APPENDIX F
Modelling Chemical Residues in Wild Game

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Appendix F
Modelling Chemical Residues in Wild Game

1. Introduction

A number of methods are available for quantifying dioxin concentrations potentially present in plants and animals that were exposed to these chemicals from their habitat (soil, sediment and surface water). These models can be classified into three main categories, namely (1) Bioaccumulation Factors (BAFs), (2) Non-linear Model Equations, and (3) Use of Food Chain Multipliers and/or Bioconcentration Factors. Each of these categories is further discussed below with emphasis on their application to the prediction of tissue residues in on-site sports fish, deer and moose.

It is important to note that these models are generally designed to provide a conservative estimate of the potential tissue residues of the chemical in either the plants or animals of interest. It is not uncommon to have the actual residue concentrations overestimated by 1 or 2 orders of magnitude. Therefore, although the models can provide an initial indication as to whether or not bioaccumulation of the chemical could be a concern, the models may need to be populated with actual data from the site to provide some level of validation. The conservative bias generates a situation where if the model estimates that risks are low or negligible there may be little needed to undertake field validation. Alternatively, marginal risks may need verification through additional field sampling to determine whether potential risks identified in the RA are present.

2. Bioaccumulation Factors

The use of bioaccumulation factors (BAFs) can be applied to biologically less-complex organisms such as invertebrates (e.g mussels, crabs), and fish (US EPA, 1999). In more complex organisms, or in specific tissues, they are usually less successful due to the variety of factors that can affect uptake and sequestration of the chemical of concern. Effective modelling of these latter organisms or tissues would require an extensive database that is typically not available for most chemicals of concern. However, since the use of BAFs typically involves conservative approaches, it can be used as a screening tool to determine where more detailed assessment would be warranted.

Using the following linear equation, the chemical concentration in the organism of interest is calculated based on the chemical concentration in the relevant environmental media and the chemical-specific BAF:

$$C_i = C_M \times BAF$$

where,

C_i is the chemical concentration in the ith plant or animal food item (mg chemical/kg)

C_M is the chemical concentration in the environmental media (mg/kg sediment or mg/L water)
BAF is the bioaccumulation factor [soil, sediment (unitless); water (L/kg)]

US EPA (1999) provides BAF values for both inorganic and organic compounds, for a variety of organisms and environmental media including:

- Soil to soil invertebrate BAFs [(mg chemical/kg wet tissue) / (mg chemical/kg dry soil)];
- Soil to plant and sediment to plant BAFs [(mg chemical/kg dry tissue) / (mg chemical/kg dry soil or sediment)];
- Water to aquatic invertebrate BAFs [(mg chemical/kg wet tissue) / (mg dissolved chemical/L water)];
- Water to algae BAFs [(mg chemical/kg wet tissue) / (mg dissolved chemical/L water)]; and
- Water to fish BAFs [(mg chemical/kg wet tissue) / (mg dissolved chemical/L water)]
- Sediment to benthic invertebrate BAFs [(mg chemical/kg wet tissue) / (mg chemical/kg dry sediment)].

The derivation method for each group of BAFs is presented in US EPA document (1999). For dioxins, BAFs applicable to the categories listed above were available for 7 specific congeners including 2,3,7,8-TCDD. The relevant BAFs were used to predict tissue residues in sports fish based on the concentration of 2,3,7,8-TCDD quantified in the on-site surface water. The specific equation was:

$$C_{fish} = C_{water} \times 4235$$

Where: C_{fish} = Fish Tissue Residue (mg/kg fw)
C_{water} = Concentration in water (mg/L)

As indicated previously, simple linear BAF models were not available for large herbivorous mammals so this approach was limited to the assessment of tissue residues in sports fish. It is also important to note that the predicted Fish Tissue Residue is a whole-body burden and not restricted to the fillets or other edible tissue. It is not uncommon for chemicals to accumulate in specific tissues such as the liver and be at relatively low concentrations in the fillets. The BAF model does not distinguish between the two but simply provides an average. Dioxins tend to be associated with fat so their partitioning within the fish will be species dependent.

3. Non-linear Model Equations

The use of empirical models to derive non-linear equations that quantify chemical concentrations in biota as a function of the chemical concentration in environmental media provides for those situations where the simple linear model associated with the BAFs does not fit appropriately. For example, US EPA (1999) presents a series of non-linear equations that enable the calculation of chemical concentrations in more biologically complex organisms of various trophic levels. Equations are available to calculate:

- chemical concentrations in herbivorous and omnivorous birds and mammals in forest, shortgrass prairie, tallgrass prairie and shrub/scrub food webs; and
- chemical concentrations in herbivorous and omnivorous birds and mammals in freshwater/wetland, brackish/intermediate marsh, and saltmarsh food webs; and
- aquatic food chain models and bioenergetics models (e.g. Gobas, Mackay) to predict concentrations in fish and fish-consuming wildlife.

With respect to small mammals, while there is often a great deal of tissue residue data available, there is a general lack of data available concerning the estimation of whole-body residues based on soil concentrations. As a result, Sample *et al*. (1998b) developed a database of chemical concentrations in soil and small mammals for 14 inorganic and 2 organic chemicals. Once again, the resulting relationship was calculated based on a regression analysis of the data.

The general model for small mammals was applied in order to generate an estimate of the potential tissue residues in large herbivores such as deer and moose. The equation for 2,3,7,8-TCDD has the form:

$$\ln(C_{mammal}) = 0.811 + 1.10 \times (\ln(C_{soil})$$

Where: C_{mammal} = Tissue Residue (mg/kg dw)
C_{soil} = Concentration in Soil (mg/kg dw)

As with the predicted Fish Tissue Residue, the tissue residues predicted in mammals is also a whole-body burden and not restricted to the muscle or other edible tissue. As mentioned earlier, dioxins tend to be associated with fat. The consumption of this fat represents a potential concern because the whole-body model will tend to underestimate the concentration of dioxins in this tissue. It is also important to note that the tissue residues are expressed in units of dry weight (dw) and a conversion to fresh weight needs to be conducted prior to insertion into the human exposure model. This conversion was accomplished with the assumption that moose and deer meat have a moisture content of approximately 85% (US EPA, 1993).

4. Biotransfer Factors

The third approach to quantifying chemical concentrations in organisms was outlined by Sample and Suter (1994) and involves a combination of the two approaches previously described. Such an approach is recommended for more biologically complex organisms, which uptake chemicals via not only the environment but multiple food sources as well. The approach has the advantage that it implicitly includes all pathways of exposure, and does not require a mechanistic understanding of uptake from different pathways.

A simplified equation is provided below for those organisms, like the deer, that are exposed via ingestion to multiple chemical sources, with varying chemical concentrations. Inhalation and dermal exposure were considered to be negligible for wildlife, thus the proposed model only considers oral exposure. Home range and habitat requirements for these more biologically complex wildlife were also accounted for through the use of additional equation parameters that partition the exposure between these elements based on their relative contributions.

The following equation illustrates this approach for deer (US EPA, 1999):

$$C_{HM} = (C_{TP} \times BCF_{TP-HM} \times P_{TP} \times F_{TP}) + (C_S \times BCF_{S-HM} \times P_S) + (C_W \times BCF_{W-HM} \times P_W)$$

Where: C_{HM} = the chemical concentration in the herbivorous mammal (mg/kg fw)
C_{TP} = the chemical concentration in terrestrial plants (mg/kg fw)
$BCF_{TP\text{-}HM}$ = the bioconcentration factor for plants to mammals
P_{TP} = time the mammal spends on-site (unitless fraction)
F_{TP} = proportion of the diet that is terrestrial plants (unitless fraction
C_S = the chemical concentration in the soil (mg/kg dw)
$BCF_{S\text{-}HM}$ = the bioconcentration factor for soil to mammals
P_S = time the mammal spends on-site (unitless fraction)
C_W = the chemical concentration in the surface water (mg/L)
$BCF_{W\text{-}HM}$ = the bioconcentration factor for water to mammals
P_W = time the mammal spends on-site (unitless fraction)

The concentration of the chemical in the mammalian tissue may be expressed as either a fresh or a dry weight and the "units" of the BCF should be noted in order to avoid errors in this regard. The concentration of dioxin in food items such as terrestrial plants was predicted based on the simple linear BAF equations discussed earlier. Deer forage primarily on terrestrial plants while moose would also include aquatic species. For the latter, tissue residues were predicted based on dioxin concentrations quantified in representative sediments.

The BCFs for each of the ingested items were based on biotransfer factors (Ba). According to US EPA (1999), a biotransfer factor can be defined as the ratio of the compound concentration in fresh (wet) weight animal tissue to the daily intake of compound (IR_f) by the animal through ingestion of food items and media (soil, sediment, surface water). Ba values can either be used directly to calculate dose to the receptor of concern or they can be used to derive BCFs. Derivation of BCF values based on Ba values is described in US EPA (1999). The general equation is:

$$\boxed{BCF_{F-A} = Ba_A \times IR_F}$$

The Ba is specific to the chemical being ingested but generally applies to a class of animals such that all mammals appear to share common values. In contrast, the IR is specific to the species. Thus, in combination, each BCF is specific to the exposure pathway and the receptor. BCFs were calculated using this approach for the ingestion of terrestrial plants by deer and moose, the ingestion of water for deer and moose, the incidental ingestion of soil by deer and moose, the ingestion of aquatic plants by moose, and the ingestion of sediment by moose. Details of these calculations are provided in the accompanying spreadsheets.

As with the other models, it is important to note that bioaccumulation models typically provide a whole animal residue and not the tissue specific residues for muscle or organ meat within the deer or moose. The whole body residue may over-estimate or under-estimate the actual chemical residues depending on the specific tissue of interest and the nature of the chemical. This uncertainty is difficult to quantify and further decreases the ability to strongly rely on predicted tissue residues within the context of the human health exposure assessment.

5. Parameter Values

In general, parameter values required to calculate chemical concentrations in organisms using the three approaches previously described are available from numerous sources. The following are a list of references where BCFs and BAFs were found.

- U.S. EPA 1999a. Screening Level Ecological Risk Assessment Protocol. Appendix C: Media-To-Receptor *BCF* Values. U.S. EPA Region 6. Multimedia Planning and Permitting Division, Center for Combustion Science and Engineering. August 1999.
- U.S. EPA 1999b. Screening Level Ecological Risk Assessment Protocol. Appendix D: Bioconcentration Factors (*BCF*s) For Wildlife Measurement Receptors U.S. EPA Region 6. Multimedia Planning and Permitting Division, Center for Combustion Science and Engineering. August 1999.
- Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter, II, 1998. Development and Validation of Bioaccumulation Models for Small Mammals.. U.S. Department of Energy Office of Environmental Management, ES/ER/TM-219. February 1998.
- US EPA, 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a.

6. References

U.S. EPA 1999a. Screening Level Ecological Risk Assessment Protocol. Appendix C: Media-To-Receptor *BCF* Values. U.S. EPA Region 6. Multimedia Planning and Permitting Division, Center for Combustion Science and Engineering. August 1999.

U.S. EPA 1999b. Screening Level Ecological Risk Assessment Protocol. Appendix D: Bioconcentration Factors (*BCF*s) For Wildlife Measurement Receptors U.S. EPA Region 6. Multimedia Planning and Permitting Division, Center for Combustion Science and Engineering. August 1999.

Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter, II, 1998. Development and Validation of Bioaccumulation Models for Small Mammals.. U.S. Department of Energy Office of Environmental Management, ES/ER/TM-219. February 1998.

US EPA, 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187a.

Dioxin Bioaccumulation

Exposure Point Concentrations

	Units	TCDD (total)	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
BEF	unitless	na	1	0.92	0.31	0.12	0.14	0.051	0.012
Reference	US EPA Region 6, 1999								
Soil	mg/kg	1.52E-05	1.52E-05						
Sediment	mg/kg	4.19E-05	4.19E-05						
Surface Water	mg/L	1.20E-09	1.20E-09						
Vegetation	mg/kg ww								

Estimated Tissue Residues

	Units	TCDD (total)	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
Earthworms	mg/kg dw	0.00							
Reference	Sample et al., 1998a								
Earthworm % Moisture	%	85							
Reference	US EPA, 1993								
Earthworms	mg/kg fw	1.04E-05							
Mammals (General)	mg/kg dw	0.00							
Mammals (Omnivore)	mg/kg dw	0.00							
Reference	Sample et al., 1998b								
Mammal % Moisture	%	85							
Reference	US EPA, 1993								
Mammals (General)	mg/kg fw	1.71E-06							
Mammals (Omnivore)	mg/kg fw	1.71E-06							
Soil Invertebrates	mg/kg fw		2.42E-05	0.00	0.00	0.00	0.00	0.000	0.000
Reference	US EPA Region 6, 1999								
Terrestrial Plants	mg/kg dw		8.512E-08	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000
Reference	US EPA Region 6, 1999								
Plant % Moisture	%	81							
Reference	US EPA, 1993								
Terrestrial Plants	mg/kg fw		1.62E-08	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000
Aquatic Plants	mg/kg dw		2.3464E-07	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000
Reference	US EPA Region 6, 1999								
Plant % Moisture	%	81							
Reference	US EPA, 1993								
Aquatic Plants	mg/kg fw		4.46E-08	0.0000	0.0000	0.00000	0.00000	0.00000	0.000000
Aquatic Invertebrates	mg/kg fw		1.87E-06	0.00	0.00	0.00	0.00	0.00	0.00
Reference	US EPA Region 6, 1999								
Algae	mg/kg fw		3.96E-06	0.00	0.00	0.00	0.00	0.00	0.00
Reference	US EPA Region 6, 1999								
Fish	mg/kg fw		5.08E-06	0.00	0.00	0.00	0.00	0.00	0.00
Reference	US EPA Region 6, 1999								
Benthic Invertebrates	mg/kg fw		8.21E-01	1	0	0	0	0	0
Reference	US EPA Region 6, 1999								

Herbivorous Mammal (HM) (Terrestrial Only)	White-tailed Deer							
	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
Soil	mg/kg dw	1.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sediment	mg/kg dw	4.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Surface Water	mg/L	1.20E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BEF	unitless	1	0.92	0.31	0.12	0.14	0.051	0.012
BCF - terrestrial plants to HM	mg/kg fw / mg/kg fw	1.09E-03	9.99E-04	3.37E-04	1.30E-04	1.52E-04	5.54E-05	1.30E-05
BCF - water to HM	mg/kg fw / mg/L	3.80E-03	3.50E-03	1.18E-03	4.56E-04	5.32E-04	1.94E-04	4.56E-05
BCF - soil/sed to HM	mg/kg fw / mg/kg dw	2.12E-05	1.95E-05	6.57E-06	2.54E-06	2.97E-06	1.08E-06	2.54E-07

$$C_{HM} = (C_{TP} \times BCF_{TP-HM} \times P_{TP} \times F_{TP}) + (C_S \times BCF_{S-HM} \times P_S) + (C_W \times BCF_{W-HM} \times P_W)$$

Terrestrial Plants	mg/kg dw	8.512E-08	0	0	0	0	0	0
Reference	US EPA Region 6, 1999							
Plant % Moisture	%	81						
Reference	US EPA, 1993							
Terrestrial Plants	mg/kg fw	1.62E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Time On-Site (P_S and P_{TP})	unitless fraction	1	1	1	1	1	1	1
Site Area	Ha	500						
HM Home Range	Ha	100						
Diet Composition (F_{TP})								
Terrestrial Plants	unitless fraction	1	1	1	1	1	1	1
Water - Proportion Contaminated (P_W)	unitless fraction	1	1	1	1	1	1	1
Tissue Residue in Deer	mg/kg fw	3.44E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	pg/g fw	3.44E-04						

Herbivorous Mammal (HM) (Terrestrial and Aquatic)	**Moose**							
	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
Soil	mg/kg dw	1.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sediment	mg/kg dw	4.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Surface Water	mg/L	1.20E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BEF	unitless	1	0.92	0.31	0.12	0.14	0.051	0.012
BCF - terrestrial plants to HM	mg/kg fw / mg/kg fw	2.61E-03	2.41E-03	8.10E-04	3.14E-04	3.66E-04	1.33E-04	3.14E-05
BCF - water to HM	mg/kg fw / mg/L	2.95E-03	2.71E-03	9.14E-04	3.54E-04	4.13E-04	1.50E-04	3.54E-05
BCF - soil/sed to HM	mg/kg fw / mg/kg dw	5.23E-05	4.81E-05	1.62E-05	6.28E-06	7.33E-06	2.67E-06	6.28E-07

$$C_{HM} = (C_{TP} \times BCF_{TP-HM} \times P_{TP} \times F_{TP}) + (C_{AV} \times BCF_{AV-HM} \times P_{AV} \times F_{AV}) + (C_S \times BCF_{S-HM} \times P_S \times F_{TP}) +$$
$$(C_{sed} \times BCF_{BS-HM} \times P_{BS} \times F_{AV}) + (C_W \times BCF_{W-HM} \times P_W)$$

Terrestrial Plants	mg/kg dw	8.512E-08	0	0	0	0	0	0
Reference	US EPA Region 6, 1999							
Plant % Moisture	%	81						
Reference	US EPA, 1993							
Terrestrial Plants	mg/kg fw	1.62E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Aquatic Plants	mg/kg dw	2.3464E-07	0	0	0	0	0	0
Reference	US EPA Region 6, 1999							
Plant % Moisture	%	81						
Reference	US EPA, 1993							
Aquatic Plants	mg/kg fw	4.46E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Time On-Site (P_S and P_{TP})	unitless fraction	1	1	1	1	1	1	1
Site Area	Ha	500						
HM Home Range	Ha	500						
Diet Composition (F_{TP} and F_{AV})								
Terrestrial Plants	unitless fraction	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Aquatic Plants	unitless fraction	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Water - Proportion Contaminated (P_W)	unitless fraction	1	1	1	1	1	1	1
Tissue Residue in Moose	mg/kg fw	1.58E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	pg/g fw	1.58E-03						

BCFs from Food Item to Animal

$$BCF_{F-A} = Ba_A \times IR_F$$

Vegetation	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
BEF	unitless	1	0.92	0.31	0.12	0.14	0.051	0.012
White-tailed Deer								
Ba_A	days/kg fw tissue	5.43E-02	5.00E-02	1.68E-02	6.52E-03	7.60E-03	2.77E-03	6.52E-04
IR_F	kg fw/day	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02	2.00E-02
$BCF_{F\text{-}A}$	mg/kg fw / mg/kg fw	1.09E-03	9.99E-04	3.37E-04	1.30E-04	1.52E-04	5.54E-05	1.30E-05
Moose								
Ba_A	days/kg fw tissue	5.43E-02	5.00E-02	1.68E-02	6.52E-03	7.60E-03	2.77E-03	6.52E-04
IR_F	kg fw/day	4.81E-02	4.81E-02	4.81E-02	4.81E-02	4.81E-02	4.81E-02	4.81E-02
$BCF_{F\text{-}A}$	mg/kg fw / mg/kg fw	2.61E-03	2.41E-03	8.10E-04	3.14E-04	3.66E-04	1.33E-04	3.14E-05

White-tailed Deer				
BW	6.60E+01	kg		
IR_F	2.00E-02	kg fw/kg bw-day	1.32E+00	kg fw/day
$IR_{S/Sed}$	3.90E-04	kg dw/kg bw-day	2.57E-02	kg dw/day
IR_W	7.00E-02	L/kg bw-day	4.62E+00	L/day
Moose				
BW	4.05E+02	kg		
IR_F	4.81E-02	kg fw/kg bw-day	1.95E+01	kg fw/day
$IR_{S/Sed}$	9.63E-04	kg dw/kg bw-day	3.90E-01	kg dw/day
IR_W	5.43E-02	L/kg bw-day	2.20E+01	L/day

BCFs from Media Ingestion to Animal

$$BCF_{M-A} = Ba_A \times IR_M$$

Soil	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
White-tailed Deer								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.97E-03	8.13E-03	2.96E-03	6.97E-04
IR_S	kg fw/day	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04
$BCF_{S\text{-}A}$	mg/kg fw / mg/kg fw	2.12E-05	2.08E-05	7.02E-06	2.72E-06	3.17E-06	1.15E-06	2.72E-07
Moose								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.97E-03	8.13E-03	2.96E-03	6.97E-04
IR_S	kg fw/day	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04
$BCF_{S\text{-}A}$	mg/kg fw / mg/kg fw	5.23E-05	5.14E-05	1.73E-05	6.71E-06	7.83E-06	2.85E-06	6.71E-07

L/day

White-tailed Deer				
BW	6.60E+01	kg		
IR_F	2.00E-02	kg fw/kg bw-day	1.32E+00	kg fw/day
$IR_{S/Sed}$	3.90E-04	kg dw/kg bw-day	2.57E-02	kg dw/day
IR_W	7.00E-02	L/kg bw-day	4.62E+00	L/day
Moose				
BW	4.05E+02	kg		
IR_F	4.81E-02	kg fw/kg bw-day	1.95E+01	kg fw/day
$IR_{S/Sed}$	9.63E-04	kg dw/kg bw-day	3.90E-01	kg dw/day
IR_W	5.43E-02	L/kg bw-day	2.20E+01	L/day

Sediment	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
White-tailed Deer								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.97E-03	8.13E-03	2.96E-03	6.97E-04
IR_{Sed}	kg fw/day	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04	3.90E-04
$BCF_{Sed\text{-}A}$	mg/kg fw / mg/kg fw	2.12E-05	2.08E-05	7.02E-06	2.72E-06	3.17E-06	1.15E-06	2.72E-07
Moose								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.97E-03	8.13E-03	2.96E-03	6.97E-04
IR_{Sed}	kg fw/day	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04	9.63E-04
$BCF_{Sed\text{-}A}$	mg/kg fw / mg/kg fw	5.23E-05	5.14E-05	1.73E-05	6.71E-06	7.83E-06	2.85E-06	6.71E-07

L/day

White-tailed Deer				
BW	6.60E+01	kg		
IR_F	2.00E-02	kg fw/kg bw-day	1.32E+00	kg fw/day
$IR_{S/Sed}$	3.90E-04	kg dw/kg bw-day	2.57E-02	kg dw/day
IR_W	7.00E-02	L/kg bw-day	4.62E+00	L/day
Moose				
BW	4.05E+02	kg		
IR_F	4.81E-02	kg fw/kg bw-day	1.95E+01	kg fw/day
$IR_{S/Sed}$	9.63E-04	kg dw/kg bw-day	3.90E-01	kg dw/day
IR_W	5.43E-02	L/kg bw-day	2.20E+01	L/day

Surface Water	Units	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD
White-tailed Deer								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.96E-03	8.12E-03	2.96E-03	6.96E-04
IR_W	kg fw/day	7.00E-02	7.00E-02	7.00E-02	7.00E-02	7.00E-02	7.00E-02	7.00E-02
$BCF_{W\text{-}A}$	mg/kg fw / mg/kg fw	3.80E-03	3.74E-03	1.26E-03	4.87E-04	5.69E-04	2.07E-04	4.87E-05
Moose								
Ba_A	days/kg fw tissue	5.43E-02	5.34E-02	1.80E-02	6.96E-03	8.12E-03	2.96E-03	6.96E-04
IR_W	kg fw/day	5.43E-02	5.43E-02	5.43E-02	5.43E-02	5.43E-02	5.43E-02	5.43E-02
$BCF_{W\text{-}A}$	mg/kg fw / mg/kg fw	2.95E-03	2.90E-03	9.77E-04	3.78E-04	4.41E-04	1.61E-04	3.78E-05

L/day

White-tailed Deer				
BW	6.60E+01	kg		
IR_F	2.00E-02	kg fw/kg bw-day	1.32E+00	kg fw/day
$IR_{S/Sed}$	3.90E-04	kg dw/kg bw-day	2.57E-02	kg dw/day
IR_W	7.00E-02	L/kg bw-day	4.62E+00	L/day
Moose				
BW	4.05E+02	kg		
IR_F	4.81E-02	kg fw/kg bw-day	1.95E+01	kg fw/day
$IR_{S/Sed}$	9.63E-04	kg dw/kg bw-day	3.90E-01	kg dw/day
IR_W	5.43E-02	L/kg bw-day	2.20E+01	L/day