PROTOCOL

TERRESTRIAL TOXICITY REFERENCE VALUES (TRVs) (INCLUDING EXPOSURE DOSE (ED) AND HAZARD QUOTIENT (HQ) CALCULATIONS)

Introduction

Toxicity reference values (TRVs) are used in the problem formulation stage of the ecological risk assessment (ERA) process per the Ecological Constituent of Potential Concern (COPC) Selection Process. The evaluation conducted using TRVs is performed in Step F of the Ecological COPC Selection Process. Step F, which includes the use of TRVs, involves the refinement of the COPCs identified in the screening step of the COPC Selection Process. Step E requires selection of appropriate assessment endpoint(s), and selection of representative receptors with which to perform TRV-based calculations for exposure dose estimates. The dose estimates, calculated based on the maximum and average concentrations, are then compared to the lowest observable adverse affect level (LOAEL) and the no observable adverse effects level (NOAEL) to calculate a hazard quotient (HQ) for each constituent.

This protocol uses soil invertebrates (earthworms), birds, and mammals as target receptors. Constituents are evaluated using exposure models (discussed in the TRV Based Estimates of Exposure section) that incorporate non-scaled TRVs. TRVs are based LOAELs and NOAELs. Where LOAELs are unavailable, the no observed adverse effects levels (NOAELs) can be estimated by multiplying the NOAEL by 10 (EPA 1995). The technical approach and supportive estimate calculations are presented in TRV Based Estimates of Exposure section. The lists of receptor- and constituent-specific TRVs are presented in the TRV Table section. The technical justification for deriving the TRVs is presented in the Terrestrial TRV Technical Justification Document that is a companion to this protocol. The TRVs used in this protocol and documented in the technical justification document have been primarily abstracted from two reports: (1) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision (Efroymson et al. 1997) for earthworm receptors, and (2) Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996) for bird and mammal receptors. The authors of these two reports have compiled and interpreted toxicity information and data from a variety of sources to develop the TRVs, cited herein for use in Savannah River Site (SRS) ERA constituent evaluation. Where more appropriate TRVs are available from other sources or to supplement the sources above when TRVs are unavailable, these are so noted in the tables (such as the use of the latest version of the Integrated Risk Information System when TRVs are unavailable from other sources). In addition, where unit-specific body burden data are available for a given waste unit, other data sources, such as the Fish and Wildlife Service reports by Eisler may be used.

The lists of TRVs provided in TRV Table section are not comprehensive lists of TRVs that will be needed for constituent evaluation at the SRS. Additional TRVs will be compiled and incorporated into the lists presented below, on a periodic basis, as required based on project-

specific needs. The additional TRVs will be obtained for constituents that exceed the ecological screening value (ESV) comparisons conducted in Step B of the Ecological COPC Selection Process. Further revisions of this protocol will focus on TRVs specific to SRS biota, beginning with the vertebrate fauna. This is contingent upon the selection of receptor species indigenous to SRS based on the protocol for "Assessment and Measurement Endpoint Selection Process."

Details

TRV Based Estimates of Exposure

This protocol is used to estimate the exposure of soil invertebrates and/or wildlife species to soil using TRVs.

The resulting soil invertebrate threshold values are used to indicate whether soil concentrations pose potential risks to soil invertebrates. The contaminant exposure is generally expressed as the average and maximum concentrations of a constituent in soil compared to a risk-based dietary benchmark

The resulting wildlife threshold values are used to indicate if tissue residues pose potential unacceptable risks to ecological receptors. The contaminant exposure is generally expressed as a daily dietary exposure with the units of mg of contaminant per kg body weight of the receptor per day (mg/kg/day). The average and maximum concentrations of a constituent in soil is incorporated into a dietary intake equation and the resulting exposure dose is compared to a risk-based dietary benchmark, as detailed below.

To quantify exposures of terrestrial receptors to each constituent, a daily intake of each constituent is calculated. Conversion of the environmental concentration of each constituent to an estimated daily intake for receptors at the unit is necessary. Exposure rates for each receptor are based upon ingestion of constituents from soil and also from consumption of other organisms. Potential risk from dermal and/or inhalation exposure pathways are generally not quantified for receptors given the insignificance of these pathways relative to the major exposure pathways (e.g., ingestion) and due to the scarcity of data available for these pathways.

The first step in measuring exposure rates for terrestrial wildlife is the calculation of food ingestion rates for the receptors under evaluation. The EPA's Wildlife Exposure Factors Handbook (EPA 1993) includes a variety of exposure information for a number of avian, herptile, and mammalian species. For other species for which data are not provided, the document provides an allometric equation (Nagy 1987, cited by Sample et al. 1996) to estimate food intake based on body mass, as follows:

$$FI = 0.648 (BW^{0.651})$$

where:

FI = food intake rate (g/day)

BW = body weight (g)

A unit-specific exposure dose of each constituent is calculated using a food chain uptake model consistent with EPA Region IV guidance (EPA 1995). This algorithm accounts for exposure via incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and ingestion of lower trophic level animals associated with contamination. The soil exposure equation for lower trophic level receptors is as follows:

$$ED_{soil} = C_s \times [(SP \times CF \times I_p) + (BAF_{inv} \times I_a) + (ST \times I_s)] \times UFF / BW$$

where:

ED_{soil}	=	Soil exposure dose for terrestrial receptor (mg/kg/d)
C_s	=	Concentration in soil (mg/kg)
SP	=	Soil-to-plant uptake factor (kg soil/kg plant)
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless)
I_p	=	Receptor-specific ingestion rate of plant material (kg/d)
BAF_{inv}	=	Invertebrate bioaccumulation factor, constituent-specific bioaccumulation factor for transfer from soil to invertebrate tissue (kg soil/kg tissue)
I_a	=	Receptor-specific ingestion rate of animal material (kg/d)
I_s	=	Receptor-specific ingestion rate of soil (kg/d)
ST	=	Bioavailability factor for constituents ingested in soil
UFF	=	Unit foraging factor (smaller of 1 and exposure area/home-range)
BW	=	Body weight (kg)

Where it is assumed that the vegetation consumed by a given receptor is comprised largely leaves, stems, and roots of plants (EPA 1993), values of SP_v (soil-to-vegetative tissue uptake factor comprised mainly of leaves, stems, and roots) are used to calculate their exposure to constituents. Where it is assumed that the vegetation consumed by a receptor is predominately berries and fruits (EPA 1993), values of SP_r (soil-to-reproductive tissue uptake factor comprised mainly of berries and fruits) are used to calculate their exposure to constituents. BAF_{inv} is used to calculate the exposure of receptors to constituents by ingestion of soil invertebrates. If soil invertebrates are not consumed by the receptor under investigation, the appropriate BAF value would be used instead. BAF and SP values are obtained from the protocol for *Bioaccumulation and Bioconcentration Screening.* Equations used to derive these values are contained within the sources cited in the BAF/BCF protocol.

For the exposure of higher trophic level receptors to constituents from their diet, an algorithm similar to the exposure equation used for lower trophic level receptors is used:

$$ED_{soil} = [(C_s \times SP \times CF \times I_{p(predator)}) + (C_p \times I_{a(predator)}) + (C_s \times I_{s(predator)} \times ST)] \times UFF / BW$$

where:

ED_{soil}	=	Soil exposure dose for terrestrial receptor (mg/kg/day)
C_s	=	Concentration in soil (mg/kg)
SP	=	Soil-to-plant uptake factor (kg soil/kg plant);
CF	=	Plant wet-weight-to-dry-weight conversion factor (unitless)
$I_{p(predator)}$	=	Ingestion rate of plant material by the predator (kg/day)
C_p	=	Concentration in prey tissue (mg/kg)
$I_{a(predator)}$	=	Ingestion rate of animal material by the predator (kg/day)
$I_{s(predator)}$	=	Ingestion rate of soil by the predator (kg/day)
ST	=	Bioavailability factor for constituents ingested in soil
UFF	=	Unit foraging factor (unitless)
BW	=	Body weight (kg)

The constituent concentration in prey tissue (C_p) is calculated using a bioaccumulation factor for ingested constituents to tissue. This factor (BAF_{mamm}) relates constituent tissue concentration to daily constituent intake rather than to soil concentrations and has units of d/kg [concentration in tissue (mg/kg) divided by daily intake (mg/d)]. The equation for concentration in prey tissue is:

$$C_p = [(C_s \times SP \times CF \times I_{p(prey)}) + (BAF_{inv} \times I_{a(prey)}) + (I_{s(prey)} \times ST)] \times BAF_{mamm}$$

where:

$I_{p(prey)}$	=	Ingestion rate of plant material by the prey (kg/day)
BAF_{inv}	=	Invertebrate bioaccumulation factor, constituent-specific bioaccumulation factor for soil invertebrates (kg soil/kg tissue); if soil invertebrates are not consumed by the receptor under investigation, the appropriate BAF value would be used instead.$I_{s(prey)}$ = Ingestion rate of soil by the prey (kg/day)
$I_{a(prey)}$	=	Ingestion rate of animal material by the prey (kg/day)
ST	=	Bioavailability factor for constituents ingested in soil
BAF_{mamm}	=	Mammalian bioaccumulation factor, bioaccumulation factor of constituent ingested by the prey (d/kg)

The intake equations presented above utilize receptor-specific input parameters. The process for identifying appropriate, unit-specific receptors is being developed as part of the protocol for "Assessment and Measurement Endpoint Selection Process."

Once the exposure doses are calculated, maximum and average-based exposure doses are compared to their associated NOAEL- and LOAEL-based or dose-based TRV. The hazard quotient is calculated by dividing the ED by the TRV for indirect toxicity constituents or by

dividing the unit media concentrations by the TRV for direct toxicity constituents. If all of the HQs are less than the one, then the constituent is dropped from further consideration.

TRV Tables

The list of terrestrial TRVs for soil invertebrates (earthworms) are presented in Table 1. The TRVs for wildlife are presented in Table 2 for mammals and Table 3 for birds. The technical justification supporting these TRVs is provided in the Terrestrial TRV Justification Document that is a companion to this TRV protocol.

Table 1. Toxicity Reference Values for Earthworms

Constituent	(mg/kg soil)	
Inorganics		
Arsenic	60	
Cadmium	20	
Chromium	32	
Copper	50	
Lead	500	
Mercury[a]	5	a
Nickel	200	
Selenium	70	
Zinc	200	
Organics		
Chloroacetamide	2	
3-chloroaniline	30	
2,4-dichloroaniline	100	
3,4-dichloroaniline	20	
2,4,5-trichloroaniline	20	
2,3,5,6-tetrachloroaniline	20	
Pentachloroaniline	100	
1,2-dichloropropane	700	
Dimethylphthalate	200	
Fluorene	30	
N-nitrosodiphenylamine	20	
Phenol	30	
4-nitrophenol	7	
3-chlorophenol	10	
3,4-dichlorophenol	20	
2,4,5-trichlorophenol	9	
2,4,6-trichlorophenol	10	
2,3,4,5-tetrachlorophenol	20	
Pentachlorophenol	6	
Chlorobenzene	40	
1,4-dichlorobenzene	20	
1,2,3-trichlorobenzene	20	
1,2,4-trichlorobenzene	20	
1,2,3,4-tetrachlorobenzene	10	
Pentachlorobenzene	20	
Nitrobenzene	40	

TRV = toxicity reference value
TRVs are from Efroymson et al. (1997) unless otherwise noted.
[a] Eisler (1987)

Table 2. Toxicity Reference Values for Mammals

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Inorganics				
Aluminum	Mouse	1.93E-00	1.93E+01	d
Antimony	Mouse	1.25E-01	1.25E-00	d
Arsenic	Mouse	1.26E-01	1.26E-00	d
Barium	Rat	5.10E-00	1.98E+01	b
Beryllium	Rat	6.60E-01	6.60E-00	c
Boron	Rat	2.80E+01	9.36E+01	a
Cadmium	Rat	1.00E-00	1.00E+01	a
Chromium	Rat	2.74E+03	2.74E+04	c
Copper	Mink	1.17E+01	1.54E+01	a
Cyanide	Rat	6.87E+01	6.87E+02	c
Fluoride	Mink	3.14E+01	5.28E+01	a
Lead	Rat	8.00E-00	8.00E+01	a
Lithium	Rat	9.40E-00	1.88E+01	a
Manganese	Rat	8.80E+01	2.84E+02	a
Mercury	Mink	1.00E-00	1.00E+01	c
Molybdenum	Mouse	2.60E-01	2.60E-00	d
Nickel	Rat	4.00E+01	8.00E+01	a
Niobium	Mouse	1.55E-01	1.55E-00	d
Nitrate	Guinea pig	5.07E+02	1.13E+03	a
Selenium	Rat	2.00E-01	3.30E-01	a
Strontium	Rat	2.63E+02	2.63E+03	c
Thallium	Rat	7.40E-03	7.40E-02	f
Tin	Mouse	2.34E+01	3.50E+01	a
Uranium	Mouse	3.07E-00	6.13E-00	a
Vanadium	Rat	2.10E-01	2.10E-00	d
Zinc	Rat	1.60E+02	3.20E+02	a
Organics				
Acenaphthene	Mouse	1.75E+02	3.50E+02	j
Acetone	Rat	1.00E+01	5.00E+01	g
Anthracene	Mouse	1.00E+02	1.00E+03	i
Benzene	Mouse	2.64E+01	2.64E+02	d
Benzidine	Mouse	2.70E-01	2.70E+00	k
Benzo(a)pyrene	Mouse	1.00E-00	1.00E+01	d
Bis(2-chloroisopropyl)ether	Mouse	3.58E+01	1.98E+02	j
Organics (cont.)				

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Bis(2-ethylhexyl) phthalate	Mouse	1.83E+01	1.83E+02	d
Bromodichloromethane	Mouse	1.79E+00	1.79E+01	k
Bromoform	Rat	2.50E+00	5.00E+01	l
Bromomethane	Rat	1.40E-01	7.10E-01	l
Butylbenzyl phthalate	Rat	1.59E+02	4.70E+02	j
Carbon tetrachloride	Rat	1.60E+01	1.60E+02	c
4-Chloroaniline	Rat	1.25E+00	1.25E+01	k
Chlorobenzene	Beagle dog	2.73E+01	5.45E+01	j
Chloroform	Rat	1.50E+01	4.10E+01	g
Dibromochloromethane	Rat	3.00E+00	6.00E+01	l
1,2-Dichlorobenzene	Rat	1.20E+02	1.20E+03	h
1,2-Dichloroethane	Mouse	5.00E+01	5.00E+02	c
1,2-Dichloroethene	Mouse	4.52E+01	4.52E+02	f
1,1-Dichloroethylene	Rat	3.00E+01	3.00E+02	c
1,2-Dichloroethylene	Rat	4.52E+01	4.52E+02	e
2,4-Dichlorophenol	Rat	3.00E-01	3.00E+00	k
1,3-Dichloropropene	Rat	3.00E+00	3.00E+01	k
Diethylphthalate	Mouse	4.58E+03	4.58E+04	d
2,4-Dimethylphenol	Mouse	5.00E+00	2.50E+01	l
Di-n-butylphthalate	Mouse	5.50E+02	1.83E+03	a
2,4-Dinitrotoluene	Beagle Dog	2.00E-01	1.50E+00	i
D-n-hexylphthalate	Mouse	5.50E+01	5.50E+02	d
Ethanol	Rat	3.19E+01	3.19E+02	d
Ethyl acetate	Rat	9.00E+01	3.60E+02	g
Fluoranthene	Mouse	1.32E+01	1.32E+02	h
Fluorene	Mouse	1.25E+01	2.50E+01	l
Formaldehyde	Beagle dog	9.40E-00	9.40E+01	c
Hexachlorocyclo-pentadiene	Rat	1.00E+00	1.9E+00	l
Hexachloroethane	Rat	1.00E-01	1.5E+00	l
Methanol	Rat	5.00E+01	2.50E+02	g
Methylene chloride	Rat	5.85E-00	5.00E+01	a
Methyl Ethyl Ketone	Rat	1.77E+03	4.57E+03	a
4-Methyl-2-pentanone	Rat	2.50E+01	2.50E+02	e
Naphthalene	Rat	1.00E+01	2.00E+01	l
Nitrobenzene	Mouse/Rat	4.60E-01	4.36E+00	m
Pentachlorophenol	Rat	2.40E-01	2.40E-00	a
Phenol	Rat	6.00E+01	1.20E+02	j
Pyrene	Mouse	7.50E+01	7.50E+02	h
Styrene	Beagle dog	2.00E+01	4.00E+01	l
Organics (cont.)				

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Tetrachloroethene	Mouse	1.40E-00	7.00E-00	a
Toluene	Mouse	2.60E+01	2.60E+02	d
1,2,4-Trichlorobenzene	Rat	1.48E+01	5.36E+01	j
1,1,1-Trichloroethane	Mouse	1.00E+03	1.00E+04	c
1,1,2-Trichloroethane	Mouse	3.90E+-01	3.90E+00	i
Trichloroethylene	Mouse	7.00E-01	7.00E+00	f
2,4,5-Trichlorophenol	Rat	1.00E+01	1.00E+02	i
Vinyl chloride	Rat	1.70E-01	1.70E-00	d
Xylenes (total)	Mouse	1.03+03	2.06E+03	a
Pesticides/PCBs				
Aldrin	Rat	2.00E-01	1.00E-00	a
Aroclor 1016	Mink	1.37E-00	3.43E-00	a
Aroclor 1242	Mink	6.90E-02	6.90E-01	d
Aroclor 1248	Rhesus monkey	1.00E-02	1.00E-01	d
Aroclor 1254	Oldfield mouse	6.80E-02	6.80E-01	d
Chlordane	Mouse	4.60E-00	9.20E-00	a
Chlordecone (kepone)	Rat	8.80E-02	4.00E-01	a
o-Cresol	Mink	2.19E+02	2.19E+03	c
DDT and metabolites	Rat	8.00E-01	4.00E-00	a
Dieldrin	Rat	2.00E-02	2.00E-01	d
1,4-Dioxane	Rat	5.00E-01	1.00E-00	a
Endosulfan	Rat	1.50E-01	1.50E-00	f
Endrin	Mouse	9.20E-02	9.20E-01	d
Heptachlor	Mink	1.00E-01	1.00E-00	a
Heptachlor epoxide	Beagle dog	1.25E-03	1.25E-02	k
Lindane	Rat	8.00E-00	8.00E+01	c
Methoxychlor	Rat	4.00E-00	8.00E-00	a
Toxaphene	Rat	8.00E-00	8.00E+01	c
Dioxins/Furans				
1,2,3,6,7,8-Hexachlorodibenzofuran	Rat	1.60E-04	1.60E-03	g
1,2,3,4,8-Pentachlorodibenzofuran	Rat	4.80E-02	4.80E-01	e
1,2,3,7,8-Pentachlorodibenzofuran	Rat	1.60E-04	1.60E-03	g
2,3,7,8-TCDD	Rat	1.00E-06	1.00E-05	a

TRV = toxicity reference value

a Sample et al. (1996)
b Sample et al. (1996); LOAEL derived from subchronic LOAEL
c Sample et al. (1996); LOAEL derived from NOAEL
d Sample et al. (1996) NOAEL derived from LOAEL
e Sample et al. (1996); LOAEL derived from subchronic NOAEL
f Sample et al. (1996); LOAEL derived from subchronic LOAEL
g Sample et al. (1996); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL
h IRIS (EPA 1998); LOAEL derived from NOAEL
i IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic NOAEL
j IRIS (EPA 1998);
k IRIS (EPA 1998); NOAEL derived from LOAEL
l IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL
m IRIS (EPA 1998); NOAEL and LOAEL derived from subchronic LOAEL

Table 3. Toxicity Reference Values for Birds

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Inorganics				
Aluminum	Ringed dove	1.10E+02	1.10E+03	b
Arsenic	Mallard duck	5.14E-00	1.28E+01	a
Barium	Chick (1-day old)	2.08E+01	4.17E+01	f
Boron	Mallard duck	2.88E+01	1.00E+02	a
Cadmium	Mallard duck	1.45E-00	2.00E+01	a
Chromium	Black duck	1.00E-00	5.00E-00	a
Copper	Chick (1-day old)	4.70E+01	6.17E+01	a
Fluoride	Screech owl	7.80E-00	3.20E+01	a
Lead	Japanese quail	1.13E-00	1.13E+01	a
Manganese	Japanese quail	9.97E+02	9.77E+03	b
Mercury	Japanese quail	4.50E-01	9.00E-01	a
Molybdenum	Chicken	3.50E-00	3.53E+01	c
Nickel	Mallard duckling	7.74E+01	1.07E+02	a
Selenium	Mallard duck	5.00E-01	1.00E-00	a
Tin	Japanese quail	6.80E+00	1.69E+01	a
Uranium	Black duck	1.60E+01	1.60E+02	d
Vanadium	Mallard duck	1.14E+01	1.14E+02	b
Zinc	White Leghorn chicken	1.45E+01	1.31E+02	a
Organics				
Bis(2-ethylhexyl)phthalate	Ringed dove	1.10E-00	1.10E+01	b
1,2-Dichloroethane	Chicken	1.72E+01	3.44E+01	a
Di-n-butyl phthalate	Ringed Dove	1.10E-01	1.10E-00	a
Pentachloronitrobenzene	Chicken	7.07E-00	7.07E+01	a
Toxaphene	Black Ducks	2.00E-00	1.00E+01	g
Pesticides/PCBs				
Aroclor 1242	Screech owl	4.10E-01	4.10E-00	b
Aroclor 1254	Ring-necked pheasant	1.80E-01	1.80E-00	c
Benzene Hexachloride (mixed isomers)	Japanese Quail	5.60E-01	2.25E+01	a
Chlordane	Red-winged blackbird	2.14E-00	1.07E+01	a

Constituent	Test Species	Toxicity benchmark (NOAEL, mg/kg/d)	Toxicity benchmark (LOAEL, mg/kg/d)	Ref.
Pesticides/PCBs (cont.)				
DDT and metabolites	Brown pelican	2.80E-03	2.80E-02	c
Dieldrin	Barn owl	7.70E-02	7.70E-01	b
Endosulfan	Gray partridge	1.00E+01	1.00E+02	b
Endrin	Screech owl	1.00E-02	1.00E-01	c
Lindane	Mallard duck	2.00E-00	2.00E+01	c
Dioxins/Furans				
2,3,7,8-TCDD	Ring-necked pheasant	1.40E-05	1.40E-04	a
2,3,7,8-Tetrachlorodibenzofuran	Chick	1.00E-06	1.00E-05	e

TRV = toxicity reference value

a Sample et al. (1996).
b Sample et al. (1996); LOAEL derived from NOAEL.
c Sample et al. (1996); NOAEL derived from LOAEL.
d Sample et al. (1996); LOAEL derived from subchronic NOAEL.
e Sample et al. (1996); LOAEL derived from subchronic LOAEL.
f Sample et al. (1996); NOAEL and LOAEL derived from subchronic NOAEL and LOAEL, respectively.
g Mehrle et al., 1979.

References

Eisler, R. 1987. Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Fish and Wildlife Service, U.S. Department of the Interior. Report No. 85(1.10).

EPA 1999. *Integrated Risk Information System (IRIS).* US EPA On-Line Database of Toxicity Values, Office of Research and Development, United States Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, OH.

EPA. 1995. Preliminary Risk Evaluation. Ecological Risk Assessment Bulletin No. 1, Supplemental Guidance to RAGS: Region 4 Bulletins, Atlanta, GA.

EPA. 1993. Wildlife Exposure Factors Handbook. Office of Health and Environmental Assessment and Office of Research and Development, EPA/600/R-93/187b.

Efroymson, R. A., M. E. Will, and G. W. Suter II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision. ES/ER/TM-126/R2, Oak Ridge National Laboratory, Environmental Sciences Division.

Mehrle, P.M., M.T. Finley, J.L. Ludke, F.L. Mayer, and T.E. Kaiser. 1979. "Bone development in black ducks as affected by dietary toxaphene." *Pestic. Biochem. Physiol. 10:168-173.*

Sample, B.E., D.M. Opresko, and G.W. Suter. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, ES/ER/TM-86/R3, Oak Ridge National Laboratory, Oak Ridge, TN.