04±0.02	0.7±0.31

[a] Mean ± standard deviation mg/kg dry weight
[b] ND = Not Detected

Table 7.17. Summary of potential risks (HQs > 1) from soils to the short-tailed shrew in the White Oak Creek Watershed

		Hazard quotients for risk driving analytes											
Subbasin	HI	As	Ba	Cd	Cr	Cu	Hg	Mo	Ni	PCB-1260	Se	Tl	Zn
Intermediate Pond	290.2						279.0	1.8	1.2	4.6			1.0
SWSA 4 Main	165.0		1.8						159.0		2.5		
Lower WOC	44.2				15.4		23.2	1.5		2.3	1.2		1.6
HF-2	39.0		3.8		29.5			1.2					3.3
WOC	41.5					1.4	25.0	1.5		4.1	1.3		3.4
SWSA 5 Drainage D-2	19.8									19.0			
SWSA 5 Seep B West	19.1						15.6	1.4			1.6		
HRE	15.2		1.0		11.5					1.2			
SWSA 6 South	9.2	8.1											
SWSA 5 Seep C	6.4		1.1					3.2			1.0		
W6MS1	6.4	4.3							1.2				
SWSA 5 Seep A	6.2										4.7		1.1
SWSA 5 Trib 1	5.2						2.1				1.3		
Pit 4 South	5.1		1.1					1.8			1.5		
SWSA 5 WOC	4.4						1.2				1.1		
East Seep	4.0		1.2								1.5	1.2	
SWSA 6 East	3.8			1.0					1.2				
W6MS3	2.5	1.8											
West Seep	2.3								0.9				
SWSA 5 Seep B East	2.2									1.6			
SWSA 5 N WOC	1.8										1.8		

Notes:

As = arsenic, Ba = barium, Cd = cadmium, Cr = chromium, Cu = copper, Hg = mercury, Mo = molybdenum, Ni = nickel, Se = selenium, Tl = thallium, Zn = zinc

HI = Sum of hazard quotients for all analytes detected.

HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.

Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.18. Summary of potential risks (HQs > 1) from soils to the white-footed mouse in the White Oak Creek Watershed

		HQs for risk driving analytes				
Subbasin	**HI**	**As**	**Cr**	**Hg**	**Ni**	**PCB-1260**
Intermediate Pond	41.0			39.4		
SWSA 4 Main	23.6				22.7	
Lower WOC	6.6		2.2	3.3		
HF-2	5.8		4.2			
WOC	5.4			3.5		
SWSA 5 Drainage D-2	2.9					2.7
SWSA 5 Seep B West	2.7			2.2		
HRE	2.2		1.6			
SWSA 6 South	1.2	1.1				

Notes:
As = arsenic, Cr = chromium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.19. Summary of potential risks (HQs > 1) from soils to the red fox in the White Oak Creek Watershed

		HQs for risk driving analytes				
Subbasin	**HI**	**Ba**	**Cr**	**Hg**	**Ni**	**PCB-1260**
Intermediate Pond	216.5			215.0		
WOC	21.8			19.3		
Lower WOC	20.3		1.2	17.9		
SWSA 4 Main	15.0				13.8	
SWSA 5 Seep B West	12.4			12.0		
HF-2	4.5	1.1	2.3			
SWSA 5 Trib 1	2.2			1.6		
SWSA 5 Drainage D-	2.1					1.9
HRE	1.6		0.9			
SWSA 5 WOC	1.5			0.9		

Notes:
Ba = barium, Cr = chromium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.20. Summary of potential risks (HQs > 1) from soils to the white-tailed deer in the White Oak Creek Watershed

		HQs for risk driving analytes		
Subbasin	**HI**	**Ba**	**Hg**	**Ni**
Intermediate Pond	3.0		2.6	
SWSA 4 Main	2.5			1.8
HF-2	1.6	1.3		

Notes:
Ba = barium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.21. Summary of potential risks (HQs > 1) from soils to the red-tailed hawk in the White Oak Creek Watershed

		HQs for risk driving analytes		
Subbasin	**HI**	**Hg**	**Ni**	**Zn**
Intermediate Pond	40.9	40.4		
WOC	4.9	3.6		1.0
Lower WOC	4.0	3.4		
SWSA 5 Seep B We	2.3	2.3		
SWSA 4 Main	2.0		1.6	
HF-2	1.2			1.0

Notes:
Hg = mercury, Ni = nickel, Zn = zinc
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.22. Summary of potential risks (HQs > 1) from soils to the wild turkey in the White Oak Creek Watershed

		HQs for risk driving analytes	
Subbasin	**HI**	**Hg**	**Ni**
Intermediate Pond	10.6	10.5	
SWSA 4 Main	2.0		1.8
WOC	1.3	1.0	
Lower WOC	1.0		

Notes:
Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.23. Summary of potential risks (HQs > 1) from soils to mink in the White Oak Creek Watershed

		HQs for risk driving analytes	
Subbasin	**HI**	**Hg**	**Ni**
Intermediate Pond	66.8	66.4	
WOC	6.9	6.0	
Lower WOC	6.0	5.5	
SWSA 5 Seep B West	3.8	3.7	
SWSA 4 Main	2.2		1.8

Notes:
Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.24. Interpretation of effects level/exposure distribution comparisons

Comparison	Meaning	Risk-based Interpretation
NOAEL>80th percentile of exposure distribution	less than 20% of exposures> NOAEL	Individual- and population-level adverse effects are highly unlikely
NOAEL<80th percentile<LOAEL	More than 20% of exposures > NOAEL, but less than 20% of exposures> LOAEL	Individuals experiencing exposures at the high end of the distribution may experience adverse effects, but those effects are unlikely to significantly contribute to effects on the WOCW population.
LOAEL<80th percentile of exposure distribution	More than 20% of exposures> LOAEL	Effects on some individuals are likely and they may contribute significantly to effects on the WOCW population.

Table 7.25. Estimated Size of Wildlife Populations within the White Oak Creek Watershed

Endpoint	Population Density[1]	Units	Amount of Suitable Habitat	Units	Estimated Population Size[1]
Short-tailed Shrew	23	indiv/ha	350	ha	8050
White-footed Mouse	57	indiv/ha	350	ha	19950
White-tailed Deer	0.1704	indiv/ha	350	ha	60
Red Fox	0.077	indiv/ha	350	ha	27
Red-Tailed Hawk	0.03	indiv/ha	350	ha	11
Wild Turkey	0.0426	indiv/ha	350	ha	15
Mink	0.6	indiv/stream km	6.4	stream km	4
Belted Kingfisher	0.4	indiv/stream km	6.4	stream km	3

[1]Number of individuals

Table 7.26. Summary of the number of individuals of terrestrial wildlife endpoints estimated to be experiencing adverse effects in the White Oak Creek Watershed

Species	Analyte	%>NOAEL	%>LOAEL	Number in Area	Number Adversely Affected[2]	% Adversely Affected
Short-tailed Shrew	Aroclor 1260	85%	27%	8050	2254	28%
	Arsenic	100%	20%	8050	0	0%
	Barium	100%	2%	8050	0	0%
	Cadmium	94%	2%	8050	0	0%
	Chromium	100%	90%	8050	8050	100%
	Copper	3%	1%	8050	0	0%
	Mercury	100%	70%	8050	5635	70%
	Molybdenum	100%	58%	8050	4790	60%
	Nickel	95%	76%	8050	6118	76%
	Selenium	97%	59%	8050	4910	61%
	Thallium	100%	0.4%	8050	0	0%
	Zinc	18%	2%	8050	0	0%
White-footed Mice	Aroclor 1260	37%	2%	19950	0	0%
	Arsenic	34%	1%	19950	0	0%
	Chromium	49%	1%	19950	0	0%
	Mercury	56%	13%	19950	0	0%
	Nickel	28%	5%	19950	0	0%
Red Fox	Aroclor 1260	11%	2%	27	0	0%
	Barium	<1%	<1%	27	0	0%
	Mercury	90%	63 %	27	18	67%
	Nickel	11%	2%	27	0	0%
Mink[1]	Mercury	20%	11%	4	0	0%
	PCB-1260	5%	2%	4	0	0%
	Nickel	2%	<1%	4	0	0%
White-tailed Deer	Mercury	4%	<1%	60	0	0%
	Nickel	1%	<1%	60	0	0%
	Barium	2%	0%	60	0	0%

Table 7.26. (continued)

Species	Analyte	%>NOAEL	%>LOAEL	Number in Area	Number Adversely Affected[2]	% Adversely Affected
Red-tailed Hawk	Mercury	70%	6%	11	0	0%
	Nickel	2%	<1%	11	0	0%
	Zinc	75%	2%	11	0	0%
Wild Turkey	Mercury	60%	2%	15	0	0%
	Nickel	0%	0%	15	0	0%

[1] Exposure through consumption of small mammals, vegetation, invertebrates, and soil.
[2]If predicted number was below 0.5, it was rounded to zero while if it was between 0.5 and 1.0, it was rounded to 1.

Table 7.27. Summary of Monte Carlo results estimating population-level risks[a] for white-footed mice and short-tailed shrews exposed to contaminants in soil within subbasins

Species	Subbasin	Analyte	%>NOAEL[b]	%>LOAEL[b]	Population-level risk in subbasin?
Short-tailed Shrew	East Seep	Barium		13	
	East Seep	Selenium		34	yes
	East Seep	Thallium		45	yes
	HF-2	Barium	95	76	yes
	HF-2	Chromium	98	71	yes
	HF-2	Molybdenum	99	33	yes
	HF-2	Zinc	58	38	yes
	HRE	Barium		12	
	HRE	Chromium		43	yes
	HRE	PCB-1260		5	
	Intermediate Pond	Mercury	100	79	yes
	Intermediate Pond	Molybdenum	100	51	yes
	Intermediate Pond	Nickel	20	9	
	Intermediate Pond	PCB-1260	82	24	yes
	Intermediate Pond	Zinc	20	9	
	Lower WOC	Chromium	92	56	yes
	Lower WOC	Mercury	82	47	yes
	Lower WOC	Molybdenum	99	35	yes
	Lower WOC	PCB-1260	56	10	
	Lower WOC	Selenium	56	33	yes
	Lower WOC	Zinc	26	12	
	PIT 4 South	Barium	97	13	
	PIT 4 South	Molybdenum	100	52	yes
	PIT 4 South	Selenium	74	48	yes
	SWSA 5 Seep A	Selenium	85	73	yes
	SWSA 5 Seep A	Zinc	20	10	
	SWSA 5 Seep B East	PCB-1260	61	8	
	SWSA 5 Seep B West	Mercury	87	56	yes
	SWSA 5 Seep B West	Molybdenum	99	42	yes
	SWSA 5 Seep B West	Selenium	58	40	yes
	SWSA 5 Seep C	Barium	89	16	
	SWSA 5 Seep C	Molybdenum	100	70	yes
	SWSA 5 Seep C	Selenium	44	26	yes
	SWSA 4 Main	Barium		37	yes
	SWSA 4 Main	Nickel		99	yes
	SWSA 4 Main	Selenium		49	yes
	SWSA 5 Trib 1	Mercury	6	2	
	SWSA 5 Trib 1	Selenium	31	18	
	SWSA 5 WOC	Mercury	15	4	
	SWSA 5 WOC	Selenium	23	13	
	SWSA 5 N WOC	Selenium	67	46	yes
	SWSA 6 East	Cadmium	85	18	
	SWSA 6 East	Nickel	54	14	
	SWSA 6 South	Arsenic	100	100	yes
	W6MS3	Arsenic	71	12	
	W6MS1	Arsenic	97	36	yes

Table 7.27. (continued)

Species	Subbasin	Analyte	%>NOAEL[b]	%>LOAEL[b]	Population-level risk in subbasin?
	SWSA 5 Drainage D-2	PCB-1260	96	67	yes
	WOC	Copper	22	17	
	WOC	Mercury	94	72	yes
	WOC	Molybdenum	98	36	yes
	WOC	PCB-1260	86	29	yes
	WOC	Selenium	48	31	yes
	WOC	Zinc	45	29	yes
White-footed mouse	HF-2	Chromium	54	20	yes
	HRE	Chromium		7	
	Intermediate Pond	Mercury	72	46	yes
	Lower WOC	Chromium	39	12	
	Lower WOC	Mercury	35	10	
	SWSA 5 Seep B West	Mercury	43	15	
	SWSA 4 Main	Nickel		86	yes
	SWSA 6 South	Arsenic	82	8	
	SWSA 5 Drainage D-2	PCB-1260	72	18	
	WOC	Mercury	60	20	yes

[a] See section 7.1 for methods used to estimate exposures and section 7.3.1.2 for discussion of Monte Carlo analysis.

[b] Percent of individuals in population experiencing exposures (mg/kg/d) greater than the No Observed Adverse Effects Level (NOAEL) or the Lowest Observed Adverse Effects Level (LOAEL).

8. ASSESSMENT OF RISKS TO PISCIVORES ON THE WHITE OAK CREEK WATERSHED

An ecological assessment has been performed to evaluate potential adverse effects to piscivorous (fish-eating) wildlife receptors resulting from exposures to contaminants in the aquatic environment in the WOCW. The assessment includes evaluations of two separate analytical data sets: 1) contaminant concentration data for water samples taken from the individual subbasins within the WOCW, and 2) fish tissue mercury and PCB concentration data taken at eight sampling locations throughout the WOCW. The analysis of water samples was limited to comparisons with benchmark concentrations associated with NOAELs and LOAELs. The water sample data were included to provide complete coverage of the entire suite of contaminants present at individual subbasins in order to identify contaminants and subbasins of potential concern.

The assessment focuses primarily on the fish tissue mercury and PCB data because these represent exposures through the immediate food source of piscivores and assumptions about the degree of bioaccumulation of contaminants through the food chain are not necessary. Mercury and PCBs are among the most important contaminants at the WOCW and on the ORR as a whole. They were the only two contaminants retained as being of potential concern as a result of the comparison of water samples with benchmarks, and fish tissue data for these contaminants were available at all sampling locations. The fish tissue data were used to estimate exposure doses which were compared to NOAELs and LOAELs in order to determine the potential for adverse effects to individuals or populations of piscivores throughout the watershed as a whole.

Results from biological surveys at the ORR and from toxicity tests performed using fish from the ORR are also presented and discussed in terms of evidence for or against potential adverse affects at the WOCW.

The following assessment endpoints were selected for the assessment of risks to piscivorous wildlife: toxicity to mink (*Mustela vison*), river otter (*Lutra canadensis*), belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*) and osprey (*Pandion haliaetus*) resulting in a reduction in population abundance or production. These assessment endpoints are those that have been agreed to be appropriate for the ORR by the FFA parties (Suter et al. 1995). The criteria for selection of the entities are those recommended by the EPA (Risk Assessment Forum 1992), plus considerations of scale and practical considerations.

Both osprey and river otter are listed as threatened species by the TWRA (Tennessee Wildlife Resources Agency). Osprey are found along the Clinch River and Poplar Creek, adjacent to the ORR and use larger bodies of water on the ORR such as the White Oak Lake and embayment. While otter are not known to occur on the ORR at the present time, they have been included in this assessment because the ORR, including the WOCW, contains suitable habitat, a reintroduction program is underway in east Tennessee, and they may become established on the ORR in the future. To determine if the ORR could support this threatened species, it is important to evaluate the nature and magnitude of risk that contaminants in the watersheds on the ORR may present to otter.

The conceptual model for exposure of piscivores to contaminants is presented in Fig. 8.1. Components of this model include aquatic biota (aquatic plants, invertebrates, fish, and amphibians) that reside in ponds and streams in the WOCW and the piscivorous wildlife that feed on aquatic biota. The aquatic biota are exposed to contaminants from surface water and sediments.

Contaminants are bioaccumulated in lower trophic levels (i.e., plants or invertebrates) and transferred to higher trophic levels (i.e., invertebrates, fish, or amphibians). Piscivorous wildlife consume fish, amphibians, and invertebrates and are therefore exposed to accumulated contaminants (Fig. 8.1).

8.1 EXPOSURE ASSESSMENT

Piscivorous wildlife may be exposed to contaminants through ingestion of contaminated media such as fish, other aquatic prey, and water. For the evaluation of water samples, concentration data were simply compared to benchmark concentrations for mink, otter, belted kingfisher, great blue heron and osprey based on water ingestion combined with ingestion of aquatic prey. It is not necessary to discuss the exposure assessment for the water samples further in this section.

For the evaluation of the fish tissue mercury and PCB concentration data, ingestion of fish and other aquatic prey was the only pathway considered. Contaminant exposure through ingestion was estimated for mink, otter, belted kingfisher, great blue heron and osprey. This assessment focused only on the two contaminants, mercury and PCBs, for which there are watershed-scale data on concentrations in fish. Exposure estimates were calculated for 8 locations in the White Oak Creek basin. Locations of fish sampling locations within White Oak Creek are presented in Fig. 8.2. WOCW subbasins for which fish samples are available are White Oak Creek Embayment (WCK 0.3 and WCK 0.9), Lower WOC/White Oak Lake (WCK 1.5 and WCK 2.3), Seep C (MEK 0.2) and WOC (WCK 2.9). The two other locations, WCK 3.5 and NTK 0.2, are immediately north of the Melton Valley portion of the WOCW, but were included because ecological receptors in Melton Valley would likely be exposed to fish at these locations due to their immediate proximity and movements of individual fish and piscivores.

8.1.1 Exposure Through Oral Ingestion of Fish

For exposure estimates to be useful in the assessment of risk to wildlife, they must be expressed in terms of a body weight-normalized-daily dose or mg contaminant per kg body weight per day (mg/kg/d). Exposure estimates expressed in this manner may then be compared with toxicological doses for wildlife, such as those derived by Sample et al. (1996a), or to doses reported in the toxicological literature. Estimation of the daily contaminant dose an individual may receive for a particular contaminant may be calculated as described in Sect. 7.1.

Exposure estimates were calculated for mercury and PCB at all 8 WOCW fish sampling locations. Because wildlife are mobile, their exposure is best represented by the mean contaminant concentration in media. To be conservative, the 95% upper confidence limit (UCL) was used in exposure estimates. To prevent bias that may result from calculating 95% UCLs using data with values below detection limits, the product limit estimator (PLE) was used to calculate the 95% UCLs. These data were used in the initial exposure estimates. Exposure estimates for contaminants that may potentially present a risk to piscivorous wildlife (based upon comparisons to NOAELs and LOAELs) were recalculated using Monte Carlo simulations.

8.1.1.1 Estimation of whole fish contaminant concentrations from fillet data

Fish data from the WOCW consisted of analyses of both whole body concentrations (generally in stonerollers, shiners, and shad) and concentrations in fillets (in sunfish, largemouth bass, and carp). Because piscivores consume whole fish (not fillets) and fillet concentrations do not accurately represent whole body concentrations, it was necessary to estimate concentrations in whole fish for those sample for which only fillet analyses were performed. Whole-fish concentrations were estimated using the following equations:

for mercury:

$$C_{WB} = e^{[-0.8 + 0.76 * \ln(C_F)]} \tag{1}$$

for PCBs in catfish:

$$C_{WB} = e^{[0.16 + 0.54 * \ln(C_F)]} \tag{2}$$

for PCBs in bass or other fish:

$$C_{WB} = e^{[0.81 + 0.95 * \ln(C_F)]} \tag{3}$$

where:

C_{WB}	=	whole body contaminant concentration
C_F	=	fillet contaminant concentration

A detailed discussion of the development of these equations is presented in Bevelheimer et al. (1996).

8.1.1.2 Contaminant concentrations in fish

Contaminant concentrations in fish are needed to estimate exposure. Fish tissue contaminant concentration data were aggregated into two size classes: <30 cm and >30 cm in length. This is because piscivore species forage on different size fish and contaminant body burdens are related to size (larger, older fish generally have higher contaminant concentrations). While mink, belted kingfisher, and great blue heron generally consume fish <30 cm in size, osprey and otter forage equally on small and large fish (see Tables 7.8 and 8.1 through 8.4). To more accurately reflect exposure, data were segregated according to size and exposure was estimated using data from the size of fish most likely to be consumed by that endpoint species. Because it was assumed that piscivores would select fish according to size and not by species, all species were pooled within each size class. The 95% UCLs (calculated using the PLE) for contaminants detected in fish from the WOCW are presented in Table 8.5.

8.1.1.3 Exposure modeling using point-estimates

Initial estimates of exposure of piscivorous wildlife to contaminants were performed for each sampling point using point estimates of parameters in the exposure model (Equation 1). Species-specific parameters necessary to estimate exposure using the Equation 1 are listed in Tables 7.8 and 8.1 through 8.4.

To estimate contaminant exposure experienced by mink, the following assumptions were made:

- Body weight = 1 kg.
- Food consumption = 0.137 kg/d (fresh weight).
- Diet consists 54.6% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by otter, the following assumptions were made:

- Body weight = 8 kg.
- Food consumption = 0.9 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 50% <30 cm and 50% >30 cm.

To estimate contaminant exposure experienced by kingfisher, the following assumptions were made:

- Body weight = 0.148 kg.
- Food consumption = 0.075 kg/d (fresh weight).
- Diet consists 100% of fish.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by great blue heron, the following assumptions were made:

- Body weight = 2.39 kg.
- Food consumption = 0.42 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by osprey, the following assumptions were made:

- Body weight = 1.5 kg.
- Food consumption = 0.3 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 92.1% <30 cm and 7.9% >30 cm.

Using Equation 1 and the assumptions and data described above, exposure to contaminants was estimated for mink (Table 8.6), otter (Table 8.7), kingfisher (Table 8.8), and great blue heron (Table 8.9) for each location on the WOCW. Because osprey use only large bodies of water, exposure estimates were generated for only for those areas where suitable habitat was available (White Oak Lake and embayment; Table 8.10).

8.1.1.4 Exposure modeling using Monte Carlo simulations

Employing point estimates for the input parameters in the exposure model does not take into account the variation and uncertainty associated with the parameters and therefore may over or under estimate the contaminant exposure that endpoints may receive in any given reach. In addition, calculating the model using point estimates produces a point estimate of exposure. This estimate provides no information concerning the distribution of exposures or the likelihood that individuals within a watershed will actually experience potentially hazardous exposures. To incorporate the variation in exposure parameters and to provide a better estimate of the potential exposure experienced by piscivores on the WOCW, the exposure model was re-calculated using Monte Carlo simulations.

Monte Carlo simulation is a resampling technique frequently used in uncertainty analysis in risk assessment (Hammonds et al. 1994). In practice, distributions are assigned to input parameters in a model and the model is recalculated many times to produce a distribution of output parameters (e.g., estimates of contaminant exposure). Each time the model is recalculated, a value is selected from within the distribution assigned for each input parameter. As a result, a distribution of exposure estimates is produced that reflects the variability of the input parameters. To determine which input parameters most strongly influence the final exposure estimate, a sensitivity analysis is performed (Hammonds et al. 1994). Detailed discussions of sensitivity and uncertainty analysis, and the use of Monte Carlo simulations in risk assessment are provided by Hammonds et al. (1994).

Monte Carlo simulations were performed to estimate WOCW-wide exposures. It was assumed that wildlife were more likely to forage in areas where food is most abundant. The biomass of fish at or near locations where fish bioaccumulation data were collected was assumed to represent measures of food abundance. The relative proportion that each location contributed to overall watershed biomass data was used to weight the contribution to the watershed-level exposure. The watershed-level exposure was estimated to be the weighted average of the exposure at each location sampled within the watershed. In this way, locations with greater fish biomass contribute more to exposure than do locations with lower biomass. Fish biomass data used to weight exposure for the WOCW are presented in Table 8.11.

The percentiles of the resulting exposure distributions represent the likelihood that an individual piscivore within a watershed will experience a given exposure level. Watershed-wide simulations were performed for mercury and PCBs because these contaminants are among the most important at WOCW and on the ORR as a whole, and data for these contaminants were available at all sampling locations.

Distributions were used for the contaminant concentrations in fish and for the proportion of fish in the diet of mink. All contaminant distributions were assumed to be lognormal. Lognormal means and standard deviations for contaminants in fish are presented in Table 8.5.

The proportion of aquatic prey in the diets of otter, kingfisher, heron and osprey were assumed to be 100%. No data suggest that non-aquatic prey constitute a significant portion of their diet (see endpoint discussion, above). In contrast, mink have a very variable diet. Aquatic prey (fish, amphibians, crayfish, etc.) may make up from 16% to 92%. Nine observations from five studies indicate the proportion of aquatic prey to be 0.546 ± 0.21 (mean ± standard deviation; Table 7.8). The proportion of aquatic prey in the diet of mink was assumed to be normally distributed.

Monte Carlo simulations were performed using the @Risk software. Samples from each distribution were selected using Latin hypercube sampling. The number of iterations, or recalculations, of each exposure simulation was determined by the convergence criteria set in the software. Under these criteria, iterations are performed until the between-iteration percent change in the percentiles, mean, and standard deviation are below 1.5% (i.e., the percentile, mean, and standard deviation for the latest iteration is less than 1.5% different than the those from the previous iteration). Using this convergence criteria, from 600 to 1000 model iterations were performed for each exposure estimate. Monte Carlo estimates of contaminant exposures are presented in Table 8.12.

8.2 EFFECTS ASSESSMENT FOR PISCIVOROUS WILDLIFE

8.2.1 Single Chemical Toxicity Data

Single-chemical toxicity data consist of NOAELs and LOAELs of toxicity studies reported in the literature. Derivation of toxicological benchmarks is as described in Sect. 7.2. Mammalian and avian NOAEL's and experimental information used to estimate wildlife NOAEL's and LOAEL's (e.g., test species, test endpoints, citation) for mercury and PCBs are listed in Tables 8.13 and 8.14. Water benchmarks available for WOCW surface water contaminants detected above background concentrations or for which no background values were available are listed in Table 8.15. Ecotoxicological profiles of the effects of contaminants to wildlife are presented in Appendix B.5.

8.2.2 Effects of Contaminants on the Reproductive Performance of Mink

Halbrook (unpubl. data collected at Michigan State University Experimental Fur Farm), evaluated bioaccumulation of contaminants and reproductive effects in mink fed fish collected from Poplar Creek, the Clinch River (upstream of Melton Hill Dam) and the ocean. Even though the study did not include fish collected from the WOCW, these data are deemed to be relevant because they provide ORR-specific fish toxicity data, which are likely to be more appropriate for evaluating effects at the WOCW than data from the general toxicological literature. Mink were fed five diets consisting of 75% fish and 25% commercial mink diet. The diet composition and contaminant concentrations for each diet are described in the following table:

		Contaminant concentration (mg/kg)	
Diet	Fish composition	Mercury	PCB 1260
A	75% ocean	0.02 ± 0.00	0.169 ± 0.002
B	75% Clinch River	0.05 ± 0.00	11.44 ± 0.327
C	25% Poplar Creek 50% ocean	0.09 ± 0.00	4.69 ± 0.174
D	50% Poplar Creek 25% ocean	0.15 ± 0.01	10.41 ± 0.250
E	75% Poplar Creek	0.22 ± 0.01	20.67 ± 0.458

Twenty-three PCB congeners were also present in varying amounts. Concentrations of most congeners increased progressively from diets A through E.

Ten mink (eight females and two males) were fed each diet for ~7 months (3 months before breeding—6 weeks postpartum). Reproductive indices measured included: number of females mated; number of females whelping; length of gestation; number of kits whelped (alive, dead); kit sex ratio; average kit body weight at birth, 3, and 6 weeks of age; and kit survival to 3 to 6 weeks of age. At 6 weeks of age, 3 kits from dietary groups A, B, C, and E were euthanized, organs (liver, spleen, and kidneys) were weighed, and tissue samples (liver, kidney, and remaining carcass) were analyzed for contaminant accumulation. (note: kits from diet D were not sampled). At the termination of the study, all adult mink were necropsied. Organs (brain, liver, kidneys, heart, lungs, gonads, and adrenal glands) were weighed and examined for histopathologies. Adipose tissue, liver, kidney, and hair were analyzed for contaminant accumulation. Liver tissue also was analyzed for ethoxyresorufin-o-deethylase (EROD) activity.

The bioaccumulation of mercury in liver, kidney, and hair, and Aroclor 1260 (and other PCB congeners) in liver and fat substantially increased in adult female mink from groups fed diet A up to diet E. Mink offspring also bioaccumulated mercury in kidney tissue and carcasses and many other PCB congeners in the liver and carcasses, increasing progressively from mink fed diets A through E. The lowest levels were observed for mink fed diet A and increased to a maximum observed among mink fed diet E.

Significant effects were observed only among mink fed diet E; no adverse effects were observed for any other diet. Adverse effects from diet E included: weight reduction in adult mink and their offspring, reduction in litter size, and increase in liver EROD activity in adult females. Weight reduction was observed at the end of the experimental period, increasing magnitude from diet groups A to E. At the end of the experiment, the mean whole body weights of female mink in diet group E were significantly less ($p = 0.03$) than mean weights of females in diet group A (percent reduction = 20%). Mean female relative organ weights (organ weights/body weight) were not significantly different among diet groups. At 6 weeks of age, mean whole body weights were also significantly lower ($p = 0.004$) in male kits from diet group E compared to those from diet group A (percent reduction = 17%). Similar trends were observed for female kits, although differences were not statistically significant. No histological lesions were attributed to any diet. Mean litter size was significantly reduced ($p = 0.01$) in diet group E compared to diet groups A, B, and C (percent reduction relative to diet A = 38%); but not diet group D. Liver EROD activity was significantly increased in adult female mink from diet groups D and E compared with those from diet group A.

8.2.3 Biological Surveys

8.2.3.1 Mink survey

Stevens (1995) investigated bioaccumulation of mercury in mink on the ORR in 1993 through 1995. The methods used in the mink survey, while indicating that mink are present at the WOCW, cannot be used to estimate abundance or density on mink at the WOCW. A total of four male mink were live-trapped over the course of 6073 trapnights (trapnight = 1 trap set for 24 h) on the ORR as a whole. Of these, one adult was captured along White Oak Creek. Captured mink were fitted with an intraperitoneal radio transmitter (to monitor movements and home range) and released. Prior to release, samples of hair were collected and metals analysis. An additional 8 roadkill mink (5 male and 3 female) were collected from the ORR and surrounding areas of Roane and Anderson counties.

While one roadkill sample (a male) was collected on a bridge over Bear Creek and was assumed to be a resident of Bear Creek, all others were collected off the ORR and were used as references.

The Results of metals analysis are presented in the following table:

Metal concentrations in hair of mink from the WOCW and from off-site reference samples[a]

Site	N	Hg	Se	As	Cd	Pb
White Oak Creek	1	8.8	1	ND[b]	ND	0.37
Off site	7	5.15 ± 3.43	1.11 ± 0.25	0.22 ± 0.31	0.04 ± 0.02	0.7 ± 0.31

[a]Mean ± standard deviation mg/kg dry weight.
[b]ND = Not detected.

Radiotelemetry data on home ranges and movements were obtained for 3 mink, including the one from the WOCW. Mean (± standard deviation) home range for these three individuals was found to be 7.5 ± 3 km of stream. The home range of the White Oak Creek mink included all of White Oak Creek from the headwater tributaries to the Clinch River, including the X-10 facility. This individual was observed to use dens within the X-10 facility and moved through the facility on several occasions.

8.2.3.2 Belted kingfisher survey

A field monitoring effort (Baron et al. 1996) was initiated in 1994 to evaluate population parameters and contaminant bioaccumulation by belted kingfisher on the ORR. Areas surveyed included: WOC, White Oak Lake, White Oak Lake Embayment, Melton Branch, Poplar Creek, portions of East Fork Poplar Creek , and portions of Bear Creek.

Methods

Nest burrows were monitored for nesting activity. If activity was observed, samples of feathers and eggshells were collected and analyzed for metals and radionuclides. In addition to specimens collected from the burrows, three carcasses of adult kingfisher were found on the ORR (one from WOC and two from East Fork Poplar Creek). These carcasses were necropsied, and organs were extracted and analyzed for metals and radionuclides. Additional detail concerning methods are reported in Baron et al. (1996).

Results

During April-July of 1994, a total of 27 potential kingfisher burrows were identified on the ORR; 11 of which contained swallow nests. Twenty-five of these burrows were found on the Clinch River. One kingfisher burrow, containing a single unhatched kingfisher egg, was found on White Oak Creek (downstream of WCK 3.5).

A burrow on the Clinch River contained fragments of egg shells and fish vertebrae from regurgitant. Analysis of the egg shells indicated that minimal metal contamination was present (CRD, Table 8.16). Metal concentrations in the egg from the burrow found on White Oak Creek (WOC, Table 8.16) were similar to that for the Clinch River egg, except for elevated cesium-137. The presence of this radionuclide in the egg indicates that the parent kingfisher bioaccumulated cesium-137 from foraging within White Oak Creek or a nearby surface impoundment (cesium-137 is a typical contaminant of this stream and the impoundments).

Cesium-137, cadmium, lead, selenium, and mercury were each detected in at least one kingfisher carcass collected from the ORR (Table 8.17). As was analyzed for but was not detected. The greatest burdens of mercury, selenium, lead, and cesium-137 were observed in the bird from the White Oak Creek watershed (Bird 3; Table 8.17). In contrast, cadmium levels were higher in the birds from East Fork Poplar Creek (Birds 1 and 2) than in the White Oak Creek bird (Table 8.17).

8.3 RISK CHARACTERIZATION FOR PISCIVOROUS WILDLIFE

Risk Characterization integrates the results of the exposure assessment (Sect. 8.1) and effects assessment (Sect. 8.2) to estimate risks (the likelihood of effects given the exposure) based on each line of evidence, and then applies a weight of evidence inference logic to determine the best estimate of risk to each assessment endpoint. In an ideal risk assessment there are three lines of evidence: literature-derived single chemical toxicity data (which indicate the potential toxic effects of the concentrations measured in site media), biological surveys of the affected system (which indicate the actual state of the receiving environment), and toxicity tests with ambient media (which indicate the toxic effects of exposures to site media). While three lines of evidence are available to assess risks to piscivorous wildlife, not all are available for each endpoint for the WOCW. Single chemical toxicity data are available for all five endpoints. Toxicity tests and a field survey/bioaccumulation study were available for mink. Field survey/bioaccumulation data were available for kingfisher.

Procedurally, the risk characterization is performed for each assessment endpoint by (1) screening all measured contaminants against literature-derived toxicological benchmarks and background concentrations (if available), (2) estimating the effects of the contaminants retained by the screening analysis, (3) estimating the toxicity of the ambient media based on the media toxicity test results, (4) estimating the effects of exposure on the endpoint biota based on the results of the biological survey data, (5) logically integrating the lines of evidence to characterize risks to the endpoint, and (6) listing and discussing the uncertainties in the assessment. A detailed discussion of methods and the approach to risk characterization on the ORR is presented in Suter et al. (1995).

8.3.1 Single Chemical Toxicity Data

Two types of single chemical toxicity data are available with which to evaluate piscivore contaminant exposure: NOAELs and LOAELs. To quantify the magnitude of hazard, a hazard quotient (HQ) was calculated where: HQ = exposure/NOAEL or LOAEL. Hazard quotients greater than 1 indicate that individuals may be experiencing exposures that are in excess of NOAELs or LOAELs. While exceeding the NOAEL suggests that adverse effects are possible, exceeding the LOAEL suggests that adverse effects are likely.

8.3.1.1 Surface water contaminant concentration data

To evaluate the potential risk to piscivores from contaminants detected in surface water samples, the lower of the 95% UCL and maximum concentrations in unfiltered water was used as an exposure concentration to compare with NOAEL and LOAEL-based water benchmark concentrations. HQs (water concentration/benchmark value) were calculated for all piscivorous receptor species and for all chemicals for which benchmark concentrations were available. These

HQs are presented in Tables 8.15. Concentration data that were below background concentrations were excluded from the evaluation.

NOAEL- and LOAEL-based HQs exceeded one for the inorganics aluminum, cadmium, mercury, selenium and thallium, and the organics bis-2-ethylhexylphthalate, di-n-butyl phthalate and PCBs, indicating potential risks of adverse effects.

LOAEL-based aluminum HQs exceeded one for mink and otter at Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and West Seep. However, aluminum is probably not highly soluble and bioavailable in the WOCW because the aquatic environment is not highly acidic. Furthermore, the aluminum benchmarks for mink and otter are based on aluminum chloride, which may not be the prevalent form of the element in the environment. Thus, it is not expected that aluminum poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based cadmium HQs exceeded one for otter and kingfisher at WAG6MS1. Cadmium was detected in only five of 18 samples at this subbasin and HQs were only 1.3 for both species. Furthermore, cadmium was not detected in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 (Ashwood 1994). Thus, it is not expected that cadmium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based mercury HQs exceeded one for all five piscivorous receptors at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. Mercury was also detected at elevated concentrations in fish tissue samples collected in the WOCW, and is retained as a contaminant of concern.

LOAEL-based selenium HQs exceeded one for heron and osprey at SWSA 5/WOC, and for mink, otter and kingfisher at Lower WOC/WOL, SWSA 5/WOC and WAG6MS1. Selenium was detected only once out of the 42, two and 14 samples taken at Lower WOC/WOL, SWSA 5/WOC and WAG6MS1, respectively. Mean selenium concentrations in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 ranged from 0.21 to 0.5 mg/kg (Ashwood 1994). These concentrations are comparable to the mean selenium concentration of 0.25 mg/kg in fish tissue samples collected at Hinds Creek, a reference stream located in Anderson County, TN (Ashwood 1994). Thus, it is not expected that selenium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based thallium HQs exceeded one for mink and otter at HF-2, Seep A , the Intermediate Pond and WOC subbasins. Thallium was detected only once out of the nine, nine and 12 samples taken at HF-2, Seep A and the Intermediate Pond, respectively, and five times out of the 20 samples taken at WOC. Furthermore, thallium was not detected in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 (Ashwood 1994). Thus, it is not expected that thallium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based bis-2-ethylhexylphthalate HQs exceeded one for mink and otter at SWSA 5/WOC, W6MS3 and W6MS1. Bis-2-ethylhexylphthalate was detected in a total of seven out of the 25 samples taken at three subbasins combined. Being a common laboratory contaminant, it is highly likely that these detections of bis-2-ethylhexylphthalate are spurious. Thus, it is not expected that bis-2-ethylhexylphthalate poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based di-n-butyl phthalate HQs exceeded one for kingfisher, heron and osprey at W6MS3 and W6MS1. Di-n-butyl phthalate was detected in only three out of 20 samples taken at W6MS3, and in one out of 4 samples at W6MS1. Being a common laboratory contaminant, it is highly likely that these detections of di-n-butyl phthalate are spurious. Thus, it is not expected that di-n-butyl phthalate poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based PCB HQs exceeded one for all five piscivorous receptors at Lower WOC/WOL and WOC. PCBs were also detected at elevated concentrations in fish tissue samples collected in the WOCW, and are retained as contaminants of concern.

Therefore, mercury and PCBs are the contaminants retained as contaminants of concern.

8.3.1.2 Fish tissue mercury and PCB concentration data

The fish tissue mercury and PCB data were used to generate both point estimates of exposure doses and Monte Carlo simulation estimates of exposure. Exposure estimates generated by the exposure model (see Sect. 8.1.1.) produced by both point estimates of parameter values and Monte Carlo simulation represent exposure at the individual level. Point estimates of exposure parameters are first screened against NOAELs and LOAELs to identify contaminants and locations that contribute significantly to risk; if the estimate is greater than the NOAEL or LOAEL, adverse effects are possible and additional evaluation is necessary. LOAELs are then compared to the watershed-level exposure distributions generated by the Monte Carlo simulation to determine the likelihood that an individual within the entire area will experience adverse effects. If the LOAEL is lower than the 80th percentile of the exposure distribution, there is a >20% likelihood that individuals within the modeled location are experiencing contaminant exposures that are likely to produce adverse effects. By combining literature-derived population density data with the likelihood or probability of exceeding the LOAEL, population-level impacts may be estimated.

Initial point estimates of exposure

To determine if the mercury and PCB exposures experienced by mink, river otter, belted kingfisher, great blue heron, and osprey on the WOCW are potentially hazardous, the dietary contaminant exposure estimates (generated using point estimates of parameter values; Tables 8.6 through 8.10) were compared to estimated NOAELs and LOAELs for these species (Tables 8.13 and 8.14). Resulting hazard quotients for mink, river otter, belted kingfisher, and great blue heron on the WOCW are presented along with the point estimates of exposure in Tables 8.6 through 8.10. It should be noted that because few data are available for specific PCB (Aroclor) mixtures, all PCBs were summed and the total was compared to Aroclor-1254 toxicity data.

A summary of the number of locations within the WOCW where HQs>1 were observed is presented in Table 8.18. NOAELs for mercury and PCBs were exceeded at at least one location for all endpoints. LOAELs for mercury and PCBs were exceeded at at least one location for both otter and belted kingfisher, but not for mink, heron and osprey (Table 8.18).

The spatial distribution of contamination and potential risks to piscivores in White Oak Creek are illustrated in Fig. 8.3. This figure displays the sum of the LOAEL-based HQs (e.g., sum of toxic units or ΣTUs) for total PCBs and mercury. Sampling locations were arranged upstream to downstream (right to left); side tributaries or ponds are included in the order in which they enter the main stream.

The pattern of cumulative risk in the WOCW was similar for mink, kingfisher, and herons but different for otters (Fig. 8.3). The pattern for osprey differed from all other species because only suitable habitat (large bodies of water; White Oak Lake and the embayment) were considered. In general, cumulative risk was greater in White Oak Creek than in it's tributaries (NTK and MEK). Mercury was the primary risk agent throughout the watershed, except at WCK 0.3 in the White Oak Creek embayment, where PCBs dominated. A peak for risk to otters from PCBs was observed at White Oak Lake (WCK 1.5). This peak can be attributed to the presence of data for large fish (>30 cm); PCBs in large fish were 3 to 5 times higher than that in small fish (Table 8.5).

Risk estimates from fish tissue data are available from four of the WOCW subbasins:

WOCE. Risk estimates from point exposures are available from two fish sampling locations in this subbasin, WCK 0.3 and WCK 0.9 (Tables 8.6 through 8.10). Based on comparison with LOAELs, no adverse effects from mercury were predicted for any of the piscivorous receptors. Adverse effects from PCBs were predicted to be likely for otter (max. HQ = 1.9) and kingfisher (max. HQ=1.9).

Lower WOC/White Oak Lake. Risk estimates from point exposures are available from two fish sampling locations in this subbasin, WCK 1.5 and WCK 2.3 (Tables 8.6 through 8.10). Based on comparisons with LOAELs, adverse effects from mercury were predicted to be likely for otter (max. HQ = 1.4) and kingfisher (Max. HQ = 1.5). Adverse effects from PCBs were predicted to be likely only for otter (max. HQ = 2.6).

Seep C. Risk estimates from point exposures are available from one sampling location in this subbasin, MEK 0.2 (Tables 8.6 through 8.10). Based on comparison with LOAELs, no adverse effects from mercury or PCBs were predicted for any of the piscivorous receptors.

WOC. Risk estimates from point exposures are available from one sampling location in this subbasin, WCK 2.9 (Tables 8.6 through 8.10). Based on comparisons with LOAELs, adverse effects from mercury were predicted to be likely for otter (HQ = 1.6) and kingfisher (HQ = 1.6). No adverse effects from PCBs were predicted for any of the piscivorous receptors.

Monte Carlo simulation estimates of exposure

To incorporate the variation present in the parameters employed in the exposure model, Monte Carlo simulations were performed for exposure of each species to mercury and PCBs in WOCW. Simulations were performed on the average exposure, weighted by the biomass of fish observed at each sampling location (see Section 8.1.1.4). The mean, standard deviation, and 80th percentile of the simulated exposures are presented in Table 8.12. By superimposing NOAEL and LOAEL values on these distributions, the likelihood of an individual experiencing potentially hazardous exposures can be estimated and the magnitude of risk may be determined. Interpretation of the comparison of exposure distributions to NOAELs and LOAELs is described in Table 7.24.

To evaluate the likelihood and magnitude of population-level effects on piscivores, literature-derived population density data (expressed as number of individuals/km of stream or pond shoreline) were combined with the length of stream or pond shorelines for which risks were assessed to estimate the number of individuals of each endpoint species expected to be present at WOCW. Literature-derived population densities used for each endpoint species were: mink: 0.6/km; river otter 0.37/km; belted kingfisher: 0.4/km; and great blue heron; 2.3/km. It should be noted that density values for all endpoint species except the great blue heron represent the maximum values obtained from the literature (see Tables 7.8, 8.1, and 8.2). The values for herons (see Table 8.3) appear inflated and are not believed to accurately represent densities on the ORR. For this reason, the minimum value was used. Population estimates based upon these densities are listed in the following table.

	Watershed length (km)			Estimated number of individuals by watershed			
Watershed	Stream length	Pond shoreline length	Total length	Mink	River otter	Belted kingfisher	Great blue heron
White Oak Creek	3.9	2.5	6.4	4	2	3	15

Population risk estimates were not performed for osprey because as a T&E species, adverse effects to any individual are significant and because suitable density data were not available. Population risk estimates however were performed for otter, another T&E species. While otter are not currently known to reside on the ORR, population estimates indicate the numbers that could reside on the WOCW given available habitat and the risks that contaminant exposure could present.

The number of individuals within the watershed likely to experience exposures >LOAELs can be estimated using cumulative binomial probability functions (Dowdy and Wearden 1983) as described in Sect. 7.1.3.1.

Binomial probability distributions were generated only for contaminant-endpoint combinations where the percent of the exposure distribution exceeding the LOAEL was 20% to 80% (these values are reported in Table 8.12). If the percent of the exposure distribution exceeding the LOAEL was <20%, it was assumed that no individuals within the area of interest were experiencing adverse effects. Conversely, if the percent of the exposure distribution exceeding the LOAEL was >80%, it was assumed that all individuals within the area of interest were experiencing adverse effects. Estimates for mercury and PCB exposure to otter met the 20% to 80% exceedance criterion. Less than 20% of the exposure distribution exceeded the LOAEL for all other contaminant-endpoint combinations. The total numbers of individuals for each endpoint species estimated to be experiencing adverse effects within the WOCW are summarized in Table 8.19.

Based on the Monte Carlo and binomial distribution analyses (Table 8.19), the following conclusions may be made:

- Because 1 individual is estimated to be experiencing exposures >LOAEL, PCBs present a significant risk to otter in the WOCW.

- Although <1 individual otter is estimated to be experiencing exposures >LOAEL for mercury, individual risks are >20% (Table 8.12). Because of the otter's status as a state threatened species, mercury presents a significant risk to otter in the WOCW.

- Because <1 individual is estimated to be experiencing exposures >LOAEL, neither mercury nor PCBs presents a significant risk to osprey in the WOCW.

- Because <20% of the WOCW populations of mink, kingfisher, and heron are estimated to be experiencing exposures >LOAEL, neither mercury nor PCBs present a significant risk to these.

8.3.1.3 Effects of retained contaminants

Mercury

For the purposes of this assessment, it is assumed that 100% of the mercury to which wildlife are exposed consists of methyl mercury.

Both the avian NOAEL and LOAEL are based upon a study of mallard ducks fed methyl mercury for three generations (Heinz 1979). The study was considered to represent a chronic exposure, and a subchronic-chronic correction factor was not employed. The only dose level administered, 0.064 mg/kg/d, caused hens to lay fewer eggs, lay more eggs outside of the nest box, and produce fewer ducklings. This dose level was considered to be an LOAEL. Because an experimental NOAEL was not established, the NOAEL was estimated using LOAEL-NOAEL correction factor of 0.1. Based on the results of Heinz (1979), kingfisher experiencing exposure ≥LOAEL are likely to display impaired reproduction.

The mink and otter NOAELs and LOAELs for mercury were derived from a study of mink fed methyl mercury for 93 d (Wobeser et al. 1976). While consumption of 0.247 mg/kg/d methyl mercury resulted in significant mortality, weight loss, and behavioral impairment, no effects were observed at the 0.15 mg/kg/d exposure level. The 0.15 mg/kg/d exposure was considered to be an NOAEL, and the 0.247 mg/kg/d exposure was considered to be an LOAEL. Because the study was subchronic in duration (<1 year), a subchronic-chronic correction factor was applied (NOAEL = 0.015, LOAEL = 0.025). Based on the results of Wobeser et al. (1976), shrews, mice, and fox experiencing exposure ≥LOAEL are likely to display increased mortality, weight loss, and behavioral impairment.

PCBs

The otter NOAEL and LOAEL for PCBs was derived from a study of mink fed Aroclor 1254 for 4.5 months (Aulerich and Ringer 1977). While consumption of 0.69 mg/kg/d Aroclor 1254 reduced kit survivorship, no effects were observed at the 0.14 mg/kg/d exposure level. The 0.14 mg/kg/d exposure was considered to be a chronic NOAEL; the 0.69 mg/kg/d exposure was considered to be a chronic LOAEL Based on the results of Aulerich and Ringer (1977), mink experiencing exposure ≥LOAEL are likely to display reduced kit survivorship.

8.3.2 Mink Toxicity Tests

To evaluate the nature and magnitude of toxicity of contaminants in fish from the ORR to mink, fish were collected from the Poplar Creek embayment, Clinch River and the ocean, formulated into mink diets, and fed to mink. Mink were fed five different diets (A through E, see Sect. 8.2.2). Ten mink (2 males, 8 females) were fed each diet for 7 months; starting approximately 3 months prior to breeding, extending to 6 weeks post-partum. Bioaccumulation, growth, histopathology, and reproduction were recorded. Significant effects were observed only among mink fed diet E (75% diet from Poplar Creek fish). These effects included statistically significant reductions in body weights of adult females and male kits and in litter size. Percent reductions were 20% and 17% for adult female and male kit weights, respectively, and 37.7% for litter size.

To estimate exposures experienced by the mink in the toxicity test, Monte Carlo simulations of mink exposure were performed using the concentrations of mercury and PCB 1260 measured in the five diets (see section 8.2.2). Parameter values in the exposure model were as follows: body weight = 0.974 ± 0.202 kg; food ingestion rate = 0.137 kg/d. Results of the exposure simulation are presented in Table 8.20.

The mercury exposure estimate for the WOCW (mean = 0.008 ± 0.002) is below that estimated for diet E (mean = 0.033 ± 0.008). The PCB exposure estimate for the WOCW (mean = 0.18 ± 0.06) is also below that estimated for diet E (mean = 3.07 ± 0.77).

The mean mercury exposure from diet D (0.022 mg/kg/d; the highest exposure at which no adverse effects were observed) was less than the LOAEL of 0.025 mg/kg/day used in the risk assessment, while that of diet E (0.033 mg/kg/d; the lowest exposure at which adverse effects were observed) was greater (Table 8.20). This suggests that the estimated mercury LOAEL for mink is appropriate and representative of toxicity of mercury to mink on the ORR.

Exposures to Aroclor 1260 in diets B, C, D, and E were greater than the LOAEL (Table 8.20). However, adverse reproductive and other effects were observed only from Diet E. Estimating that toxicity should be observed in four diets, but actually observing it only in the highest concentration diet suggests that the LOAEL value for PCBs used in this assessment is too low and is not representative of the toxicity of the PCBs present on the ORR. ORR-specific NOAEL and LOAEL values for PCBs (represented by PCB 1260) of 1.7 mg/kg/d and 3 mg/kg/d can be derived from the toxicity test exposure estimate for diets B and E, respectively (Table 8.20). The estimated total PCB exposure to mink in WOCW (mean = 0.18 ± 0.06 mg/kg/d, Table 8.12) is less than the ORR-specific NOAEL, corroborating the conclusion from the literature-derived toxicity data that PCBs do not present a significant risk to mink in the WOCW.

Adverse effects from PCB were predicted for the otter at WOCW using the literature-derived toxicity data for the mink. Using the ORR-specific NOAEL and LOAEL for the mink and standardizing for differences in body weight (equation 6), one can derive ORR-specific NOAEL and LOAEL values for the otter of 1 mg/kg/d and 1.8 mg/kg/d, respectively. The estimated total PCB exposure to otter in WOCW (mean = 0.52 ± 0.18 mg/kg/d, Table 8.12) is less the ORR-specific NOAEL, bringing into question the conclusion from the literature-derived toxicity data that PCBs present a significant risk to otter in the WOCW.

Several conclusions may be drawn from these toxicity test data.

- Estimated mercury and PCB exposures for WOCW mink are below those observed to cause adverse reproductive and other effects in minks fed fish from Poplar Creek.
- Because the estimated LOAEL used in this assessment is comparable to the exposure level that resulted in adverse effects in the toxicity test, the estimated mercury LOAEL for mink is appropriate and representative of toxicity of mercury to mink on the ORR.
- Given the difference between predicted and observed toxicity from the test diets, the PCB LOAEL used in this assessment is too low and does not reflect toxicity observed among mink exposed to ORR fish, at least those obtained from Poplar Creek.

- ORR-specific NOAEL and LOAEL values can be derived for the otter, based on the mink study. Using the ORR-specific value rather than the literature value, PCBs would not be expected to cause toxic effects on survival, growth, or reproduction of otter in WOCW.

8.3.3 Biological Surveys

8.3.3.1 Mink survey

Results of the mink survey (see Sect. 8.2.3) indicate that mink are present on the ORR, including the WOCW, have large home ranges and do not avoid the industrial facilities on the ORR. The methods employed in the study do not allow numbers or density of mink to be determined. Arsenic, cadmium, lead, mercury and selenium were either not detected in the hair of a White Oak Creek mink or at levels compatible with those in reference samples.

8.3.3.2 Belted kingfisher survey

Results of the kingfisher survey indicate that contaminants are being accumulated in both eggs and adult birds at the WOCW. Metal concentrations in the egg from a burrow found on White Oak Creek contained elevated levels of cesium-137, indicating that the parent kingfisher bioaccumulated cesium-137 from foraging within White Oak Creek or a nearby surface impoundment. While contaminants in eggshells indicate exposure, there is insufficient information to evaluate the toxicological significance of this contamination.

Cadmium, mercury, selenium, lead, and cesium-137 were detected in a kingfisher carcass collected from the White Oak Creek watershed. Cesium-137 levels in the White Oak Creek bird were extremely elevated (91.27 pCi/g) compared to those in a bird collected from East Fork Poplar Creek (<2 pCi/g). The internal dose rate (mrad/d) expected from the cesium-137 (and its daughter product barium-137m) for the White Oak Creek kingfishers was estimated following the methodology of Blaylock et al. (1993):

$$D = \sum C_{tissue} \; \dot{E}_i \; CFa \qquad (10)$$

where:

D =		Internal dose rate (mrad/d)
C_{tissue}	=	Activity (pCi/g) of radionuclide *i* in kingfisher tissue
ϵ_i =		Energy for α, β, or λ emissions by nuclide *i* (MeV/nuclear transformation). Obtained from Eckerman and Ryman (1993). (Cesium-137: $\beta = 0.187$, no α or γ emissions. Barium-137m: $\beta = 0.065$, $\gamma = 0.597$, no α emissions)
CFa	=	Conversion factor to convert MeV/nt to g mrad/pCi d. (5.12×10^{-2})

The measured tissue activity level of 91.27 pCi/g results in an estimated internal dose rate of 3.81 mrad/d. While this body burden is relatively high, the internal dose rate is well below the 100 mrad/d dose limit recommended for terrestrial organisms by the International Atomic Energy Agency (IAEA 1992). This level of exposure to the maximally exposed individual is thought to be protective of the overall population (IAEA 1992, DOE 1995a).

The toxicological significance of the tissue metals concentrations in adult kingfisher was evaluated by comparison of burdens and effects levels reported in other bird species. This comparison suggests that it is unlikely that cadmium or lead in the kingfisher from White Oak Creek contribute significantly to risk. Leach et al. (1979) observed a 50% reduction in egg production among chickens consuming a diet containing 48 mg/kg cadmium. Cadmium concentrations in the livers and kidneys of these birds were 100 mg/kg and 40 mg/kg, respectively. Cadmium concentrations in healthy birds from unpolluted areas ranged from 0.1 to 32 mg/kg in liver and 0.3 to 137 mg/kg in kidney (Furness 1996). In comparison, the cadmium concentration in the kidney (1.53 mg/kg) and liver (0.90 mg/kg) of the kingfisher collected from the White Oak Creek were significantly less than concentrations associated with reproductive impairment and at the low end of the ranges observed among healthy birds from unpolluted areas. Lead concentrations in the kidney (0.42 mg/kg) and liver (0.4 mg/kg) of the White Oak Creek kingfisher were approximately one order of magnitude lower than the minimal level at which overt toxicity is observed in birds (3 to 6 mg/kg; Franson 1996), suggesting that lead accumulation is unlikely to be contributing to risks to kingfishers on the ORR.

In contrast to cadmium and lead, selenium and mercury burdens may present a hazard to kingfishers on the WOCW. The concentration of selenium observed in the liver of the White Oak Creek kingfisher (7.5 mg/kg) is less than the 10 mg/kg toxicity threshold recommended by Heinz (1996), but greater than the 3 mg/kg reproductive impairment threshold, suggesting the potential for adverse effects on reproduction. Mercury concentrations of 49 to 125 mg/kg in kidney and 4.6 to 91 mg/kg in liver have been reported for free-living birds found dead or dying (Thompson 1996). Nephrotoxicity and kidney lesions occur in birds at mercury concentrations in the kidney of 5 to 13 mg/kg (Nicholson and Osborn 1983). While observed mercury concentrations in the kidney (26.8 mg/kg) and liver (17.6 mg/kg) of the kingfisher were generally lower than concentrations associated with mortality, the kidney concentration exceeds nephrotoxic levels, suggesting that mercury accumulation may be causing kidney damage to kingfishers on the WOCW.

8.3.4 Weight of Evidence

8.3.4.1 Mink

Three lines of evidence, literature toxicity data, toxicity test data, and field surveys were available to evaluate risk to mink.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to mink at HF-2, Lower WOC/WOL, SWSA 6 East, W6MS3, W6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern. Note that results of analyses using measured fish tissue data take precedence over comparison to screening water concentration benchmarks, and modeling with fish tissue data suggests no risks from mercury or PCBs in the watershed.

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW, indicating no significant risk to individual mink (Table 8.6). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) also indicate no significant risk from mercury or PCBs for the WOCW-wide mink population.

Toxicity test data

Estimated mercury and PCB exposures for WOCW mink are below those observed to cause adverse reproductive and other effects in the toxicity test.

Field surveys

Limited data from field surveys indicate that while mink are present on the reservation, including the WOCW, the health and abundance of the population is unknown (the trapping methods that were employed, while suitable for capturing animals for radiotelemetry purposes, were not adequate to estimate population abundance and density). Mink on the ORR have large home ranges and make use of the creeks within the industrial facilities. Metals concentrations in the hair of a White Oak Creek mink were similar to those from off-site locations.

- The weight of evidence suggests that risks to the WOCW mink population from mercury and PCBs are not significant.

8.3.4.2 River otter

Two lines of evidence, literature toxicity data and PCB and mercury NOAEL and LOAEL values derived from the Poplar Creek mink toxicity test, were available to evaluate potential risk to river otter.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to otter at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern.

Based on the fish tissue data, point estimates of exposure exceeded literature-derived LOAELs for mercury at the Lower WOC/WOL and WOC subbasins, indicating significant risk to individual otters from mercury at these locations (Table 8.7). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) also indicate a significant risk from mercury for a future WOCW otter individual (i.e. >20%). However, because the future WOCW-wide otter population was estimated to be only two, calculation of the binomial probability distribution indicated no risk to the population as a whole (Table 8.19). Because of the special concern for individuals of T&E species, we conclude that the literature toxicity data indicate a potential risk for the otter from mercury.

Point estimates of exposure exceeded literature-derived LOAELs for PCBs at the White Oak Creek Embayment and Lower WOC/WOL subbasins, indicating significant risk to individual otters from PCBs at these locations (Table 8.7). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) indicate a significant risk (50% or 1 individual) from PCBs in a future WOCW otter population.

Toxicity tests data

Using Equation 6 and the ORR-specific NOAELs and LOAELs for PCBs and mercury from mink toxicity tests (see Sect. 8.3.2), ORR-specific values for otter were estimated to be as follows:

Analyte	Estimated NOAEL (mg/kg/d)	Estimated LOAEL (mg/kg/d)
PCBs	0.92	1.8
Mercury	0.013	0.02

The ORR-specific mercury LOAEL is somewhat higher, but still comparable to the literature-derived LOAEL (0.015 mg/kg/d; Table 8.13). Therefore, the results of the Poplar Creek mink toxicity test do not significantly alter the conclusions derived from evaluation of the literature-based toxicity data. Because the river otter is a state threatened species, effects to any individual is significant. Therefore, the weight of evidence suggests that mercury is a significant risk to any individual otter that may occupy the WOCW in the future, particularly from levels at the Lower White Oak Creek/White Oak Lake and White Oak Creek subbasins. Based on water concentrations, mercury may also be of concern at HF-2, SWSA 6 East, WAG6MS3, WAG6MS and SWSA5/WOC.

Comparison of the ORR-specific PCB LOAEL to the exposure distributions presented in Table 8.12 indicate that there is a <1% likelihood of individuals in the WOCW experiencing PCB exposure greater than the ORR-specific LOAEL. Therefore, based upon the results of the Poplar Creek mink toxicity test, PCBs are unlikely to present a significant risk to WOCW otters.

- The weight of evidence suggests that risks to an individual WOCW otter are potentially significant from exposure to mercury, but not PCBs.

8.3.4.3 Belted kingfisher

Two lines of evidence, literature toxicity data and biomonitoring data, were available to evaluate potential risk to belted kingfisher.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to kingfisher at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern

Based on the fish tissue data, point estimates of exposure exceeded literature-derived LOAELs for mercury at the Lower White Oak Creek/White Oak Lake and White Oak Creek subbasins, indicating significant risk to individual kingfishers from mercury at these locations (Table 8.8). Point estimates of exposure exceeded literature-derived LOAELs for PCBs at the White Oak Creek Embayment, indicating a significant risk to individual kingfishers from mercury at this location (Table 8.8). However, Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) indicate no significant risk from mercury or PCBs for the WOCW-wide population.

Biomonitoring data

The limited biomonitoring data indicate that kingfisher in the White Oak Creek area are accumulating mercury to potentially nephrotoxicty levels and selenium to levels potentially associated with impaired reproduction.

- The weight of evidence suggests mercury and selenium in WOCW may present a significant risk to the WOCW belted kingfisher population. Risks from PCBs are not significant.

8.3.4.4 Great blue heron

One line of evidence, literature toxicity data, was available to evaluate ecological risk to great blue heron. Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to heron at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW, indicating no significant risk to individual herons (Table 8.9). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) also indicate no significant risk from mercury or PCBs in the WOCW-wide population.

- The weight of evidence suggests mercury and PCB do not present a significant risk to great blue heron on or near the WOCW.

8.3.4.5 Osprey

One line of evidence, literature toxicity data, was available to evaluate ecological risk to osprey. As a T&E species, any adverse impact to individual osprey is significant. Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to osprey at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern.

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW that provides suitable habitat (i.e., White Oak Lake and embayment), indicating no significant risk to individual ospreys (Table 8.10). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) also indicate no significant risk from mercury or PCBs.

- The weight of evidence suggests mercury and PCB do not present a significant risks to osprey on or near the WOCW.

8.3.5 Uncertainties Concerning Risks to Piscivorous Wildlife

8.3.5.1 Bioavailability of contaminants

Bioavailability of contaminants was assumed to be comparable between fish collected from the WOCW and the diets used in the literature toxicity tests. Because bioavailability may not be comparable, exposure estimates based upon the contaminant concentrations in WOCW fish may either under- or overestimate the actual contaminant exposure experienced.

8.3.5.2 Extrapolation from published toxicity data

While published toxicity studies are available for mink, there are no published data for otter, kingfisher, great blue heron or osprey. To estimate toxicity of contaminants at the site, it was necessary to extrapolate from studies performed on test species (i.e., mallard ducks, ring-necked pheasant, and rats). While it was assumed that toxicity could be estimated as a function of body size, the accuracy of the estimate is not known. For example, osprey or herons may be more or less sensitive to contaminants than ducks or pheasants, due to factors other than metabolic rate.

Additional extrapolation uncertainty exists for those contaminants for which data consisted of only LOAELs or tests were subchronic in duration. For either case, an uncertainty factor of 10 was employed to estimate NOAELs or chronic data. The uncertainty factor of 10 may either over- or underestimate the actual LOAEL-NOAEL or subchronic-chronic relationship.

Toxicity of PCBs to piscivorous wildlife was evaluated using toxicity data from studies on Aroclor 1254. Because toxicity of PCB congeners can vary dramatically, the applicability of data for Aroclor 1254 is unknown. Comparison of the results of the mink toxicity test results and the estimated LOAELs for mink, suggests the Aroclor 1254 data do not accurately reflect (i.e., they overestimate) the toxicity of the PCB mixture present in WOCW fish.

8.3.5.3 Variable food consumption

While food consumption by piscivorous wildlife was assumed to be similar to that reported for the same or related species in other locations, the validity of this assumption cannot be determined. Food consumption by wildlife on the WOCW may be greater or less than that reported in the literature, resulting in either an increase or decrease in contaminant exposure.

8.3.5.4 Single contaminant tests vs exposure to multiple contaminants in the field

While piscivores on the WOCW are exposed to multiple contaminants concurrently, published toxicological values only consider effects experienced by exposures to single contaminants. Because some contaminants to which wildlife are exposed can interact antagonistically, single contaminant studies may overestimate their toxic potential. Similarly, for those contaminants that interact additively or synergistically, single contaminant studies may underestimate their toxic potential.

8.3.5.5 Inorganic forms or species present in the environment

Toxicity of metal species varies dramatically depending upon the valence state or form (organic or inorganic) of the metal. For example, Arsenic (III) and methyl mercury are more toxic than arsenic (V) and inorganic mercury, respectively. The available data on the contaminant concentrations in media do not report which species or form of contaminant was observed. Because benchmarks used for comparison represented the more toxic species/forms of the metals (particularly for arsenic and mercury), if the less toxic species/form of the metal was actually present in fish from the WOCW, potential toxicity at the sites may be overestimated.

8.3.5.6 Contaminant concentrations in aquatic prey

While fish are the primary prey of piscivores, other aquatic prey are also consumed. It was assumed that the contaminant concentration in fish was representative of that in other aquatic prey. Due to the different life histories of other aquatic prey (i.e., amphibians, crayfish, benthic invertebrates), their contaminant burdens are likely to differ from that in fish. Therefore, assuming comparability to fish may either over or underestimate exposure.

8.3.5.7 Fish size selection

Data concerning the sizes of fish consumed by piscivores were obtained from the literature. Because fish sizes consumed by piscivores on the WOCW may differ from that reported in the literature, exposure may be overestimated or underestimated.

8.3.5.8 Monte Carlo simulation

To perform Monte Carlo simulations, distributions must be assigned to parameters. Because wildlife are mobile, the mean of the contaminant concentration is likely to best represent their exposure. For this report, the contaminant concentrations in fish were assumed to be normally distributed. In future revisions of this report, goodness-of-fit analyses will be performed to determine which distribution best fits the data.

The literature values used for body weights of each endpoint are nationwide values which may overestimate or underestimate the body weight of species found at the site. Similarly the proportion of fish and aquatic prey in mink diet were derived from data from northern locations (i.e., MI, Canada, etc.). The applicability of these data to the percentage of fish and aquatic prey consumed by mink in Tennessee is unknown.

8.3.5.9 Estimated whole fish concentrations

Contaminant concentrations in whole fish were estimated using contaminant specific fillet to whole fish ratios. Data to generate ratios were available only for PCBs in largemouth bass and channel catfish from the Clinch River. Ratios for metals were obtained from spotted bass samples from near the PORTS facility in Ohio. Applicability of these ratios to species other than those from which they were developed is unknown. Similarly, applicability of metal ratios from Ohio spotted bass to fish on the ORR is unknown.

Table 8.1. Life history parameters for river otter

Parameter	Value	Comments	Reference
Body Weight	8.0 kg (mean ♂+♀)		EPA 1993b
Food Consumption Rate	0.9 kg/d (mean ♂+♀)		EPA 1993b
Water Consumption Rate	0.64 L/d		EPA 1993b
Diet Composition	Almost exclusively fish 2-50 cm in size; most ≥30 cm.		Melquist and Hornocker 1983
	50% large and 50% small fish		EPA 1993b
Home Range	10-78 km	river-Idaho	Melquist and Hornocker 1983
		range size and shape depends on habitat - linear along streams, circular in marshes	EPA 1993b
Habitat Requirements	aquatic habitats - streams, lakes, marshes;		EPA 1993b
Population Density	0.17 - 0.37 /km	river-Idaho	Melquist and Hornocker 1983
	0.0094-0.014/ha		EPA 1993b
Behavior	Generally most active morning and evening, but may be active at any time in day.		Melquist and Hornocker 1983
	active year-round, does not hibernate		EPA 1993b

Table 8.2. Life history parameters for belted kingfisher

Parameter	Value	Comments	Reference
Body Weight	**0.148** kg		Dunning 1984
Food Consumption Rate	50% bw		Alexander 1977
	0.075 kg/d	assuming 0.148 kg bw	
Water Consumption Rate	**0.016** L/d	estimated using allometric equation[a] assuming 0.148 kg bw	
Soil Consumption Rate	as a piscivore, assumed to be negligible		
Diet Composition	Cyprinids - 76.4% other fish - 10.2% crayfish - 13.3%	Ohio - creek	Davis 1982
	lizards, small snakes, frogs, salamanders, and insects may be consumed if fish are unavailable		Landrum et al. 1993
Home Range	1.03 km (breeding) 0.39 km (non-breeding)	Ohio - creek	Davis 1982
	2.19 km (breeding)	Pennsylvania - stream summer	Brooks and Davis 1987
Habitat Requirements	uses a diverse aquatic habitats (stream, river, lake, marsh, coastline)		Brooks and Davis 1987
	require high vertical banks composed of >75% sand and <7% clay for nest construction		
	prefer relatively clear waters free of thick vegetation		Bent 1940.
Population Density	0.11 - 0.19 pairs/km shore	Pennsylvania - stream summer	Brooks and Davis 1987
Behavior	while most migrate from northern parts of range, some may stay in areas where water remains ice-free		Bent 1940.

Table 8.3. Life history parameters for great blue heron

Parameter	Value	Comments	Reference
Body Weight	2.576 kg (♂) 2.204 kg (♀) **2.39** kg (mean♂+♀)		Dunning 1984
Food Consumption Rate	**0.42** kg/d	estimated using allometric equation[a] specific for herons and egrets assuming 2.39 kg bw	Kushlan 1978
Water Consumption Rate	**0.1058** L/d	estimated using allometric equation[b] assuming 2.39 kg bw	After Calder and Braun 1983
Diet Composition	diet predominantly fish but may include crustaceans, insects, snails, amphibians, reptiles, birds, and mammals fish sizes: 0-10 cm=39.2% 11-20 cm=47.1% 21-30 cm=13.7%		Kushlan 1978 Collazo 1985 Hoffman 1978 Alexander 1977
Home Range (foraging distance from colony)	3.1 km 7 - 8 km	up to 24.2 km - S. Dakota - river N. Carolina - coastal	EPA 1993a. Short and Cooper 1985
Habitat Requirements	use both coastal and inland water-associated habitats Foraging: shallow shores of ponds, lakes, streams, wet meadows, wooded swamps, bays, and marshes breeding: trees for rookery sites. In absence of trees will use rock ledges, cliffs, and artificial structures		Short and Cooper 1985 DeGraaf et al. 1981 Short and Cooper 1985

Table 8.3. (continued)

Parameter	Value	Comments	Reference
Population Density	nest colonially, therefore population density depends on availability of nest habitat and suitable foraging habitat		EPA 1993a
	2.3 - 3.6 /km	North Dakota rivers and streams	
Behavior	may or may not defend a feeding territory depending on local population size and food availability		Kushlan 1978
	Migrates in northern U.S. and southern Canada; year round resident from WV, PA south.		National Geographic Society 1987.

Table 8.4. Life history parameters for osprey

Parameter	Value	Comments	Reference
Body Weight	1.5 kg (♂+♀)		EPA 1993c
Food Consumption Rate	0.3 kg/d	fresh weight	EPA 1993c
Water Consumption Rate	0.077 L/d		EPA 1993c
Diet Composition	almost 100% fish	all parts of fish consumed except large bones	EPA 1993c
	fish sizes: 0-10 cm=3.3% 11-20 cm=42.1% 21-30 cm=46.7% 31-40 cm=6.6% >41 cm=1.3%		VanDaele and VanDaele 1982
Home Range (foraging distance from nest site)	10-15 km		VanDaele and VanDaele 1982
Habitat Requirements	Coastal areas plus large rivers and lakes Nesting habitat requires open, shallow water nearby plus abundant fish. Nests atop isolated (often dead) trees and man-made structures		EPA 1993b
Population Density	0.005-0.1 nests/ha		EPA 1993b
Behavior	year-round resident in southern part of range (i.e. Florida) Migratory in Tennessee		EPA 1993b

Table 8.5. Summary statistics for fish data from the White Oak Creek watershed

Analyte	Location	Size	Obs	Det	Contaminant concentrations in fish (mg/kg)					
					Mean	Standard error	95% UCL	Maximum	Lognormal mean	Lognormal standard deviation
Mercury	WCK 0.9	small	16	16	0.103	0.006	0.114	0.161	0.103	0.024
Mercury	WCK 1.5	small	16	16	0.096	0.009	0.111	0.166	0.096	0.035
Mercury	WCK 1.5	large	16	16	0.154	0.018	0.185	0.301	0.155	0.082
Mercury	WCK 2.3	small	8	8	0.154	0.020	0.191	0.261	0.155	0.052
Mercury	MEK 0.2	small	24	24	0.090	0.006	0.099	0.161	0.090	0.025
Mercury	WCK 2.9	small	8	8	0.176	0.016	0.207	0.245	0.177	0.046
Mercury	WCK 3.5	small	16	16	0.111	0.007	0.124	0.166	0.112	0.033
Mercury	NTK 0.2	small	8	8	0.123	0.008	0.139	0.157	0.124	0.026
PCBs	WCK 0.3	large	4	4	5.829	0.421	6.819	6.702	5.847	0.887
PCBs	WCK 0.9	small	13	13	0.587	0.110	0.783	1.724	0.609	0.470
PCBs	WCK 0.9	large	10	10	6.483	1.236	8.748	13.008	7.501	8.244
PCBs	WCK 1.5	small	24	24	2.097	0.284	2.584	6.587	2.100	1.371
PCBs	WCK 1.5	large	16	16	13.149	1.814	16.329	28.445	13.520	9.065
PCBs	WCK 2.3	small	8	8	1.592	0.304	2.169	3.502	1.603	0.805
PCBs	MEK 0.2	small	20	15	0.247	0.062	0.355	1.330	0.257	0.384
PCBs	WCK 2.9	small	16	16	1.107	0.195	1.448	2.915	1.141	0.978
PCBs	WCK 3.5	small	16	16	1.300	0.160	1.580	2.303	1.349	0.889
PCBs	NTK 0.2	small	8	8	0.290	0.108	0.495	0.992	0.300	0.344

Table 8.6. Estimated exposure of mink on the WOCW to mercury and PCBs

Analyte	Sampling station	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0085	0.57	0.34
Mercury	WCK 1.5	0.0083	0.55	0.33
Mercury	WCK 2.3	0.0143	0.95	0.57
Mercury	MEK 0.2	0.0074	0.49	0.30
Mercury	WCK 2.9	0.0155	1.03	0.62
Mercury	WCK 3.5	0.0093	0.62	0.37
Mercury	NTK 0.2	0.0104	0.69	0.42
PCBs	WCK 0.3	0.5101	3.64	0.74
PCBs	WCK 0.9	0.0586	0.42	0.08
PCBs	WCK 1.5	0.1933	1.38	0.28
PCBs	WCK 2.3	0.1622	1.16	0.24
PCBs	MEK 0.2	0.0265	0.19	0.04
PCBs	WCK 2.9	0.1083	0.77	0.16
PCBs	WCK 3.5	0.1182	0.84	0.17
PCBs	NTK 0.2	0.0370	0.26	0.05

Table 8.7. Estimated exposure of river otter on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0128	1.43	0.86
Mercury	WCK 1.5	0.0166	1.85	1.11
Mercury	WCK 2.3	0.0215	2.39	1.43
Mercury	MEK 0.2	0.0111	1.24	0.74
Mercury	WCK 2.9	0.0233	2.59	1.55
Mercury	WCK 3.5	0.0140	1.55	0.93
Mercury	NTK 0.2	0.0157	1.74	1.04
PCBs	WCK 0.3	0.7671	9.24	1.87
PCBs	WCK 0.9	0.5362	6.46	1.31
PCBs	WCK 1.5	1.0638	12.82	2.59
PCBs	WCK 2.3	0.2440	2.94	0.60
PCBs	MEK 0.2	0.0399	0.48	0.10
PCBs	WCK 2.9	0.1629	1.96	0.40
PCBs	WCK 3.5	0.1777	2.14	0.43
PCBs	NTK 0.2	0.0557	0.67	0.14

Table 8.8. Estimated exposure of belted kingfisher on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0579	9.65	0.90
Mercury	WCK 1.5	0.0560	9.34	0.88
Mercury	WCK 2.3	0.0969	16.16	1.51
Mercury	MEK 0.2	0.0502	8.37	0.78
Mercury	WCK 2.9	0.1048	17.47	1.64
Mercury	WCK 3.5	0.0630	10.50	0.98
Mercury	NTK 0.2	0.0706	11.77	1.10
PCBs	WCK 0.3	3.4556	19.20	1.92
PCBs	WCK 0.9	0.3969	2.21	0.22
PCBs	WCK 1.5	1.3093	7.27	0.73
PCBs	WCK 2.3	1.0990	6.11	0.61
PCBs	MEK 0.2	0.1797	1.00	0.10
PCBs	WCK 2.9	0.7339	4.08	0.41
PCBs	WCK 3.5	0.8005	4.45	0.44
PCBs	NTK 0.2	0.2508	1.39	0.14

Table 8.9. Estimated exposure of great blue heron on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0201	3.34	0.31
Mercury	WCK 1.5	0.0194	3.24	0.30
Mercury	WCK 2.3	0.0336	5.60	0.53
Mercury	MEK 0.2	0.0174	2.90	0.27
Mercury	WCK 2.9	0.0364	6.06	0.57
Mercury	WCK 3.5	0.0218	3.64	0.34
Mercury	NTK 0.2	0.0245	4.08	0.38
PCBs	WCK 0.3	1.1983	6.66	0.67
PCBs	WCK 0.9	0.1377	0.76	0.08
PCBs	WCK 1.5	0.4540	2.52	0.25
PCBs	WCK 2.3	0.3811	2.12	0.21
PCBs	MEK 0.2	0.0623	0.35	0.03
PCBs	WCK 2.9	0.2545	1.41	0.14
PCBs	WCK 3.5	0.2776	1.54	0.15
PCBs	NTK 0.2	0.0870	0.48	0.05

Table 8.10. Estimated exposure of osprey on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0228	3.81	0.36
Mercury	WCK 1.5	0.0233	3.88	0.36
PCBs	WCK 0.3	1.3638	7.58	0.76
PCBs	WCK 0.9	0.2825	1.57	0.16
PCBs	WCK 1.5	0.7339	4.08	0.41

Table 8.11. Total biomass of fish observed at fish sampling locations in WOCW

Sample location		Fish biomass (g/m²)				Proportion of total biomass at sampled locations	
Fish community	Bioaccumulation	Spring	Fall	Year	Mean annual biomass	data from all 8 locations	data from only 7 locations
WOL [a]	WCK 0.3	-	-	1987	53.66	0.248	
WOL [a]	WCK 0.9	-	-	1987	53.66	0.248	0.33
WOL [a]	WCK 1.5	-	-	1987	53.66	0.248	0.33
WCK 2.3 [b]	WCK 2.3	10.49	17.06	1993	13.78	0.064	0.085
MEK 0.6 [b]	MEK 0.2	10.52	9.6	1993	10.06	0.046	0.062
WCK 2.9 [b]	WCK 2.9	10.80	13.34	1993	12.07	0.056	0.075
WCK 3.4 [b]	WCK 3.5	17.16	14.30	1993	15.73	0.073	0.097
NTK 0.3 [b]	NTK 0.2	3.27	4.50	1993	3.89	0.018	0.024

[a] Source:Loar et al. 1992.
[b] Source:Ashwood et al. 1994.

Table 8.12. Results of Monte Carlo simulation of exposure for piscivores on the WOCW

Analyte	Species	Number of sampling locations	Mean	Standard deviation	80th percentile	%> NOAEL	%> LOAEL
Mercury	Mink	7	0.0083	0.0019	0.0098	<5%	<5%
Mercury	Otter	7	0.0136	0.0018	0.0150	>95%	25%
Mercury	Kingfisher	7	0.0564	0.0077	0.0625	>95%	15%
Mercury	Heron	7	0.0198	0.0028	0.0220	>95%	<5%
Mercury	Osprey	7	0.0202	0.0037	0.0229	>95%	<5%
PCBs	Mink	8	0.1785	0.0563	0.2194	75%	<5%
PCBs	Otter	8	0.5242	0.1784	0.6249	>95%	70-75%
PCBs	Kingfisher	8	1.2136	0.2056	1.3590	>95%	<5%
PCBs	Heron	8	0.4202	0.0753	0.4721	>95%	<5%
PCBs	Osprey	8	0.6605	0.1144	0.7489	>95%	<5%

Table 8.13. Estimated NOAELs and LOAELs for mink and river otter

Contaminant	Experimental information: Form	Test species	NOAEL (mg/kg/d) and duration	LOAEL (mg/kg/d) and duration	Endpoint	Citation	Estimated NOAEL (mg/kg/d): mink	Estimated NOAEL (mg/kg/d): otter	Estimated LOAEL (mg/kg/d): mink	Estimated LOAEL (mg/kg/d): otter
Mercury	methyl	mink	0.015[2] 93 d	0.025[2] 93 d	mortality	Wobeser et al. 1976	0.015	0.009	0.025	0.015
PCB's	Aroclor 1254	mink	0.14 4.5 mo.	0.69 4.5 mo.	reproduction	Aulerich and Ringer 1987	0.14	0.083	0.69	0.41

[2] Estimated value: subchronic-chronic factor of 10 applied.

Table 8.14. Estimated NOAEL's and LOAEL's for belted kingfisher, great blue heron, and osprey

Contaminant	Experimental information						Estimated Values (mg/kg/d)	
	Form	Test species	NOAEL (mg/kg/d) and duration	LOAEL (mg/kg/d) and duration	Endpoint	Citation	NOAEL	LOAEL
Mercury	methyl	mallard duck	0.006[2] 3 gen.	0.064 3 gen.	reproduction	Heinz 1979	0.006	0.064
PCB's	Aroclor 1254	Ring-necked Pheasant	0.18[2] 17 wk	1.8 17 wk	reproduction	Dahlgren et al. 1972	0.18	1.8

[2] Estimated NOAEL: LOAEL-NOAEL factor of 10 applied.

Table 8.15. Comparison of mainstem water concentrations (mg/L) in White Oak Creek watershed subbasins to piscivore water benchmarks[a]

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
HF-2	AS	4/10	2.80E-03	3.78E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.34E-02	4.47E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Belted Kingfisher	3.20E-01	4.20E-01	5.47E-02	4.17E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Belted Kingfisher	4.53E-07	4.53E-06	2.96E+05	2.96E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Belted Kingfisher	3.20E-01	4.20E-01	2.46E-02	1.88E-02
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Belted Kingfisher	9.36E-01		9.62E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Belted Kingfisher	2.82E-01	8.46E-01	4.96E-02	1.65E-02
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Belted Kingfisher	2.31E-04	3.18E-03	4.33E+00	3.14E-01
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.93E-02	1.48E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Belted Kingfisher	4.53E-07	4.53E-06	2.08E+02	2.08E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Belted Kingfisher	1.44E+00	1.99E+00	4.73E-03	3.43E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Belted Kingfisher	3.79E-04	7.59E-04	2.64E+00	1.32E+00
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Belted Kingfisher	2.82E-01	8.46E-01	1.95E-03	6.50E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Belted Kingfisher	3.20E-01	4.20E-01	6.88E-03	5.24E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Belted Kingfisher	2.82E-01	8.46E-01	7.09E-03	2.36E-03
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.53E-02	1.17E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Belted Kingfisher	1.44E+00	1.99E+00	4.65E-03	3.37E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Belted Kingfisher	2.82E-01	8.46E-01	4.61E-03	1.54E-03
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Belted Kingfisher	1.44E+00	1.99E+00	3.61E-03	2.62E-03
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Belted Kingfisher	9.36E-01		6.51E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Belted Kingfisher	3.20E-01	4.20E-01	3.94E-02	3.00E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Belted Kingfisher	1.44E+00	1.99E+00	3.06E-03	2.21E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Belted Kingfisher	3.79E-04	7.59E-04	8.18E+00	4.08E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Belted Kingfisher	7.59E-07		1.32E+03	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Belted Kingfisher	9.36E-01		5.58E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.74E-02	5.79E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Belted Kingfisher	4.53E-07	4.53E-06	6.62E+02	6.63E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Belted Kingfisher	9.36E-01		3.80E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.06E-02	3.54E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.76E+01	1.28E+00
W6MS1	CU	10/21	1.07E-02	1.45E-02	Belted Kingfisher	3.20E-01	4.20E-01	4.53E-02	3.46E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Belted Kingfisher	4.53E-07	4.53E-06	8.96E+02	8.97E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Belted Kingfisher	1.44E+00	1.99E+00	8.61E-03	6.22E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Belted Kingfisher	3.79E-04	7.59E-04	4.46E+00	2.23E+00
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Belted Kingfisher	7.59E-07		1.21E+04	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Belted Kingfisher	5.93E-05	5.93E-04	5.06E+01	5.06E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Belted Kingfisher	9.36E-01		3.80E+00	

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	AS	9/37	1.68E-03	2.19E-03	Belted Kingfisher	2.82E-01	8.46E-01	7.77E-03	2.59E-03
W6MS3	CD	18/45	2.58E-03	2.97E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.29E+01	9.32E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Belted Kingfisher	3.20E-01	4.20E-01	7.09E-02	5.41E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Belted Kingfisher	4.53E-07	4.53E-06	5.94E+02	5.94E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Belted Kingfisher	1.44E+00	1.99E+00	1.46E-02	1.05E-02
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Belted Kingfisher	4.28E+00	8.57E+00	4.67E-04	2.33E-04
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Belted Kingfisher	7.59E-07		8.21E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Belted Kingfisher	5.93E-05	5.93E-04	1.22E+02	1.22E+01
West Seep	AL	4/6	2.04E-01	5.22E-01	Belted Kingfisher	9.36E-01		5.58E-01	
West Seep	AS	1/4	1.25E-03	1.84E-03	Belted Kingfisher	2.82E-01	8.46E-01	6.52E-03	2.17E-03
West Seep	CD	2/5	1.56E-03	2.34E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.01E+01	7.35E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Belted Kingfisher	3.20E-01	4.20E-01	2.87E-02	2.19E-02
WOC	AS	8/61	1.67E-02	1.95E-02	Belted Kingfisher	2.82E-01	8.46E-01	6.91E-02	2.31E-02
WOC	CD	1/57	1.82E-03	5.00E-05	Belted Kingfisher	2.31E-04	3.18E-03	2.16E-01	1.57E-02
WOC	CU	18/66	3.56E-03	4.99E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.56E-02	1.19E-02
WOC	HG	15/56	5.72E-05	7.48E-05	Belted Kingfisher	4.53E-07	4.53E-06	1.65E+02	1.65E+01
WOC	NI	1/61	6.89E-03	8.79E-03	Belted Kingfisher	1.44E+00	1.99E+00	6.10E-03	4.42E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Belted Kingfisher	4.93E-02	4.93E-01	4.06E-01	4.05E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Belted Kingfisher	1.68E-01		1.19E-01	
WOCE	CD	2/2	1.38E-03	2.40E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.04E+01	7.54E-01
HF-2	AS	4/10	2.80E-03	3.78E-03	Great Blue Heron	8.11E-01	2.43E+00	4.66E-03	1.55E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Great Blue Heron	9.21E-01	1.21E+00	1.90E-02	1.45E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Great Blue Heron	1.31E-06	1.31E-05	1.02E+05	1.03E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Great Blue Heron	9.21E-01	1.21E+00	8.55E-03	6.51E-03
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Great Blue Heron	2.70E+00		3.33E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Great Blue Heron	8.11E-01	2.43E+00	1.73E-02	5.75E-03
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Great Blue Heron	6.65E-04	9.18E-03	1.50E+00	1.09E-01
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Great Blue Heron	9.21E-01	1.21E+00	6.72E-03	5.12E-03
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Great Blue Heron	1.31E-06	1.31E-05	7.18E+01	7.20E+00
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Great Blue Heron	4.15E+00	5.73E+00	1.64E-03	1.19E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Great Blue Heron	1.09E-03	2.19E-03	9.17E-01	4.57E-01
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Great Blue Heron	8.11E-01	2.43E+00	6.78E-04	2.26E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Great Blue Heron	9.21E-01	1.21E+00	2.39E-03	1.82E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Great Blue Heron	8.11E-01	2.43E+00	2.47E-03	8.22E-04
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Great Blue Heron	9.21E-01	1.21E+00	5.32E-03	4.05E-03
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Great Blue Heron	4.15E+00	5.73E+00	1.61E-03	1.17E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Great Blue Heron	8.11E-01	2.43E+00	1.60E-03	5.34E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Great Blue Heron	4.15E+00	5.73E+00	1.25E-03	9.07E-04

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Great Blue Heron	2.70E+00		2.26E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Great Blue Heron	9.21E-01	1.21E+00	1.37E-02	1.04E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Great Blue Heron	4.15E+00	5.73E+00	1.06E-03	7.68E-04
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Great Blue Heron	1.09E-03	2.19E-03	2.84E+00	1.42E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Great Blue Heron	2.19E-06		4.57E+02	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Great Blue Heron	2.70E+00		1.93E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Great Blue Heron	8.11E-01	2.43E+00	6.04E-03	2.01E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Great Blue Heron	1.31E-06	1.31E-05	2.29E+02	2.30E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Great Blue Heron	2.70E+00		1.32E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Great Blue Heron	8.11E-01	2.43E+00	3.69E-03	1.23E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Great Blue Heron	6.65E-04	9.18E-03	6.12E+00	4.43E-01
W6MS1	CU	10/21	1.07E-02	1.45E-02	Great Blue Heron	9.21E-01	1.21E+00	1.57E-02	1.20E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Great Blue Heron	1.31E-06	1.31E-05	3.10E+02	3.11E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Great Blue Heron	4.15E+00	5.73E+00	2.99E-03	2.16E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Great Blue Heron	1.09E-03	2.19E-03	1.55E+00	7.72E-01
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Great Blue Heron	2.19E-06		4.20E+03	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Great Blue Heron	1.71E-04	1.71E-03	1.75E+01	1.75E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Great Blue Heron	2.70E+00		1.32E+00	
W6MS3	AS	9/37	1.68E-03	2.19E-03	Great Blue Heron	8.11E-01	2.43E+00	2.70E-03	9.01E-04
W6MS3	CD	18/45	2.58E-03	2.97E-03	Great Blue Heron	6.65E-04	9.18E-03	4.47E+00	3.23E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Great Blue Heron	9.21E-01	1.21E+00	2.46E-02	1.88E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Great Blue Heron	1.31E-06	1.31E-05	2.05E+02	2.06E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Great Blue Heron	4.15E+00	5.73E+00	5.06E-03	3.66E-03
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Great Blue Heron	1.23E+01	2.46E+01	1.63E-04	8.13E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Great Blue Heron	2.19E-06		2.84E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Great Blue Heron	1.71E-04	1.71E-03	4.23E+01	4.23E+00
West Seep	AL	4/6	2.04E-01	5.22E-01	Great Blue Heron	2.70E+00		1.93E-01	
West Seep	AS	1/4	1.25E-03	1.84E-03	Great Blue Heron	8.11E-01	2.43E+00	2.27E-03	7.55E-04
West Seep	CD	2/5	1.56E-03	2.34E-03	Great Blue Heron	6.65E-04	9.18E-03	3.52E+00	2.55E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Great Blue Heron	9.21E-01	1.21E+00	9.98E-03	7.60E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Great Blue Heron	8.11E-01	2.43E+00	2.40E-02	8.01E-03
WOC	CD	1/57	1.82E-03	5.00E-05	Great Blue Heron	6.65E-04	9.18E-03	7.52E-02	5.45E-03
WOC	CU	18/66	3.56E-03	4.99E-03	Great Blue Heron	9.21E-01	1.21E+00	5.42E-03	4.13E-03
WOC	HG	15/56	5.72E-05	7.48E-05	Great Blue Heron	1.31E-06	1.31E-05	5.71E+01	5.73E+00
WOC	NI	1/61	6.89E-03	8.79E-03	Great Blue Heron	4.15E+00	5.73E+00	2.12E-03	1.53E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Great Blue Heron	1.42E-01	1.42E+00	1.41E-01	1.41E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Great Blue Heron	4.84E-01		4.13E-02	
WOCE	CD	2/2	1.38E-03	2.40E-03	Great Blue Heron	6.65E-04	9.18E-03	3.61E+00	2.61E-01

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
HF-2	AS	4/10	2.80E-03	3.78E-03	Mink	2.16E-02	2.16E-01	1.75E-01	1.75E-02
HF-2	BE	2/11	3.26E-04	4.00E-04	Mink	1.88E-01		2.13E-03	
HF-2	CR	2/11	2.91E-03	5.26E-03	Mink	4.95E+00	1.98E+01	1.06E-03	2.66E-04
HF-2	CU	7/11	9.55E-03	1.75E-02	Mink	2.94E-01	3.87E-01	5.95E-02	4.53E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Mink	3.92E-06	6.54E-06	3.42E+04	2.05E+04
HF-2	TL	1/9	2.82E-01	4.10E-01	Mink	1.21E-03	1.21E-02	3.39E+02	3.39E+01
HF-2	ACETONE	1/3	2.67E-03	3.00E-03	Mink	5.05E+01	2.52E+02	5.94E-05	1.19E-05
HF-2	METHYLENE CHLORIDE	3/3	1.00E-04	1.00E-04	Mink	5.50E+00	4.70E+01	1.82E-05	2.13E-06
Intermediate Pond	BE	2/13	5.11E-04	5.00E-04	Mink	1.88E-01		2.66E-03	
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Mink	2.94E-01	3.87E-01	2.68E-02	2.04E-02
Intermediate Pond	TL	1/12	1.72E-01	1.69E-01	Mink	1.21E-03	1.21E-02	1.40E+02	1.40E+01
Intermediate Pond	ACETONE	3/3	3.00E-03	3.00E-03	Mink	5.05E+01	2.52E+02	5.94E-05	1.19E-05
Intermediate Pond	CHLOROFORM	3/3	2.00E-03	2.00E-03	Mink	4.74E+00	1.30E+01	4.22E-04	1.54E-04
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Mink	2.53E-02	2.53E-01	3.56E+01	3.56E+00
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Mink	2.16E-02	2.16E-01	6.48E-01	6.48E-02
Lower WOC	BE	10/53	4.65E-04	5.94E-04	Mink	1.88E-01		3.16E-03	
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Mink	4.37E-04	4.37E-03	2.29E+00	2.29E-01
Lower WOC	CR	62/142	7.26E-03	9.31E-03	Mink	4.95E+00	1.98E+01	1.88E-03	4.70E-04
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Mink	2.94E-01	3.87E-01	2.11E-02	1.60E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Mink	3.92E-06	6.54E-06	2.40E+01	1.44E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Mink	2.10E+00	4.21E+00	3.24E-03	1.62E-03
Lower WOC	SB	3/53	1.79E-02	1.91E-02	Mink	2.20E-01	2.20E+00	8.68E-02	8.66E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Mink	4.32E-04	7.12E-04	2.31E+00	1.40E+00
Lower WOC	TL	5/50	1.66E-04	7.56E-03	Mink	1.21E-03	1.21E-02	6.25E+00	6.25E-01
Lower WOC	ACETONE	1/9	2.56E-03	2.66E-03	Mink	5.05E+01	2.52E+02	5.27E-05	1.05E-05
Lower WOC	CHLOROFORM	5/93	2.27E-03	1.00E-03	Mink	4.74E+00	1.30E+01	2.11E-04	7.72E-05
Lower WOC	METHYLENE CHLORIDE	5/9	2.09E-04	3.46E-04	Mink	5.50E+00	4.70E+01	6.29E-05	7.36E-06
Lower WOC	TRICHLOROETHENE	2/93	2.35E-03	2.50E-03	Mink	3.08E-02	3.08E-01	8.12E-02	8.09E-03
MB-15	1,1-DICHLOROETHENE	1/1	5.00E-04	5.00E-04	Mink	1.28E+00		3.91E-04	
MB-15	METHYLENE CHLORIDE	1/1	2.00E-04	2.00E-04	Mink	5.50E+00	4.70E+01	3.64E-05	4.26E-06
MB-15	TETRACHLOROETHENE	1/1	7.00E-04	7.00E-04	Mink	6.61E-02	3.31E-01	1.06E-02	2.12E-03
MB-15	TRICHLOROETHENE	1/1	9.00E-03	9.00E-03	Mink	3.08E-02	3.08E-01	2.92E-01	2.92E-02
MB-15	VINYL CHLORIDE	1/1	1.50E-02	1.50E-02	Mink	1.08E-01	1.08E+00	1.39E-01	1.39E-02
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Mink	2.16E-02	2.16E-01	2.55E-02	2.55E-03
SWSA 5 SEEP A	BE	1/10	4.88E-04	2.80E-04	Mink	1.88E-01		1.49E-03	
SWSA 5 SEEP A	CR	1/10	2.49E-03	3.00E-03	Mink	4.95E+00	1.98E+01	6.06E-04	1.51E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Mink	2.94E-01	3.87E-01	7.48E-03	5.69E-03
SWSA 5 SEEP A	SB	1/9	1.98E-02	1.91E-02	Mink	2.20E-01	2.20E+00	8.68E-02	8.66E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5 SEEP A	TL	1/9	1.84E-01	1.68E-01	Mink	1.21E-03	1.21E-02	1.39E+02	1.39E+01
SWSA 5 SEEP A	ACETONE	1/3	2.00E-03	1.00E-03	Mink	5.05E+01	2.52E+02	1.98E-05	3.96E-06
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Mink	2.16E-02	2.16E-01	9.26E-02	9.26E-03
SWSA 5 SEEP C	BE	2/3	2.67E-04	1.90E-04	Mink	1.88E-01		1.01E-03	
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Mink	2.94E-01	3.87E-01	1.67E-02	1.27E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Mink	2.10E+00	4.21E+00	3.19E-03	1.59E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Mink	2.16E-02	2.16E-01	6.02E-02	6.02E-03
SWSA 5 Trib 1	CR	2/2	3.15E-03	4.10E-03	Mink	4.95E+00	1.98E+01	8.28E-04	2.07E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Mink	2.10E+00	4.21E+00	2.48E-03	1.24E-03
SWSA 5 Trib 1	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	1.28E+00		7.81E-03	
SWSA 5 Trib 1	BENZENE	1/2	7.50E-03	1.00E-02	Mink	3.16E+00	3.16E+01	3.16E-03	3.16E-04
SWSA 5 Trib 1	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	Mink	1.26E+00		7.94E-03	
SWSA 5 Trib 1	CHLOROFORM	1/2	7.50E-03	1.00E-02	Mink	4.74E+00	1.30E+01	2.11E-03	7.72E-04
SWSA 5 Trib 1	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	Mink	5.50E+00	4.70E+01	1.82E-03	2.13E-04
SWSA 5 Trib 1	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	6.61E-02	3.31E-01	1.51E-01	3.03E-02
SWSA 5 Trib 1	TOLUENE	1/2	7.50E-03	1.00E-02	Mink	1.05E+00	1.05E+01	9.52E-03	9.52E-04
SWSA 5 Trib 1	XYLENE (TOTAL)	1/2	3.50E-03	2.00E-03	Mink	3.83E-02	4.74E-02	5.22E-02	4.22E-02
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Mink	2.53E-02	2.53E-01	2.41E+02	2.41E+01
SWSA 5/WOC	CR	1/2	3.63E-03	5.20E-03	Mink	4.95E+00	1.98E+01	1.05E-03	2.62E-04
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Mink	2.94E-01	3.87E-01	4.29E-02	3.26E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Mink	2.10E+00	4.21E+00	2.10E-03	1.05E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Mink	4.32E-04	7.12E-04	7.18E+00	4.35E+00
SWSA 5/WOC	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	1.28E+00		7.81E-03	
SWSA 5/WOC	BENZENE	1/2	7.50E-03	1.00E-02	Mink	3.16E+00	3.16E+01	3.16E-03	3.16E-04
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Mink	1.94E-05	1.94E-04	5.15E+01	5.14E+00
SWSA 5/WOC	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	Mink	1.26E+00		7.94E-03	
SWSA 5/WOC	CHLOROFORM	1/2	7.50E-03	1.00E-02	Mink	4.74E+00	1.30E+01	2.11E-03	7.72E-04
SWSA 5/WOC	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	Mink	5.50E+00	4.70E+01	1.82E-03	2.13E-04
SWSA 5/WOC	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	6.61E-02	3.31E-01	1.51E-01	3.03E-02
SWSA 5/WOC	TOLUENE	1/2	7.50E-03	1.00E-02	Mink	1.05E+00	1.05E+01	9.52E-03	9.52E-04
SWSA 5/WOC	XYLENE (TOTAL)	1/2	7.50E-03	1.00E-02	Mink	3.83E-02	4.74E-02	2.61E-01	2.11E-01
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Mink	2.53E-02	2.53E-01	2.06E+02	2.06E+01
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Mink	2.16E-02	2.16E-01	2.27E-01	2.27E-02
SWSA 6 East	CR	1/2	7.60E-03	1.02E-02	Mink	4.95E+00	1.98E+01	2.06E-03	5.15E-04
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Mink	3.92E-06	6.54E-06	7.65E+01	4.59E+01
SWSA 6 East	METHYLENE CHLORIDE	1/1	5.00E-03	5.00E-03	Mink	5.50E+00	4.70E+01	9.09E-04	1.06E-04
W6MS1	AL	44/45	2.22E+00	3.56E+00	Mink	2.53E-02	2.53E-01	1.41E+02	1.41E+01
W6MS1	AS	2/15	1.06E-03	2.99E-03	Mink	2.16E-02	2.16E-01	1.38E-01	1.39E-02

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS1	CD	5/18	2.15E-03	4.07E-03	Mink	4.37E-04	4.37E-03	9.31E+00	9.31E-01
W6MS1	CR	12/22	1.13E-02	1.40E-02	Mink	4.95E+00	1.98E+01	2.83E-03	7.05E-04
W6MS1	CU	10/21	1.07E-02	1.45E-02	Mink	2.94E-01	3.87E-01	4.93E-02	3.75E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Mink	3.92E-06	6.54E-06	1.04E+02	6.21E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Mink	2.10E+00	4.21E+00	5.90E-03	2.94E-03
W6MS1	SB	1/14	1.36E-02	5.00E-03	Mink	2.20E-01	2.20E+00	2.27E-02	2.27E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Mink	4.32E-04	7.12E-04	3.91E+00	2.37E+00
W6MS1	1,1,1-TRICHLOROETHANE	1/15	2.07E-03	2.00E-03	Mink	6.81E+01		2.94E-05	
W6MS1	2-BUTANONE	11/19	7.16E-03	8.96E-03	Mink	5.91E+03	1.53E+04	1.52E-06	5.87E-07
W6MS1	4-METHYL-2-PENTANONE	2/16	1.67E-03	2.07E-02	Mink	2.58E+01		8.02E-04	
W6MS1	ACETONE	17/21	1.04E-02	1.57E-02	Mink	5.05E+01	2.52E+02	3.11E-04	6.23E-05
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Mink	1.94E-05	1.94E-04	4.74E+02	4.72E+01
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Mink	4.56E-01	1.52E+00	6.58E-03	1.97E-03
W6MS1	METHYLENE CHLORIDE	15/19	6.71E-03	8.69E-03	Mink	5.50E+00	4.70E+01	1.58E-03	1.85E-04
W6MS1	TETRACHLOROETHENE	1/14	2.11E-03	2.52E-03	Mink	6.61E-02	3.31E-01	3.81E-02	7.64E-03
W6MS1	TOLUENE	1/14	2.25E-03	2.80E-03	Mink	1.05E+00	1.05E+01	2.67E-03	2.66E-04
W6MS1	TOTAL-1,2-DICHLOROETHENE	3/14	2.32E-03	2.00E-03	Mink	8.54E+00		2.34E-04	
W6MS1	TRICHLOROETHENE	7/17	3.49E-03	5.45E-03	Mink	3.08E-02	3.08E-01	1.77E-01	1.77E-02
W6MS3	AL	66/80	2.13E+00	3.56E+00	Mink	2.53E-02	2.53E-01	1.41E+02	1.41E+01
W6MS3	AS	9/37	1.68E-03	2.19E-03	Mink	2.16E-02	2.16E-01	1.01E-01	1.02E-02
W6MS3	BE	16/47	1.06E-03	1.25E-03	Mink	1.88E-01		6.65E-03	
W6MS3	CD	18/45	2.58E-03	2.97E-03	Mink	4.37E-04	4.37E-03	6.80E+00	6.79E-01
W6MS3	CR	39/60	1.85E-02	2.22E-02	Mink	4.95E+00	1.98E+01	4.48E-03	1.12E-03
W6MS3	CU	41/63	1.88E-02	2.27E-02	Mink	2.94E-01	3.87E-01	7.72E-02	5.87E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Mink	3.92E-06	6.54E-06	6.86E+01	4.11E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Mink	2.10E+00	4.21E+00	1.00E-02	4.98E-03
W6MS3	SB	3/31	1.40E-02	5.00E-03	Mink	2.20E-01	2.20E+00	2.27E-02	2.27E-03
W6MS3	1,1-DICHLOROETHENE	3/33	2.30E-03	2.51E-03	Mink	1.28E+00		1.96E-03	
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Mink	1.87E+01		1.07E-04	
W6MS3	1,4-DIOXANE	1/3	1.01E+00	2.30E-02	Mink	2.75E+00	5.49E+00	8.36E-03	4.19E-03
W6MS3	2-BUTANONE	41/50	1.06E-02	1.24E-02	Mink	5.91E+03	1.53E+04	2.10E-06	8.13E-07
W6MS3	4-METHYL-2-PENTANONE	4/34	4.84E-03	5.34E-03	Mink	2.58E+01		2.07E-04	
W6MS3	ACETONE	35/50	9.42E-03	1.19E-02	Mink	5.05E+01	2.52E+02	2.36E-04	4.73E-05
W6MS3	BENZENE	4/34	2.26E-03	2.45E-03	Mink	3.16E+00	3.16E+01	7.75E-04	7.74E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Mink	1.94E-05	1.94E-04	3.21E+02	3.20E+01
W6MS3	CHLOROFORM	3/35	4.82E-04	5.20E-03	Mink	4.74E+00	1.30E+01	1.10E-03	4.01E-04
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Mink	4.56E-01	1.52E+00	1.59E-02	4.75E-03
W6MS3	METHYLENE CHLORIDE	38/48	5.77E-03	6.62E-03	Mink	5.50E+00	4.70E+01	1.20E-03	1.41E-04

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	TETRACHLOROETHENE	12/39	3.21E-03	7.30E-03	Mink	6.61E-02	3.31E-01	1.10E-01	2.21E-02
W6MS3	TOLUENE	11/34	2.78E-03	3.14E-03	Mink	1.05E+00	1.05E+01	2.99E-03	2.99E-04
W6MS3	TOTAL-1,2-DICHLOROETHENE	19/42	7.82E-03	1.44E-02	Mink	8.54E+00		1.69E-03	
W6MS3	TRICHLOROETHENE	19/43	8.27E-03	2.18E-02	Mink	3.08E-02	3.08E-01	7.08E-01	7.06E-02
W6MS3	VINYL CHLORIDE	5/33	4.77E-03	5.43E-03	Mink	1.08E-01	1.08E+00	5.03E-02	5.03E-03
West Seep	AL	4/6	2.04E-01	5.22E-01	Mink	2.53E-02	2.53E-01	2.06E+01	2.06E+00
West Seep	AS	1/4	1.25E-03	1.84E-03	Mink	2.16E-02	2.16E-01	8.52E-02	8.51E-03
West Seep	BE	1/4	6.25E-04	9.19E-04	Mink	1.88E-01		4.89E-03	
West Seep	CD	2/5	1.56E-03	2.34E-03	Mink	4.37E-04	4.37E-03	5.35E+00	5.36E-01
West Seep	CR	2/4	9.25E-03	1.40E-02	Mink	4.95E+00	1.98E+01	2.83E-03	7.06E-04
West Seep	CU	1/4	6.25E-03	9.19E-03	Mink	2.94E-01	3.87E-01	3.13E-02	2.38E-02
West Seep	2-BUTANONE	2/4	5.00E-03	5.00E-03	Mink	5.91E+03	1.53E+04	8.46E-07	3.28E-07
West Seep	ACETONE	3/4	1.55E-02	3.49E-02	Mink	5.05E+01	2.52E+02	6.91E-04	1.38E-04
West Seep	METHYLENE CHLORIDE	3/4	3.63E-03	5.00E-03	Mink	5.50E+00	4.70E+01	9.09E-04	1.06E-04
West Seep	TOLUENE	2/4	3.75E-03	5.00E-03	Mink	1.05E+00	1.05E+01	4.76E-03	4.76E-04
West Seep	TRICHLOROETHENE	1/4	2.38E-03	2.00E-03	Mink	3.08E-02	3.08E-01	6.49E-02	6.48E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Mink	2.16E-02	2.16E-01	9.03E-01	9.03E-02
WOC	BE	5/20	3.89E-04	5.00E-04	Mink	1.88E-01		2.66E-03	
WOC	CD	1/57	1.82E-03	5.00E-05	Mink	4.37E-04	4.37E-03	1.14E-01	1.14E-02
WOC	CR	16/61	2.66E-03	4.26E-03	Mink	4.95E+00	1.98E+01	8.61E-04	2.15E-04
WOC	CU	18/66	3.56E-03	4.99E-03	Mink	2.94E-01	3.87E-01	1.70E-02	1.29E-02
WOC	HG	15/56	5.72E-05	7.48E-05	Mink	3.92E-06	6.54E-06	1.91E+01	1.14E+01
WOC	NI	1/61	6.89E-03	8.79E-03	Mink	2.10E+00	4.21E+00	4.19E-03	2.09E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Mink	9.82E-01	9.82E+00	2.04E-02	2.03E-03
WOC	SB	4/22	1.80E-02	2.18E-02	Mink	2.20E-01	2.20E+00	9.91E-02	9.89E-03
WOC	TL	5/20	6.58E-03	6.09E-02	Mink	1.21E-03	1.21E-02	5.03E+01	5.03E+00
WOC	ACETONE	1/4	3.13E-03	4.60E-03	Mink	5.05E+01	2.52E+02	9.11E-05	1.82E-05
WOC	CHLOROFORM	36/47	1.87E-03	2.02E-03	Mink	4.74E+00	1.30E+01	4.26E-04	1.56E-04
WOC	METHYLENE CHLORIDE	3/5	2.20E-04	3.00E-04	Mink	5.50E+00	4.70E+01	5.45E-05	6.38E-06
WOCE	CD	2/2	1.38E-03	2.40E-03	Mink	4.37E-04	4.37E-03	5.49E+00	5.50E-01
WOCE	CR	1/2	7.45E-03	1.00E-02	Mink	4.95E+00	1.98E+01	2.02E-03	5.05E-04
HF-2	AS	4/10	2.80E-03	3.78E-03	Osprey	7.13E-01	2.14E+00	5.30E-03	1.77E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Osprey	8.10E-01	1.06E+00	2.16E-02	1.65E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Osprey	1.15E-06	1.15E-05	1.17E+05	1.17E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Osprey	8.10E-01	1.06E+00	9.72E-03	7.41E-03
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Osprey	2.37E+00		3.80E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Osprey	7.13E-01	2.14E+00	1.96E-02	6.55E-03
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Osprey	5.85E-04	8.06E-03	1.71E+00	1.24E-01

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Osprey	8.10E-01	1.06E+00	7.64E-03	5.83E-03
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Osprey	1.15E-06	1.15E-05	8.17E+01	8.20E+00
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Osprey	3.64E+00	5.03E+00	1.87E-03	1.35E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Osprey	9.61E-04	1.92E-03	1.04E+00	5.20E-01
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Osprey	7.13E-01	2.14E+00	7.71E-04	2.57E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Osprey	8.10E-01	1.06E+00	2.72E-03	2.07E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Osprey	7.13E-01	2.14E+00	2.81E-03	9.35E-04
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Osprey	8.10E-01	1.06E+00	6.05E-03	4.61E-03
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Osprey	3.64E+00	5.03E+00	1.84E-03	1.33E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Osprey	7.13E-01	2.14E+00	1.82E-03	6.08E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Osprey	3.64E+00	5.03E+00	1.43E-03	1.03E-03
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Osprey	2.37E+00		2.57E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Osprey	8.10E-01	1.06E+00	1.56E-02	1.19E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Osprey	3.64E+00	5.03E+00	1.21E-03	8.74E-04
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Osprey	9.61E-04	1.92E-03	3.23E+00	1.61E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Osprey	1.92E-06		5.21E+02	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Osprey	2.37E+00		2.20E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Osprey	7.13E-01	2.14E+00	6.87E-03	2.29E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Osprey	1.15E-06	1.15E-05	2.61E+02	2.62E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Osprey	2.37E+00		1.50E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Osprey	7.13E-01	2.14E+00	4.19E-03	1.40E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Osprey	5.85E-04	8.06E-03	6.96E+00	5.04E-01
W6MS1	CU	10/21	1.07E-02	1.45E-02	Osprey	8.10E-01	1.06E+00	1.79E-02	1.37E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Osprey	1.15E-06	1.15E-05	3.53E+02	3.54E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Osprey	3.64E+00	5.03E+00	3.41E-03	2.45E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Osprey	9.61E-04	1.92E-03	1.76E+00	8.79E-01
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Osprey	1.92E-06		4.79E+03	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Osprey	1.50E-04	1.50E-03	2.00E+01	2.00E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Osprey	2.37E+00		1.50E+00	
W6MS3	AS	9/37	1.68E-03	2.19E-03	Osprey	7.13E-01	2.14E+00	3.07E-03	1.03E-03
W6MS3	CD	18/45	2.58E-03	2.97E-03	Osprey	5.85E-04	8.06E-03	5.08E+00	3.68E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Osprey	8.10E-01	1.06E+00	2.80E-02	2.13E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Osprey	1.15E-06	1.15E-05	2.34E+02	2.34E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Osprey	3.64E+00	5.03E+00	5.77E-03	4.17E-03
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Osprey	1.08E+01	2.16E+01	1.85E-04	9.26E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Osprey	1.92E-06		3.24E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Osprey	1.50E-04	1.50E-03	4.82E+01	4.81E+00
West Seep	AL	4/6	2.04E-01	5.22E-01	Osprey	2.37E+00		2.20E-01	

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
West Seep	AS	1/4	1.25E-03	1.84E-03	Osprey	7.13E-01	2.14E+00	2.58E-03	8.60E-04
West Seep	CD	2/5	1.56E-03	2.34E-03	Osprey	5.85E-04	8.06E-03	4.00E+00	2.90E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Osprey	8.10E-01	1.06E+00	1.13E-02	8.65E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Osprey	7.13E-01	2.14E+00	2.73E-02	9.12E-03
WOC	CD	1/57	1.82E-03	5.00E-05	Osprey	5.85E-04	8.06E-03	8.55E-02	6.20E-03
WOC	CU	18/66	3.56E-03	4.99E-03	Osprey	8.10E-01	1.06E+00	6.16E-03	4.70E-03
WOC	HG	15/56	5.72E-05	7.48E-05	Osprey	1.15E-06	1.15E-05	6.50E+01	6.52E+00
WOC	NI	1/61	6.89E-03	8.79E-03	Osprey	3.64E+00	5.03E+00	2.41E-03	1.74E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Osprey	1.25E-01	1.25E+00	1.60E-01	1.60E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Osprey	4.25E-01		4.71E-02	
WOCE	CD	2/2	1.38E-03	2.40E-03	Osprey	5.85E-04	8.06E-03	4.10E+00	2.98E-01
HF-2	AS	4/10	2.80E-03	3.78E-03	River Otter	1.56E-02	1.56E-01	2.42E-01	2.42E-02
HF-2	BE	2/11	3.26E-04	4.00E-04	River Otter	1.36E-01		2.94E-03	
HF-2	CR	2/11	2.91E-03	5.26E-03	River Otter	3.59E+00	1.44E+01	1.47E-03	3.66E-04
HF-2	CU	7/11	9.55E-03	1.75E-02	River Otter	2.13E-01	2.80E-01	8.22E-02	6.25E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	River Otter	1.58E-06	2.63E-06	8.48E+04	5.10E+04
HF-2	TL	1/9	2.82E-01	4.10E-01	River Otter	8.76E-04	8.76E-03	4.68E+02	4.68E+01
HF-2	ACETONE	1/3	2.67E-03	3.00E-03	River Otter	3.32E+01	1.66E+02	9.04E-05	1.81E-05
HF-2	METHYLENE CHLORIDE	3/3	1.00E-04	1.00E-04	River Otter	3.99E+00	3.41E+01	2.51E-05	2.93E-06
Intermediate Pond	BE	2/13	5.11E-04	5.00E-04	River Otter	1.36E-01		3.68E-03	
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	River Otter	2.13E-01	2.80E-01	3.69E-02	2.81E-02
Intermediate Pond	TL	1/12	1.72E-01	1.69E-01	River Otter	8.76E-04	8.76E-03	1.93E+02	1.93E+01
Intermediate Pond	ACETONE	3/3	3.00E-03	3.00E-03	River Otter	3.32E+01	1.66E+02	9.04E-05	1.81E-05
Intermediate Pond	CHLOROFORM	3/3	2.00E-03	2.00E-03	River Otter	3.44E+00	9.40E+00	5.81E-04	2.13E-04
Lower WOC	AL	120/149	7.07E-01	9.00E-01	River Otter	1.83E-02	1.83E-01	4.92E+01	4.91E+00
Lower WOC	AS	11/128	1.72E-02	1.40E-02	River Otter	1.56E-02	1.56E-01	8.97E-01	8.95E-02
Lower WOC	BE	10/53	4.65E-04	5.94E-04	River Otter	1.36E-01		4.37E-03	
Lower WOC	CD	3/127	1.73E-03	1.00E-03	River Otter	3.16E-04	3.16E-03	3.16E+00	3.16E-01
Lower WOC	CR	62/142	7.26E-03	9.31E-03	River Otter	3.59E+00	1.44E+01	2.59E-03	6.47E-04
Lower WOC	CU	58/147	5.23E-03	6.19E-03	River Otter	2.13E-01	2.80E-01	2.91E-02	2.21E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	River Otter	1.58E-06	2.63E-06	5.95E+01	3.58E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	River Otter	1.52E+00	3.05E+00	4.48E-03	2.23E-03
Lower WOC	SB	3/53	1.79E-02	1.91E-02	River Otter	1.61E-01	1.61E+00	1.19E-01	1.19E-02
Lower WOC	SE	1/42	1.07E-02	1.00E-03	River Otter	2.36E-04	3.90E-04	4.24E+00	2.56E+00
Lower WOC	TL	5/50	1.66E-04	7.56E-03	River Otter	8.76E-04	8.76E-03	8.63E+00	8.63E-01
Lower WOC	ACETONE	1/9	2.56E-03	2.66E-03	River Otter	3.32E+01	1.66E+02	8.01E-05	1.60E-05
Lower WOC	CHLOROFORM	5/93	2.27E-03	1.00E-03	River Otter	3.44E+00	9.40E+00	2.91E-04	1.06E-04
Lower WOC	METHYLENE CHLORIDE	5/9	2.09E-04	3.46E-04	River Otter	3.99E+00	3.41E+01	8.67E-05	1.01E-05

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
Lower WOC	TRICHLOROETHENE	2/93	2.35E-03	2.50E-03	River Otter	2.24E-02	2.24E-01	1.12E-01	1.12E-02
MB-15	1,1-DICHLOROETHENE	1/1	5.00E-04	5.00E-04	River Otter	9.29E-01		5.38E-04	
MB-15	METHYLENE CHLORIDE	1/1	2.00E-04	2.00E-04	River Otter	3.99E+00	3.41E+01	5.01E-05	5.87E-06
MB-15	TETRACHLOROETHENE	1/1	7.00E-04	7.00E-04	River Otter	4.80E-02	2.40E-01	1.46E-02	2.92E-03
MB-15	TRICHLOROETHENE	1/1	9.00E-03	9.00E-03	River Otter	2.24E-02	2.24E-01	4.02E-01	4.03E-02
MB-15	VINYL CHLORIDE	1/1	1.50E-02	1.50E-02	River Otter	7.82E-02	7.82E-01	1.92E-01	1.92E-02
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	River Otter	1.56E-02	1.56E-01	3.53E-02	3.51E-03
SWSA 5 SEEP A	BE	1/10	4.88E-04	2.80E-04	River Otter	1.36E-01		2.06E-03	
SWSA 5 SEEP A	CR	1/10	2.49E-03	3.00E-03	River Otter	3.59E+00	1.44E+01	8.36E-04	2.08E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	River Otter	2.13E-01	2.80E-01	1.03E-02	7.86E-03
SWSA 5 SEEP A	SB	1/9	1.98E-02	1.91E-02	River Otter	1.61E-01	1.61E+00	1.19E-01	1.19E-02
SWSA 5 SEEP A	TL	1/9	1.84E-01	1.68E-01	River Otter	8.76E-04	8.76E-03	1.92E+02	1.92E+01
SWSA 5 SEEP A	ACETONE	1/3	2.00E-03	1.00E-03	River Otter	3.32E+01	1.66E+02	3.01E-05	6.02E-06
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	River Otter	1.56E-02	1.56E-01	1.28E-01	1.28E-02
SWSA 5 SEEP C	BE	2/3	2.67E-04	1.90E-04	River Otter	1.36E-01		1.40E-03	
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	River Otter	2.13E-01	2.80E-01	2.30E-02	1.75E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	River Otter	1.52E+00	3.05E+00	4.41E-03	2.20E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	River Otter	1.56E-02	1.56E-01	8.33E-02	8.31E-03
SWSA 5 Trib 1	CR	2/2	3.15E-03	4.10E-03	River Otter	3.59E+00	1.44E+01	1.14E-03	2.85E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	River Otter	1.52E+00	3.05E+00	3.42E-03	1.71E-03
SWSA 5 Trib 1	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	9.29E-01		1.08E-02	
SWSA 5 Trib 1	BENZENE	1/2	7.50E-03	1.00E-02	River Otter	2.29E+00	2.29E+01	4.37E-03	4.36E-04
SWSA 5 Trib 1	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	9.13E-01		1.10E-02	
SWSA 5 Trib 1	CHLOROFORM	1/2	7.50E-03	1.00E-02	River Otter	3.44E+00	9.40E+00	2.91E-03	1.06E-03
SWSA 5 Trib 1	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	3.99E+00	3.41E+01	2.51E-03	2.93E-04
SWSA 5 Trib 1	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	4.80E-02	2.40E-01	2.08E-01	4.17E-02
SWSA 5 Trib 1	TOLUENE	1/2	7.50E-03	1.00E-02	River Otter	7.64E-01	7.64E+00	1.31E-02	1.31E-03
SWSA 5 Trib 1	XYLENE (TOTAL)	1/2	3.50E-03	2.00E-03	River Otter	2.79E-02	3.45E-02	7.17E-02	5.79E-02
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	River Otter	1.83E-02	1.83E-01	3.33E+02	3.32E+01
SWSA 5/WOC	CR	1/2	3.63E-03	5.20E-03	River Otter	3.59E+00	1.44E+01	1.45E-03	3.61E-04
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	River Otter	2.13E-01	2.80E-01	5.92E-02	4.50E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	River Otter	1.52E+00	3.05E+00	2.89E-03	1.44E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	River Otter	2.36E-04	3.90E-04	1.31E+01	7.95E+00
SWSA 5/WOC	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	9.29E-01		1.08E-02	
SWSA 5/WOC	BENZENE	1/2	7.50E-03	1.00E-02	River Otter	2.29E+00	2.29E+01	4.37E-03	4.36E-04
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	River Otter	1.24E-05	1.24E-04	8.06E+01	8.04E+00
SWSA 5/WOC	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	9.13E-01		1.10E-02	
SWSA 5/WOC	CHLOROFORM	1/2	7.50E-03	1.00E-02	River Otter	3.44E+00	9.40E+00	2.91E-03	1.06E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5/WOC	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	3.99E+00	3.41E+01	2.51E-03	2.93E-04
SWSA 5/WOC	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	4.80E-02	2.40E-01	2.08E-01	4.17E-02
SWSA 5/WOC	TOLUENE	1/2	7.50E-03	1.00E-02	River Otter	7.64E-01	7.64E+00	1.31E-02	1.31E-03
SWSA 5/WOC	XYLENE (TOTAL)	1/2	7.50E-03	1.00E-02	River Otter	2.79E-02	3.45E-02	3.58E-01	2.90E-01
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	River Otter	1.83E-02	1.83E-01	2.85E+02	2.85E+01
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	River Otter	1.56E-02	1.56E-01	3.14E-01	3.13E-02
SWSA 6 East	CR	1/2	7.60E-03	1.02E-02	River Otter	3.59E+00	1.44E+01	2.84E-03	7.09E-04
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	River Otter	1.58E-06	2.63E-06	1.90E+02	1.14E+02
SWSA 6 East	METHYLENE CHLORIDE	1/1	5.00E-03	5.00E-03	River Otter	3.99E+00	3.41E+01	1.25E-03	1.47E-04
W6MS1	AL	44/45	2.22E+00	3.56E+00	River Otter	1.83E-02	1.83E-01	1.95E+02	1.94E+01
W6MS1	AS	2/15	1.06E-03	2.99E-03	River Otter	1.56E-02	1.56E-01	1.92E-01	1.91E-02
W6MS1	CD	5/18	2.15E-03	4.07E-03	River Otter	3.16E-04	3.16E-03	1.29E+01	1.29E+00
W6MS1	CR	12/22	1.13E-02	1.40E-02	River Otter	3.59E+00	1.44E+01	3.90E-03	9.71E-04
W6MS1	CU	10/21	1.07E-02	1.45E-02	River Otter	2.13E-01	2.80E-01	6.81E-02	5.18E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	River Otter	1.58E-06	2.63E-06	2.57E+02	1.55E+02
W6MS1	NI	2/16	1.01E-02	1.24E-02	River Otter	1.52E+00	3.05E+00	8.16E-03	4.05E-03
W6MS1	SB	1/14	1.36E-02	5.00E-03	River Otter	1.61E-01	1.61E+00	3.11E-02	3.11E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	River Otter	2.36E-04	3.90E-04	7.16E+00	4.34E+00
W6MS1	1,1,1-TRICHLOROETHANE	1/15	2.07E-03	2.00E-03	River Otter	4.94E+01		4.05E-05	
W6MS1	2-BUTANONE	11/19	7.16E-03	8.96E-03	River Otter	4.31E+03	1.11E+04	2.08E-06	8.05E-07
W6MS1	4-METHYL-2-PENTANONE	2/16	1.67E-03	2.07E-02	River Otter	1.87E+01		1.11E-03	
W6MS1	ACETONE	17/21	1.04E-02	1.57E-02	River Otter	3.32E+01	1.66E+02	4.73E-04	9.46E-05
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	River Otter	1.24E-05	1.24E-04	7.41E+02	7.39E+01
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	River Otter	3.48E-01	1.16E+00	8.62E-03	2.59E-03
W6MS1	METHYLENE CHLORIDE	15/19	6.71E-03	8.69E-03	River Otter	3.99E+00	3.41E+01	2.18E-03	2.55E-04
W6MS1	TETRACHLOROETHENE	1/14	2.11E-03	2.52E-03	River Otter	4.80E-02	2.40E-01	5.25E-02	1.05E-02
W6MS1	TOLUENE	1/14	2.25E-03	2.80E-03	River Otter	7.64E-01	7.64E+00	3.66E-03	3.66E-04
W6MS1	TOTAL-1,2-DICHLOROETHENE	3/14	2.32E-03	2.00E-03	River Otter	6.20E+00		3.23E-04	
W6MS1	TRICHLOROETHENE	7/17	3.49E-03	5.45E-03	River Otter	2.24E-02	2.24E-01	2.43E-01	2.44E-02
W6MS3	AL	66/80	2.13E+00	3.56E+00	River Otter	1.83E-02	1.83E-01	1.95E+02	1.94E+01
W6MS3	AS	9/37	1.68E-03	2.19E-03	River Otter	1.56E-02	1.56E-01	1.40E-01	1.40E-02
W6MS3	BE	16/47	1.06E-03	1.25E-03	River Otter	1.36E-01		9.19E-03	
W6MS3	CD	18/45	2.58E-03	2.97E-03	River Otter	3.16E-04	3.16E-03	9.40E+00	9.38E-01
W6MS3	CR	39/60	1.85E-02	2.22E-02	River Otter	3.59E+00	1.44E+01	6.18E-03	1.55E-03
W6MS3	CU	41/63	1.88E-02	2.27E-02	River Otter	2.13E-01	2.80E-01	1.07E-01	8.10E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	River Otter	1.58E-06	2.63E-06	1.70E+02	1.02E+02
W6MS3	NI	10/39	1.43E-02	2.10E-02	River Otter	1.52E+00	3.05E+00	1.38E-02	6.88E-03
W6MS3	SB	3/31	1.40E-02	5.00E-03	River Otter	1.61E-01	1.61E+00	3.11E-02	3.11E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	1,1-DICHLOROETHENE	3/33	2.30E-03	2.51E-03	River Otter	9.29E-01		2.70E-03	
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	River Otter	1.36E+01		1.47E-04	
W6MS3	1,4-DIOXANE	1/3	1.01E+00	2.30E-02	River Otter	2.01E+00	4.02E+00	1.14E-02	5.72E-03
W6MS3	2-BUTANONE	41/50	1.06E-02	1.24E-02	River Otter	4.31E+03	1.11E+04	2.88E-06	1.12E-06
W6MS3	4-METHYL-2-PENTANONE	4/34	4.84E-03	5.34E-03	River Otter	1.87E+01		2.86E-04	
W6MS3	ACETONE	35/50	9.42E-03	1.19E-02	River Otter	3.32E+01	1.66E+02	3.58E-04	7.18E-05
W6MS3	BENZENE	4/34	2.26E-03	2.45E-03	River Otter	2.29E+00	2.29E+01	1.07E-03	1.07E-04
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	River Otter	1.24E-05	1.24E-04	5.02E+02	5.01E+01
W6MS3	CHLOROFORM	3/35	4.82E-04	5.20E-03	River Otter	3.44E+00	9.40E+00	1.51E-03	5.53E-04
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	River Otter	3.48E-01	1.16E+00	2.08E-02	6.23E-03
W6MS3	METHYLENE CHLORIDE	38/48	5.77E-03	6.62E-03	River Otter	3.99E+00	3.41E+01	1.66E-03	1.94E-04
W6MS3	TETRACHLOROETHENE	12/39	3.21E-03	7.30E-03	River Otter	4.80E-02	2.40E-01	1.52E-01	3.05E-02
W6MS3	TOLUENE	11/34	2.78E-03	3.14E-03	River Otter	7.64E-01	7.64E+00	4.11E-03	4.12E-04
W6MS3	TOTAL-1,2-DICHLOROETHENE	19/42	7.82E-03	1.44E-02	River Otter	6.20E+00		2.32E-03	
W6MS3	TRICHLOROETHENE	19/43	8.27E-03	2.18E-02	River Otter	2.24E-02	2.24E-01	9.73E-01	9.74E-02
W6MS3	VINYL CHLORIDE	5/33	4.77E-03	5.43E-03	River Otter	7.82E-02	7.82E-01	6.94E-02	6.94E-03
West Seep	AL	4/6	2.04E-01	5.22E-01	River Otter	1.83E-02	1.83E-01	2.85E+01	2.85E+00
West Seep	AS	1/4	1.25E-03	1.84E-03	River Otter	1.56E-02	1.56E-01	1.18E-01	1.17E-02
West Seep	BE	1/4	6.25E-04	9.19E-04	River Otter	1.36E-01		6.76E-03	
West Seep	CD	2/5	1.56E-03	2.34E-03	River Otter	3.16E-04	3.16E-03	7.41E+00	7.40E-01
West Seep	CR	2/4	9.25E-03	1.40E-02	River Otter	3.59E+00	1.44E+01	3.90E-03	9.73E-04
West Seep	CU	1/4	6.25E-03	9.19E-03	River Otter	2.13E-01	2.80E-01	4.31E-02	3.28E-02
West Seep	2-BUTANONE	2/4	5.00E-03	5.00E-03	River Otter	4.31E+03	1.11E+04	1.16E-06	4.50E-07
West Seep	ACETONE	3/4	1.55E-02	3.49E-02	River Otter	3.32E+01	1.66E+02	1.05E-03	2.10E-04
West Seep	METHYLENE CHLORIDE	3/4	3.63E-03	5.00E-03	River Otter	3.99E+00	3.41E+01	1.25E-03	1.47E-04
West Seep	TOLUENE	2/4	3.75E-03	5.00E-03	River Otter	7.64E-01	7.64E+00	6.54E-03	6.55E-04
West Seep	TRICHLOROETHENE	1/4	2.38E-03	2.00E-03	River Otter	2.24E-02	2.24E-01	8.93E-02	8.94E-03
WOC	AS	8/61	1.67E-02	1.95E-02	River Otter	1.56E-02	1.56E-01	1.25E+00	1.25E-01
WOC	BE	5/20	3.89E-04	5.00E-04	River Otter	1.36E-01		3.68E-03	
WOC	CD	1/57	1.82E-03	5.00E-05	River Otter	3.16E-04	3.16E-03	1.58E-01	1.58E-02
WOC	CR	16/61	2.66E-03	4.26E-03	River Otter	3.59E+00	1.44E+01	1.19E-03	2.96E-04
WOC	CU	18/66	3.56E-03	4.99E-03	River Otter	2.13E-01	2.80E-01	2.34E-02	1.78E-02
WOC	HG	15/56	5.72E-05	7.48E-05	River Otter	1.58E-06	2.63E-06	4.73E+01	2.85E+01
WOC	NI	1/61	6.89E-03	8.79E-03	River Otter	1.52E+00	3.05E+00	5.78E-03	2.88E-03
WOC	PB	1/57	1.71E-02	2.00E-02	River Otter	7.11E-01	7.11E+00	2.81E-02	2.81E-03
WOC	SB	4/22	1.80E-02	2.18E-02	River Otter	1.61E-01	1.61E+00	1.35E-01	1.36E-02
WOC	TL	5/20	6.58E-03	6.09E-02	River Otter	8.76E-04	8.76E-03	6.95E+01	6.95E+00
WOC	ACETONE	1/4	3.13E-03	4.60E-03	River Otter	3.32E+01	1.66E+02	1.39E-04	2.77E-05

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
WOC	CHLOROFORM	36/47	1.87E-03	2.02E-03	River Otter	3.44E+00	9.40E+00	5.87E-04	2.15E-04
WOC	METHYLENE CHLORIDE	3/5	2.20E-04	3.00E-04	River Otter	3.99E+00	3.41E+01	7.52E-05	8.80E-06
WOCE	CD	2/2	1.38E-03	2.40E-03	River Otter	3.16E-04	3.16E-03	7.59E+00	7.59E-01
WOCE	CR	1/2	7.45E-03	1.00E-02	River Otter	3.59E+00	1.44E+01	2.79E-03	6.95E-04

Note: Only analytes with a NOAEL or a LOAEL and detected concentrations above background (or with no background value available) are included in the table.
[a] Piscivore NOAELs and LOAELs were obtained from Sample et al. (1996).
[b] The exposure concentration used was the minimum of the UCL95 and the maximum detected concentration.

Table 8.16. Contaminant concentrations (mg/kg) found in Kingfisher egg shells on the ORR

Matrix	Burrow[a]	As	Cd	Se	Pb	Hg	^{60}Co (pCi/g)	^{137}Cs (pCi/g)
egg shell	CRD	0.135	< 0.0333[b]	1.58	2.0	< 0.020	< 7.45	< 9.09
egg shell	WOC	0.0536	0.0583	1.41	5.31	0.182	< 1.89	58.1

[a] CRD = Clinch River downstream of WOL Embayment; WOC = White Oak Creek downstream of WCK 3.5; CRU = Clinch River upstream of Oak Ridge Reservation.

[b] Less than values are below minimum detection limit.

Table 8.17. Contaminant concentrations in tissues of the three kingfishers found on the ORR

Bird No.	Watershed and Location	Organ	^{137}Cs (pCi/g)	Cd (mg/kg)[a]	Pb (mg/kg)a	Se (mg/kg)	Hg (mg/kg)
1	East Fork Poplar Creek, Lake Reality	whole body	< 2				
		feathers		ND	2.67	5.38	13.9
		kidney		4.04	ND	5.81	8.65
		liver		0.95	ND	2.71	3.69
		heart		ND	ND	1.25	1.1
		muscle		ND	ND	ND	0.572
2	East Fork Poplar Creek	feathers		7.21	1.86	5.63	4.55
		kidney		0.40	ND	3.14	1.46
		liver		0.23	ND	3.45	0.955
		heart		ND	ND	2.01	0.594
		muscle	3	ND	ND	1.04	0.805
3	White Oak Creek, Bldg. 4505	whole body	91.27				
		feathers		0.34	4.88	7.29	2.72
		kidney	69	1.53	0.42	6.01	26.8
		liver	76	0.90	0.40	7.5	17.6
		heart	81	ND	ND	2.2	9.52
		muscle	151	ND	0.58	1.84	6.34

[a]ND= Nondetect: As- <0.40 mg/kg, Cd- <0.20 mg/kg, Pb- <0.40 mg/kg, and Se-<0.40 mg/kg.

Table 8.18. Summary of number of locations where HQs>1 were observed

Watershed	Endpoint	Analyte	No. locations where NOAEL-based HQ>1	No. locations where LOAEL-based HQ>1
Bear Creek	Mink	Hg	2	0
		PCBs	2	0
	River Otter	Hg	4	3
		PCBs	4	1
	Kingfisher	Hg	5	3
		PCBs	5	1
	Heron	Hg	5	0
		PCBs	3	0
East Fork Poplar Creek	Mink	Hg	7	6
		PCBs	3	1
	Otter	Hg	7	7
		PCBs	6	2
	Kingfisher	Hg	7	7
		PCBs	7	3
	Heron	Hg	7	6
		PCBs	5	1
K-25	Mink	Hg	9	1
		PCBs	7	0
	Otter	Hg	13	11
		PCBs	15	5
	Kingfisher	Hg	16	10
		PCBs	14	4
	Heron	Hg	16	0
		PCBs	13	0
	Osprey	Hg	16	3
		PCBs	14	1
White Oak Creek	Mink	Hg	1	0
		PCBs	3	0

Table 8.18. (continued)

Watershed	Endpoint	Analyte	No. locations where NOAEL-based HQ>1	No. locations where LOAEL-based HQ>1
	Otter	Hg	7	3
		PCBs	6	3
	Kingfisher	Hg	7	3
		PCBs	7	1
	Heron	Hg	7	0
		PCBs	5	0
	Osprey	Hg	2	0
		PCBs	3	0

Table 8.19. Summary of number of individuals of piscivore endpoint species estimated to be experiencing adverse effects by watershed and for the ORR

Location	Analyte	Species	%> LOAEL	Number in Watershed	Number Adversely Affected	Percent Adversely Affected
Bear Creek	Mercury	Mink	<5%	7	0	0%
East Fork Poplar Creek	Mercury	Mink	80%	15	12	80%
K-25	Mercury	Mink	<5%	14	0	0%
White Oak Creek	Mercury	Mink	<5%	4	0	0%
ORR-wide	Mercury	Mink		40	12	30%
Bear Creek	Mercury	Otter	50%	5	2	40%
East Fork Poplar Creek	Mercury	Otter	>95%	9	9	100%
K-25	Mercury	Otter	>95%	9	9	100%
White Oak Creek	Mercury	Otter	25%	2	0	0%
ORR-wide	Mercury	Otter		25	20	80%
Bear Creek	Mercury	Kingfisher	65-70%	5	3	60%
East Fork Poplar Creek	Mercury	Kingfisher	>95%	10	10	100%
K-25	Mercury	Kingfisher	>95%	9	9	100%
White Oak Creek	Mercury	Kingfisher	15%	3	0	0%
ORR-wide	Mercury	Kingfisher		27	22	81.5%
Bear Creek	Mercury	Heron	<5%	29	0	0%
East Fork Poplar Creek	Mercury	Heron	>95%	57	57	100%
K-25	Mercury	Heron	<5%	54	0	0%
White Oak Creek	Mercury	Heron	<5%	15	0	0%
ORR-wide	Mercury	Heron		155	57	36.8%
K-25	Mercury	Osprey	<5%		0	0%
White Oak Creek	Mercury	Osprey	<5%		0	0%
Bear Creek	PCBs	Mink	<5%	7	0	0%
East Fork Poplar Creek	PCBs	Mink	<5%	15	0	0%
K-25	PCBs	Mink	<5%	14	0	0%

Table 8.19. (continued)

Location	Analyte	Species	%> LOAEL	Number in Watershed	Number Adversely Affected	Percent Adversely Affected
White Oak Creek	PCBs	Mink	<5%	4	0	0%
ORR-wide	PCBs	Mink		40	0	0%
Bear Creek	PCBs	Otter	<5%	5	0	0%
East Fork Poplar Creek	PCBs	Otter	15-20%	9	1	11%
K-25	PCBs	Otter	5-10%	9	0	0%
White Oak Creek	PCBs	Otter	70-75%	2	1	50%
ORR-wide	PCBs	Otter		25	2	8%
Bear Creek	PCBs	Kingfisher	<5%	5	0	0%
East Fork Poplar Creek	PCBs	Kingfisher	10-15%	10	0	0%
K-25	PCBs	Kingfisher	<5%	9	0	0%
White Oak Creek	PCBs	Kingfisher	<5%	3	0	0%
ORR-wide	PCBs	Kingfisher		27	0	0%
Bear Creek	PCBs	Heron	<5%	29	0	0%
East Fork Poplar Creek	PCBs	Heron	<5%	57	0	0%
K-25	PCBs	Heron	<5%	54	0	0%
White Oak Creek	PCBs	Heron	<5%	15	0	0%
ORR-wide	PCBs	Heron		155	0	0%
K-25	PCBs	Osprey	<5%		0	0%
White Oak Creek	PCBs	Osprey	<5%		0	0%

Table 8.20. Simulation of exposure of mink to mercury and PCBs in toxicity test diets

Diet	Analyte	Concentration in diet				Distribution used in simulation	Modeled exposure (mg/kg-d)		
		Mean	STD	Min	Max		Mean	STD	80th percentile
A	Mercury	0.02	0	0.02	0.03	Triangular	0.0034	0.0009	0.0042
B	Mercury	0.05	0	0.04	0.06	Triangular	0.0074	0.0019	0.0088
C	Mercury	0.09	0	0.08	0.11	Triangular	0.0138	0.0035	0.016
D	Mercury	0.15	0.01			Normal	0.022	0.0059	0.026
E	Mercury	0.22	0.01			Normal	0.033	0.008	0.038
A	PCB 1260	0.169	0.002			Normal	0.025	0.0063	0.029
B	PCB 1260	11.44	0.327			Normal	1.70	0.43	1.97
C	PCB 1260	4.697	0.174			Normal	0.698	0.18	0.82
D	PCB 1260	10.41	0.25			Normal	1.54	0.39	1.79
E	PCB 1260	20.67	0.458			Normal	3.07	0.77	3.55

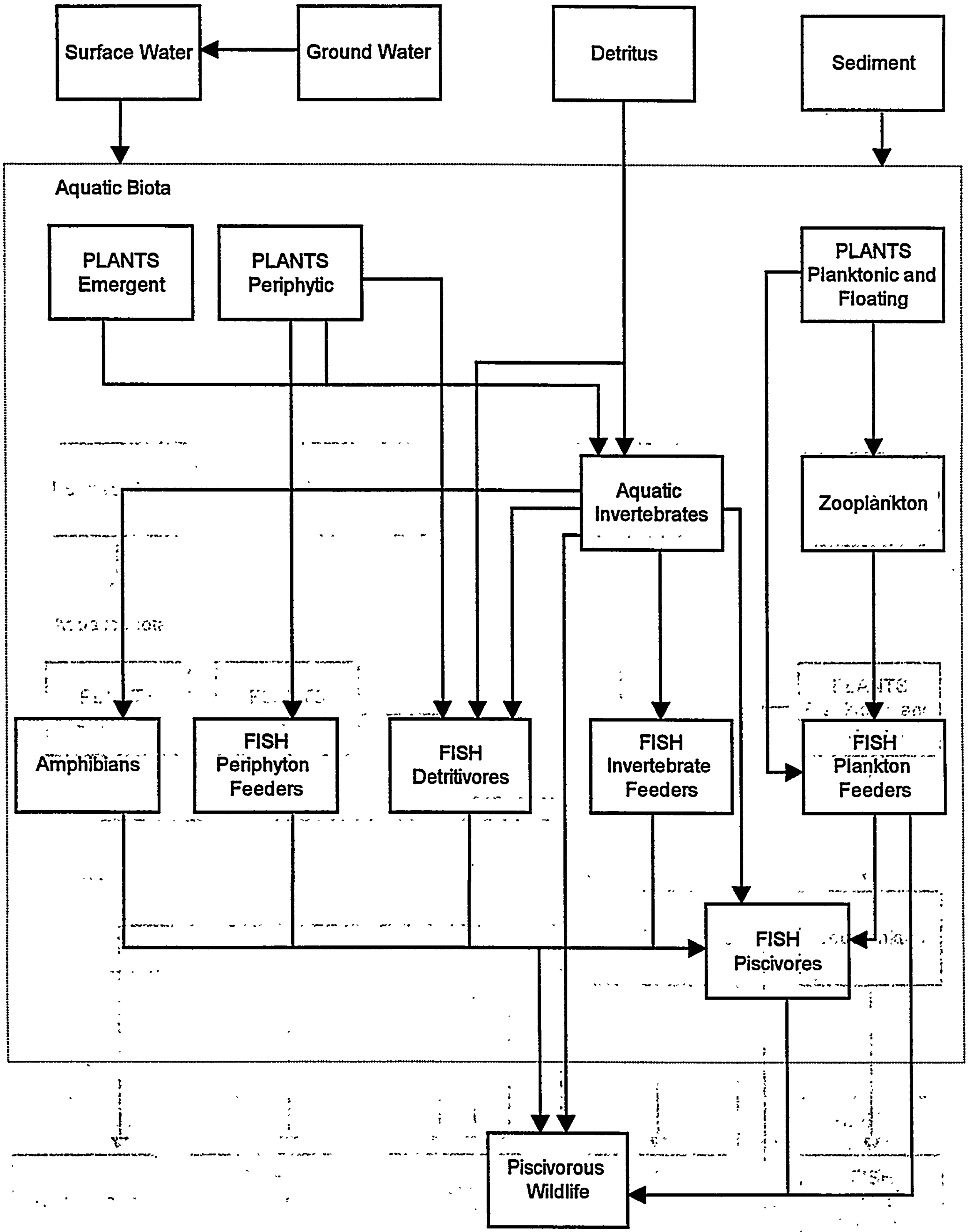

Figure 8.1 **Conceptual model of the mechanisms by which piscivorous wildlife are exposed to contaminants in the White Oak Creek watershed.**

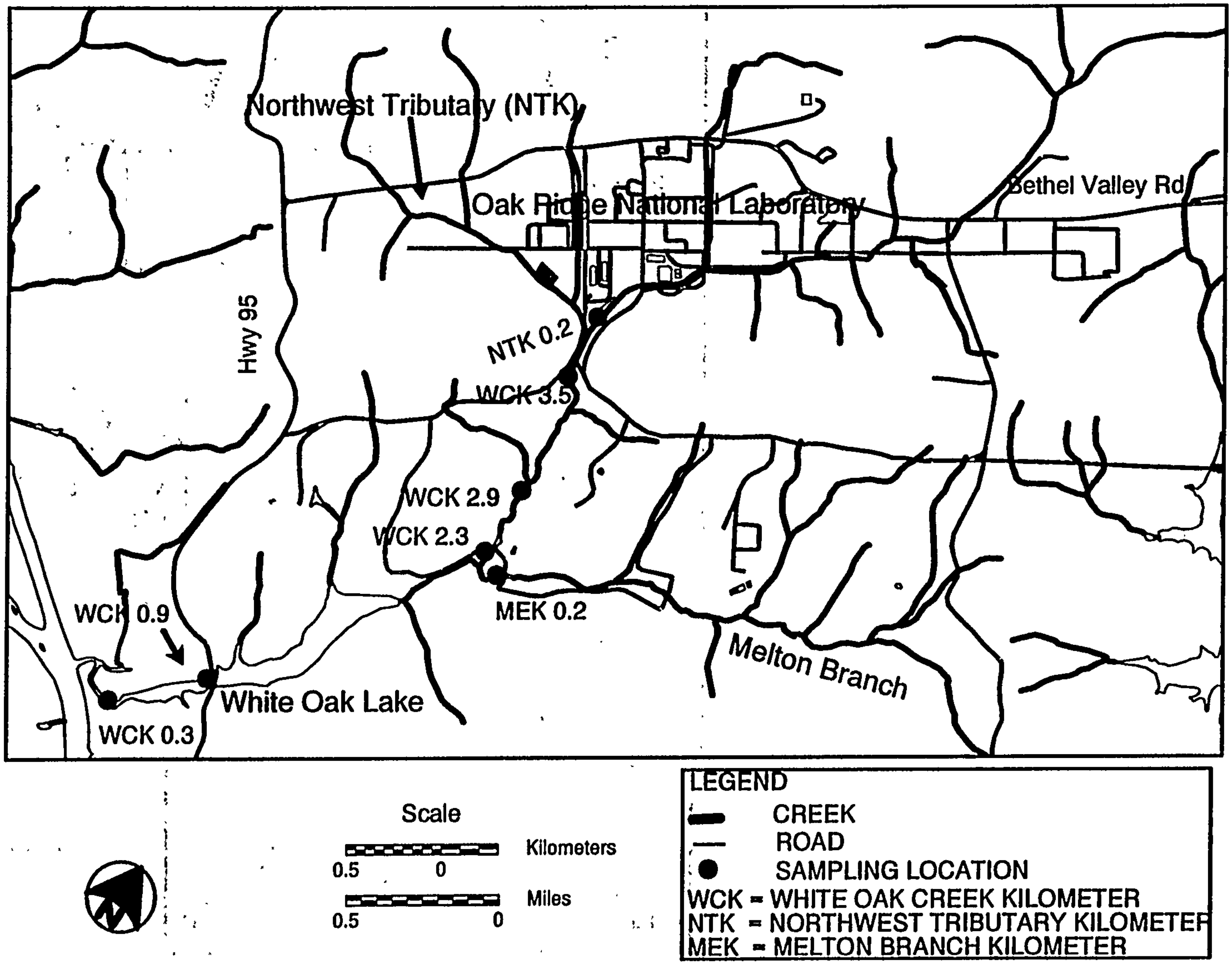

Figure 8.2 **Fish sampling locations within the White Oak Creek watershed**

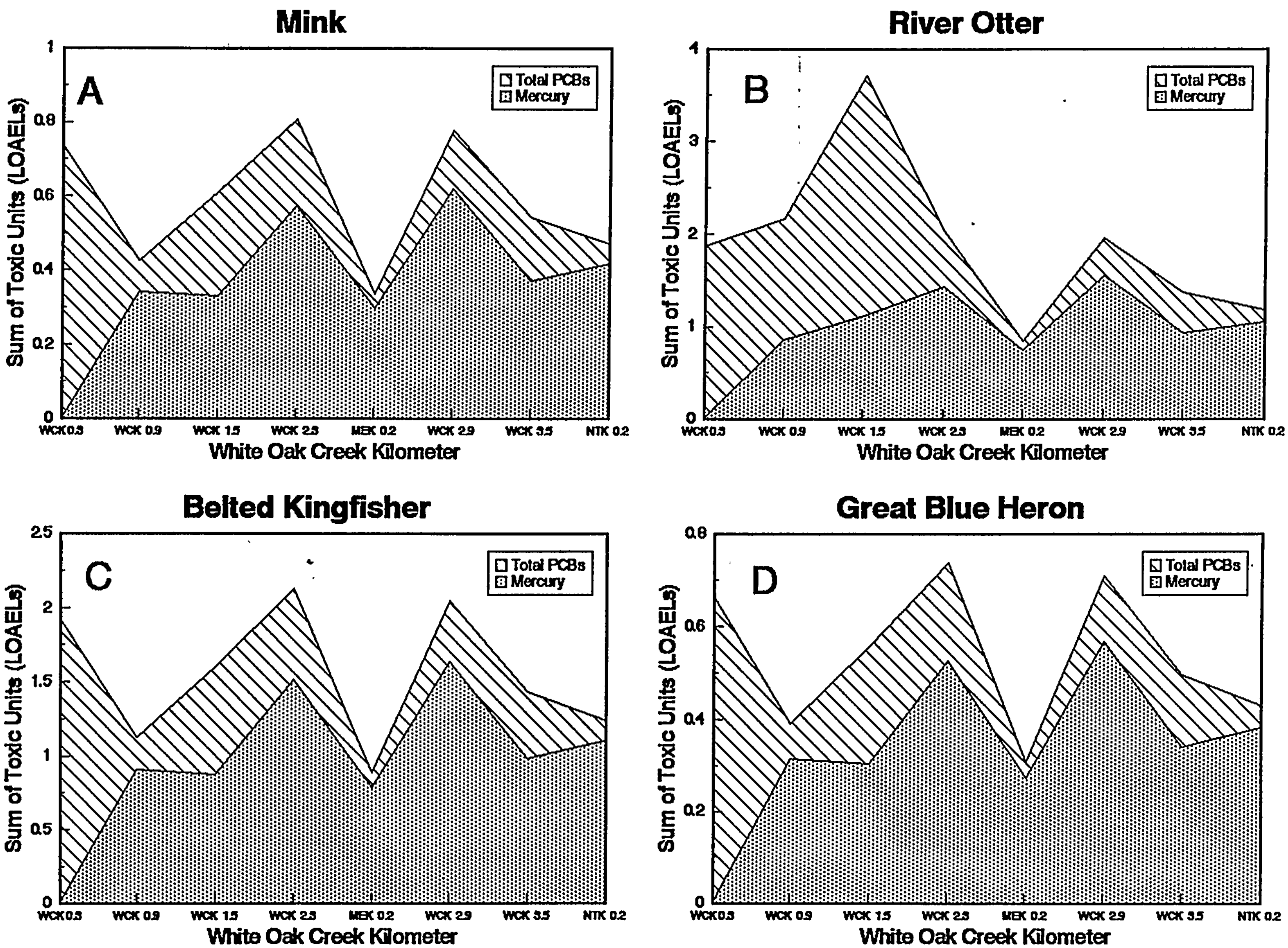

Figure 8.3 **Summary of LOAEL-based toxic units for piscivorous wildlife in the White Oak Creek watershed.**

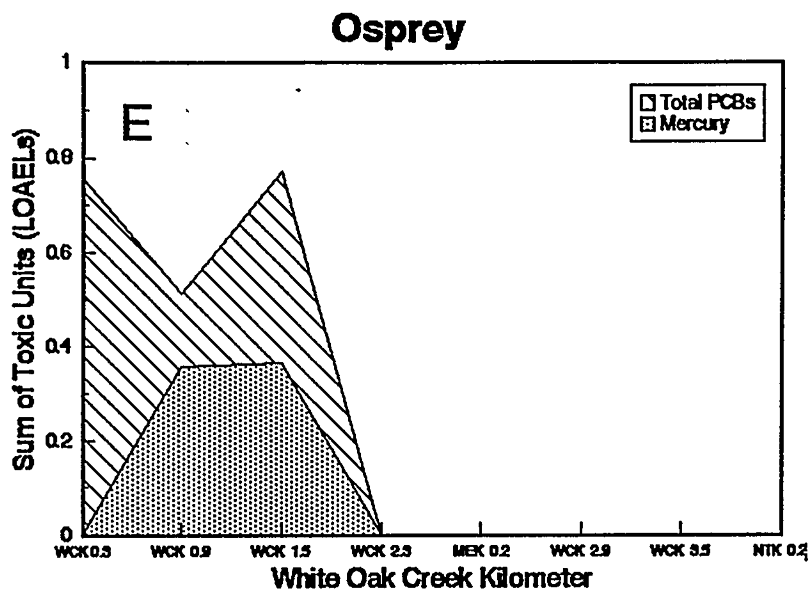

Figure 8.3 (cont.) Summary of LOAEL-based toxic units for piscivorous wildlife in the White Oak Creek watershed.