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DEVELOPMENT OF DOSE ESTIMATION MODELS AND TOXICITY REFERENCE VALUES ECOLOGICAL RISK ASSESSMENT

IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

Prepared for

U.S. Army Corps of Engineers
Omaha District

By

MWH
MONTGOMERY WATSON HARZA

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DEVELOPMENT OF DOSE ESTIMATION MODELS AND TOXICITY REFERENCE VALUES ECOLOGICAL RISK ASSESSMENT IOWA ARMY AMMUNITION PLANT

The purpose of this report is to present models to be used for estimating doses to the four representative feeding guilds (White-footed Mouse, Short-tailed Shrew, Belted Kingfisher, and Indiana Bat) at the Iowa Army Ammunition Plant (IAAAP). Toxicity Reference Values (TRVs) for the selected ecological receptors for exposure to each of the COPECs are proposed in this memorandum. Methods for deriving values for the water-biota, sediment-biota, and plant-biota accumulation factors for the contaminants of potential ecological concern (COPECs) are also presented.

DERIVATION OF TRVs

Research for the TRVs on each COPEC began with searches of published toxicity studies on mammals and birds in several databases. The databases searched for papers on toxicological effects of the specific COPECs include Current Content, Agency of Toxic Substance and Disease Registry (ATSDR) toxicological profiles, National Library of Medicine's Hazardous Substance Database (Toxline), Oak Ridge National Laboratory's Risk Assessment Information System (RAIS), U.S. Environmental protection Agency's (EPA) Integrated Risk Information System (IRIS) and EPA's ECOTOX. Several comprehensive reports such as EPA Region 6 Screening Level Ecological Risk Assessment Protocol (EPA 1999), Toxicological Benchmarks for Wildlife (Sample and others. 1996), and CH2MHILL and USACE's review of TRVs (2000) were reviewed.

Several selection criteria were used to identify relevant literature. Literature that provided information on study design such as duration, handling of test species, physical information on test species, and dose route, was selected over literature with limited information. Chronic toxicity studies were considered preferentially because at most sites receptors are exposed over a long period. For study on laboratory rodents at least over one year is considered to be a chronic exposure (Sample and others. 1996). For avian study, exposure duration greater than ten weeks is considered to be chronic study (Sample and others. 1996). Toxicity endpoints that correlate with significant ecological impact such as reproduction, development, and survival, were preferred over systemic and acute effects. Dose administered through oral route (diet, water, gavage) was preferred over other routes.

The literature search focused on laboratory studies to obtain information on the lowest observed adverse effect level (LOAEL) and the no observed adverse effect level (NOAEL). The lowest chronic LOAEL value is used as the TRV, if both LOAEL and NOAEL data are available; otherwise, the NOAEL value is used. LOAEL and NOAEL values available only from subchronic studies were adjusted by dividing the value by an uncertainty factor of 10. If a LOAEL or NOAEL is available for a mammalian or avian test species, then the equivalent LOAEL or NOAEL for a mammalian or avian wildlife species was calculated by using the adjustment factor for differences in body weight (Sample and others. 1996). The equations for the adjustment are as follows:

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

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

Where the subscripts w and t refer to the wildlife species of interest and the test species, respectively. The body weight scale factors used to derive TRVs for the species of interest and the test species are presented in Appendix A, Table A-1. The derived TRVs for each receptor are presented in Appendix A, Tables A-2 through Table A-5.

DEVELOPMENT OF DOSE MODELS

Procedures for estimating exposures of four wildlife-feeding guilds are required for completing this risk assessment. The feeding guilds are:

1. A piscivore represented by the Belted Kingfisher
2. An aquatic insectivore, represented by the Indiana Bat
3. A terrestrial herbivore, represented by the White-footed Mouse
4. A terrestrial carnivore, represented by the Short-tailed Shrew

Exposure to contaminants experienced by an endpoint species may come from multiple sources. The sources include food (plant or animal), water, soil, and sediment. Figure 1 through Figure 4 represent the ecorisk pathways for the four ecological receptors. The generalized equation for estimating daily contaminant dose that an endpoint receptor may receive from a particular contaminant in a particular medium may be expressed as

$$E_j = \sum_{i=1}^{m} P_{ik}\left(IR_i \times C_{ijk}\right)/(\mathrm{BW}) \qquad (1)$$

Where:
E_j = Total exposure to contaminant j, mg/kg/d
m = Total number of ingested media
P_{ik} = Proportion of type (k) of medium (i) consumed
IR_i = Consumption rate for medium (i), kg/d or L/d
C_{ijk} = Concentration of contaminant (j) in type (k) of medium (i), mg/kg or mg/L
BW = Body weight, kg

Parameter values required for estimating dose for all four feeding guilds are presented in Table 1.

Table 1. Exposure Parameter Values [a]

Parameter	Short-tailed Shrew	White-footed Mouse	Belted Kingfisher	Indiana Bat
Body Weight (kg)	0.0150	0.0220[d]	0.1360	0.0072[f]
Food Intake (kg/d)	0.0080	0.0034[d]	0.0680	0.0025[g]
Water Intake (L/d)	0.0033	0.0066[d]	0.0150	0.0012[g]
Soil Intake in diet, %	13[b]	2[e]	0	0
Terrestrial invertebrate in diet, %	87[c]	49[c]	0	0
Fish in diet, %	0	0	100[c]	0
Aquatic invertebrate in diet, %	0	0	0	100[c]
Vegetation in diet, %	0	49[c]	0	0

Notes:
- a Values from EPA (1993), unless otherwise mentioned
- b Talmage and Walton (1993)
- c Assumed
- d Sample and others (1996)
- e Beyer and others (1994)
- f USAMC (1998)
- g Values for the Brown Bat (Sample and others, 1996)

Specific models for estimating doses to the four feeding guilds are presented below.

Belted Kingfisher

Belted Kingfishers are exposed to contaminants through ingestion of water and food. Information presented in EPA (1993) indicates that its diet consists primarily of fish. The exposure model for the aquatic piscivore may be expressed as

$$E_j = (IR_w \times C_w - j)/(BW) + (IR_f \times C_{fish-j})/(BW) \qquad (2)$$

Where:
IR_w = Ingestion rate of water, L/d
C_{w-j} = Contaminant concentration (j) in water, mg/L
IR_f = Ingestion rate of fish, kg/d
C_{fish-j} = Contaminant concentration (j) in fish, mg/kg
BW = Body Weight, kg

Contaminant concentrations in fish at the IAAAP are needed for estimating exposure dose. Whole fish samples were collected from Brush Creek, Spring Creek, and Long Creek. These samples were analyzed for mercury, explosives, and pesticide/PCBs. The results were presented in the Ecological Risk Assessment Addendum (Harza 1998). Mercury and dieldrin were the only two compounds detected in fish tissue. Actual fish tissue concentrations in each watershed for mercury and dieldrin will be used in the risk assessment. The analytical procedures including detection limits for the compounds were in accordance with the approved work plan and were lower than the corresponding available LOAELs or NOAELs. Therefore, chemicals that were not detected in the fish tissue samples will not be considered as contaminants of potential ecological concern (COPEC).

For other contaminants that were not analyzed in fish sample, the contaminants concentration in fish (C_{fish}) will be calculated using the following equation:

$$C_{fish-j} = C_{w-j} \times BAF_{fish} + C_{se-j} \times BSAF_{fish} \times \frac{F_l}{F_{oc}} \qquad (3)$$

Where:
$C_{w\text{-}j}$ = Contaminant concentration (j) in water, mg/kg (one liter of water assumed to weigh one kg)
$C_{se\text{-}j}$ = Contaminant concentration (j) in sediment, mg/kg
BAF_{fish} = Bioaccumulation Factor (Water-To-Fish)
= Concentration in fish tissue/Concentration in water, unitless
$BSAF_{fish}$ = Bioaccumulation Factor (Sediment-To-Fish)
= Concentration in fish tissue/Concentration in sediment, unitless
F_l = Fraction of lipid in fish, unitless
F_{oc} = Fraction of organic carbon in the sediment = Total organic carbon (TOC)/100, unitless

F_l is estimated to be 0.05 (Leblanc, 1995). Sediment samples collected from Spring Creek, Brush Creek, and Long Creek were analyzed for TOC. The lowest measured TOC value in each watershed will be used. The lowest measured TOC value of all watersheds will be used as the default value for the Skunk River watershed. A $BSAF_{fish}$ value of 1.7 will be used for organic chemicals (Konemann and van Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke, 1987). The $BSAF_{fish}$ and BAF_{fish} values of inorganic chemicals were obtained from available literature. The organic BAF_{fish} values were estimated from octanol-water coefficients (Kow), using an equation developed by Meglan and others (1999).

$$\text{Log BAF}_{fish} = 0.76 \times \log \text{Kow} - 0.39 \qquad (4)$$

The values of logKow, BAF_{fish} and $BSAF_{fish}$ are listed in Appendix B, Table B-1.

Insectivore- Indiana Bat

It was assumed that the diet for Indiana bat consists primarily of aquatic insects. The exposure model for the aquatic insectivore may be expressed as

$$E_j = (IR_w \times C_{w\text{-}j})/(BW) + (IR_{in} \times C_{insect\text{-}j})/(BW) \qquad (5)$$

Where:
IR_w = Ingestion rate of water, L/d
$C_{w\text{-}j}$ = Contaminant concentration (j) in water, mg/L
IR_{in} = Ingestion rate of insect, kg/d

$C_{insect-j}$ = Contaminant concentration (j) in insect, mg/kg
BW = Body weight, kg

The contaminant concentrations in insect (C_{insect}) is calculated by the following equation:

$$C_{insect-j} = C_{w-j} \times BAF_{invert} + C_{se-j} \times BSAF_{invert} \qquad (6)$$

Where:
C_{w-j} = Contaminant concentration (j) in water, mg/kg
C_{se-j} = Contaminant concentration (j) in sediment, mg/kg
BAF_{invert} = Bioaccumulation Factor (Water-To-Aquatic invertebrate)
= Concentration in invertebrate tissue/Concentration in water, unitless
$BSAF_{invert}$ = Bioaccumulation Factor (Sediment-To-Aquatic invertebrate)
= Concentration in invertebrate tissue/Concentration in sediment, unitless

A $BSAF_{invert}$ value of 1.7 will be used for organic chemicals (Konemann and van Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke, 1987). The $BSAF_{invert}$ and BAF_{invert} values of inorganic chemicals were obtained from the available literature. The organic BAF_{invert} values were calculated by multiplying the bioconcentration factor (BCF) for the contaminant by the aquatic food chain multiplying factor (FCM).

The BCFs were estimated from octanol-water coefficients (Kow), using the following equation (Lyman and others, 1990)

$$\log BCF = 0.76 \log Kow - 0.23 \qquad (7)$$

The FCM for Indiana Bat is 1 (Sample and others. 1996).

The values of logKow, BCF, BAF_{invert} and $BSAF_{invert}$ are listed in Appendix B, Table B-2.

<u>Terrestrial Herbivore-White-footed Mouse</u>

Terrestrial herbivores are exposed to contaminants via ingestion of soil, plants and terrestrial invertebrate. The exposure model may be expressed as

$$E_j = (P_s \times F \times C_{s-j})/(BW) + (P_v \times F \times C_{v-j})/(BW) + (P_{inv} \times F \times C_{inv-j})/(BW) \qquad (8)$$

Where:
P_s = Fraction soil ingested, unitless
F = Food intake, kg/d
C_{s-j} = Contaminant concentration (j) in soil, mg/kg
P_v = Fraction vegetation ingested, unitless
C_{v-j} = Contaminant concentration (j) in vegetation, mg/kg
P_{inv} = Fraction invertebrate ingested, unitless
C_{inv-j} = Contaminant concentration (j) in invertebrate, mg/kg
BW = Body weight, kg

The contaminant concentrations in vegetation and invertebrate are calculated by the following equations:

$$C_{v-j} = C_{s-j} \times U_{s-v} \quad (9)$$

$$C_{inv-j} = C_{s-j} \times BAF_{ti} \quad (10)$$

Where:
U_{s-v} = Bioaccumulation Factor (Soil-To-Vegetation), unitless
BAF_{ti} = Bioaccumulation Factor (Soil-To-Terrestrial invertebrate), unitless

For organic contaminant concentration in vegetation, the U_{s-v} values were estimated from relationships based on Kow developed by Travis and Arms (1988).

$$\log U_{s-v} = 1.588 - 0.578 (\log Kow) \quad (11)$$

The BAF_{ti} values for organic contaminants were derived using the following equation, developed by Connell and Markwell (1990).

$$BAF_{ti} = \frac{Y_1 \times \log K_{ow}{}^{b-a}}{x \times f_{oc}} \quad (12)$$

Where:
Y_1 = Terrestrial invertebrate lipid content = 0.02 (Stafford and Tacon, 1988), unitless
logKow = Octanol-water partition coefficient, unitless
b-a = Nonlinearity constant = 0.05
x = Proportionality constant = 0.66
foc = Site-Specific of organic carbon in soil = 0.006, unitless (EPA 1996)

The value of inorganic contaminant U_{s-v} and BAF_{ti} were obtained from the available literature. The values of logKow, BAF_{ti}, and U_{s-v} are listed in Appendix B, Table B-3.

Terrestrial Carnivore-Short-Tailed Shrew

Terrestrial carnivores are exposed to contaminants via ingestion of soil and terrestrial invertebrate. The exposure model may be expressed as

$$E_j = (P_s \times F \times C_{s-j})/(BW) + (P_{inv} \times F \times C_{inv-j})/(BW) \quad (13)$$

Where:
P_s = Fraction soil ingested, unitless
F = Food intake, kg/d
C_{s-j} = Contaminant concentration (j) in soil, mg/kg
P_{inv} = Fraction invertebrate ingested, unitless
C_{inv-j} = Contaminant concentration (j) in invertebrate, mg/kg

IR_w = Ingestion rate of water, L/d
BW = Body weight, kg

The contaminant concentrations in invertebrate are calculated by Equation (10) and the BAF_{ti} values for organics were derived by Equation (12). The inorganic BAF_{ti} values were obtained from the available literature.

The values of logKow and BAF_{ti} are listed in Appendix B, Table B-4.

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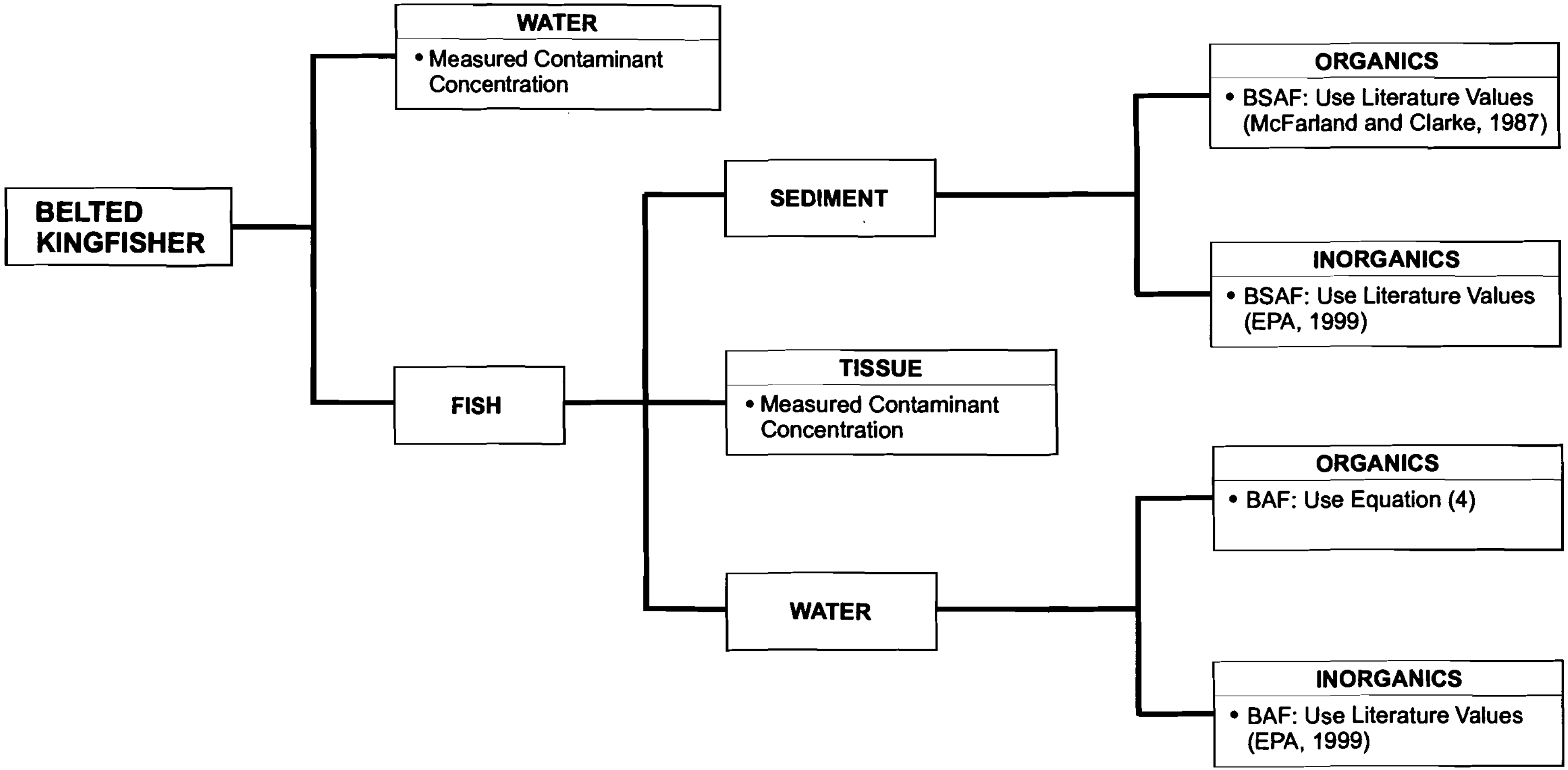

Figure 1
ECORISK PATHWAY FOR BELTED KINGFISHER
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

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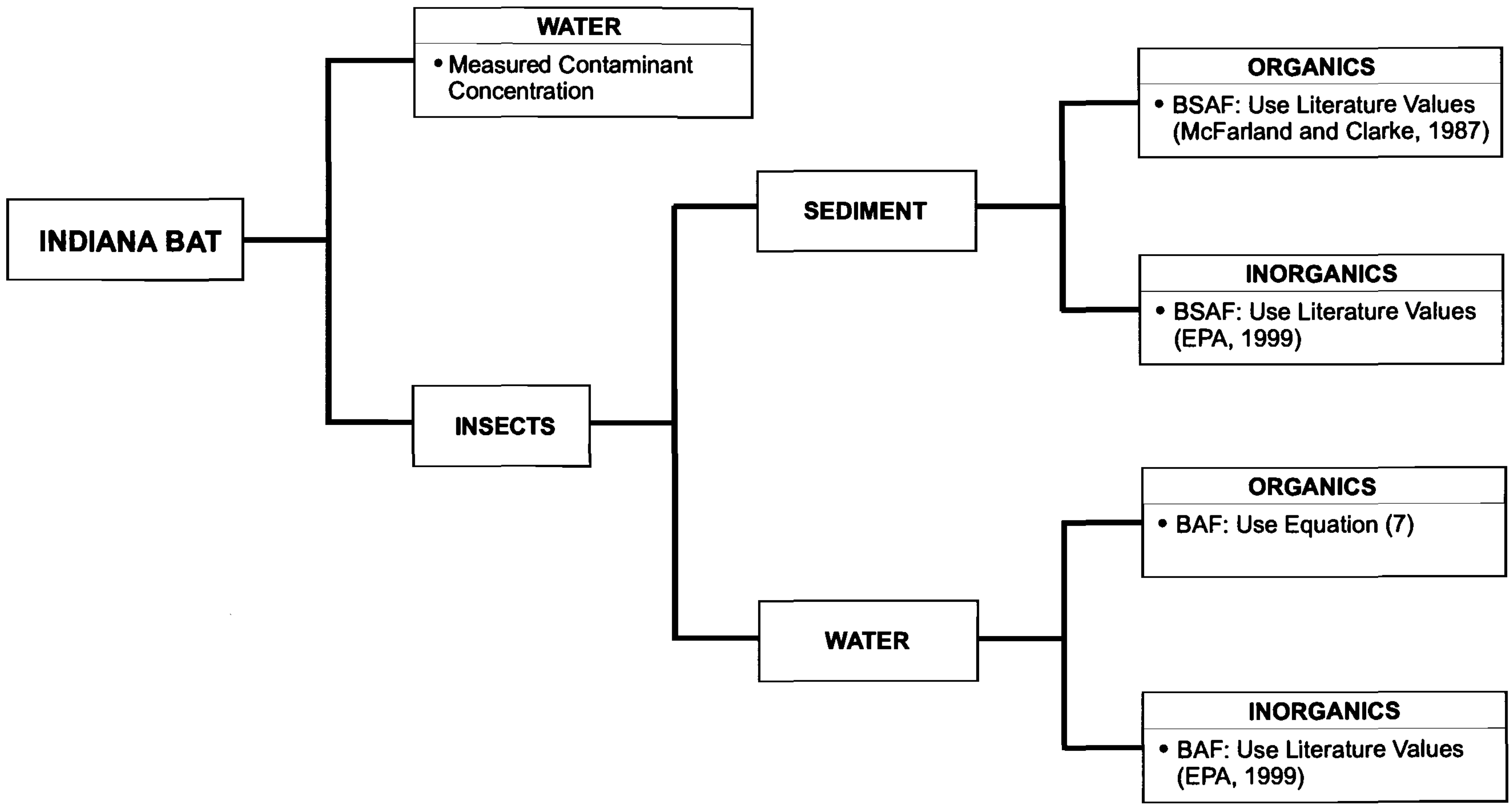

Figure 2
ECORISK PATHWAY FOR INDIANA BAT
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

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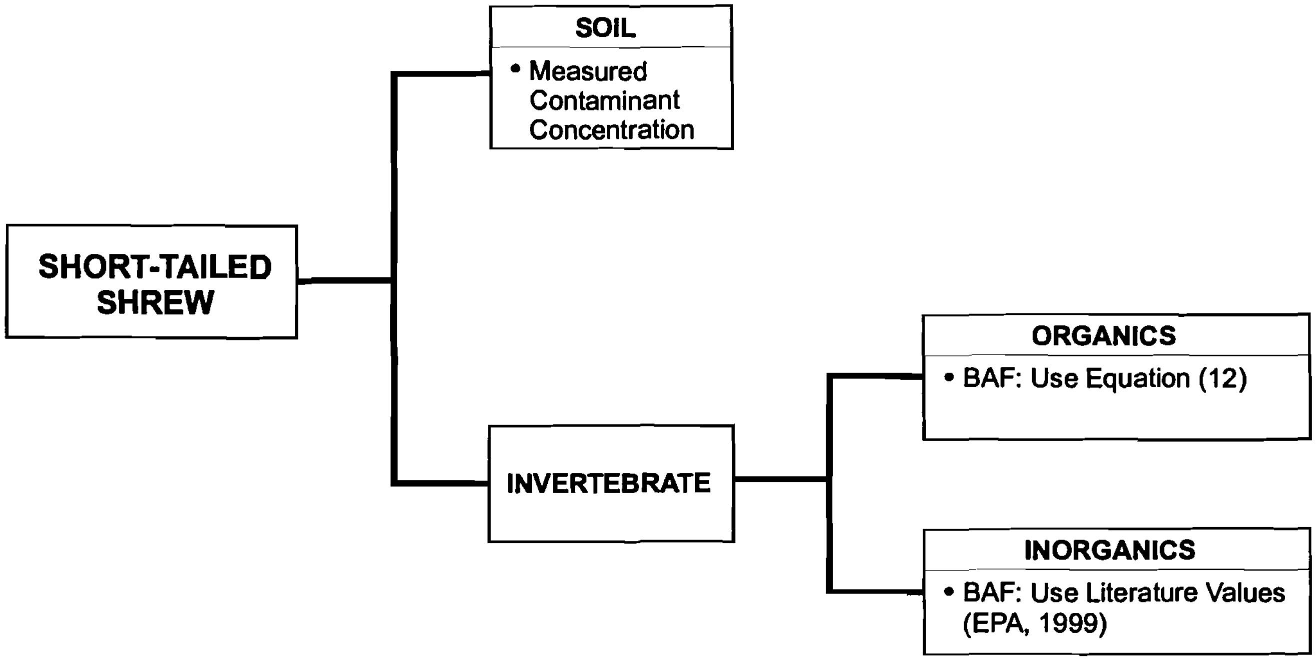

Figure 3
ECORISK PATHWAY FOR SHORT-TAILED SHREW
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

HARZA ENGINEERING COMPANY
WATER & ENVIRONMENT

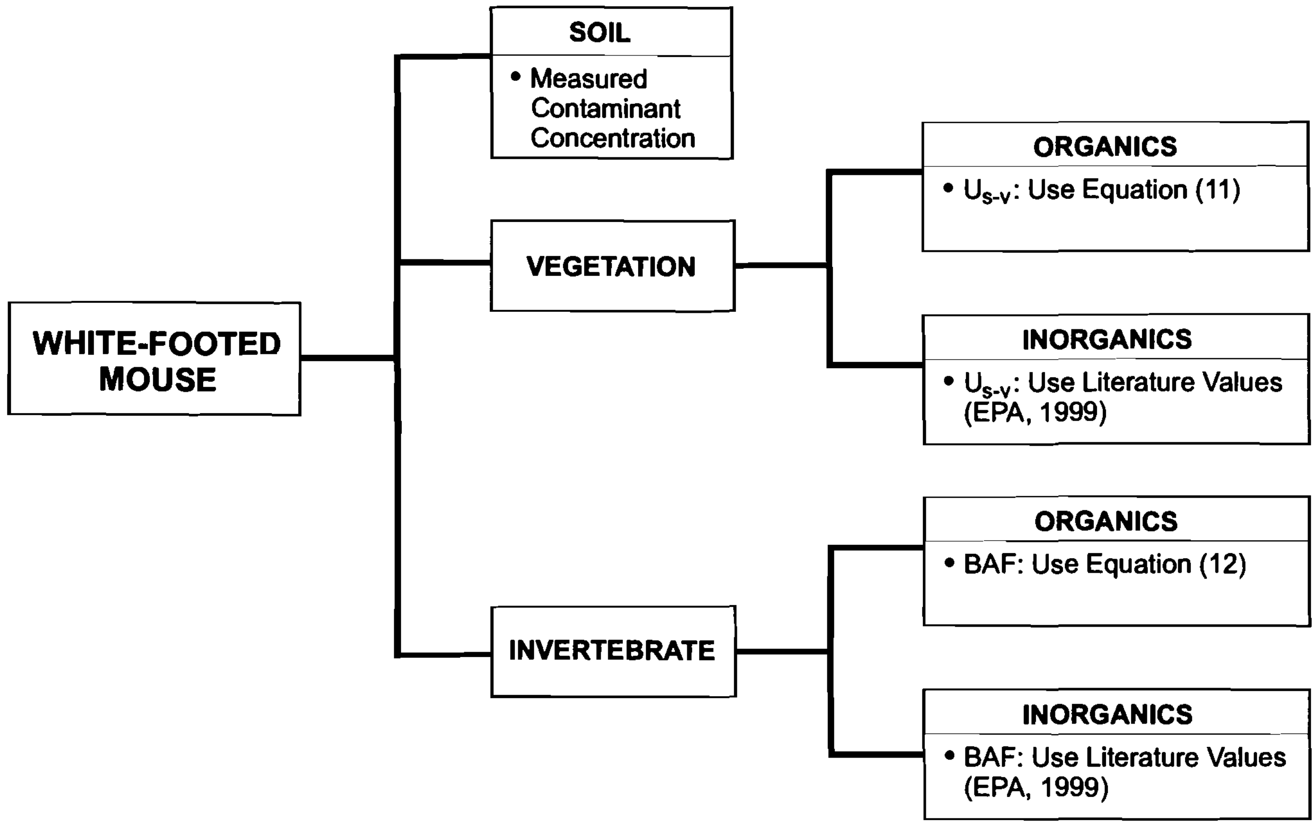

Figure 4
ECORISK PATHWAY FOR WHITE-FOOTED MOUSE
ECOLOGICAL RISK ASSESSMENT
IOWA ARMY AMMUNITION PLANT
Middletown, Iowa

APPENDIX A

TRVs FOR FOUR RECEPTORS

Table A-1 Body Weight Scale Factors

Experimental Animals [a]		Wildlife [a]		
Species	Body weight (bw_t in kg)	Species	Body Weight (bw_w in kg)	Scaling Factor $(bw_t/bw_w)^{1/4}$
Rat	0.350	White-footed mouse	0.0220	1.997
Rat	0.350	Short-tailed shrew	0.0150	2.198
Rat	0.350	Indiana Bat	0.0072	2.640
Mouse	0.030	White-footed mouse	0.0220	1.081
Mouse	0.030	Short-tailed shrew	0.0150	1.189
Mouse	0.030	Indiana Bat	0.0072	1.429
Mink	1.000	White-footed mouse	0.0220	2.597
Mink	1.000	Short-tailed shrew	0.0150	2.857
Mink	1.000	Indiana Bat	0.0072	3.433
Rabbit	3.800	White-footed mouse	0.0220	3.625
Rabbit	3.800	Short-tailed shrew	0.0150	3.990
Rabbit	3.800	Indiana Bat	0.0072	4.793
Mallard	1.000	Belted kingfisher	0.1360	1.647
Ringed Turtle Dove	0.155	Belted kingfisher	0.1360	1.033
Barn owl	0.466	Belted kingfisher	0.1360	1.361
Black duck	1.250	Belted kingfisher	0.1360	1.741
chick	1.500	Belted kingfisher	0.1360	1.822
One day old chick	0.121	Belted kingfisher	0.1360	0.971
Japanese quail	0.150	Belted kingfisher	0.1360	1.025
White-footed mouse	0.022	Short-tailed shrew	0.0150	1.100
White-footed mouse	0.022	Indiana Bat	0.0072	1.322

Notes:

[a] Sample B. E., D. M. Opresko and G. W. Suter II, Body weight data from Toxicological Benchmarks for Wildlife: 1996 Revision ES/ER/TM-86/R3

Table A-2 TRVs for White-footed Mouse

COEC	Species	Test Animal LOAEL mg/kg/day	Test Animal NOAEL mg/kg/day	White footed Mouse LOAEL mg/kg/day	White footed Mouse NOAEL mg/kg/day	White footed Mouse TRV mg/kg/day	Remarks	Reference
Aldrin	Rat	1.000	0.200	1.997	0.399	1.997	Rats were fed for three generation,while the number of litters and offspring did not significantly reduced among rats receiving 0.2 mg/kg/day doses level, these parameters were reduced at the 1 mg/kg/day dose level. The study by Treon and Cleveland (1955) was considered to be more ecologically relevent. The TRV is based on adjusted LOAEL.	Treon and Cleveland (1955), cited in C
2-Amino-4,6-Dinitrotoluene	Rat	2.500	0.500	4.993	0.999	4.993	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	Levine et al.(1984), Talmage et al.(1999)
4-Amino-2,6-Dinitrotoluene	Rat	2.500	0.500	4.993	0.999	4.993	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	Levine et al.(1984), Talmage et al.(1999)
Anthracene	Mouse		100.000		108.062	108.062	Mice were treated by gavage once daily for 90 days with 0, 250, 500, or 1000 mg anthracene/kg/day, There were no compound-related effects. The 1000 mg/kg/day was considered to be a subchronic NOAEL. Chronic NOAEL is derived from subchronic value by an uncertainty factor of 10. TRV based on adjusted chronic NOAEL.	Schmahl (1955), cited in U.S. EPA, 1989.
Arochlor 1260	White-footed Mouse	0.680	0.068	0.680	0.068	0.680	TRVs based on Arochlor 1254	McCoy et al. (1995), cited in C
Arochlor 1254	White-footed Mouse	0.680	0.068	0.680	0.068	0.680	Reproduction study for 12 months (chronic). Arochlor 1254 at 5ppm (0.68 mg/kg/day) reduced litters number, offspring weights and survival. This dose is considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	McCoy et al. (1995), cited in C
Benzo(a)anthracene	Mouse	16.666		18.010	0.000	18.010	Mouse Single dose LOAEL = 16.666 mg/kg/day (gastrointestinal effects). TRV based on adjusted LOAEL.	Bock and King (1959), cited in B
Benzo(a)pyrene	Mouse	10.000	1.000	10.806	1.081	10.806	Mice were exposed (by gavage) to 3 dose levels of BaP during gestational days 7-16. BaP exposure of 160mg/kg/day significantly reduced pregnancy rates and percentage of viable litters. Pup weights were significantly reduced by all three dose levels. The 10 mg/kg/day dose was considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	Mackenzie and Angevine (1981), cited in C
Benzo(b)fluoranthene	Mouse	10.000	1.000	10.806	1.081	10.806	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C
beta-BHC	Rat	2.000	0.400	3.994	0.799	3.994	Subchronic study (13 weeks), exposure of four dose levels: 2, 10, 50 and 250 ppm. No significant effects observed at 50ppm level while consumption of 250ppm in diet caused gonadl atrophy. The 250ppm(20 mg/kg/day) and 50ppm(4 mg/kg/day) were considered to be a subchronic LOAEL and NOAEL. Chronic LOAEL is derived from subchronic value. TRV based on adjusted chronic LOAEL.	Sample et al. (1996)
delta-BHC	Rat	2.000	0.400	3.994	0.799	3.994	TRV based on beta BHC	Sample et al. (1996)
gamma-BHC	Rat	2.000	0.400	3.994	0.799	3.994	TRV based on beta BHC	Sample et al. (1996)
Bis(2-ethylhexyl) Phthalate	Rat	183.000	18.300	365.479	36.548	365.479	Exposure during critical lifestage (104 days), no adverse effects were observed among 0.01% bis(2-ethylhexyl)phthalate dose group, while 0.1 % dose had significant reproductive effects. The 0.1% (183.3 mg/kg/day) was considered to be a chronic LOAEL.	Sample et al. (1996)
Benzyl Butyl Phthalate	Rat	47.000	15.900	93.866	31.755	93.866	Twenty-six subchronic study in rat, the lowest subchronic LOAEL (470 mg/kg/day) and NOAEL (159 mg/kg/day) are proposed for use. Chronic LOAEL and NOAEL are derived from subchronic value by an uncertainty factor of 10. TRV based on chronic LOAEL.	NTP (1985), cited in IRIS
Carbazole							No data available in ATSDR or EPA database	
4,4'-DDD	Rat	4.000	0.800	7.989	1.598	7.989	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, chronic LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C
4,4'-DDE	Rat	4.000	0.800	7.989	1.598	7.989	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C
4,4'-DDT	Rat	4.000	0.800	7.989	1.598	7.989	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C

Table A-2 TRVs for White-footed Mouse

COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Chlordane	Rat	8.000	0.180	15.977	0.359	15.977	No histopathological effects were observed in rats fed 0.18 mg/kg/day in a 2-year feeding study. 8.0 mg/kg-day dose was associated with altered endocrine function in mice exposed throughout their lifespan, which was considered to be a chronic LOAEL TRV based on adjusted LOAEL.	Khasawinah and Grutsch (1989), Cranmer et al. (1984)
Chrysene	Mouse	10.000	1.000	10.806	1.081	10.806	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C
Dibenzofuran	Mouse	10.000	1.000	10.806	1.081	10.806	TRV based on Phenanthrene	
1,4-Dichlorobenzene	Rat	43.000		85.878	0.000	85.878	Two generations study (chronic), exposed to three dose levels (66.3, 211, and 538 ppm) . For both generations of offspring in the 538 ppm group, weight,average litter size, and offspring survival were decreased. The 538 ppm (43 mg/kg/day) was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Tyl and Neeper-Bradley (1989), cited in RAIS
Dieldrin	White-footed Mouse	0.020	0.002	0.020	0.020	0.020	White-footed mice were fed diets treated with 0.02 mg/kg-day of dieldrin in corn oil. This dose caused behavioral changes, such as decreased predator avoidance behavior, in treated animals	Bildstein and Forsyth (1979)
1,3-Dinitrobenzene	Rat	0.173	0.035	0.346	0.070	0.346	Thirteen weeks study with rats found testicular degeneration effects at 1.73 mg/kg/day, which is the lowest of all subchronic testicular effect studies with rats. Chronic LOAEL was derived from subchronic value devided by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Reddy et al. (1995); Talmage et al. (1999)
2,4-Dinitrotoluene	Mouse	35.000	5.000	37.822	5.403	37.822	Three generations study (chronic) oral diet at four doses (0, 0.75, 5, 35 mg/kg/day). The 35 mg/kg/day level was associated with reduced pup survival, and slightly lower mean litter size, and pup weight. No effects at other three doses. The 35 mg/kg/day was considered to be a chronic LOAEL and TRV based on derived LOAEL.	Ellis et al. (1979)
2,6-Dinitrotoluene	Mouse	35.000	5.000	37.822	5.403	37.822	TRV is based on 2,4 Dinitrobenzene	Ellis et al. (1979)
Endrin	Mouse	0.920	0.092	0.994	0.099	0.994	Chronic study (during a critical life stage). Significant reproductive effects including reduced litter size and parental survival was observed at dose 0.92 mg/kg/day. TRV based on derived chronic LOAEL.	LOAEL-Good and Ware (1969), cited in A
Ethylbenzene	Rat	29.100	9.710	58.117	19.392	58.117	Female rats receiving 408 mg/kg/day, 5 days per week for 6 months (subchronic study) by oral intubation (in olive oil) exhibited slight increases in liver and kidney weights. No adverse effects were seen at dose levels of 136 mg/kg/day. LOAEL and NOAEL value are converted to 291 mg/kg/day and 97.1 mg/kg/day by 7 days per week. Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Wolf et al. 1956, cited in IRIS
Fluoranthene	Mouse	25.000	12.500	27.016	13.508	27.016	Mice were administered 0, 125, 250, or 500 mg/kg/day of fluoranthene for 13 weeks (subchronic) by gavage. No significant or adverse effects were observed at 125 mg/kg/day. Mice exposed to 250 mg/kg/day showed significant increase in liver weights. The chronic LOAEL and NOAEL are derived from subchronic value by an uncertainty factor of 10 . TRV based on adjusted chronic LOAEL.	U.S. EPA, 1988
Heptachlor	Rat	1.500	0.250	2.996	0.499	2.996	No effects were observed in rats fed dietary doses of 0.25 mg/kg/day over 2 years. Increased mortality was observed in mice fed heptachlor/heptachlor epoxide for 2 years at dose levels 1.5 mg/kg/day. TRV based on adjusted LOAEL.	ATSDR, 1989
HMX	Mouse	7.500	3.000	8.105	3.242	8.105	Subchronic LOAELs range from 75 (male) to 250 (female) mg/kg/day . 75 mg/kg/day was the lowest subchronic LOAEL for mouse at 13 week (mortality endpoint). Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Talmage et al. (1999);
Indeno(1,2,3-cd)pyrene	Mouse	10.000	1.000	10.806	1.081	10.806	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C

Table A-2 TRVs for White-footed Mouse

COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
2-methylnaphthalene	Mouse	14.300	7.100	15.453	7.672	15.453	TRV based on Naphthalene	Battelle's Columbus Laboratories (1980), cited in IRIS
Naphthalene	Mouse	14.300	7.100	15.453	7.672	15.453	90 days gavage exposure (subchronic) study obtained a subchronic NOAEL of 71 mg/kg/day and LOAEL of 143 mg/kg/day. Chronic values were derived from subchronic value by an uncertainty factor of 10. TRV based on derived chronic LOAEL.	Battelle's Columbus Laboratories (1980), cited in IRIS
Phenanthrene	Mouse	10.000	1.000	10.806	1.081	10.806	Chronic oral exposure to rats for 2 years. A NOAEL of 3 mg/kg/day and a LOAEL of 10 mg/kg/day for histopathologic findings in the liver and kidneys of rats. TRV based on adjusted LOAEL.	Mackenzie and Angevine (1981), cited in C
Pyrene	Mouse	12.500	7.500	13.508	8.105	13.508	Mice were given suspensions of pyrene in corn oil at doses of 0, 75, 125, or 250 mg/kg/day for 13 weeks. Relative liver weights were increased in males exposed to 250 mg/kg/day and in females exposed to 125 mg/kg/day. The 125 mg/kg/day was considered to be a subchronic LOAEL. Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Toxicity Research Laboratories (1989), cited in RAIS, 1993
RDX	Mouse	13.800		14.913	0.000	14.913	Reduced birth weight for male rat during 13 weeks at dose of 13.8 mg/kg/day . It is the lowest chronic LOAEL of other reproductive studies. TRV based on adjusted LOAEL.	Cholakis et al. (1980); Talmage et al. (1999)
1,1,2,2-Tetrachloroethane	Rat	3.200		6.391		6.391	Chronic study (27 weeks), oral diets with adverse effect at 3.2 mg/kg/day, which was considered to be a chronic LOAEL. TRV is based on adjusted LOAEL.	Gohlke et al. (1977), cited in ATSDR, 1989
Tetryl	Rat	6.200		12.382	0.000	12.382	Only one dietary subchronic study was found. LOAEL was 62 mg/kg/day for rats at 13 week (several different effects endpoint). Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Reddy et al. (1994c), cited in Talmage et al. (1999)
Toluene	Mouse	260.000	26.000	280.962	28.096	280.962	Toluene exposure of 0.3, 0,5 and 1.0 mL/kg/d significantly reduced embryomortality level, the 0.5 and 1.0 mL/kg/d significantly reduced fetal weights. While the toluene exposures evaluated in this study were of short duration, they occurred during a critical lifestage. The 0.3 mL/kg/d(260 mg/kg/day) was considered to be a chronic LOAEL.	Sample et al. (1996)
1,1,1-Trichloroethane	Mouse		1000.000		1080.624	1080.624	Chronic study (two generation, > one year and during a critical lifestage) at three dose levels: 100, 300 and 1000 mg/kg/day. No effects observed at any dose level. TRV base on adjusted NOAEL.	Sample et al. (1996)
1,2,4-Trimethylbenzene	Rat	13.220		29.055		29.055	Rats exposed to 1,700 ppm (132.22 mg/kg/day) for four months caused diminished weight gain and increasing lymphopenia and neutrophillia. The 132.22 mg'kg/day was considered to be a subchronic LOAEL. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10. TRV is based on derived chronic LOAEL.	American Conference of Governmental Industrial Hygienists, 1979, cited in HSDB, 2001
1,3,5-Trinitrobenzene	White-footed Mouse	11.351	6.744	11.351	6.744	11.351	White-footed Mouse subchronic (13 weeks) study with testicular effects at LOAEL of 113.51 mg/kg/day. Other chronic testicular effect studies are with rats. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10.	Pathology Associates, Inc. (1994); Talmage et al. (1999)
2,4,6-Trinitrotoluene	Rat	*2.500*	0.500	4.993	0.999	4.993	Thirteen weeks study with testicular atrophy at 25 mg/kg/day, which is the lowest subchronic LOAEL of all other testicular atrophy studies. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10. TRV is based on derived chronic LOAEL.	Levine et al.(1984), Talmage et al.(1999)
Aluminum	Rat	19.300		38.545	0.000	38.545	Mice received 19.3 mg/kd/day aluminum in drinking water for three generations. While the number of litters and offspring per litter were not reduced, growth was significantly reduced among all offspring in the second and third generations. The 19.3 mg/kg/day was considered to be a LOAEL. TRV based on adjusted LOAEL.	Ondreicka et al. (1966), cited in B

Table A-2 TRVs for White-footed Mouse

COEC	Species	LOAEL mg/kg/day	NOAEL mg/kg/day	LOAEL mg/kg/day	NOAEL mg/kg/day	TRV mg/kg/day	Remarks	Reference
Antimony	Rat	1.250	0.125	2.496	0.250	2.496	Chronic study (lifetime), reduced median lifespan at dose level of 1.25 mg/kg.day, which was considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	Schroeder et. al (1968b), cited in A
Arsenic	Rabbit	1.580	0.396	5.728	1.436	5.728	Rabbits were exposed (by gavage) to 3 dose levels of arsenic acid and during gestational days 6-18. Reproductive and maternal effects were observed only at the highest dose level (1.58 mg/kg/day). This level is assumed as the chronic LOAEL. Rat TRV values are not used because rats matabolize arsenic differently than most mammal species (Eisler 1988)	Nemec et al. (1998), cited in C
Barium	Rat	19.800	0.510	39.544	1.019	39.544	Rat chronic (16 months) NOAEL = 0.51 mg/kg/day	Perry et al. (1983), cited in B; LOAEL-A
Beryllium	Rat		0.660		1.318	1.318	Life time chronic study (>1 year). No significant adverse effects observed at 0.66 mg/kg/day dose level.	Schroeder and Mitchner (1975), cited in B
Cadmium	Rat	10.000	1.000	19.972	1.997	19.972	Rats were exposed (by gavage) to 3 dose levels of CdCl2 for 6 weeks (through reproduction). Although no adverse effects were observed at the 1 mg/kg/day dose level, fetal implantations were reduced by 28%, fetal survivorship was reduced by 50% and fetal resorptions increased by 400% amongst the 10 mg/kg/day group. Because the study considered oral exposure during reproduction, the 1 mg/kg/day dose and 10 mg/kg/day were considered to be chronic NOAELs and LOAELs, respectively	Sutou et al. (1980), cited in C
Chromium	Rat		2737.000		5466.208	5466.208	Reproductive study for 90 days. No significant adverse effects were observed at 2737 mg/kg/day dose level	A, NOAEL based on Cr_2O_3
Cobalt	Rat	1.200		2.397		2.397	Rat gestation day 14 through lactation day 21 (oral gavage), decreased pup growth at dose level of 1.2 mg/kg/day. Since the study considered exposure during reproduction effect, this dose was considered to be a chronic LOAEL.	Domingo et al. (1985), cited in C
Copper	Mink	9.760	6.340	25.342	16.462	25.342	Mink were exposed to four levels of supplemental Cu in the diet for 1 year (through reproduction) Consumption of 25, 50, 100, and 200 ppm supplemental Cu increased the percentage mortality of mink kits. Kit survivorship among the 25ppm supplemental Cu group was actually greater than the controls. The 25ppm supplemental Cu (6.34 mg/kg/day) dose was considered to be a chronic NOAEL and the 50 ppm supplemental Cu dose (9.76 mg/kg/day) was considered to be a chronic LOAEL	Aulerich et al. (1982), cited in C
Lead	Rat	126.000	42.000	251.641	83.880	251.641	Rats were exposed to lead acetate in water from day 5 of gestation through parturition. Although pup mortality was not affected by Pb doses up to 126 mg/kg/day, 380 mg/kg/day significantly increases pup mortality. Birth weights of male pups were significantly reduced at both the 126 and 380 mg/kg/day doses while female birth weights were reduced only at the highest dose. Because exposure occurred during reproduction, the 42 mg/kg/day and 126 mg/kg/day doses can be considered to be chronic NOAEL and LOAEL.	Ronis et al. (1998), cited in C
Manganese	Rat	284.000	88.000	567.191	175.749	567.191	Rats were fed diets with three concentrations of Mn for 224 days. While the pregnancy percentage and fertility among rats consuming 3550 ppm Mn (284 mg/kg/day) in their diet was significantly reduced, all other reproductive parameters were not affected. No effects were observed at lower Mn exposure levels. Therefore the 1100 ppm Mn (88 mg/kg/day) and 3550 ppm Mn (284 mg/kg/day) dose was considered to be a chronic NOAEL and a chronic LOAEL, respectively.	Laskey et al. (1982), cited in C
Mercury	Rat	0.160	0.032	0.320	0.064	0.320	Rats were exposed to methyl mercury for 3 generations. While exposure to 2.5 ppm methyl mercury chloride (0.16 mg/kg/day Hg) reduced pup viability in the first generation, adverse effects were not observed at lower doses. Because significant effects were not observed at the 0.5 ppm methyl mercury chloride dose level, this was considered to be a chronic NOAEL and the 2.5ppm methyl mercury was considered to be a chronic LOAEL	Verschuuren et al. (1976), cited in C

Table A-2 TRVs for White-footed Mouse

COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Nickel	Rat		5.000		9.986	9.986	Rat fed for two years, 100 ppm in diet (5mg/kg/day), did not result in any reduction in body weight, therefore it was considered to be a chronic NOAEL.	Ambrose et. al (1976), cited in C
Niobium	Mouse	1.550	0.155	1.675	0.167	1.675	Chronic study (lifetime, > 1 year) exposed to a single dose (5ppm Nb in water and 1.62ppm Nb in food), median lifespan was reduced. Because the study considered exposure throughout the entire lifetime, this dose (1.55 mg/kg/day) was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)
Selenium	Rat	0.330	0.200	0.659	0.399	0.659	Rats were exposed to selenium in drinking water at three concentrations for 1 year and 2 generations. While no adverse effects on reproduction were observed among rats exposed to 1.5 mg Se/L in drinking water, the number of second-generation young was reduced by 50% among females in the 2.5mg/L group. In the 7.5 mg/L group, fertility, juvenile growth and survival were all reduced. Because the study considered exposure over multiple generations, the 1.5 (0.2 mg/kg/day) and 2.5 mg/L (0.33 mg/kg/day) doses were considered to be chronic NOAEL and LOAEL, respectively.	Rosenfeld and Beath (1954), cited in F
Silver	Mouse	0.375	0.038	0.405	0.041	0.405	Mouse subchronic (125 days) study, a LOAEL value of 3.75 mg/kg/day. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Rungdy and Mitchner (1971), cited in B
Thallium	Rat	0.074	0.007	0.148	0.015	0.148	Rats exposed to 10 ppm Tl in water (0.74 mg/kg/day) displayed reduced sperm motility and the study considered exposures only for 60 days, this dose was considered to be a subchronic LOAEL. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Formigli et al. (1986), cited in C
Vanadium	Rat	2.100	0.210	4.194	0.419	4.194	Chronic study (during a critical lifestage), exposed to three dose levels: 5, 10 and 20 mg NaVO3/kg/day (2.1 mg V/kg/day), significant difference in reproductive parameters were observed at all three dose levels. The lowest dose was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)
Zinc	Rat	320.000	160.000	639.089	319.544	639.089	Rats were exposed to two concentrations of Zn in the diet during gestational days 1 to 16. Rats exposed to 4000 ppm Zn in the diet displayed increased rates of fetal resorption and reduced fetal growth rates. No effects were observed at the 2000 ppm Zn dose rate (160 mg/kg/day) which was considered a chronic NOAEL. The 4000 ppm Zn dose (320 mg/kg/day) was considered to be a chronic LOAEL.	Schlicker and Cox (1968), cited in C

Notes:

A - Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Report No. ES/ER/TM-86/R3. Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

B- U.S. Environmental Protection Agency (USEPA), 2000. Ecological Soil Screening Level Guidance-Draft, Appendix E, Table E-7

C- CH2MHILL, 2000. Review of the Navy - EPA Region 9 BTAG Toxicity Reference Values for Wildlife, Prepared for U.S. Army Biological Technical Assistant Group (BTAG) and U.S. Army Corps of Engineers. March 2000

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Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Aldrin	Rat	1.000	0.200	2.198	0.440	2.198	Rats were fed for three generation,while the number of litters and offspring did not significantly reduced among rats receiving 0.2 mg/kg/day doses level, these parameters were reduced at the 1 mg/kg/day dose level. The study by Treon and Cleveland (1955) was considered to be more ecologically relevent. The TRV is based on adjusted LOAEL.	Treon and Cleveland (1955), cited in C
2-Amino-4,6-Dinitrotoluene	Rat	2.500	0.500	5.495	1.099	5.495	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	Levine et al.(1984), Talmage et al.(1999)
4-Amino-2,6-Dinitrotoluene	Rat	2.500	0.500	5.495	1.099	5.495	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	Levine et al.(1984), Talmage et al.(1999)
Anthracene	Mouse		100.000		118.921	118.921	Mice were treated by gavage once daily for 90 days with 0, 250, 500, or 1000 mg anthracene/kg/day, There were no compound-related effects. The 1000 mg/kg/day was considered to be a subchronic NOAEL. Chronic NOAEL is derived from subchronic value by an uncertainty factor of 10. TRV based on adjusted chronic NOAEL.	Schmahl (1955), Cited in U.S. EPA, 1989.
Arochlor 1260	White-footed Mouse	0.680	0.068	0.748	0.075	0.748	TRVs based onArochlor 1254	McCoy et al. (1995), cited in C
Arochlor 1254	White-footed Mouse	0.680	0.068	0.748	0.075	0.748	Reproduction study for 12 months (chronic). Arochlor 1254 at 5ppm (0.68 mg/kg/day) reduced litters number, offspring weights and survival. This dose is considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	McCoy et al. (1995), cited in C
Benzo(a)anthracene	Mouse	16.666	1.667	19.819	1.982	19.819	Mouse Single dose LOAEL = 16.666 mg/kg/day (gastrointestinal effects). TRV based on adjusted LOAEL.	Bock and King (1959), cited in B
Benzo(a)pyrene	Mouse	10.000	1.000	11.892	1.189	11.892	Mice were exposed (by gavage) to 3 dose levels of BaP during gestational days 7-16. BaP exposure of 160mg/kg/day significantly reduced pregnancy rates and percentage of viable litters. Pup weights were significantly reduced by all three dose levels. The 10 mg/kg/day dose was considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	Mackenzie and Angevine (1981), cited in C
Benzo(b)fluoranthene	Mouse	10.000	1.000	11.892	1.189	11.892	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C
Bis(2-ethylhexyl) Phthalate	Rat	183.000	18.300	402.203	40.220	402.203	Subchronic study (13 weeks), exposure of four dose levels: 2, 10, 50 and 250 ppm. No significant effects observed at 50ppm level while consumption of 250ppm in diet caused gonadl atrophy. The 250ppm(20 mg/kg/day) and 50ppm(4 mg/kg/day) were considered to be a subchronic LOAEL and NOAEL. Chronic LOAEL is derived from subchronic value. TRV based on adjusted chronic LOAEL.	Sample et al. (1996)
beta-BHC	Rat	2.000	0.400	4.396	0.799	4.396	TRV based on beta BHC	Sample et al. (1996)
delta-BHC	Rat	2.000	0.400	4.396	0.799	4.396	TRV based on beta BHC	Sample et al. (1996)
gamma-BHC	Rat	2.000	0.400	4.396	0.799	4.396	Exposure during critical lifestage (104 days), no adverse effects were observed among 0.01% bis(2-ethylhexyl)phthalate dose group, while 0.1 % dose had significant reproductive effects. The 0.1% (183.3 mg/kg/day) was considered to be a chronic LOAEL.	Sample et al. (1996)
Benzyl Butyl Phthalate	Rat	47.000	15.900	103.298	34.946	103.298	Twenty-six subchronic study in rat, the lowest subchronic LOAEL (470 mg/kg/day) and NOAEL (159 mg/kg/day) are proposed for use. Chronic LOAEL and NOAEL are derived from subchronic value by an uncertainty factor of 10. TRV based on chronic LOAEL.	NTP (1985), cited in IRIS
Carbazole							No data available in ATSDR or EPA database	
4,4'-DDD	Rat	4.000	0.800	8.791	1.758	8.791	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, chronic LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C
4,4'-DDE	Rat	4.000	0.800	8.791	1.758	8.791	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C

Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
4,4'-DDT	Rat	4.000	0.800	8.791	1.758	8.791	Oral in diet, 2 years, reproductive effect NOAEL = 0.8 mg/kg/day, LOAEL = 4 mg/kg/day. TRV based on adjusted LOAEL.	Fitzhugh et al. (1948), cited in C
Chlordane	Rat	8.000	0.180	17.583	0.396	17.583	No histopathological effects were observed in rats fed 0.18 mg/kg/day in a 2-year feeding study. 8.0 mg/kg-day dose was associated with altered endocrine function in mice exposed throughout their lifespan, which was considered to be a chronic LOAEL TRV based on adjusted LOAEL.	Khasawinah and Grutsch (1989), Cranmer et al. (1984)
Chrysene	Mouse	10.000	1.000	11.892	1.189	11.892	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C
Dibenzofuran	Mouse	10.000	1.000	11.892	1.189	11.892	TRV based on Phenanthrene	
1,4-Dichlorobenzene	Rat	43.000		94.507		94.507	Two generations study (chronic), exposed to three dose levels (66.3, 211, and 538 ppm) . For both generations of offspring in the 538 ppm group, weight,average litter size, and offspring survival were decreased. The 538 ppm (43 mg/kg/day) was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Tyl and Neeper-Bradley (1989), cited in RAIS
Dieldrin	White-footed Mouse	0.020	0.002	0.022	0.002	0.022	White-footed mice were fed diets treated with 0.02 mg/kg-day of dieldrin in corn oil. This dose caused behavioral changes, such as decreased predator avoidance behavior, in treated animals	Bildstein and Forsyth (1979)
1,3-Dinitrobenzene	Rat	0.173	0.035	0.380	0.077	0.380	Thirteen weeks study with rats found testicular degeneration effects at 1.73 mg/kg/day, which is the lowest of all subchronic testicular effect studies with rats. Chronic LOAEL was derived from subchronic value devided by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Reddy et al. (1995); Talmage et al. (1999)
2,4-Dinitrotoluene	Mouse	35.000	5.000	41.622	5.946	41.622	Three generations study (chronic) oral diet at four doses (0, 0.75, 5, 35 mg/kg/day). The 35 mg/kg/day level was associated with reduced pup survival, and slightly lower mean litter size, and pup weight. No effects at other three doses. The 35 mg/kg/day was considered to be a chronic LOAEL and TRV based on derived LOAEL.	Ellis et al. (1979)
2,6-Dinitrotoluene	Mouse	35.000	5.000	41.622	5.946	41.622	TRV is based on 2,4 Dinitrobenzene	Ellis et al. (1979)
Endrin	Mouse	0.920	0.092	1.094	0.109	1.094	Chronic study (during a critical life stage). Significant reproductive effects including reduced litter size and parental survival was observed at dose 0.92 mg/kg/day. TRV based on derived chronic LOAEL.	LOAEL-Good and Ware (1969), cited in A
Ethylbenzene	Rat	29.100	9.710	63.957	21.341	63.957	Female rats receiving 408 mg/kg/day, 5 days per week for 6 months (subchronic study) by oral intubation (in olive oil) exhibited slight increases in liver and kidney weights. No adverse effects were seen at dose levels of 136 mg/kg/day. LOAEL and NOAEL value are converted to 291 mg/kg/day and 97.1 mg/kg/day by 7 days per week. Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Wolf et al. 1956, cited in RAIS
Fluoranthene	Mouse	25.000	12.500	29.730	14.865	29.730	Mice were administered 0, 125, 250, or 500 mg/kg/day of fluoranthene for 13 weeks (subchronic) by gavage. No significant or adverse effects were observed at 125 mg/kg/day. Mice exposed to 250 mg/kg/day showed significant increase in liver weights. The chronic LOAEL and NOAEL are derived from subchronic value by an uncertainty factor of 10 . TRV based on adjusted chronic LOAEL.	U.S. EPA, 1988
Heptachlor	Rat	1.500	0.250	3.297	0.549	3.297	No effects were observed in rats fed dietary doses of 0.25 mg/kg/day over 2 years. Increased mortality was observed in mice fed heptachlor/heptachlor epoxide for 2 years at dose levels 1.5 mg/kg/day. TRV based on adjusted LOAEL.	ATSDR, 1989

Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
HMX	Mouse	7.500	3.000	8.919	3.568	8.919	Subchronic LOAELs range from 75 (male) to 250 (female) mg/kg/day . 75 mg/kg/day was the lowest subchronic LOAEL for mouse at 13 week (mortality endpoint). Chronic value is derived from subcronic value by an uncertainty factor o 10. TRV based on adjusted chronic LOAEL.	Talmage et al. (1999);
Indeno(1,2,3-cd)pyrene	Mouse	10.000	1.000	11.892	1.189	11.892	TRV based on Benzo(a)pyrene	Mackenzie and Angevine (1981), cited in C
2-methylnaphthalene	Mouse	14.300	7.100	17.006	8.443	17.006	TRV based on Naphthalene	Battelle's Columbus Laboratories (1980), cited in IRIS
Naphthalene	Mouse	14.300	7.100	17.006	8.443	17.006	90 days gavage exposure (subchronic) study obtained a subchronic NOAEL of 71 mg/kg/day and LOAEL of 143 mg/kg/day. Chronic values were derived from subchronic value by an uncertainty factor of 10. TRV based on derived chronic LOAEL.	Battelle's Columbus Laboratories (1980), cited in IRIS
Phenanthrene	Mouse	10.000	1.000	11.892	1.189	11.892	Chronic oral exposure to rats for 2 years. A NOAEL of 3 mg/kg/day and a LOAEL of 10 mg/kg/day for histopathologic findings in the liver and kidneys of rats. TRV based on adjusted LOAEL.	Mackenzie and Angevine (1981), cited in C
Pyrene	Mouse	12.500	7.500	14.865	8.919	14.865	Mice were given suspensions of pyrene in corn oil at doses of 0, 75, 125, or 250 mg/kg/day for 13 weeks. Relative liver weights were increased in males exposed to 250 mg/kg/day and in females exposed to 125 mg/kg/day. The 125 mg/kg/day was considered to be a subchronic LOAEL. Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Toxicity Research Laboratories (1989), cited in RAIS, 1993
RDX	Mouse	13.800	1.380	16.411	1.641	16.411	Reduced birth weight for male rat during 13 weeks at dose of 13.8 mg/kg/day . It is the lowest chronic LOAEL of other reproductive studies. TRV based on adjusted LOAEL.	Cholakis et al. (1980); Talmage et al. (1999)
1,1,2,2-Tetrachloroethane	Rat	3.200		7.033		7.033	Chronic study (27 weeks), oral diets with adverse effect at 3.2 mg/kg/day, which was considered to be a chronic LOAEL. TRV is based on adjusted LOAEL.	Gohlke et al. (1977), cited in ATSDR, 1989
Tetryl	Rat	6.200		13.627	0.000	13.627	Only one dietary subchronic study was found. LOAEL was 62 mg/kg/day for rats at 13 week (several different effects endpoint). Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Reddy et al. (1994C), cited in Talmage et al. (1999)
Toluene	Mouse	260.000	26.000	309.194	30.919	309.194	Toluene exposure of 0.3, 0,5 and 1.0 mL/kg/d significantly reduced embryomortality level, the 0.5 and 1.0 mL/kg/d significantly reduced fetal weights. While the toluene exposures evaluated in this study were of short duration, they occurred during a critical lifestage. The 0.3 mL/kg/d(260 mg/kg/day) was considered to be a chronic LOAEL.	Sample et al. (1996)
1,1,1-Trichloroethane	Mouse		1000.000		1189.207	1189.207	Chronic study (two generation, > one year and during a critical lifestage) at three dose levels: 100, 300 and 1000 mg/kg/day. No effects observed at any dose level. TRV base on adjusted NOAEL.	Sample et al. (1996)
1,2,4-Trimethylbenzene	Rat	13.220		29.055		29.055	Rats exposed to 1,700 ppm (132.22 mg/kg/day) for four months caused diminished weight gain and increasing lymphopenia and neutrophillia. The 132.22 mg'kg/day was considered to be a subchronic LOAEL. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10. TRV is based on derived chronic LOAEL.	American Conference of Governmental Industrial Hygienists, 1979, cited in HSDB, 2001

Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
1,3,5-Trinitrobenzene	White-footed Mouse	11.351	6.744	11.351	6.744	11.351	White-footed Mouse subchronic (13 weeks) study with testicular effects at LOAEL of 113.51 mg/kg/day. Other chronic testicular effect studies are with rats. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10.	Pathology Associates, Inc. (1994); Talmage et al. (1999)
2,4,6-Trinitrotoluene	Rat	*2.500*	0.500	5.495	1.099	5.495	Thirteen weeks study with testicular atrophy at 25 mg/kg/day, which is the lowest subchronic LOAEL of all other testicular atrophy studies. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10. TRV is based on derived chronic LOAEL.	Levine et al.(1984), Talmage et al.(1999)
Aluminum	Rat	19.300		42.418		42.418	Mice received 19.3 mg/kd/day aluminum in drinking water for three generations. While the number of litters and offspring per litter were not reduced, growth was significantly reduced among all offspring in the second and third generations. The 19.3 mg/kg/day was considered to be a LOAEL. TRV based on adjusted LOAEL.	Ondreicka et al. (1966), cited in B
Antimony	Rat	1.250	0.125	2.747	0.275	2.747	Chronic study (lifetime), reduced median lifespan at dose level of 1.25 mg/kg.day, which was considered to be a chronic LOAEL. TRV based on adjusted LOAEL.	Schroeder et. al (1968b), cited in A
Arsenic	Rabbit	1.580	0.396	6.303	1.580	6.303	Rabbits were exposed (by gavage) to 3 dose levels of arsenic acid and during gestational days 6-18. Reproductive and maternal effects were observed only at the highest dose level (1.58 mg/kg/day). This level is assumed as the chronic LOAEL. Rat TRV values are not used because rats matabolize arsenic differently than most mammal species (Eisler 1988)	Nemec et al. (1998), cited in C
Barium	Rat	19.800	0.510	43.517	1.121	43.517	Rat chronic (16 months) NOAEL = 0.51 mg/kg/day	Perry et al. (1983), cited in B; LOAEL-A
Beryllium	Rat		0.660		1.451	1.451	Life time chronic study (>1 year). No significant adverse effects observed at 0.66 mg/kg/day dose level.	Schroeder and Mitchner (1975), cited in B
Cadmium	Rat	10.000	1.000	21.978	2.198	21.978	Rats were exposed (by gavage) to 3 dose levels of CdCl2 for 6 weeks (through reproduction). Although no adverse effects were observed at the 1 mg/kg/day dose level, fetal implantations were reduced by 28%, fetal survivorship was reduced by 50% and fetal resorptions increased by 400% amongst the 10 mg/kg/day group. Because the study considered oral exposure during reproduction, the 1 mg/kg/day dose and 10 mg/kg/day were considered to be chronic NOAELs and LOAELs, respectively	Sutou et al. (1980), cited in C
Chromium	Rat		2737.000		6015.462	6015.462	Reproductive study for 90 days. No significant adverse effects were observed at 2737 mg/kg/day dose level	A, NOAEL based on Cr_2O_3
Cobalt	Rat		1.200		2.637	2.637	Rat gestation day 14 through lactation day 21 (oral gavage), decreased pup growth at dose level of 1.2 mg/kg/day. Since the study considered exposure during reproduction effect, this dose was considered to be a chronic LOAEL.	Domingo et al. (1985), cited in C
Copper	Mink	9.760	6.340	25.342	16.462	25.342	Mink were exposed to four levels of supplemental Cu in the diet for 1 year (through reproduction) Consumption of 25, 50, 100, and 200 ppm supplemental Cu increased the percentage mortality of mink kits. Kit survivorship among the 25ppm supplemental Cu group was actually greater than the controls. The 25ppm supplemental Cu (6.34 mg/kg/day) dose was considered to be a chronic NOAEL and the 50 ppm supplemental Cu dose (9.76 mg/kg/day) was considered to be a chronic LOAEL	Aulerich et al. (1982), cited in C

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Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Lead	Rat	126.000	42.000	276.927	92.309	276.927	Rats were exposed to lead acetate in water from day 5 of gestation through parturition. Although pup mortality was not affected by Pb doses up to 126 mg/kg/day, 380 mg/kg/day significantly increases pup mortality. Birth weights of male pups were significantly reduced at both the 126 and 380 mg/kg/day doses while female birth weights were reduced only at the highest dose. Because exposure occurred during reproduction, the 42 mg/kg/day and 126 mg/kg/day doses can be considered to be chronic NOAEL and LOAEL.	Ronis et al. (1998), cited in C
Manganese	Rat	284.000	88.000	624.184	193.409	624.184	Rats were fed diets with three concentrations of Mn for 224 days. While the pregnancy percentage and fertility among rats consuming 3550 ppm Mn (284 mg/kg/day) in their diet was significantly reduced, all other reproductive parameters were not affected. No effects were observed at lower Mn exposure levels. Therefore the 1100 ppm Mn (88 mg/kg/day) and 3550 ppm Mn (284 mg/kg/day) dose was considered to be a chronic NOAEL and a chronic LOAEL, respectively.	Laskey et al. (1982), cited in C
Mercury	Rat	0.160	0.032	0.352	0.070	0.352	Rats were exposed to methyl mercury for 3 generations. While exposure to 2.5 ppm methyl mercury chloride (0.16 mg/kg/day Hg) reduced pup viability in the first generation, adverse effects were not observed at lower doses. Because significant effects were not observed at the 0.5 ppm methyl mercury chloride dose level, this was considered to be a chronic NOAEL and the 2.5ppm methyl mercury was considered to be a chronic LOAEL	Verschuuren et al. (1976), cited in C
Nickel	Rat		5.000		10.989	10.989	Rat fed for two years, 100 ppm in diet (5mg/kg/day), did not result in any reduction in body weight, therefore it was considered to be a chronic NOAEL.	Ambrose et. al (1976), cited in C
Niobium	Mouse	1.550	0.155	1.843	0.184	1.843	Chronic study (lifetime, > 1 year) exposed to a single dose (5ppm Nb in water and 1.62ppm Nb in food), median lifespan was reduced. Because the study considered exposure throughout the entire lifetime, this dose (1.55 mg/kg/day) was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)
Selenium	Rat	0.330	0.200	0.725	0.440	0.725	Rats were exposed to selenium in drinking water at three concentrations for 1 year and 2 generations. While no adverse effects on reproduction were observed among rats exposed to 1.5 mg Se/L in drinking water, the number of second-generation young was reduced by 50% among females in the 2.5mg/L group. In the 7.5 mg/L group, fertility, juvenile growth and survival were all reduced. Because the study considered exposure over multiple generations, the 1.5 (0.2 mg/kg/day) and 2.5 mg/L (0.33 mg/kg/day) doses were considered to be chronic NOAEL and LOAEL, respectively.	Rosenfeld and Beath (1954), cited in F
Silver	Mouse	0.375	0.038	0.446	0.045	0.446	Mouse subchronic (125 days) study, a LOAEL value of 3.75 mg/kg/day. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Rungdy and Mitchner (1971), cited in B
Thallium	Rat	0.074	0.007	0.163	0.016	0.163	Rats exposed to 10 ppm Tl in water (0.74 mg/kg/day) displayed reduced sperm motility and the study considered exposures only for 60 days, this dose was considered to be a subchronic LOAEL. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Formigli et al. (1986), cited in C
Vanadium	Rat	2.100	0.210	4.615	0.462	4.615	Chronic study (during a critical lifestage), exposed to three dose levels: 5, 10 and 20 mg NaVO3/kg/day (2.1 mg V/kg/day), significant difference in reproductive parameters were observed at all three dose levels. The lowest dose was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)

Table A-3 TRVs for Short-tailed Shrew

	Test Animal			Short-tailed Shrew				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Zinc	Rat	320.000	160.000	703.306	351.653	703.306	Rats were exposed to two concentrations of Zn in the diet during gestational days 1 to 16. Rats exposed to 4000 ppm Zn in the diet displayed increased rates of fetal resorption and reduced fetal growth rates. No effects were observed at the 2000 ppm Zn dose rate (160 mg/kg/day) which was considered a chronic NOAEL. The 4000 ppm Zn dose (320 mg/kg/day) was considered to be a chronic LOAEL.	Schlicker and Cox (1968), cited in C

Notes:

A - Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Report No. ES/ER/TM-86/R3.
Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

B- U.S. Environmental Protection Agency (USEPA), 2000. Ecological Soil Screening Level Guidance-Draft, Appendix E, Table E-7

C- CH2MHILL, 2000. Review of the Navy - EPA Region 9 BTAG Toxicity Reference Values for Wildlife, Prepared for U.S. Army Biological Technical Assistant Group (BTAG)
and U.S. Army Corps of Engineers. March 2000

D - National Technical Information Service (NTIS), Department of Commence, 5285 Port Royal Rd. Springfield, VA 22161

Table A-4 TRVs for Belted Kingfisher

	Test Animal			Belted Kingfisher				
COEC	Test Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Bis(2-ethylhexyl) phthalate	Ring Dove		1.110		1.147	1.147	Ring dove subchronic (4 weeks) NOAEL = 1.11 mg/kg/day. Chronic NOAEL was derived from subchronic value by an uncertainty factor of 10.	Peakall (1974), cited in B
Dieldrin	Barn owl		0.077		0.105	0.105	Two years(chronic) reproduction study. Exposure of one dose level: 0.58 ppm (0.077 mg/kg/day) reduced eggshell thickness slightly but had no other adverse effects. Therefore, this dose is considered to be a chronic NOAEL. TRV is based on derived NOAEL.	Sample et al. (1996)
Arsenic	Mallard	40.300	9.300	66.362	15.314	66.362	Study covered 4 weeks prior to breeding, through reproduction, to 14 days post hatch. As at 40.3 mg/kg/day significantly reduced duckling production. Because the study considered exposure over 10 weeks and through reproduction, it was considered to be a chronic LOAEL	Stanley et al. (1994), cited in C
Aluminum	Ringed Turtle Dove		110.000		113.656	113.656	Ringed Turtle Dove chronic (4 months) NOAEL (reproduction) = 110 mg/kg/day	Carriere et al. (1986), cited in B
Barium	one day old chick	4.170		4.050	0.000	4.050	One day old chick subchronic (4 weeks) LOAEL = 41.7 mg/kg/day at endpoint of mortality. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10.	Johnson et al. (1960), cited in B
Beryllium							Insufficient information on bird ecotoxicity	
Cadmium	mallard	20.000	1.450	32.934	2.388	32.934	Mallards were exposed to 3 dose levels of CdCl2 in their diet for 6 weeks (through reproduction). Birds in the 210ppm (20 mg/kg/day) group produced significantly fewer eggs than those in the other groups. The 15.2 ppm (1.45 mg/kg/day) Cd dose was considered to be a chronic NOAEL and the 210 ppm dose was considered to be a chronic LOAEL	White and Finley (1978), cited in C
Total Chromium	Black duck	5.000	1.000	8.706	1.741	8.706	Adult black ducks fed a diet containing 0, 10, or 50 ppm chromium (III) for ten months. While no significant effect was observed among 10ppm (1mg/kg/day) dose level, duckling survival was reduced at 50ppm (5 mg/kg/day) dose level.The 5 mg/kg/day was considered to be a chronic LOAEL. TRV is based on derived LOAEL.	Sample et al. (1996)
Cobalt							Insufficient data to derive TRV	
Copper	Chick		0.230		0.419	0.419	Chicken were fed for 8 weeks and weight gain at dose level 2.3 mg/kg/daywas observed, which is considered to be a subchronic NOAEL. Chronic NOAEL was derived from subchronic value by an uncertainty factor of 10.	Norvell et al.(1975), cited in C
Lead	Japanese quail	1.780	0.190	1.824	0.195	1.824	Japanese quail were fed diets with three concentrations of lead acetate during reproduction for 5 weeks. Egg production was significantly reduced among birds consuming the 10 ppm Pb (1.78 mg/kg/day) and 100 ppm Pb (15.65 mg/kg/day) doses, but not affected by the 1 ppm Pb (0.19 mg/kg/day) dose. Because the study considered reproduction exposure, 1.78 mg/kg/day and 0.19 mg/kg/day were considered to be chronic LOAEL and NOAEL, respectively	Edens and Garlich (1983), cited in C
Manganese	Japanese quail		766.000		784.995	784.995	Japanese quails were fed diets with one concentration of Mn for 75 days. At dose of 776 mg/kg/day, significant decrease in the increase in locomotor behavior with age and aggressive behavio were observed. However, these are not significant adverse effects. The 776 mg/kg/day doser was considered to be a chronic NOAEL.	Laskey and Edens (1985), cited in C
Mercury	mallard	0.370	0.068	0.609	0.112	0.609	TRVs are based on two studies with similar methods in which mallards were fed diets containing methyl-mercury for 2.5 months for 2 generations. No significant effe was observed at the 0.068 mg/kg/day dose. Because exposure occurred during reproduction, the 0.37 mg/kg/day dose was considered to be a chronic LOAEL	Heinz (1976), Heinz abd Hoffman (1998), cited in C

Table A-4 TRVs for Belted Kingfisher

	Test Animal			Belted Kingfisher				
COEC	Test Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Nickel	Mallard	77.400	17.600	127.455	28.982	127.455	Mallard ducklings were fed diets containing nickel sulfate for over 90 days. While consumption of up to 774 ppm Ni (77.4 mg/kg/day) in diet resulted in a significant increase in tremors and joint edema, 176 ppm (17.6 mg/kg/day) did not. Because the study considered exposure over 90 days, the 176 ppm and 774 ppm dose were considered to be chronic NOAEL and LOAEL, respectively.	Cain and Pafford (1981), cited in C
Selenium	mallard	0.800	0.400	1.317	0.659	1.317	Mallards were fed diets containing 5 concentrations of selenomethionine. Consumption of 8 or 16 ppm Se in the diet as selenomethionine resulted in a reduced duckling survival as compared to the 1,2,4 ppm Se exposures. 4ppm (0.4 mg/kg/day) was considered to be a chronic NOAEL and 0.8 Se mg/kg/day was considered to be a chronic LOAEL.	Heinz et al. (1989), cited in C
Silver	one day old chick	48.000		46.618		46.618	Significantly decreased body weight at a dose of 48 mg/kg/day $AgNO_3$. The lowest LOAEL in literature.	Peterson and Jensen 1975a
Thallium							insufficient toxicological data available to derive TRV	
Vanadium	mallard		11.400		18.772	18.772	Twelve weeks oral diet (chronic) study at three dose levels (2.84, 10.36 and 110ppm), no effects observed at all three doses. The 110ppm(11.4 mg/kg/day) was considered to be a chronic NOAEL. TRV based on derived NOAEL.	Sample et al. (1996)
Zinc	chicken	131.000	14.500	238.731	26.424	238.731	Chickens were fed diets containing four levels of Zn for 44 weeks. While no effects were observed among hens consuming 48 and 228 ppm Zn, egg hatchability was less than 20% of controls among hens consuming 2028 ppm Zn. The 2028 ppm(131 mg/kg/day) and the 228 ppm (14.5 mg/kg/day) were considered to be chronic LOAEL and NOAEL, respectively	Stahl et al. (1990), cited in C

Notes:

A - Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Report No. ES/ER/TM-86/R3.
Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

B- U.S. Environmental Protection Agency (USEPA), 2000. Ecological Soil Screening Level Guidance-Draft, Appendix E, Table E-7

C- CH2MHILL, 2000. Review of the Navy - EPA Region 9 BTAG Toxicity Reference Values for Wildlife, Prepared for U.S. Army Biological Technical Assistant Group (BTAG)
Prepared for U.S. Army Biological Technical Assisstant Group (BTAG)

D - Environmental Restoration Division, Savanna River Site, Terrestrial Toxicity Refenence Values (TRVs), ERD-AG-003, 04/06/99

Table A-5 TRVs for Indiana Bat

COEC	Test Animal Species	Test Animal LOAEL mg/kg/day	Test Animal NOAEL mg/kg/day	Indiana Bat LOAEL mg/kg/day	Indiana Bat NOAEL mg/kg/day	Indiana Bat TRV mg/kg/day	Remarks	Reference
1,3,5 - Trinitrobenzene	White-footed Mouse	11.35	6.74	15.01	8.92	15.01	White-footed Mouse subchronic (13 weeks) study with testicular effects at LOAEL of 113.51 mg/kg/day. Other chronic testicular effect studies are with rats. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10.	Pathology Associates, Inc. (1994); Talmage et al. (1999)
2,4,6-Trinitrotoluene	Rat	2.50	0.50	6.60	1.32	6.60	Thirteen weeks study with testicular atrophy at 25 mg/kg/day, which is the lowest subchronic LOAEL of all other testicular atrophy studies. Chronic LOAEL was derived from subchronic value by an uncertainty factor of 10. TRV is based on derived chronic LOAEL.	Levine et al.(1984), Talmage et al. (1999)
2,4-Dinitrotoluene	Mouse	35.00	5.00	50.01	7.14	50.01	Three generations study (chronic) oral diet at four doses (0, 0.75, 5, 35 mg/kg/day). The 35 mg/kg/day level was associated with reduced pup survival, and slightly lower mean litter size, and pup weight. No effects at other three doses. The 35 mg/kg/day was considered to be a chronic LOAEL and TRV based on derived LOAEL.	Ellis et al. (1979)
2-Amino-4,6-Dinitrotoluene	Rat	2.50	0.50	6.60	1.32	6.60	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	Pennington (1988 a, b)
4-Amino-2,6-Dinitrotoluene	Rat	2.50	0.50	6.60	1.32	6.60	TRVs for 2-Amino-4,6-Dinitrotoluene are not available in the literature. TRVs of TNT are used	
HMX	Mouse	7.50	3.00	10.72	4.29	10.72	Subchronic LOAELs range from 75 (male) to 250 (female) mg/kg/day . 75 mg/kg/day was the lowest subchronic LOAEL for mouse at 13 week (mortality endpoint). Chronic value is derived from subcronic value by an uncertainty factor of 10. TRV based on adjusted chronic LOAEL.	Talmage et al. (1999)
RDX	Mouse	13.80		19.72		19.72	Reduced birth weight for male rat during 13 weeks at dose of 13.8 mg/kg/day . It is the lowest chronic LOAEL of other reproductive studies. TRV based on adjusted LOAEL.	Cholakis et al. (1980); Talmage et al. (1999)
Aluminum	Rat	19.30		50.96		50.96	Mice received 19.3 mg/kd/day aluminum in drinking water for three generations. While the number of litters and offspring per litter were not reduced, growth was significantly reduced among all offspring in the second and third generations. The 19.3 mg/kg/day was considered to be a LOAEL. TRV based on adjusted LOAEL.	Ondreicka et al. (1966), cited in B
Arsenic	Mouse	1.26	0.13	1.80	0.18	1.80	Three generations (chronic) study, oral in water at one dose level (1.261 mg/kg/day) reduced litter sizes with each successive generation. This dose is considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)
Barium	Rat	19.80	0.51	52.28	1.35	52.28	Rat chronic (16 months) NOAEL = 0.51 mg/kg/day	Perry et al. (1983), cited in B; LOAEL-A
Beryllium	Rat		0.66		1.74	1.74	Life time chronic study (>1 year). No significant adverse effects observed at 0.66 mg/kg/day dose level.	Schroeder and Mitchner (1975), cited in B
Bis(2-ethylhexyl) phthalate	Rat	183.00	18.30	483.21	48.32	483.21	Exposure during critical lifestage (104 days), no adverse effects were observed among 0.01% bis(2-ethylhexyl)phthalate dose group, while 0.1 % dose had significant reproductive effects. The 0.1% (183.3 mg/kg/day) was considered to be a chronic LOAEL.	Sample et al. (1996)
Cadmium	Rat	10.00	1.00	26.40	2.64	26.40	Rats were exposed (by gavage) to 3 dose levels of CdCl2 for 6 weeks (through reproduction). Although no adverse effects were observed at the 1 mg/kg/day dose level, fetal implantations were reduced by 28%, fetal survivorship was reduced by 50% and fetal resorptions increased by 400% amongst the 10 mg/kg/day group. Because the study considered oral exposure during reproduction, the 1 mg/kg/day dose and 10 mg/kg/day were considered to be chronic NOAELs and LOAELs, respectively	Sutou et al. (1980), cited in C
Total Chromium	Rat		2737.00		7227.01	7227.01	Reproductive study for 90 days. No significant adverse effects were observed at 2737 mg/kg/day dose level	D, NOAEL based on Cr_2O_3
Cobalt	Rat	1.20		3.17		3.17	Rat gestation day 14 through lactation day 21 (oral gavage), decreased pup growth at dose level of 1.2 mg/kg/day. Since the study considered exposure during reproduction effect, this dose was considered to be a chronic LOAEL.	Domingo et al. (1985), cited in C

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Table A-5 TRVs for Indiana Bat

	Test Animal			Indiana Bat				
COEC	Species	LOAEL	NOAEL	LOAEL	NOAEL	TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		
Copper	Mink	9.76	6.34	33.51	21.76	33.51	Mink were exposed to four levels of supplemental Cu in the diet for 1 year (through reproduction) Consumption of 25, 50, 100, and 200 ppm supplemental Cu increased the percentage mortality of mink kits. Kit survivorship among the 25ppm supplemental Cu group was actually greater than the controls. The 25ppm supplemental Cu (6.34 mg/kg/day) dose was considered to be a chronic NOAEL and the 50 ppm supplemental Cu dose (9.76 mg/kg/day) was considered to be a chronic LOAEL	Aulerich et al. (1982), cited in C
Lead	Rat	126.00	42.00	332.70	110.90	332.70	Rats were exposed to lead acetate in water from day 5 of gestation through parturition. Although pup mortality was not affected by Pb doses up to 126 mg/kg/day, 380 mg/kg/day significantly increases pup mortality. Birth weights of male pups were significantly reduced at both the 126 and 380 mg/kg/day doses while female birth weights were reduced only at the highest dose. Because exposure occurred during reproduction, the 42 mg/kg/day and 126 mg/kg/day doses can be considered to be chronic NOAEL and LOAEL.	Ronis et al. (1998), cited in C
Manganese	Rat	284.00	88.00	749.90	232.36	749.90	Rats were fed diets with three concentrations of Mn for 224 days. While the pregnancy percentage and fertility among rats consuming 3550 ppm Mn (284 mg/kg/day) in their diet was significantly reduced, all other reproductive parameters were not affected. No effects were observed at lower Mn exposure levels. Therefore the 1100 ppm Mn (88 mg/kg/day) and 3550 ppm Mn (284 mg/kg/day) dose was considered to be a chronic NOAEL and a chronic LOAEL, respectively.	Laskey et al. (1982), cited in C
Mercury	Rat	0.16	0.03	0.42	0.08	0.42	Rats were exposed to methyl mercury for 3 generations. While exposure to 2.5 ppm methyl mercury chloride (0.16 mg/kg/day Hg) reduced pup viability in the first generation, adverse effects were not observed at lower doses. Because significant effects were not observed at the 0.5 ppm methyl mercury chloride dose level, this was considered to be a chronic NOAEL and the 2.5ppm methyl mercury was considered to be a chronic LOAEL	Verschuuren et al. (1976), cited in C
Nickel	Rat	159.80	5.00	421.95	13.20	421.95	Rat fed for two years, 100 ppm in diet (5mg/kg/day), did not result in any reduction in body weight, therefore it was considered to be a chronic NOAEL.	Ambrose et. al (1976), cited in C; LOAEL - A
Selenium	Rat	0.33	0.20	0.87	0.53	0.87	Rats were exposed to selenium in drinking water at three concentrations for 1 year and 2 generations. While no adverse effects on reproduction were observed among rats exposed to 1.5 mg Se/L in drinking water, the number of second-generation young was reduced by 50% among females in the 2.5mg/L group. In the 7.5 mg/L group, fertility, juvenile growth and survival were all reduced. Because the study considered exposure over multiple generations, the 1.5 (0.2 mg/kg/day) and 2.5 mg/L (0.33 mg/kg/day) doses were considered to be chronic NOAEL and LOAEL, respectively.	Rosenfeld and Beath (1954), cited in C
Silver	Mouse	0.38	0.04	0.54	0.05	0.54	Mouse subchronic (125 days) study, a LOAEL value of 3.75 mg/kg/day. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Rungdy and Mitchner (1971), cited in B
Thallium	Rat	0.07	0.01	0.20	0.02	0.20	Rats exposed to 10 ppm Tl in water (0.74 mg/kg/day) displayed reduced sperm motility and the study considered exposures only for 60 days, this dose was considered to be a subchronic LOAEL. Chronic LOAEL was derived from subchronic LOAEL by an uncertainty factor of 10.	Formigli et al. (1986), cited in C
Vanadium	Rat	2.10	0.21	5.55	0.55	5.55	Chronic study (during a critical lifestage), exposed to three dose levels: 5, 10 and 20 mg NaVO3/kg/day (2.1 mg V/kg/day), significant difference in reproductive parameters were observed at all three dose levels. The lowest dose was considered to be a chronic LOAEL. TRV based on derived LOAEL.	Sample et al. (1996)
Zinc	Rat	320.00	160.00	844.96	422.48	844.96	Rats were exposed to two concentrations of Zn in the diet during gestational days 1 to 16. Rats exposed to 4000 ppm Zn in the diet displayed increased rates of fetal resorption and reduced fetal growth rates. No effects were observed at the 2000 ppm Zn dose rate (160 mg/kg/day) which was considered a chronic NOAEL. The 4000 ppm Zn dose (320 mg/kg/day) was considered to be a chronic LOAEL.	Schlicker and Cox (1968), cited in C

Notes:

A - Sample, B.E., D.M. Opresko, G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Report No. ES/ER/TM-86/R3.

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COEC	Test Animal Species	Test Animal LOAEL	Test Animal NOAEL	Indiana Bat LOAEL	Indiana Bat NOAEL	Indiana Bat TRV	Remarks	Reference
		mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day	mg/kg/day		

Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

B- U.S. Environmental Protection Agency (USEPA), 2000. Ecological Soil Screening Level Guidance-Draft, Appendix E, Table E-7

C- CH2MHILL, 2000. Review of the Navy - EPA Region 9 BTAG Toxicity Reference Values for Wildlife, Prepared for U.S. Army Biological Technical Assistant Group (BTAG)

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APPENDIX A-REFERENCE

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APPENDIX B

PHYSICAL/CHEMICAL COEFFICIENT VALUES

Table B-1. Physical/Chemical Coefficients of COPEC for Belted Kingfisher

Belt Kingfisher			
COPEC	LogKow [a]	$BSAF_{fish}$ [b]	BAF_{fish} [c]
Sediment			
Bis(2-ethylhexyl) phthalate	7.3	1.7	
Surface water			
Bis(2-ethylhexyl) phthalate	7.3		70.00
Arsenic			114.00
Aluminum			2.70
Barium			633.00
Beryllium			62.00
Cadmium			907.00
Total Chromium			19.00
Cobalt [d]			300.00
Copper			710.00
Lead			0.09
Manganese [d]			400.00
Nickel			78.00
Selenium			129.00
Silver			87.71
Thallium			10000.00
Vanadium [d]			0.01
Zinc			2059.00

Notes:

[a] Soil Screening Guidance: Technical Background Document -USEPA and Office of Solid Waste and Emergency Response EPA/540/R-95/128 (May 1996) or Basics of Pump and Treat Groudnwater Remediation Technology,USEPA and Robert S. Kerr Environmental Research Laboratory.EPA/600/8-90/003 March 1990

[b] Konemann and van Leeuwen (1980) and Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke (1987)

[c] U.S. EPA (1999) Region 6 *Screening Level Ecological Risk Assessment Protocol Appendix C: Media-To-Receptor BCF Values*

[d] HAZWRAP (1994). *Loring Air Force Base Ecological Risk Methodology. Martin Marietta Energy Systems, Inc. Draft*

Table B-2. Physical/Chemical Coefficients of COPEC for Indiana Bat

Indiana Bat				
COPEC	Log Kow [a]	$BSAF_{Invert}$ [b,c]	$BCF_{aqu\text{-}invert}$ [c]	$BAF_{aqu\text{-}invert}$
Sediment				
1,3,5-Trinitrobenzene	1.36	1.70		
2,4,6-Trinitrotoluene	2.03	1.70		
2,4-Dinitrotoluene	2.01	1.70		
2-Amino-4,6-Dinitrotoluene	1.94	1.70		
4-Amino-2,6-Dinitrotoluene	1.94	1.70		
HMX	0.15	1.70		
RDX	0.85	1.70		
Bis(2-ethylhexyl) phthalate	7.3	1.70		
Mercury		0.48		
Surface water				
2-Amino-4,6-Dinitrotoluene	1.94		17.55	17.55
4-Amino-2,6-Dinitrotoluene	1.94		17.55	17.55
Bis(2-ethylhexyl) phthalate	7.3		318.00	318.00
Aluminum			4066.00	4066.00
Arsenic			73.00	73.00
Barium			200.00	200.00
Beryllium			45.00	45.00
Cadmium			3461.00	3461.00
Total Chromium			3000.00	3000.00
Cobalt [d]			1.00	1.00
Copper			3718.00	3718.00
Lead			5059.00	5059.00
Manganese [d]			0.02	0.02
Mercury			55000.00	55000.00
Nickel			28.00	28.00
Selenium			1262.00	1262.00
Silver			298.00	298.00
Thallium			15000.00	15000.00
Vanadium [d]			0.13	0.13
Zinc			4578.00	4578.00

Notes:

[a] *Soil Screening Guidance: Technical Background Document -USEPA and Office of Solid Waste and Emergency Response EPA/540/R-95/128 (May 1996) or Basics of Pump and Treat Groudnwater Remediation Technology,USEPA and Robert S. Kerr Environmental Research Laboratory.EPA/600/8-90/003 March 1990*

[b] Konemann and van Leeuwen (1980) and Leeuwen, 1980, Karickhoff, 1981, cited in McFarland and Clarke (1987)

[c] U.S EPA (1999) Region 6 *Screening Level Ecological Risk Assessment Protocol Appendix C: Media-To-Receptor BCF Values*

[d] HAZWRAP (1994). *Loring Air Force Base Ecological Risk Methodology. Martin Marietta Energy Systems, Inc. Draft*

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Table B-3. Physical/Chemical Coefficients of COPEC for White-footed Mouse

White-footed Mouse				
COPEC	Log Kow [a]	BCF_{ti} [b]	$BAF_{soil\text{-}invert}$	$U_{s\text{-}v}$ [c]
Aldrin	6.5	5.546	5.546	0.007
2-Amino-4,6-Dinitrotoluene	1.94	5.221	5.221	2.929
4-Amino-2,6-Dinitrotoluene [1]	1.94	5.221	5.221	2.929
Anthracene	4.55	5.448	5.448	0.091
Arochlor 1260	6.91	5.563	5.563	0.004
Arochlor 1254	6.5	5.546	5.546	0.007
Benzo(a)anthracene	5.7	5.510	5.510	0.020
Benzo(a)pyrene	6.11	5.529	5.529	0.011
Benzo(b) fluoranthene	6.2	5.533	5.533	0.010
Beta BHC	3.81	5.400	5.400	0.243
Delta BHC	4.14	5.422	5.422	0.157
Bis(2-ethylhexyl)phthalate	7.3	5.578	5.578	0.002
Butyl-benzylphthalate	4.84	5.465	5.465	0.062
Carbazole	3.59	5.384	5.384	0.326
4,4' DDD	4.92	5.469	5.469	0.055
4,4' DDE	5.69	5.509	5.509	0.020
4,4' DDT	5.73	5.511	5.511	0.019
Chlordane	6	5.524	5.524	0.013
Chrysene	5.7	5.510	5.510	0.020
Dibenzofuran	4.12	5.421	5.421	0.161
1,4-Dichlorobenzene	3.42	5.371	5.371	0.409
Dieldrin	5.37	5.493	5.493	0.030
1,3 Dinitrobenzene	1.62	5.174	5.174	4.483
2,4 Dinitrotoluene	2.01	5.230	5.230	2.668
2,6 Dinitrotoluene	1.87	5.211	5.211	3.215
Endrin	5.06	5.477	5.477	0.046
Ethylbenzene	3.14	5.348	5.348	0.593
Fluoranthene	5.12	5.480	5.480	0.043
Heptachlor	6.26	5.536	5.536	0.009
HMX	0.15	4.593	4.593	31.718
Indeno(1,2,3) perylene	6.65	5.552	5.552	0.006
Methylene Chloride	1.25	5.107	5.107	7.337
2-methyl naphthalene	4.11	5.420	5.420	0.163
Naphthalene	3.36	5.366	5.366	0.443
Phenanthrene	4.46	5.443	5.443	0.102
Pyrene	5.11	5.480	5.480	0.043
RDX	0.85	5.010	5.010	12.494

Table B-3. Physical/Chemical Coefficients of COPEC for White-footed Mouse

White-footed Mouse				
COPEC	Log Kow [a]	BCF_{ti} [b]	$BAF_{soil-Invert}$	U_{s-v} [c]
1,1,2,2-Tetrachloroethane	2.39	5.275	5.275	1.609
Tetryl	1.65	5.179	5.179	4.308
Toluene	2.75	5.313	5.313	0.997
1,1,1-Trichloroethane	2.48	5.285	5.285	1.427
1,2,4-Trimethylbenzene [2]	3.78	5.398	5.398	0.253
1,3,5-Trinitrobenzene	1.36	5.129	5.129	6.338
2,4,6-Trinitrotoluene	2.03	5.233	5.233	2.598
Aluminum		0.220	0.220	0.004
Antimony		0.220	0.220	0.200
Arsenic		0.110	0.110	0.036
Barium		0.220	0.220	0.150
Beryllium		0.220	0.220	0.010
Cadmium		0.960	0.960	0.364
Chromium		0.010	0.010	0.008
Cobalt		0.065	0.065	0.052
Copper		0.040	0.040	0.400
Lead		0.030	0.030	0.045
Manganese		0.160	0.160	0.290
Mercury *		8.500	8.500	0.137
Nickel		0.020	0.020	0.032
Niobium		NA	NA	NA
Selenium		0.220	0.220	0.016
Silver		0.220	0.220	0.400
Thallium		0.220	0.220	0.004
Vanadium		0.030	0.030	0.063
Zinc		0.560	0.560	0.000

Notes:

* BCF of methyl mercury is used.

[1] using LogKow value of 2-Amino-4,6-Dinitrotoluene

[2] LogKow reference: *Chemical Summary for 1,2,4-trimethylbenzene Prepared by office of Pullution and Toxic U.S. EPA, August 1994 EPA 749-F-94-022a*

[a] Soil Screening Guidance: Technical Background Document -USEPA and Office of Solid Waste and Emergency Response EPA/540/R-95/128 (May 1996) or Basics of Pump and Treat Groudnwater Remediation Technology,USEPA and Robert S. Kerr Environmental Research Laboratory.EPA/600/8-90/003 Mar 1990

[b] Inorganic data: U.S. EPA 1999. Region 6. *Screening Level Ecological Risk Assessment Protocol Appendix C: Media-To-Receptor BCF Values*
Organic data calculated by the equation: BCFti = (Y1*LogKow^(b-a))/(x*foc)

[c] Inorganic data from *U.S. EPA 1999. Region 6. Screening Level Ecological Risk Assessment Protocol Appendix C: Media-To-Receptor BCF Values*
Organic data calculated by the equation: LogUs-v = 1.588 - 0.578logKow

Table B-4. Physical/Chemical Coefficients of COPEC for Short-tailed Shrew

Short-tailed Shrew			
COPEC	LogKow [a]	BCF_{ti} [b]	$BAF_{soil-invert}$
Aldrin	6.5	5.546	5.546
2-Amino-4,6-Dinitrotoluene	1.94	5.221	5.221
4-Amino-2,6-Dinitrotoluene [1]	1.94	5.221	5.221
Anthracene	4.55	5.448	5.448
Arochlor 1260	6.91	5.563	5.563
Arochlor 1254	6.5	5.546	5.546
Benzo(a)anthracene	5.7	5.510	5.510
Benzo(a)pyrene	6.11	5.529	5.529
Benzo(b) fluoranthene	6.2	5.533	5.533
Beta BHC	3.81	5.400	5.400
Delta BHC	4.14	5.422	5.422
Bis(2-ethylhexyl)phthalate	7.3	5.578	5.578
Butyl-benzylphthalate	4.84	5.465	5.465
Carbazole	3.59	5.384	5.384
4,4' DDD	4.92	5.469	5.469
4,4' DDE	5.69	5.509	5.509
4,4' DDT	5.73	5.511	5.511
Chlordane	6	5.524	5.524
Chrysene	5.7	5.510	5.510
Dibenzofuran	4.12	5.421	5.421
1,4-Dichlorobenzene	3.42	5.371	5.371
Dieldrin	5.37	5.493	5.493
1,3-Dinitrobenzene	1.62	5.174	5.174
2,4-Dinitrotoluene	2.01	5.230	5.230
2,6-Dinitrotoluene	1.87	5.211	5.211
Endrin	5.06	5.477	5.477
Ethylbenzene	3.14	5.348	5.348
Fluoranthene	5.12	5.480	5.480
Heptachlor	6.26	5.536	5.536
HMX	0.15	4.593	4.593
Indeno(1,2,3) perylene	6.65	5.552	5.552
Methylene Chloride	1.25	5.107	5.107
2-methyl naphthalene	4.11	5.420	5.420
Naphthalene	3.36	5.366	5.366
Phenanthrene	4.46	5.443	5.443
Pyrene	5.11	5.480	5.480

Table B-4. Physical/Chemical Coefficients of COPEC for Short-tailed Shrew

Short-tailed Shrew			
COPEC	LogKow [a]	BCF_{ti} [b]	$BAF_{soil-invert}$
RDX	0.85	5.010	5.010
1,1,2,2-Tetrachloroethene	2.39	5.275	5.275
Tetryl	1.65	5.179	5.179
Toluene	2.75	5.313	5.313
1,1,1-Trichloroethane	2.48	5.285	5.285
1,2,4-Trimethylbenzene [2]	3.78	5.398	5.398
1,3,5-Trinitrobenzene	1.36	5.129	5.129
2,4,6-Trinitrotoluene	2.03	5.233	5.233
Aluminum		0.220	0.220
Antimony		0.220	0.220
Arsenic		0.110	0.110
Barium		0.220	0.220
Beryllium		0.220	0.220
Cadmium		0.960	0.960
Chromium		0.010	0.010
Cobalt		0.065	0.065
Copper		0.040	0.040
Lead		0.030	0.030
Manganese		0.160	0.160
Mercury *		8.500	8.500
Nickel		0.020	0.020
Niobium		NA	NA
Selenium		0.220	0.220
Silver		0.220	0.220
Thallium		0.220	0.220
Vanadium		0.030	0.030
Zinc		0.560	0.560

Notes:

* BCF of methyl mercury is used.

[1] using LogKow value of 2-Amino-4,6-Dinitrotoluene

[2] LogKow reference: *Chemical Summary for 1,2,4-trimethylbenzene Prepared by office of Pullution and Toxic U.S. EPA, August 1994 EPA 749-F-94-022a*

[a] Soil Screening Guidance: Technical Background Document -USEPA and Office of Solid Waste and Emergency Response EPA/540/R-95/128 (May 1996) or Basics of Pump and Treat Groudnwater Remediation Technology,USEPA and Robert S. Kerr Environmental Research Laboratory.EPA/600/8-90/003 March 1990

[b] Inorganic data: *Screening Level Ecological Risk Assessment Protocol Appendix C: Media-To-Receptor BCF Values*

Organic data calculated by the equation: BCFti = (Y1*LogKow^(b-a))/(x*foc)

RESPONSES TO USEPA COMMENTS ON THE DEVELOPMENT OF DOSE ESTIMATION MODELS AND TOXICITY REFERENCE VALUES ECOLOGICAL RISK ASSESSMENT IOWA ARMY AMMUNITION PLANT

GENERAL COMMENTS

1. **Calculation of Exposure.** Equations 3, 6, 9, and 10 include bioaccumulation factors (BAFs) and biota-to-sediment accumulation factors (BSAFs) which are obtained from recognized ecotoxicological literature. However, the text and equations presented indicate that the BAFs and BSAFs have to be calculated. The approach is unclear since the BAFs and BSAFs must either be obtained from literature or calculated using the original equations as cited in this document. For example, Equation 2 indicates that the BSAF (apparently obtained from the literature, as cited in Table B-1) will be multiplied by a lipid fraction/total organic carbon variable. However, the BSAF value obtained from literature implies that the lipid fraction/total organic carbon is already accounted for as part of a BSAF variable (i.e., the BSAF implicitly incorporates lipid fraction and organic carbon factors as part of the total exposure). The approach or terminology needs to be clarified as indicated in the specific comment for Equation 2 before it can be determined if it can be considered appropriate.

Response: Equation 3 will be revised to remove correction for biota-sediment accumulation factors (BSAF) based on lipid fraction/total organic carbon. Text will be revised to state that equations available in the literature for calculating bioaccumulation factors (BAF) and BASF will not be used because literature values are available for all contaminants of potential ecological concern (COPECs) as listed in Tables B-1 and B-2.

2. **Measured Concentrations in Fish Tissue.** Concentrations of contaminants in fish are to be used in the dose model for the belted kingfisher. The bottom of the third page states that fish tissue samples were analyzed for mercury, explosives, and pesticides/PCBs. However, mercury and dieldrin were the only chemicals detected in fish tissue samples. The approach indicates that explosives, pesticides, and PCBs that were not detected in fish tissue samples will be excluded from exposure dose calculations and only the actual detected chemicals in fish tissue will be used in the dose model for the belted kingfisher. The approach implies that the fish tissue samples are considered adequately representative of current conditions and exposures at the site, and that these samples represent worst case or average contaminant uptake. It has not been adequately documented that the number and locations of fish tissue samples, species type, and sampling approach can be considered sufficient to represent potential uptake and exposures to upper trophic-level receptors. The dose model should include all chemicals of potential ecological concern (COPECs) in sediment, as determined by the results of the screening level ecological risk assessment (SLERA). If appropriate, based on an evaluation of representativeness, the results of the fish tissue samples may be used as a line of evidence in the Risk Characterization section as part of the baseline ecological risk assessment (BERA).

Response: Ten locations in three of the watersheds were sampled for fish in 1997 (fish were not collected from Skunk River). Objectives of the fish sampling, presented in the Work/Quality

Assurance Project Plan developed in connection with the Ecological Risk Assessment Addendum (Harza 1997), included measurement of representative contaminant body burdens. The species type (darters), sampling locations, sampling methods, and analytical methods were also included in the Work/Quality Assurance Project Plan that was reviewed by all stakeholders. USACE believes that the number and locations of fish tissue samples, species type, and sampling approach are sufficient to represent potential uptake and exposures to upper trophic-level receptors.

Seventeen surface water and sediment samples were collected from each of the watershed and analyzed during groundwater investigation in 1997. Sediment and surface water samples were also collected in connection with the current ecological risk assessment during Spring and Fall of 2000. USACE, Harza, USEPA, and Techlaw (USEPA's contractor) personnel reviewed surface water, sediment, and fish tissue sampling locations and results during selection of two rounds of surface water and sediment sampling. Locations were selected based upon known or suspected sources of aquatic pollution, identified locations of fine sediment deposition, and threatened or endangered species records. The sampling locations also included several locations sampled during the earlier event. Concentrations of explosives (as representative of chemical contamination of the watersheds) detected in surface water and sediment samples are presented in the tables below. The results show that explosive concentrations in 1997 are comparable to those monitored during more recent sampling events. Therefore, fish tissue samples collected in 1997 appear to be representative of current conditions at the four watersheds. USACE proposes to use measured fish tissue concentrations because it believes measured values are of superior quality compared to tissue concentrations estimated based on empirical relations.

Surface Water Concentrations, ug/L		
Watershed	**1997**	**2000**
Brush Creek	HMX: ND-23; RDX: ND-9.3	HMX: ND-7.5; RDX: ND-15; other explosives: trace amount
Spring Creek	RDX:ND-0.72	HMX:ND-1.2; RDX: ND-8.9 (2.2 during the other sampling event); Nitrotolune: trace in 1 sample
Long Creek	None detected	HMX: ND-1.7; RDX:ND-9.1(one sample only in Fall, ND during Spring); other explosives: trace amount
Skunk River	HMX:ND-1.6; RDX: ND-7.8	HMX: ND-2.6; RDX: ND-8.8

Sediment Concentrations, ug/kg		
Watershed	**1997**	**2000**
Brush Creek	HMX: ND-1,900; RDX: ND-9,900	HMX: ND-570; RDX: ND-6,700; other explosives: detected in few samples at low level
Spring Creek	None detected	None detected
Long Creek	None detected	RDX:ND-270
Skunk River	None detected	None detected

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3. Allometric Scaling Factors. The no observable adverse effects levels (NOAELs) and lowest observable adverse effect levels (LOAELs) are selected from typically used ecological literature for use as toxicity reference values (TRVs). The literature and selected TRVs appear to be appropriate. In addition, the method used to adjust the TRVs to account for body weight differences between the actual test species and the representative species used for this risk assessment is also appropriate. However, an allometric scaling factor of "1/4" is included in the equation based on an approach published by Sample, et al, 1996. The justification for using allometric scaling factors has not been adequately documented. The allometric conversion of TRVs for body weights which differ by less than two orders of magnitude is not recommended. It has not been clearly documented that mammalian TRVs need to be adjusted, however, if the scaling factor is used, sufficient and specific written justification is needed. In general, based on Sample, et al, 1996, allometric scaling for avian receptors is not recommended. However, if an avian receptor is to be adjusted, the more appropriate allometric relationship is body weight $^{1.15}$ (Mineau 1996), which should be used with supporting documentation. The use of allometric scaling is considered controversial, and has been the subject of significant scientific debate. It is recommended that the scaling factors be removed from the equation and the TRVs adjusted only for body weight.

Response: The allometric scaling factors will not be used as suggested.

4. Appendix A, TRVs for Four Receptors. A thorough presentation of TRVs for the four receptors of concern at the site and all COPECs has been provided. A cursory review of the TRVs has been conducted, and specific comments are provided. However, the absence of a comment does not necessarily constitute concurrence with any given TRV. An exhaustive review was not completed at this time due to the extensive resources required to obtain and scrutinize each TRV and corresponding citation. The review of TRVs will be an iterative process and changes may be requested in the event that a more suitable TRV is identified during the risk assessment process. As indicated in the specific comments for Appendix A (Comment Nos. 13-18), the selected TRVs did not always include complete or sufficient documentation. It is recommended that the specific TRVs be reviewed to verify that appropriate documentation is provided to justify their use.

Response: Comment acknowledged.

SPECIFIC COMMENTS

1. First page, Derivation of TRVs, Third paragraph. It is stated that the lowest chronic LOAEL value is used as the TRV. EPA guidance, [*Ecological Risk Assessment Guidance for Superfund: Process for designing and Conducting Ecological Risk Assessments* (USEPA 1997)] indicates that conservative exposure assumptions and the NOAEL be used as a conservative assessment for determination of the hazard quotient in the SLERA. The SLERA associated with this site used a media specific benchmark screening approach, which did not include the use of upper trophic level species. This is acceptable since the media-specific benchmarks are used in the selection of chemicals of potential concern and are conservative to prevent an underestimation of risk for the upper trophic level receptors. However, since the SLERA did not include the use of food-chain models and an evaluation of the NOAEL, the Hazard Quotient (HQ) based on the NOAEL will need to be evaluated. It should be recognized that the actual no-effect and lowest-effect levels in the ecosystem are highly uncertain, and it must be assumed that the actual-effect level concentration may fall somewhere between the NOAEL and the LOAEL, to account for this uncertainty. This information and approach is especially important when a threatened or endangered species is present and using the site. It is recommended that the HQ for the upper trophic level receptors be calculated using both the NOAEL and LOAEL. Cases where the NOAEL is exceeded, but the LOAEL is not, can then be discussed based on the specific receptor and COPEC related to the expected sources at the site. Revise the document to reflect these changes.

Response: HQs will be calculated using both LOAELs and NOAELs in order to present a range. In cases where the NOAEL is exceeded but the LOAEL is not, a discussion based on the specific receptor and COPEC related to the expected source at the site will be provided in the Risk Characterization.

2. **Second Page, Derivation of TRVs.** It is indicated that the equation at the top of the page represents the adjustment that was calculated by using the adjustment factor for differences in body weight for a mammalian or avian wildlife species based on Sample and others, 1996. However, the scaling factor presented by the equation represents the scaling factor recommended by the literature cited for the mammalian adjustments. The literature does not specify this value for avian receptors. As indicated in the general comments, it is recommended that the TRVs be calculated using only the body weight adjustment and the scaling factor be removed from the equation, or that proper justification be provided for the use of scaling factors.

Response: See response to General Comment No. 3.

3. **Third Page, Belted Kingfisher, Equation 2.** The equation includes the variable "$C_{W\ -\ j}$." The equation should correct the variable to include the appropriate subscript notation as "$C_{w\text{-}j}$." In addition, the term "E_j" should be included in the definitions for Equations 2, 5, 8, and 13. Revise the document to reflect these changes.

Response: The term E_j is defined for Equation 1. The document will be revised to include definition of E_j for equations 2,5,8, and 13.

4. **Third Page, Belted Kingfisher, Equation 2.** The exposure parameters for the belted kingfisher should include incidental ingestion of sediment. While it is recognized that the specific feeding habits of the belted kingfisher may not necessarily include the ingestion of sediment, it is selected as a representative of the avian piscivore feeding guild, of which others in the group do have this type of exposure. The exposure parameters and equation should include two percent incidental ingestion of sediment based on potential representative exposures for the blue heron, as indicated by the EPA Wildlife Factors Handbook (WFHB). Revise the document to add the incidental ingestion of sediment by the belted kingfisher.

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Response: Table 1, Equation 2, and Figure 1 will be revised to include two percent incidental ingestion of sediment by the belted kingfisher.

5. **Third Page, Belted Kingfisher, Third paragraph.** It is indicated that only mercury and dieldrin will be modeled in the dose equations for the belted kingfisher since these were the only chemicals detected in fish tissue. It is not evident that the available fish tissue samples should be considered representative of expected exposures and bioaccumulation from the site. The approach is not recommended. All COPECs identified by the SLERA should be considered. Revise the document to include all COPECs identified in the SLERA, regardless of whether or not the COPEC was detected in fish tissue.

Response: Please see response to General Comment No. 2.

6. **Fourth Page, Belted Kingfisher, Equation 3.** This section states, "...the contaminants concentration in fish (C_{fish}) will be calculated using the following equation...." The equation includes the variable "BAF_{fish}" defined as the "concentration in fish tissue/concentration in water" which implies that the contaminant concentration in fish tissue is being calculated with site-specific information. However, the corresponding Table B-1 indicates that the BAFs are not calculated, but rather were obtained from various literature sources. It should be clarified that the concentration in fish tissue are based on values obtained from the literature. The approach and definition for the term C_{fish} and BAF should be clarified since the equation implies that the BAFs from water are added to BSAFs from sediment to provide a total concentration in fish tissue. However, BAFs obtained from the literature may be derived based on the total bioaccumulation by the fish regardless of the media. The terms and approach for "calculating" the BAFs in fish tissue should be clarified to indicate which portions are being obtained and which portions are actually being calculated using site-specific information. In addition, the final variables in Equation 3 indicate that the $BSAF_{fish}$ will be multiplied by the fraction of lipid in fish/fraction of total organic carbon (TOC) in sediment. The next paragraph states that the lipid fraction is estimated to be 0.05 (Lablanc 1995), and that the lowest TOC values sampled from all watersheds will be used. However, Table B-1, indicates that the $BSAF_{fish}$ is obtained from literature. It should be noted that the confusion may be associated with use of the term BSAF. In USEPA1995, BSAFs are defined as:

"the ratio of a substance's lipid-normalized concentration in tissue of an aquatic organism to its organic carbon-normalized concentration in surface sediment, in situations where the ratio does not change substantially over time, both the organism and its food are exposed, and the surface sediment is representative of average surface sediment in the vicinity of the organism."

Based on this definition, the lipid content and TOC values should already be accounted for in obtained literature values. Therefore, it is not clear how the 0.05 lipid content or the site-specific TOC values have been used. It appears that the use of Equation 3, multiplying a literature-derived BSAF by the lipid and TOC variables, may have been a duplicative effort. Revise the discussion to clarify the definitions and approach for use of the BSAFs. The presentation and approach for the BSAFs should be clarified to indicate whether BSAFs are being calculated from site-specific data, or are being selected from literature, or if both methods are being used.

This section further states, "A $BSAF_{fish}$ value of 1.7 will be used for organic chemicals...," however, the equation indicates that the $BSAF_{fish}$ = concentration in fish tissue/concentration in sediment, implying that a site-specific fish tissue concentration and co-located sediment concentration is being used in the equation to calculate a site-specific BSAF. The approach is not clear based on this conflicting information. The document indicates that BSAF values are taken from the literature, however, the equations for calculating site-specific BSAFs are also presented. Revise the document to indicate whether BSAF values are being taken from the literature, or whether a portion of the BSAFs are being derived through a combination of equations and site-specific data. Also include the specific references and rationale for the equations used to derive the BSAFs. This comment is also applicable to Equation 6.

Response: Equations for calculating BAF and BASF will not be used because literature values are available for all COPECs as listed in Tables B-1 and B-2.

7. **Fourth Page, Belted Kingfisher, Equation 4.** This section states, "The $BSAF_{fish}$ and BAF_{fish} values of inorganic chemicals were obtained from available literature." However, Table B-1 only lists BAF_{fish} values for inorganic chemicals. In addition, the document states, "The organic BAF_{fish} values were estimated from octanol-water coefficients (Kow), using an equation developed by Meglan and others (1999)." However, the values presented in Table B-1 appear to have been obtained from literature. It should be clarified whether the values have been calculated or were obtained from the Meglan paper.

Response: The text will be revised to delete reference to Equation 4. BAF_{fish} values are obtained from the literature for all COPECs.

8. **Fifth Page, Indiana Bat.** This section states, "The FCM for Indiana Bat is 1 (Sample and others. 1996)." It is not clear how the food chain multiplier (FCM) is being used for this assessment since it does not appear in any equation and the citation listed (Sample and others. 1996) does not include FCM assumptions related to the Indiana bat. Sample and others, 1996, includes the application of the FCM within the context of aquatic trophic transfer. The application of the FCM should be clarified.

Response: Text will be revised to state that the FCM for all inorganic compounds is assumed to be 1 (Sample and others, 1996). The FCM for organics depends on the prey trophic level and the chemical's octanol-water partition coefficient (Kow). The prey trophic level for the Indiana Bat is 3 because the primary food source is aquatic insects with a trophic level of 2. Only three organic compounds were identified as COPECs. In accordance with Sample and others (1996), text will be revised to state that the FCM for the two organic compounds with log Kow values less than 2 is assumed to be 1. Text and Table B-1 will be revised to state that the FCM for bis(2-ethylhexyl)phthalate with a log Kow of 7.3 is 13.474.

9. **Fifth Page, Terrestrial Herbivore-White-footed Mouse, Equation 8.** The equation does not include ingestion of water. It is recommended that water ingestion be included in the equation using the ingestion rates indicated for the mouse on Table 1, Exposure Parameter

Values (third page). In addition, the equation includes the factor "F" which is defined as food intake. However, Equations 2 and 5 define this variable as ingestion rate, IR. It is recommended that similar terms for food ingestion be made consistent for all receptors. Equations 8 and 13 should be revised to present and use the same terminology as used in Equations 2 and 5.

Response: Equation 8 will be revised to include ingestion of water and to replace "F" with "IR."

10. Sixth Page, Terrestrial Carnivore-Short-Tailed Shrew, Equation 13. The equation does not include ingestion of water, however the factors presented below the equation indicate that water is to be included as a variable. It is recommended that water ingestion be included in the equation using the ingestion rates for the short-tailed shrew indicated on Table 1, Exposure Parameter Values (third page). The equation and definition should use consistent terminology for food ingestion as indicated in the Specific Comment No. 9.

Response: Equation 13 will be revised to include ingestion of water and to replace "F" with "IR."

11. Figure 1, Ecorisk Pathways For Belted Kingfisher. The figure includes a box indicating "fish" connected to a box indicating "Tissue - measured contaminant concentration." The text should indicate that fish tissue concentrations are derived based on modeled and measured methods. In addition, the figure should be clarified to include incidental ingestion of sediment. It is recommended that the figure be revised to include water, fish, and sediment as the first exposure column. The fish and tissue boxes should be combined to include all of this information in the one fish box in order to avoid confusion and to be consistent with the other exposure variables.

Response: Figure 1 will be revised as suggested.

12. Figures 3 and 4, Ecorisk Pathways For Short-Tailed Shrew and White-Footed Mouse (respectively). Exposure to water has not been indicated on these figures. It is recommended that the first exposure column be revised to include concentrations in water.

Response: Figures 3 and 4 will be revised as suggested.

13. Appendix A, TRVs For Four Receptors, Table A-2, TRVs for White-Footed Mouse. The table includes adjusted LOAELs and NOAELs values. The LOAEL test species dose listed for benzo(a)anthracene, 16.666 mg/kg/day, does not match the dose cited in the referenced literature. The dose should be 16,666 mg/kg/day. The LOAEL and TRV should be corrected based on the cited literature and the adjustment approach should be clarified.

The table includes LOAEL and NOAEL values for benzo(a)pyrene and provides a citation Mackenzie and Angevine, 1981. However, the information in the remarks column (160 mg/kg/day) and the LOAEL column (10 mg/kg/day) is not consistent. Please verify and revise the information as appropriate.

Response: The cited literature lists the dose as 16,666 g/kg/day, which translates to 16.666 mg/kg/day.

Text will be revised to state that mice were exposed to benzo(a)pyrene doses of 10, 40, and 160 mg/kg/day. Fertility was impaired among offsprings at the 10 mg/kg/day dose level. Therefore, this value was considered to be a chronic LOAEL.

Appendix A, TRVs For Four Receptors, Table A-3, TRVs for Short-tailed Shrew

14. The LOAEL for barium is not consistent with the information presented in the remarks column of the table. The NOAEL is listed as 0.51 mg/kg/day, but a LOAEL is not provided in the remarks column. Please verify the information provided, revise as needed, and clarify how the LOAEL was derived.

Response: Text will be added to state that rats were exposed in a 10-day study and a LOAEL was determined to be 198 mg/kg/day. The chronic LOAEL was estimated by adjusting the subchronic LOAEL (Sample and others, 1996).

15. The NOAEL (1 mg/kg/day) and LOAEL (10 mg/kg/day) for cadmium are based on a 1980 study involving rats (Sutou, et al, 1980). However, the USEPA Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (SLREAP) (USEPA 1999), provides a chronic LOAEL (reproduction) based on a >150 day study involving mice (Schroeder and Mitchner, 1971). The Schroeder study should be used instead of the Sutou study since exposure was through oral doses (rather than through observations of fetal implants as indicated for the Sutou study). Please revise the cadmium TRVs to reflect the oral dose literature (i.e., LOAEL=2.52 mg/kg/day).

Response: Experimental designs such as route of ingestion and exposure duration of the two studies will be further reviewed to determine study results that are more applicable for this site. Justification for the use of the selected study will be presented in the BERA.

16. A NOAEL of 2,737 mg/kg/day has been presented for chromium, however, no citation was provided. Please provide the citation for the chromium NOAEL.

Response: Table A-3 will be revised to state that the NOAEL value was obtained from Sample and others (1996).

17. The NOAEL (42 mg/kg/day) and LOAEL (126 mg/kg/day) for lead are based on a 1998 study involving rats (Ronis, et al, 1998). However, the SLREAP provides an acute LOAEL (mortality) based on a >150 day study involving mice (Schroeder and Mitchner, 1971). The Schroeder study should be used instead of the Ronis study since mortality was observed at significantly lower concentrations through diet. It is not known whether exposure through water oral doses (Ronis study) may have resulted in the significantly higher LOAEL, however, it is recommended that the lower of the available LOAELs be used for this assessment. Please revise the lead TRVs to reflect the lower oral dose (i.e., LOAEL=3.75 mg/kg/day).

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Response: Experimental designs such as route of ingestion and exposure duration of the two studies and additional studies will be further reviewed to determine study results that are more applicable for this site. Justification for the use of the selected study will be presented in the BERA.

18. It is indicated that the NOAEL for nickel (5 mg/kg/day) is based on Ambrose, et al, 1976. However, the SLERAP presents the NOAELs from Ambrose, et al, 1976 as 50 mg/kg/day. Please verify that the NOAEL is correct.

Response: SLERAP cites Ambrose et al (1976) for the NOAEL value of 5 mg/kg/day.

19. Appendix B, Physical/Chemical Coefficient Values, Tables B-1 and B-2. The tables include a footnote "HAZWRAP (1994). *Loring Air Force Base Ecological Risk Methodology. Martin Marietta Energy Systems, Inc. Draft.*" The citation appears to be an internal document that cannot be readily accessed to verify the information cited in the tables. Please provide the original citation for the information presented in the tables.

Response: Text will be revised to cite the original reference.